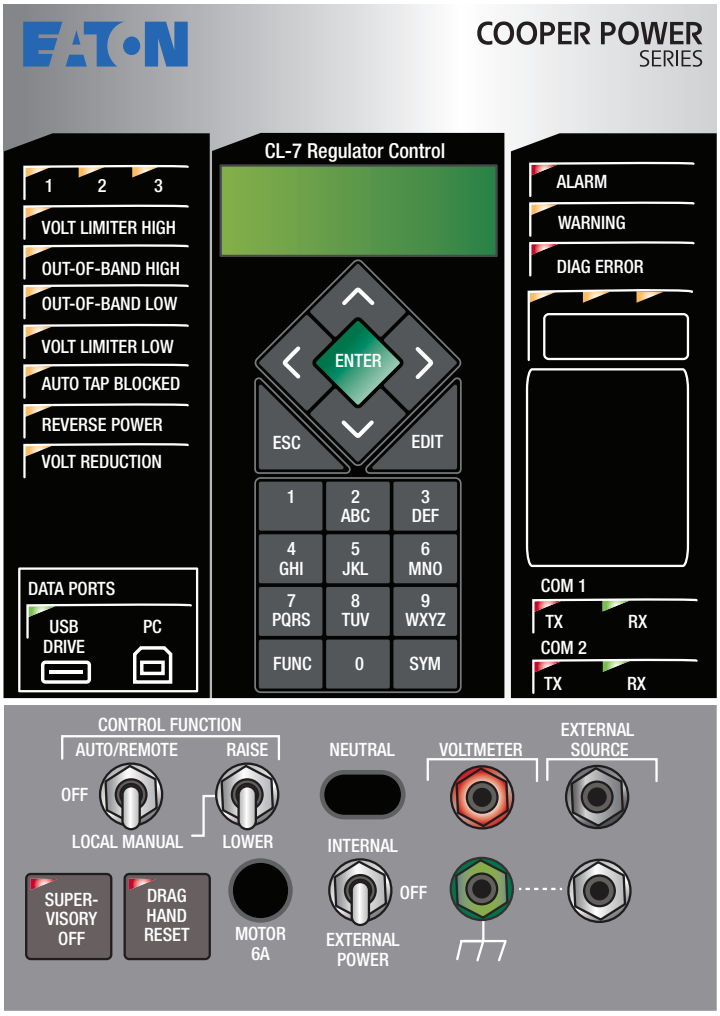
CL-7 Voltage Regulator Control; Installation, Operation, and Maintenance Instructions



Powering Business Worldwide

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Contents

Safety for life

Eaton meets or exceeds all applicable industry standards relating to product safety in its Cooper Power™ series products. We actively promote safe practices in the use and maintenance of our products through our service literature, instructional training programs, and the continuous efforts of all Eaton employees involved in product design, manufacture, marketing, and service.

We strongly urge that you always follow all locally-approved safety procedures and safety instructions when working around high-voltage lines and equipment, and support our "Safety For Life" mission.

Safety information

The instructions in this manual are not intended as a substitute for proper training or adequate experience in the safe operation of the equipment described. Only competent technicians who are familiar with this equipment should install, operate, and service it.

A competent technician has these qualifications:

- Is thoroughly familiar with these instructions.
- Is trained in industry-accepted high- and low-voltage safe operating practices and procedures.
- Is trained and authorized to energize, de-energize, clear, and ground power distribution equipment.
- Is trained in the care and use of protective equipment such as arc flash clothing, safety glasses, face shield, hard hat, rubber gloves, clampstick, hotstick, etc.

Following is important safety information. For safe installation and operation of this equipment, be sure to read and understand all cautions and warnings.

Hazard Statement Definitions

This manual may contain four types of hazard statements:

DANGER

Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

NOTICE

Indicates a potentially hazardous situation which, if not avoided, may result in equipment damage only.

Safety instructions

Following are general caution and warning statements that apply to this equipment. Additional statements, related to specific tasks and procedures, are located throughout the manual.

DANGER

Hazardous voltage. Contact with hazardous voltage will cause death or severe personal injury. Follow all locally-approved safety procedures when working around high- and low-voltage lines and equipment. G103.3

WARNING

Before installing, operating, maintaining, or testing this equipment, carefully read and understand the contents of this manual. Improper operation, handling, or maintenance can result in death, severe personal injury, and equipment damage. G101.0

WARNING

This equipment is not intended to protect human life. Follow all locally-approved procedures and safety practices when installing or operating this equipment. Failure to comply can result in death, severe personal injury, and equipment damage. G102.1

WARNING

Power distribution and transmission equipment must be properly selected for the intended application. It must be installed and serviced by competent personnel who have been trained and understand proper safety procedures. These instructions are written for such personnel and are not a substitute for adequate training and experience in safety procedures. Failure to properly select, install, or maintain power distribution and transmission equipment can result in death, severe personal injury, and equipment damage. G122.2

Product information

Introduction

This document describes the operation and maintenance instructions for the CL-7 Voltage Regulator Control for Eaton's Cooper Power™ series voltage regulators. Refer to document *MN225008EN VR-32 Voltage Regulator with Quik-Drive™ Tap-Changer Installation, Operation, and Maintenance Instructions* for installation and operation information on Eaton's Cooper Power series Voltage Regulator.

Read this manual first

Read and understand the contents of this manual and follow all locally approved procedures and safety practices before installing or operating this equipment. Read and understand the manual detailing the installation and operation of the regulator used with this control.

Additional information

These instructions cannot cover all details or variations in the equipment, procedures, or processes described nor provide directions for meeting every possible contingency during installation, operation, or maintenance. For additional information, please contact your Eaton representative.

Acceptance and initial inspection

This product is completely assembled, tested, and inspected at the factory. It is carefully calibrated, adjusted, and in good condition when accepted by the carrier for shipment.

Upon receipt, inspect the carton for signs of damage. Unpack the control and inspect it thoroughly for damage incurred during shipment. If damage is discovered, file a claim with the carrier immediately.

Handling and storage

Be careful during handling and storage of equipment to minimize the possibility of damage.

⚠ CAUTION

Lifting hazard. A complete control box assembly with control can weigh in excess of 50 lbs. Proper lifting techniques and team lifts should be employed in order to avoid personal injury.

Standards

Eaton's regulators are designed and tested in accordance with the following standards:

IEEE Std C37.90.1™-2012 Standard

IEEE Std C37.90.2™-2004 Standard

IEEE Std C57.13™-2008 Standard

IEEE Std C57.15™-2009 Standard

IEEE Std C57.91™-2011 Standard

IEEE Std C57.131™-2012 Standard

EN 50081-2

EN 61000-4

IEC 60068-2

IEC 60214-1

IEC 60255-5

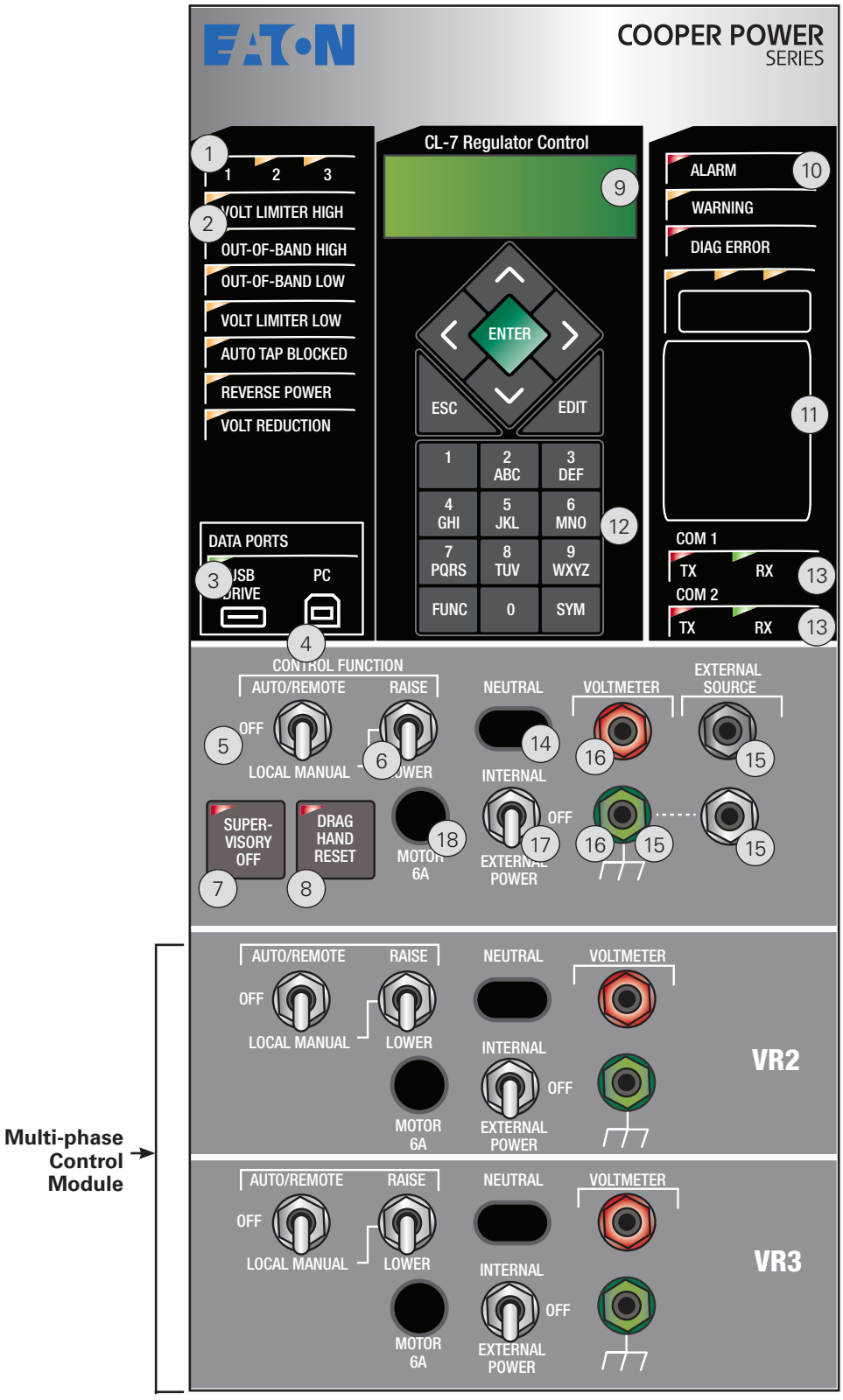
Quality standards

ISO 9001 Certified Quality Management System.

Description

The CL-7 voltage regulator control from Eaton's Cooper Power series incorporates the latest in digital technology to provide accurate, rapid, and dependable control of a step-voltage regulator. Utilizing surface-mount technology and low-power electronics, the CL-7 control is CE (Commonwealth Europe) compliant. The nameplate located on the control box defines the power circuit.

The CL-7 control provides the first of its kind single- or multi-phase voltage regulation utilizing a single control platform. During every step of develop, focus was placed on producing a control to meet the growing demand for smart grid ready features and for flexibility to meet the needs of the future. While great effort was put into enhancing its features, the CL-7 control remains true to its roots by maintaining the ease of use of its predecessor CL controls. The control features the same look and feel of the earlier controls and whenever possible, the same function codes were utilized. The CL-7 control allows keypad programming, Metering-PLUS™ status inquiries, USB memory device uploading and downloading, and multiple communication ports with user-selectable protocols of DNP3 (serial and IP), IEC 60870-5-101 and -104, Cooper 2179, Modbus RTU, Modbus TCP. LED indicators provide instant information on alarm, communications, and regulation condition status. A four-line display provides detailed information and further simplifies programming. In addition, the CL-7 control is highly configurable and ready for use in applications where either digital or analog SCADA is required.



1 Multi-phase Active Display LEDs
2 Status Indicators
3 USB Drive Data Port and LED
4 USB Type B PC Data Port
5 Control Function Switch
6 Manual Raise/Lower Switch
7 Supervisory Off Switch
8 Drag-Hand Reset Switch
9 4 X 20 Character LCD
10 Alarm and Warning Indicators
11 Hot Key Descriptions
12 Multi-Use Keypad: Numeric Keys, Function Keys, Short-Cut Keys
13 Communications Indicators–Tx and Rx LEDs
14 Redundant LED Neutral Light
15 External Source Terminals with Ground
16 Voltmeter Terminals
17 Power Switch
18 Motor Fuse

Figure 1. Control panel layout

Section 1: Control front panel

Lower panel (grey)

The lower (lineman's) section of the front panel contains components and features used to operate the voltage regulator. This section is similar to that of other controls in Eaton's Cooper Power series CL line. Refer to **Figure 2**.

Power switch

In the External position, the control and tap-changer motor are powered from an external source connected to the external source terminals (120 Vac standard, 240 Vac as indicated by decal). In the Internal position, the control and motor are powered from the regulator. In the Off position, no power is delivered to either the control or the motor.

Control function switch

In the AUTO/REMOTE position, the tap-changer motor can be controlled by either the front panel (auto) or remotely by SCADA. In the OFF position, manual and automatic operation and remote motor control are inhibited. In the LOCAL MANUAL position, automatic operation and remote motor control are inhibited and the tap-changer may be raised or lowered locally by momentarily toggling the RAISE/LOWER switch.

Manual raise/lower switch

This switch allows the operator to manually raise or lower the tap-changer motor when the control switch is set to LOCAL MANUAL.

Supervisory off switch

This is a momentary switch used only to inhibit digital communications. When the LED in the top left corner of the switch is not illuminated, SCADA has full capabilities. When the LED is illuminated, SCADA may only read the control database.

Drag-hand reset switch

This is a momentary switch that operates a solenoid in the Position Indicator to move the drag hands to the present tap position.

Neutral light

This is an indication that the tap-changer is in the neutral position. See **Section 2: Control Installation: Determining neutral position** for more detailed guidance on determining when the regulator is in the neutral position.

⚠ WARNING

Explosion Hazard. Bypass a regulator with the line energized only if the position indicator, the neutral light, and the control tap position indicate neutral and the voltage measured between the source and load bushings using an approved voltmeter is zero. If both neutral indicators do not indicate neutral or there is a voltage between the source and load bushings, the line should be de-energized to avoid shorting part of the series winding and resultant high circulating current. Failure to comply can result in death or personal injury and equipment damage. VR-T206.0

Voltmeter Terminals

These terminals allow the connection of a voltmeter to measure the potential sensed by the control between the load (L) bushing and the source load (SL) bushing of the regulator. There are two terminals: a red positive and a green ground. The voltmeter terminals are equipped with protection to prevent back-feeding of the regulator through the control winding.

Fuse

The motor fuse is a 125 V, 6 A, fast-blow fuse.

External source terminals

NOTICE

Equipment damage. Be mindful of polarity when using an external source. Polarity reversal will result in control damage. VR-T201.0

Providing 120 Vac to these terminals powers the control and tap-changer motor. Controls wired for an external source of 220–240 Vac have a decal specifying "240" at the terminals. Caution should be taken when connecting external voltage to the terminals. The voltage should be checked to insure the polarity is correct. The black terminal is the hot terminal, the white is the neutral terminal, and the green, which is directly connected to the chassis, is the external supply ground.

Consult **Section 1: Control Front Panel: Connecting power to external source terminals** before applying external power to the control.

NOTICE

Equipment damage. Only a true AC power supply is to be used to energize the control externally. Do not use a DC-to-AC voltage inverter. Failure to comply can cause excessive harmonics to be generated and result in damage to the control. VR-T204.1

Connecting power to external source terminals

120 Vac applications to an Eaton's Cooper Power series 120 V control

Option 1:

The control box assembly is connected to earth ground to provide protection to operations personnel. This is a typical field application where the control is mounted on a grounded regulator tank or dropped down a pole with the control box grounded properly.

Since the control is configured for 120 Vac, a 1:1 isolation transformer must be used to isolate the supply voltage. This isolation transformer must isolate both the neutral and line on the secondary side. Also, the neutral and ground on the secondary side should not be bonded or connected. To check isolation from earth ground, check the continuity of each lead on the isolation transformer with respect to ground (G). Check this before connecting the leads to the control panel. See **Figure 2**.

The control panel assembly is grounded through the tank or a separate grounding strap. Earth ground of the isolation transformer is not connected to the control. The only source of earth ground reference on secondary of the isolation transformer is through the control box connection to ground.

Option 2:

The control box assembly is floating. This is a typical shop or lab application where the control is mounted on an ungrounded regulator tank or sitting on a workbench.

The 120 Vac external source must be completely isolated. In most cases an isolation transformer is needed. This isolation transformer must isolate both the neutral and line on the secondary side. Also, the neutral and ground on the secondary side should not be bonded or connected. To check isolation from earth ground, check the continuity of each lead on the isolation transformer with respect to ground (G). Check this before connecting the leads to the control panel. See **Figure 3**.

In this case, the ground of the isolation transformer is connected to the green terminal post on the CL-7 control. In this configuration, the only source of earth ground reference on the secondary side of the isolation transformer is through the control box connection to the isolation transformer ground.

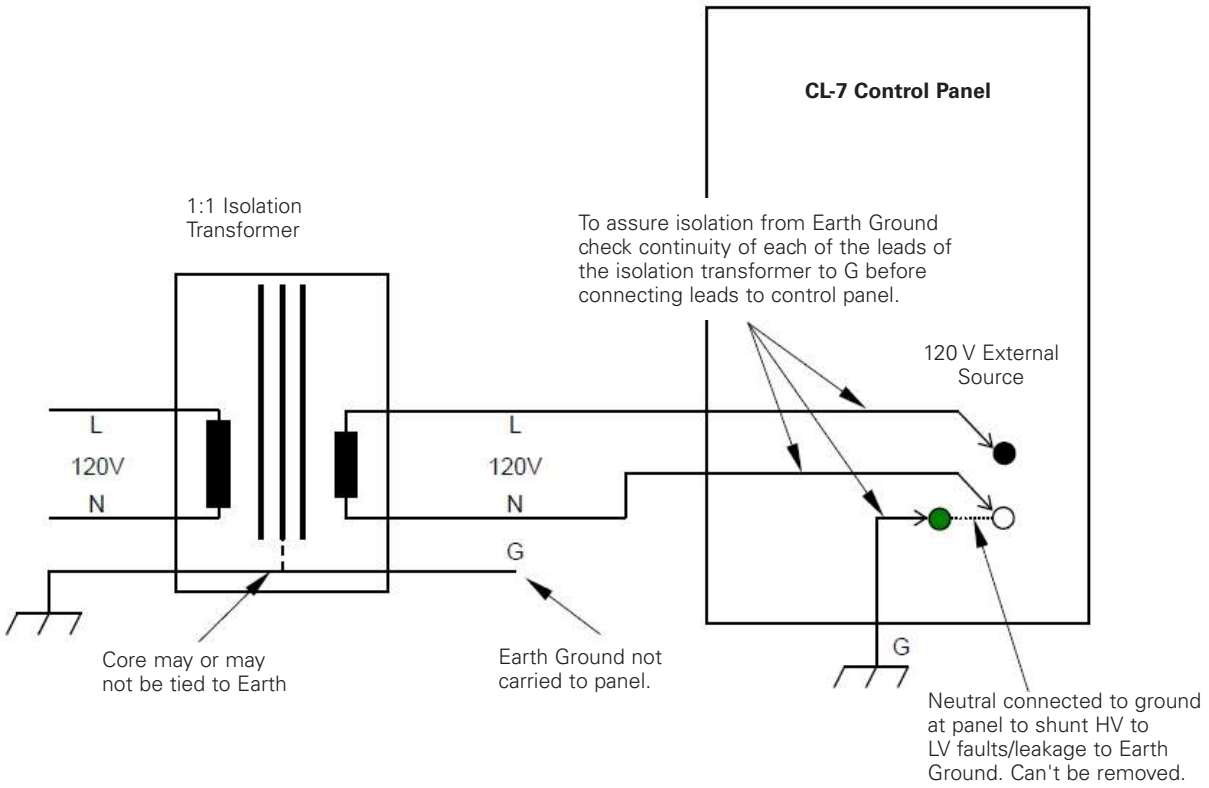


Figure 2. 120 Vac application with Eaton's Cooper Power series 120 V Control—Option 1

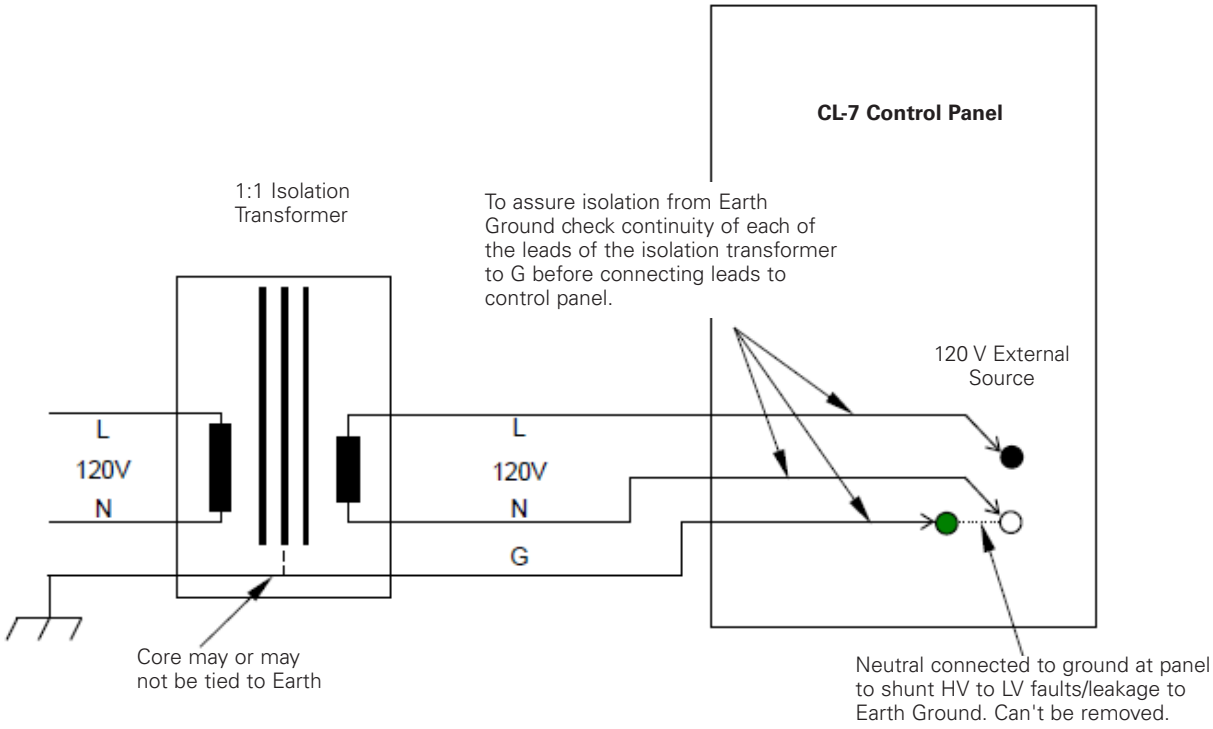


Figure 3. 120 Vac application with Eaton's Cooper Power series 120 V Control—Option 2

240 Vac applications to an Eaton's Cooper Power series 120 V control

Option 1:

The control box assembly/panel is connected to earth ground to provide protection to operations personnel. This is a typical field application where the control is mounted on a grounded regulator tank or dropped down a pole with the control box grounded properly.

Since the control is configured for 120 Vac, a 2:1 isolation transformer must be used to step and isolate the supply voltage. This isolation transformer must isolate both the neutral and line on the secondary side. Also, the neutral and ground on the secondary side should not be bonded or connected. To check isolation from earth ground, check the continuity of each lead on the isolation transformer with respect to ground (G). Check this before connecting the leads to the control panel. See **Figure 4**.

The control panel assembly is grounded through the tank or a separate grounding strap. Earth ground of the isolation transformer is not connected to the control. The only source of earth ground reference on secondary of the isolation transformer is through the control box connection to ground.

Option 2:

The control box assembly is floating. This is a typical shop or lab application when the control is mounted on an ungrounded regulator tank or setting on a workbench.

Since the control is configured for 120 Vac, a 2:1 isolation transformer must be used to step and isolate the supply voltage. This isolation transformer must isolate both the neutral and line on the secondary side. Also, the neutral and ground on the secondary side should not be bonded or connected. To check isolation from earth ground, check the continuity of each lead on the isolation transformer with respect to ground (G). Check this before connecting the leads to the control panel. See **Figure 5**.

In this case the ground of the isolation transformer is connected to the green terminal post on the CL-7 control. In this configuration, the only source of earth ground reference on the secondary side of the isolation transformer is through the control box connection to the isolation transformer ground.

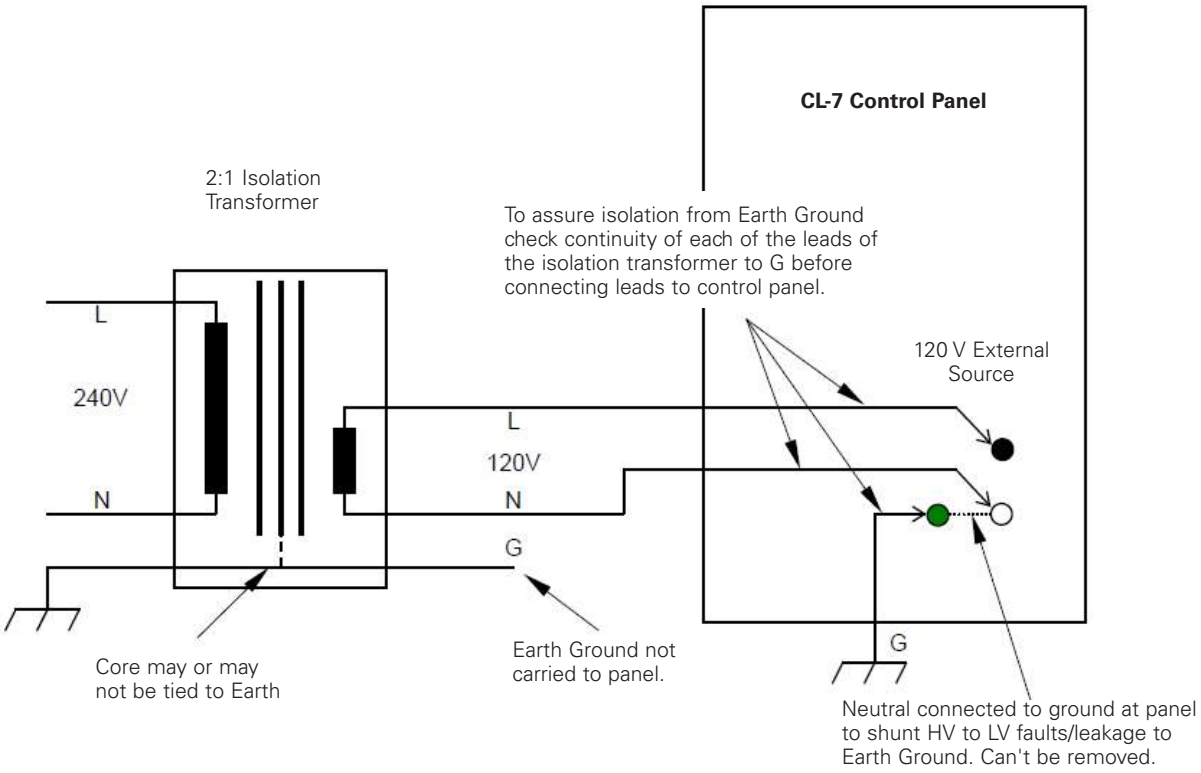


Figure 4. 240 Vac application with Eaton's Cooper Power series 120 V Control—Option 1

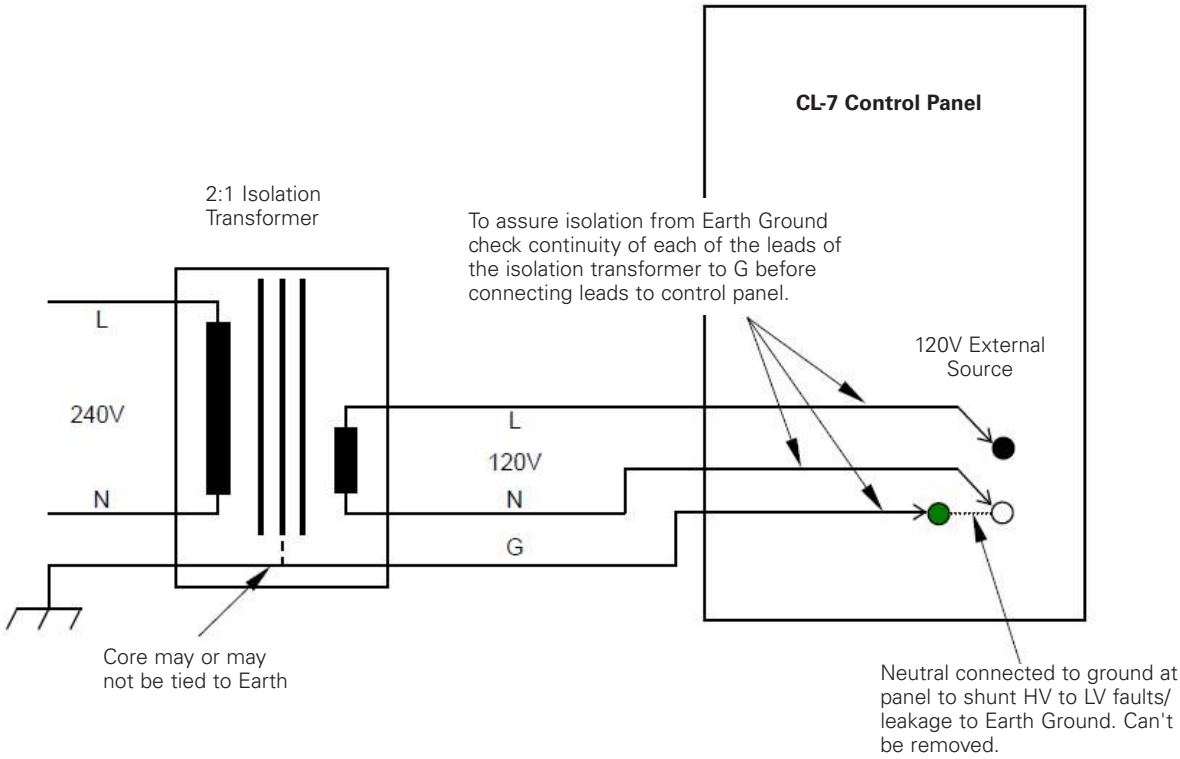


Figure 5. 240 Vac application with Eaton's Cooper Power series 120 V Control—Option 2

240 Vac applications to and Eaton's Cooper Power series 240 V control

Option 1:

The control box assembly/panel is connected to earth ground to provide protection to operations personnel. This is a typical field application where the control is mounted on a grounded regulator tank or dropped down a pole with the control box grounded properly.

The 240 Vac control cabinet from Eaton's Cooper Power series utilizes a 240 Vac to 120 Vac (2:1) auto transformer inside the control cabinet on the back panel. This transformer steps down the 240 Vac external supply to provide 120 Vac to the control panel. Inside the CL-7 control, the neutral and ground are connected in several locations. Care should be taken when applying external power.

The 240 Vac external source must be completely isolated. In most cases an isolation transformer is needed. This isolation transformer must isolate both the neutral and line on the secondary side. Also, the neutral and ground on the secondary side should not be bonded or connected. To check isolation from earth ground, check the continuity of each lead on the isolation transformer with respect to ground (G). Check this before connecting the leads to the control panel. See **Figure 6**.

The control panel assembly is grounded through the tank or a separate grounding strap. Earth ground of the isolation transformer is not connected to the control. The only source of earth ground reference on the secondary side of the isolation transformer is through the control box connection to ground.

Option 2:

The control box assembly is floating. This is a typical shop or lab application where the control is mounted on an ungrounded regulator tank or sitting on a workbench.

Eaton's Cooper Power series offers an optional control configuration that accepts 240 Vac external power. In this configuration, a 240 Vac to 120 Vac (2:1) auto transformer is installed inside the control cabinet on the back panel. This transformer steps down the 240 Vac external supply to provide 120 Vac to the control panel. Inside the CL-7 control, the neutral and ground are connected in several locations.

The 240 Vac external source must be completely isolated. In most cases an isolation transformer is needed. This isolation transformer must isolate both the neutral and line on the secondary side. Also, the neutral and ground on the secondary side should not be bonded or connected. To check isolation from earth ground, check the continuity of each lead on the isolation transformer with respect to ground (G). Check this before connecting the leads to the control panel. See **Figure 7**.

In this case, the ground of the isolation transformer is connected to the green terminal post on the CL-7 control. In this configuration, the only source of earth ground reference on the secondary side of the isolation transformer is through the control box connection to the isolation transformer ground.

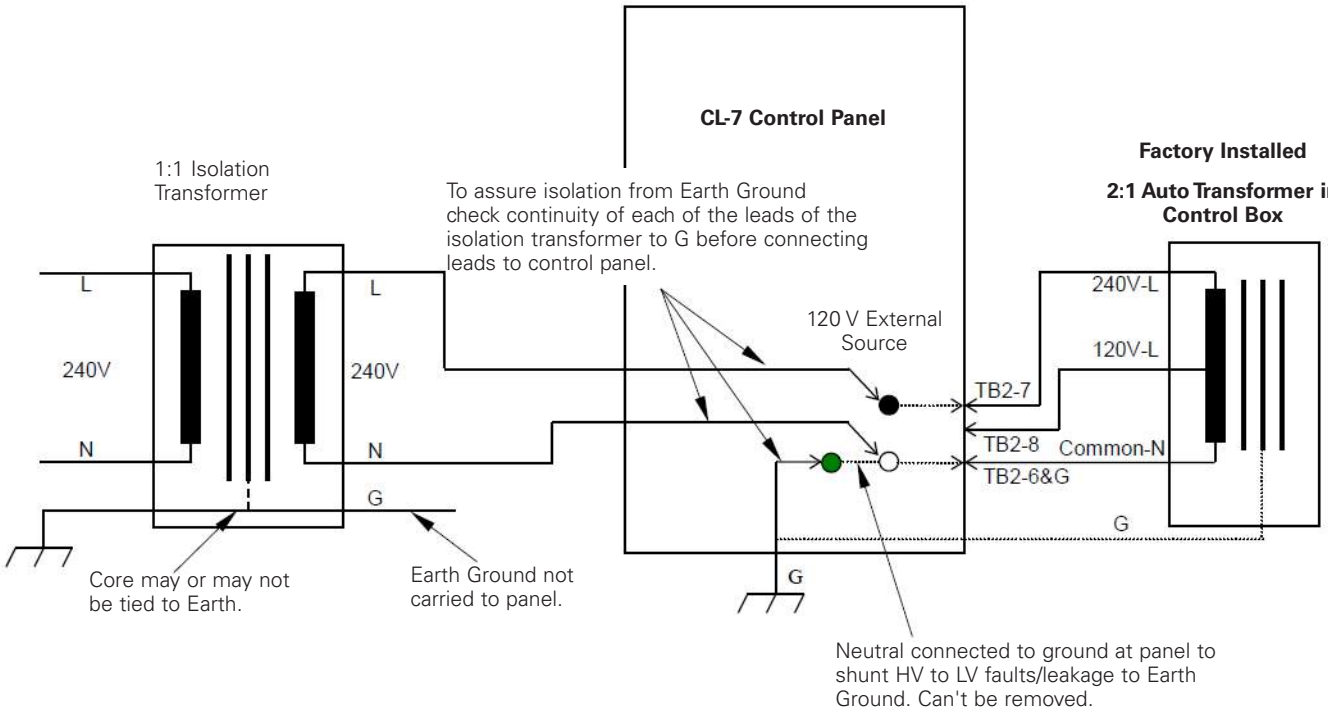


Figure 6. 240 Vac application with Eaton's Cooper Power series 240 V Control—Option 1

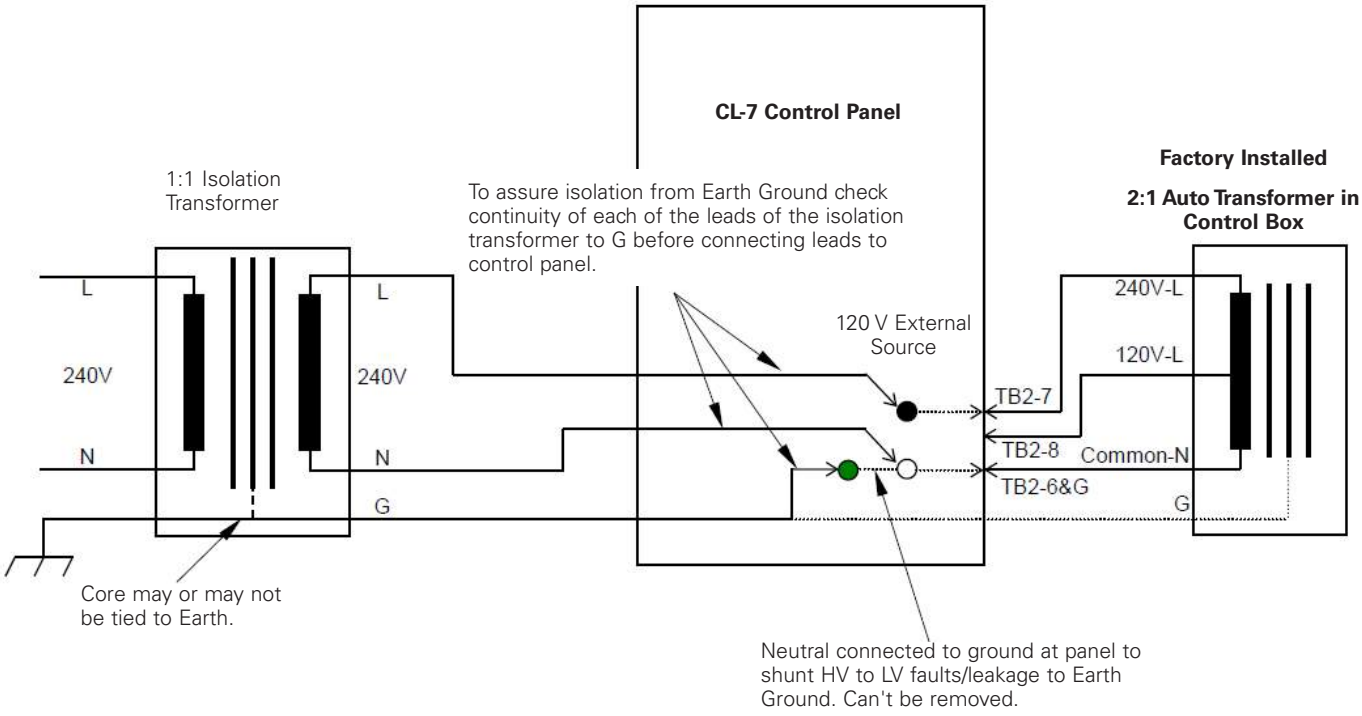


Figure 7. 240 Vac application with Eaton's Cooper Power series 240 V Control—Option 2

Upper panel (black)

Display

The display is a back-lit LCD that will display information in four lines of twenty characters and in four different languages: English, French, Portuguese, and Spanish. See **Figure 8**.

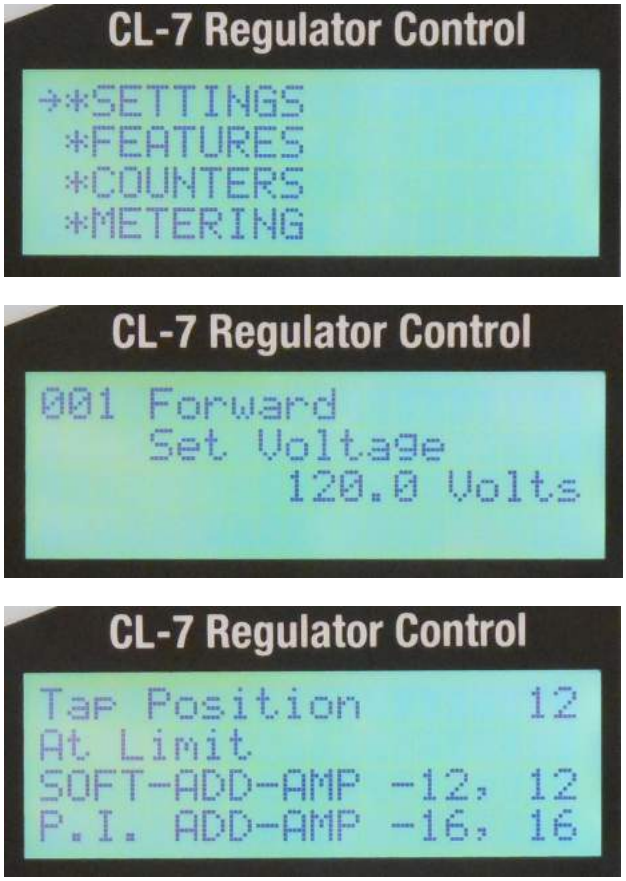


Figure 8. Main Menu, Forward Direction, and Metering-PLUS Tap Position screens

The CL-7 control utilizes a nested menu structure, items are structured with a main menu and then one, two, three, or four sub-menus. The final sub-menu in any of the menus contains the control parameters. The main menu is the default display; refer to **Table 8** for the complete nested menu. When a menu is displayed, the current menu item is indicated by a cursor arrow (→) on the display screen. Parameter values appear on the LCD, right justified, with a decimal point shown as necessary.

Note: Only four line items appear on the display at one time. Moving the cursor down from the fourth line will shift the line items up one item at a time.

LCD display contrast

The LCD display panel contrast is adjustable. Press and hold the **FUNC** key, then press the scroll up arrow key to increase or the scroll down arrow key to decrease contrast.

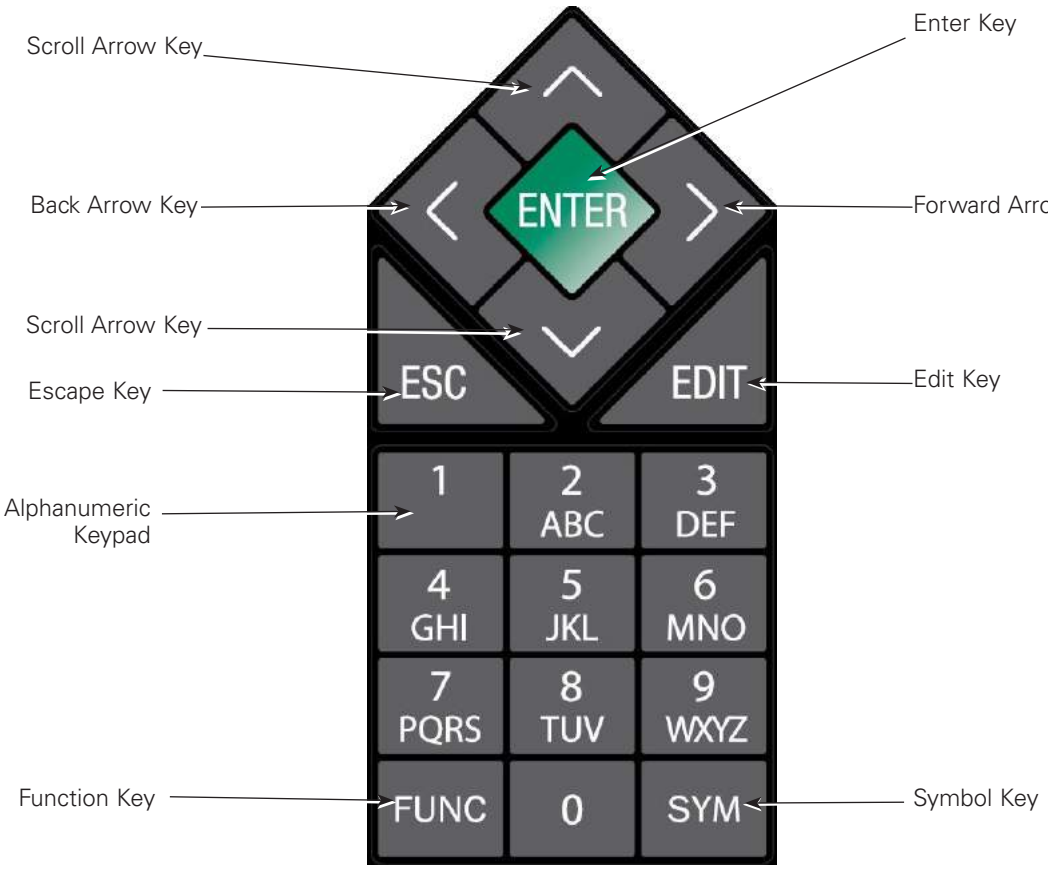


Figure 9. Alphanumeric, scrollable keypad with user-definable Metering-PLUS and shortcut options

Keypad

The front panel interface for the CL-7 control uses a 19-key touchpad with a cell-phone style alphanumeric keypad, arrow keys, a symbol key and four keys used to access and edit control parameters. Refer to **Figure 9**. The keypad allows for three modes of interface with the nested menu structure: alphanumeric keys, short-cut hot-keys, and scroll keys.

Parameter access and editing

Use function codes to quickly read and edit control parameters. To display a parameter on the LCD using a function code (FC), press function (**FUNC**), key in the FC number and then press **ENTER**. For security, certain parameters, as noted in **Table 7**, can only be accessed via the function code method. Also, certain parameters and data, such as alarms, configurable logic and profiler data, can only be accessed using ProView™ NXG interface software.

See **Table 9** for a list of the functions grouped by menu level and **Table 10** for a numerical listing of function codes.

Alphanumeric and symbol keys

After pressing the **FUNC** or **EDIT** keys, the alphanumeric keypad is enabled to enter function code numbers or parameter information. When the alphanumeric keying is complete, pressing **ENTER** will complete the process and enable hot-key functionality (see **Short-cut hot-keys** below).

The alpha characters, used to enter passwords and identification information, are accessed by pressing the keys multiple times to scroll through the letters available for each key. Capitalization of a letter is accomplished by pressing an up or down arrow key while the letter is active on the screen.

Symbols (#, /, ? and !) can be entered by repeatedly pressing the **SYM** key to scroll through the characters.

Short-cut hot-keys

The keypad can be configured to create shortcut access to a variety of commonly used Metering-PLUS, menu and parameter displays. Keys mapped to support the Metering-PLUS feature provide, with one touch, commonly used diagnostic data. Refer to **Section 7: Advanced Control Features: Metering-PLUS feature** for more information. Mapping can also provide one-button access to top-level nested items, some function codes, and enabling of configurable logic.

The default keypad map corresponds to that of the predecessor CL-6 control. A slide out panel (see **Figure 10**) provides a key-code for the key assignments. Two additional pre-programmed key maps can be selected or a custom keypad map can be created. Keypad mapping is available through the nested menu path MENU SYSTEM > Hot Keys or by using FC 944. A custom keypad map can only be created using ProView NXG software.

Options available in the User Defined mapping are CL Exclusive and CL Exclusive w/ Confirm. CL is configurable logic. These options allow for one-button activation of functionality created in configurable logic. Configurable logic inputs are available that correspond to the user-defined key assignments. After programming configurable logic and assigning a control key to activate the logic, a single key press (or key press and then a confirming key press) is all that is required to active the functionality of the logic. See document *MN225015EN, CL-7 Regulator Control ProView NXG Software Programming Guide* for more information on this feature and creating configurable logic.

Slide-out panels are available for the alternate pre-programmed keypad assignments or a user-defined custom panel can be created.

The following options are available when creating a custom keypad map:

- Comp Voltage Metering-PLUS
- Load Voltage Metering-PLUS
- Load Current Metering-PLUS
- Tap Position Metering-PLUS
- USB Memory Drive
- SETTINGS Menu
- FEATURES Menu
- SEQUENCE OF EVENTS Log
- METERING Menu
- ALARMS Menu
- COUNTERS Menu
- COMMUNICATIONS Menu
- System Calendar and Clock FC 50
- DIAGNOSTICS Menu
- Security Access
- Total Operations FC 0
- Forward Set Voltage FC 1
- Forward Band Width FC 2
- Forward Time Delay FC 3
- Forward Line Drop Compensation Resistance FC 4
- Forward Line Drop Compensation Reactance FC 5
- Load Voltage FC 6
- Source Voltage FC 7
- Comp Voltage FC 8
- Load Current FC 9
- CL Exclusive
- CL Exclusive w/Confirm

Scroll arrow keys

Use the arrow keys to move up or down between menu levels, scroll through parameter options when editing parameters, change the case of letters and change numerical values from positive to negative. When the multi-phase option is active on the control, the right arrow key can also be used to change the display between the connected regulators.

The ENTER and Escape (ESC) keys are used like the arrow keys to enter the menu structure or move between menu levels. ENTER is used to access sub-menus. ESC is used to step back or exit submenus. Repeated pressing of the ESC key will return the display screen to the top level main menu.

The LCD displays only four menu items at one time. For nested menu levels that contain more than 4 items, the arrow keys are used to move the cursor down from the fourth line and then shift the menu items up one item at a time. After reaching the last item, the menu will scroll to the top item.

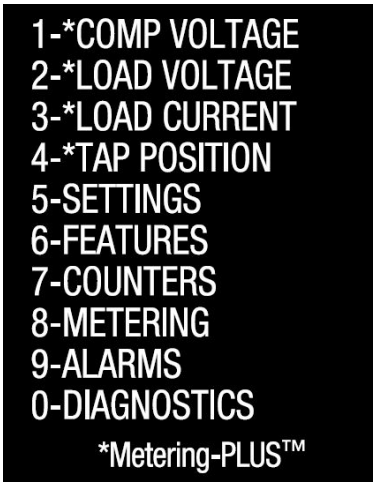


Figure 10. Standard keypad hot-key assignments

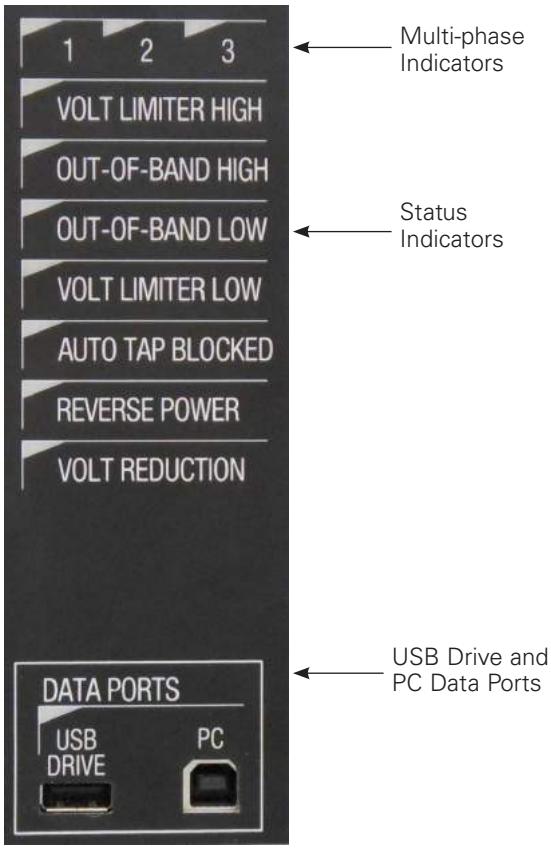


Figure 11. Status indicators and USB ports

Figure 12. Alarm, communication indicators and slide-out hot-key map

Indicator LEDs

Multi-phase indicators

These LEDs provide an indication of which connected voltage regulator is active for the parameter displayed on the LCD screen and for the Status Indicator LEDs. Pressing the right arrow key will scroll through the LEDs. They are active and used only for multi-phase functionality. Refer to **Figure 11**.

Status indicators

These LEDs indicate regulation conditions: Voltage Limiter High, Out-of-Band High, Out-of-Band Low, Voltage Limiter Low, Tapping Blocked, Reverse Power, and Voltage Reduction. Refer to **Figure 11**.

Alarm indicators

These LEDs indicate an Alarm, Warning, user-defined condition, or a diagnostic error. See **Figure 12**.

Communications indicators

These LEDs illuminated to indicate transmit (Tx) and receive (Rx) activity when the transfer of information is taking place through the communications ports on the side of the control. See **Figure 12**.

Data ports

USB drive

The USB Drive data port accepts any USB 2.0 compatible memory device that is formatted with the FAT32 file system. It is used to download data logs and to load and save settings files. See **Figure 11**. USB functionality can be accessed in the top-level menu item USB MEMORY DRIVE or directly using FC 950 through FC 953. See **Section 7: Advanced Control Features: USB memory device** for more information. The LED above the port illuminates to indicate an active connection between the control and USB memory Drive.

PC

The PC data port is a USB type B port that interfaces local communication between the control and a PC using a standard USB type A to B printer cable. See **Figure 11**. The purpose of the port is for communications between a control and a PC loaded with ProView NXG software. The green data ports LED will flash when communications traffic is being processed through the PC data port.

Hot-key mapping

This slide out card provides information about the hot key mapping assignments. See **Figure 12**.

Section 2: Control installation

⚠ WARNING

Hazardous Voltage. To protect personnel from surges while operating the control, follow these control enclosure grounding procedures: a) If the enclosure is attached to the regulator tank or is remote from the tank but only accessible with a ladder, connect the enclosure to the regulator-to-ground rod conductor; b) If the enclosure is accessible by personnel standing on the ground, connect the enclosure directly to a ground mat and ground rod. Failure to comply can result in severe personal injury or death. VR-T202.0

⚠ WARNING

Hazardous Voltage. The control box must be solidly earth grounded. Failure to comply can cause severe personal injury and equipment damage. VR-T203.0

NOTICE

Equipment damage. Only an AC power supply is to be used to energize the control externally. Do not use a DC-to-AC voltage inverter. Failure to comply can cause excessive harmonics to be generated and result in damage to the front panel. VR-T204.1

NOTICE

Equipment damage. Be mindful of polarity when using an external source. Polarity reversal will result in control damage. VR-T201.0

Mounting the control

The CL-7 regulator control in a control box can be mounted on the regulator tank or at a point remote from the unit. Rubber-covered cable of various lengths is available for interconnection between the control and the regulator.

Mounting a multi-phase control

As with the single-phase control, the multi-phase control can be mounted on one of the regulator tanks or on a separate mounting point remote from the regulators. An individual control cable will be connected between the junction box of each regulator and the control box.

Placing the control into service

Refer to the appropriate regulator manual, as indicated on the regulator nameplate for specific information on regulator installation (see **Figure 15**). Refer to **Table 1** and **Table 2** for control specifications and metering accuracy.

When energizing the control from an external source, use only a 120 Vac source, unless the control was configured for 240 Vac, as indicated by a decal adjacent to the terminals.

Table 1. Control Specifications

Description	Specifications
Physical Size*	
Height	
Single-phase Model	11.5 in. (292 mm)
Multi-phase Model	17.5 in. (445 mm)
Width	7.9 in. (201 mm
Depth	3.9 in. (98 mm)
Weight*	
Single-phase Model	7.5 lbs (3.4 kg)
Multi-phase Model	12.9 lbs (5.9 kg)
Burden @ 120 V	4 VA
Operating Temperature Range	-40 °F to +185 °F (-40 °C to +85 °C)
Control System Accuracy	±1%

* Information provided for base units. Additional features will add to weight and dimension.

† Accuracy is based on full scale of 127 Vac and 0.800 A.

Table 2. Metering Accuracy

Load Voltage and Differential/Source Voltage
For a full range of 147 Vac at 45-65 Hz accuracy is ± 0.5% under all conditions.* †
The control will withstand up to 147 V without damage or loss of calibration.
Current Input/Output
For a full range of 0-0.800 A at 45-65 Hz accuracy is ±0.5% under all conditions.**
The control will withstand the short-circuit rating of the regulator without damage or loss of calibration.
Calculated Values, kVA, kW, kvar
Accuracy within 1% under all conditions.*
Harmonic Analysis, Current and Voltage Harmonics
All harmonics metered values shall be computed and displayed with error not to exceed ±3% under nominal conditions.

* Basic accuracy of the device, excluding PT and CT errors.

** 0.5% on range of 0-0.0800 A (±0.5%)(0.800 A) = ±0.004 A

† 0.5% on full scale 147 Vac: (0.5%) (147 Vac) = 0.735 Vac

Setting the control for service

The control must be properly programmed for service. Controls that come pre-installed at the factory on a voltage regulator will be set up for operation on that regulator. For controls that are retrofit onto a regulator, programming must be performed before the unit can be put into service. Refer to **Section 3: Initial control programming** for more information.

The control must be energized to be programmed. Apply 120 Vac, or other voltage as indicated by the decal on the control, to the external source terminals; ensure the ground wire is connected to the ground terminal; and place the power switch in the external position. Alternately, the regulator may be energized at line potential and the power switch placed in the Internal position.

When power is applied to the control, the self-test routine will commence and the LCD display will activate, followed by a PASS message. Check the date and time displayed and reset if necessary. If a failure or diagnostic error message is displayed, refer to **Section 8: Troubleshooting**.

Setting the control for multi-phase service

When programming a control for multi-phase operation, there are a number of settings that configure the control for operation and a number that configure the control to function with the connected voltage regulators. It is important to identify the pertinent settings for the individual regulators and enter each setting into the control appropriately. Refer to **Section 6: Control Features: Multi-phase voltage regulation** and document *MZ225003EN CL-7 Multi-phase Control Reference* for guidance on programming the control for multi-phase operation.

Operational check

Pre-installation check

The CL-7 control has the facilities for either manual or automatic operation of the tap-changer, using either the internal source of power (the regulator) or an external source. To perform an operational check of the control before installing the regulator, follow these steps.

Note: For use with a non-Eaton's Cooper Power series voltage regulator, refer to the manufacturer's manual for equipment specific information.

1. Open **V1** (and **V6**, if present) knife switch(es) located on back panel of control enclosure.
2. Place POWER switch in **OFF** position and CONTROL FUNCTION switch in **OFF** position.
3. Connect a variable 120 Vac 50/60 Hz source to EXTERNAL SOURCE terminals. Controls wired for an external source of 220–240 Vac have a decal specifying "240" at the terminals. Verify proper polarity.
4. Place POWER switch in **EXTERNAL** position.
5. Move CONTROL FUNCTION switch to **LOCAL MANUAL**, press and hold **RAISE/LOWER** momentary toggle switch. Allow tap-changer to operate to **8 L**, the 5% buck position. Verify tap position indication (TPI) is registering properly by pressing **Metering-PLUS Tap Position** key or viewing FC 12.
6. Raise and hold the **RAISE/LOWER** momentary toggle switch. Allow tap-changer to operate to **8 R**, the 5% boost position.
7. Place CONTROL FUNCTION switch in the **AUTO/ REMOTE** position.
8. Increase the variable voltage source until applied voltage is out-of-band. Note that the **OUT-OF-BAND HIGH** LED on the front panel will come on. After the time delay period, the control will issue a lower-tap-change signal. Verify tap position indication (TPI) is registering properly by pressing the **Metering-PLUS Tap Position** key or viewing FC 12 and comparing the reading to the tap position indicator on the regulator junction box.
9. Decrease the variable voltage source until applied voltage is out of band. Note that the **OUT-OF-BAND LOW** LED on the front panel will come on. After the time delay period, the control will issue a raise-tap-change signal. Verify tap position indication (TPI) is registering properly by pressing the **Metering-PLUS Tap Position** key or viewing FC 12 and comparing the reading to the tap position indicator on the regulator junction box.
10. Place the CONTROL FUNCTION switch in the **LOCAL MANUAL** position and manually return the tap-changer to neutral. When on neutral, the **NEUTRAL** light will illuminate continuously and position indicator will point to zero.
11. Place CONTROL FUNCTION switch in **OFF** position.
12. Depress the DRAG HAND Reset momentary switch and release; the position indicator drag hands will reset to indicating hand.
13. Turn POWER switch to **OFF** and disconnect power supply from EXTERNAL SOURCE terminals.

In-service check

With the control programmed for basic operation, perform an operational check of manual and automatic operation.

1. Press the **Metering-PLUS Comp Voltage** key to display compensated voltage and both band edges on the LCD panel.
2. Place the CONTROL FUNCTION switch in **LOCAL MANUAL** position.
3. Toggle the **RAISE/LOWER** switch up to activate a raise operation. Allow tap-changer to operate for enough steps to take voltage out of band. Note that the **OUT-OF-BAND HIGH** LED on the front panel will come on.
4. Place the CONTROL FUNCTION switch in the **AUTO/ REMOTE** position. After the time delay period, the control should cause the regulator to step down to the top band edge. This will display on the LCD panel.

   Example: 120 V and a 2 V bandwidth = 121 V top band edge.
5. After voltage is brought in-band and tap changing has stopped, move the CONTROL FUNCTION switch to the **LOCAL MANUAL** position.
6. Toggle the **RAISE/LOWER** switch down to activate a lower operation. Allow tap-changer to operate for enough steps to take voltage out of band. Note that the **OUT-OF-BAND LOW** LED on the front panel will come on.

7. Place the CONTROL FUNCTION switch in the **AUTO/ REMOTE** position. After the time delay period, the control should cause the regulator to step up to the lower band edge. This will display on the LCD panel.

   Example: 120 V and a 2 V bandwidth = 119 V lower band edge.

Control bench testing

When applying external voltage to a CL-7 control, disconnected from the control box back panel, follow these steps:

1. Place a jumper between positions **7** and **8** of the disconnect plug on the wiring harness of the control.
2. Place a second jumper between positions **6** and terminal **G** of the disconnected plug. There are two G terminals on the harness plug. The jumper would be placed into the G terminal with a wire connected to the other side.
3. Connect the external source to the external source post on the front of the control. Connect the hot lead to the black terminal post, the neutral to the white post, and the ground to the green terminal post. Refer to **Section 1: Control Front Panel: Connecting power to external source terminals** for detailed instructions on applying power to the external source terminals.

Note: For a multi-phase control, this method will only enable powering of the main control. It is recommended to install the control into a control box to fully power a multi-phase control using the external source terminals.

Field calibration check

To check the calibration of the control, compare the voltage that the control reports on the display to the voltage measured at the test terminals.

Note: Field calibration checks are only an indication of calibration and are not as precise as the procedure described in **Section 8: Troubleshooting**.

1. Connect an accurate true-RMS responding voltmeter to the voltmeter terminals.
2. Use the keypad to access FC 47 parameter. Key in:

   FUNC, *47*, **ENTER**.

   Or access via the menu: **FEATURES > Calibration > Voltage Calibration**.

3. Under ideal conditions, the displayed voltage of the control will match the voltage of the voltmeter. Realistically, the voltages may be slightly different because:

   a. The metering and operation is based upon the RMS value of the fundamental power line frequency. Thus, the metered values exclude the influences of harmonic voltages which are probably present on the line. A true RMS meter, however, will include these harmonic voltages in its calculations of the RMS voltage. This does not present a problem with either metering device, since each device uses a different approach to metering.

   b. The calibration of the voltmeter being used for measurement is probably not exact. Even a very good meter with a basic accuracy of 0.5% could be in error by as much as 0.6 V (out of 120 V) and still be considered to be "in calibration." The control is calibrated using a conditioned power supply and reference voltmeters which are periodically calibration-checked, traceable to the National Bureau of Standards.

Note: The control firmware is designed to perform ratio correction. Through the use of the ratio-correction transformer (RCT) located on the back panel, the voltage brought to the control is usually corrected to the 120 V base voltage. However, there are some ratings in which this voltage is not fully corrected by the RCT. Refer to the regulator nameplate for specific information for that regulator. **Table 5** gives a general indication of these voltages.

When mounting the CL-7 control into an existing enclosure, the existing enclosure may not have an RCT installed. In this case the voltage measured on the voltmeter terminals may not match the voltage read on the control.

Whatever voltage results from dividing the nominal system voltage, FC 43, by the overall PT ratio, FC 44, is considered by the control to be the nominal voltage. Therefore, when that voltage appears at the input of the control, 120 V will be reported as the output voltage, FC 6, whether the nominal is actually 120 V or not. Likewise, the compensated voltage, FC 8, and input voltage, FC 7, will be scaled accordingly. If the regulator is equipped and programmed for reverse power operation, the compensated voltage will be correct even during reverse power conditions.

Also note that the base voltage can be set to a 240 V base using FC 148. When this is done, all secondary voltage displays will also be scaled to correspond to the 240 V base. Despite the displays however, the control itself is still powered using an approximate 120 V input.

The load voltage, FC 10; source voltage, FC 11; and calculated parameters such as the kVA, kW, and kvar, are not scaled similarly to FC 6 and FC 8. Instead, they reflect the true value of line voltage.

Note: The voltage measured at the test terminals during reverse power flow is the new source voltage at the load bushing of the regulator.

Removal from service

Refer to the appropriate regulator manual as indicated on the regulator nameplate for further information.

Determining neutral position

⚠ DANGER

Explosion Hazard. During bypass switching, the regulator must be in the neutral position. Prior to bypass switching: 1) The regulator must be placed in the neutral position; 2) Tap-changer operation must be disabled during the bypass switching. If the regulator is in any other position, part of the series winding will be shorted when the bypass switch is closed, resulting in high circulating current. Failure to comply will result in death or severe personal injury and equipment damage. VR-T205.0

⚠ WARNING

Explosion Hazard. Bypass a regulator with the line energized only if the position indicator, the neutral light, and the control tap position indicate neutral and the voltage measured between the source and load bushings using an approved voltmeter is zero. If both neutral indicators do not indicate neutral or there is a voltage between the source and load bushings, the line should be de-energized to avoid shorting part of the series winding and resultant high circulating current. Failure to comply can result in death or personal injury and equipment damage. VR-T206.0

Return the regulator to neutral. Only a regulator in the neutral position can be safely removed from service without interrupting load continuity. It is recommended to use four (4) methods to determine the neutral condition.

⚠ WARNING

Explosion Hazard. Always use the CONTROL FUNCTION switch (labeled AUTO/REMOTE, OFF, LOCAL MANUAL, and RAISE and LOWER) to operate the regulator, not the power switch. Failure to comply can result in the tap-changer stepping off of neutral immediately upon being energized, causing personal injury and equipment damage. VR-T207.0

⚠ WARNING

Explosion Hazard. To stop the regulator on the neutral position, the CONTROL FUNCTION switch should be returned to Off during the switching operation from positions 1R or 1L to position neutral. Switching to Off prior to reaching the neutral position prevents overshoot. Failure to comply can result in death or severe personal injury and equipment damage. VR-T208.0

Return the regulator to neutral

1. Use the Raise/Lower switch to bring the regulator to the neutral position.
2. When in neutral, the Neutral light will be continuously and brightly lit on the control front panel and the position indicator will point to zero.
3. Verify the neutral position of the regulator using four methods.
   a. Verify that the neutral indicator light on the control is indicating the neutral position. Neutral is indicated only when the light is continuously and brightly illuminated.
   b. Verify the tap position on the control indicates neutral by using the Metering-PLUS key or FC 12. When in neutral, the display will show "0" (zero).
   c. Verify that the position indicator on the regulator is in the neutral position. The indicator should point straight up to either zero or N for Neutral.
   d. Using an approved voltmeter, verify that there is no voltage difference between the source and load bushings.

⚠ WARNING

Explosion Hazard. After placing the regulator in the neutral position for bypass switching, always disable the motor to prevent a tap change during bypassing which can result in the tap-changer stepping off of neutral. Failure to comply can cause death or severe personal injury and equipment damage. VR-T209.0

4. When the regulator has been placed in the neutral position, but prior to bypassing, additional safety actions must be taken to disable the tap-changer motor and ensure that the tap-changer will not inadvertently switch to an off-neutral position. This can be accomplished by doing the following:
   a. Place the CONTROL FUNCTION switch in the **OFF** position.
   b. Remove the motor fuse.
   c. Place the control POWER switch in the **OFF** position.
   d. Open **V1**, knife switch (and **V6** if present) located on the control back panel.

Removal of control

The control may be removed from the regulator with the regulator energized. Record settings, etc., to facilitate replacement of the control.

To open the control, unscrew the captive knob(s) on the left side of the panel. This allows the control to swing open on its hinges. With the control open, the back panel is readily accessible. The design of the control enclosure, back panel, and control enables easy replacement of the control, leaving the back panel, control enclosure, and cable intact. To remove the control, proceed as follows:

⚠ WARNING

Flashover Hazard. Push the C shorting switch closed before attempting to remove the front panel. Failure to comply can open the regulator CT circuit, producing a flashover in the control, causing personal injury and equipment damage. VR-T210.0

1. Push closed the current shorting switch C. This shorts out the secondary of the regulator CT.

Note: Regulators shipped with a quick-disconnect cable contain a solid-state CT monitoring circuit in the junction box. This device automatically places a burden on the CT anytime the CT circuit is opened. For consistency and redundancy, it is recommended that the CT shorting switch be used whenever it is present on the back panel.

2. Pull open disconnect switch **V1** (and **V6** if present). This de-energizes terminal board **TB3** (or **TB2** if present).
3. Disconnect the control from the back panel at **TB3** (or **TB2** if present), located at the bottom of the back panel.
4. Disconnect the control ground lead from the back panel.

The control can now be lifted off its hinges. Care should be taken to prevent damage to a control while in transit and/or storage.

Replacement of control

⚠ WARNING

Flashover Hazard. Do not pull open the current shorting switch C until the TB3 (or TB2 if present) connection is completed. Failure to comply can open the regulator CT secondary and cause a flashover in the control, causing personal injury and equipment damage. VR-T211.0

To place a control into the control enclosure, follow the procedure outlined below:

1. Engage control on enclosure hinges.
2. Connect control ground lead to back panel.
3. Reconnect control to back panel at **TB3** (or **TB2** if present), located at the bottom of back panel.
4. Push closed the disconnect switch **V1** (and **V6** if present).
5. Pull open the current shorting switch C.
6. Close the control and tighten locking screw(s).

Section 3: Initial control programming

This section explains each step for properly completing initial control programming settings on a CL-7 voltage regulator control and back panel. Check the System Line Voltage rating on the regulator nameplate. Refer to the regulator service manual as identified on the regulator nameplate for additional information on the regulator.

This section covers standard set-up procedures for controls, including control replacement. Refer to **Programming and reconfiguring for different voltage systems** when installing/replacing the CL-7 control and reconfiguring the regulator for a different voltage system.

1. Start with all switches on the control front panel turned **OFF**.
2. There are two options for powering the control: internal power or external power. Select one method and follow the appropriate step.

   a. Internal Power
   Turn POWER switch to **Internal** from the **Off** position.

   b. External Power
   Apply external source to the EXTERNAL SOURCE binding posts: hot lead to black, top binding post; neutral lead to white, bottom binding post; ground to green ground binding post. Refer to **Section 1: Control Front Panel: Connecting power to external source terminals** for detailed instructions on applying power to the external source terminals.

   Turn POWER switch to **External** from the **Off** position.

Basic programming

Set the parameters in **Table 3** to program the control for basic operation. Continue with the steps in **Table 4** to program the control for reverse power and additional features.

Note: After turning on the control and the LCD displays the results of the Self-Test, press **ESC** for further keypad use.

Step-by-step programming instructions are included in **Table 3** and **Table 4**. The Instructions column lists keys to press (i.e.; ENTER, Edit, 7, etc.). Also, italicized instructions denote a choice or an entry; Value denotes a desired value entered via the numeric keypads; and following each "Scroll" is an italicized list of alternatives that appear in the display, within that function code. Scroll through the list until the desired alternative is selected, and then press Enter.

Perform a Demand Master Reset (FC 38) after completing the initial control programming to reset to present demand values.

Note: Go to FC 941 to change the language setting.

Table 3. Programming for basic operations

Function code	Description	Instructions
99	Security Function	FUNC, 99, ENTER, Password *Admin* (default), ENTER
1	Forward Set Voltage	FUNC, 1, ENTER, EDIT, *Value*, ENTER
2	Forward Bandwidth	FUNC, 2, ENTER, EDIT, *Value*, ENTER
3	Forward Time Delay	FUNC, 3, ENTER, EDIT, *Value*, ENTER
4	Forward Line Drop Comp. Resistance	FUNC, 4, ENTER, EDIT, *Value*, ENTER
5	Forward Line Drop Comp. Reactance	FUNC, 5, ENTER, EDIT, *Value*, ENTER
40	Control Identification	FUNC, 40, ENTER, EDIT, *I. D. number*, ENTER
41	Regulator Configuration	FUNC, 41, ENTER, EDIT, Scroll - *Wye*; *Delta Lagging*; *Delta Leading*, ENTER
42	Control Operating Mode	FUNC, 42, ENTER, EDIT, Scroll - *Sequential*; *Time Integrating*; *Voltage Averaging*, ENTER
43	System Line Voltage	FUNC, 43, ENTER, EDIT, *Value*, ENTER
44	Overall PT Ratio	FUNC, 44, ENTER, EDIT, *Value*, ENTER
44	Internal PT Ratio	FUNC 44, Down Arrow, EDIT, *Value*, ENTER
45	C.T. Primary Rating	FUNC, 45, ENTER, EDIT, *Value*, ENTER
46	Demand Time Interval	FUNC, 46, ENTER, EDIT, *Value*, ENTER
49	Tap-Changer Type	FUNC, 49, ENTER, EDIT, Scroll - *Cooper QD8*; *Cooper QD5*; *Cooper QD3*; *Cooper Spring Drive*; *Cooper Direct Drive*; *Siemens*; *General Electric*; *Howard*; *LTC-Reinhausen*, *ITB*, *Toshiba*, *User-Defined,* ENTER
50	Calendar/Clock	FUNC, 50, ENTER, EDIT, *Month*, *Day*, *Year*, *Hour*, *Minute*, ENTER
140	Regulator Type	FUNC, 140, ENTER, EDIT, Scroll - *Type A*; *Type B*; *Type C*; *Type D*, ENTER
144	P.I. ADD-AMP™ High Limit	FUNC, 144, ENTER, EDIT, *Value*, ENTER
145	P.I. ADD-AMP Low Limit	FUNC, 145, ENTER, EDIT, *Value*, ENTER
146	Vin PT Configuration	FUNC, 146, ENTER, EDIT, Scroll - *Vdiff without RCT2*; *Vin*, Vdiff with RCT2, ENTER
69	Auto Operation Blocking Status	FUNC, 69, ENTER, EDIT, Scroll - *Normal*; *Blocked*, ENTER
148	Nominal Sec Load voltage	FUNC, 141, ENTER, EDIT, Scroll - *120*, *240*, *System Line Voltage* ENTER

Table 4. Programming for reverse power and additional features

Function code	Description	Instructions
141	Regulator Identification	FUNC, 141, ENTER, EDIT, *Value*, ENTER
Requirements for Reverse Sensing Mode without IDPTs		
039	Source Voltage Calculation	FUNC, 39, ENTER, EDIT Scroll - *On*; *Off*, ENTER
Required for Reverse Sensing Modes		
051	Reverse Set Voltage	FUNC, 51, ENTER, EDIT, *Value*, ENTER
052	Reverse Bandwidth	FUNC, 52, ENTER, EDIT, *Value*, ENTER
053	Reverse Time Delay	FUNC, 53, ENTER, EDIT, *Value*, ENTER
054	Reverse Line Drop Comp. Resistance	FUNC, 54, ENTER, EDIT, *Value*, ENTER
055	Reverse Line Drop Comp. Reactance	FUNC, 55, ENTER, EDIT, *Value*, ENTER
056	Reverse Sensing Mode	FUNC, 56, ENTER, EDIT, Scroll - *Locked Forward*; *Locked Reverse*; *Reverse Idle*; *Bi-directional; Neutral Idle; Co-generation; React Bi-directional, Bias Bi-directional, Bias Co-generation; Reverse Co-generation,* ENTER
Required for Voltage Reduction Mode		
070	Voltage Reduction Mode	FUNC, 70, ENTER, EDIT, Scroll - *Off*; *Local/Digital Remote*; *Remote/Latch*; *Remote/Pulse*, ENTER
072	Local/Digital Reduction Value	FUNC, 72, ENTER, EDIT, *Value*, ENTER
073	Remote #1 Value	FUNC, 73, ENTER, EDIT, *Value*, ENTER
074	Remote #2 Value	FUNC, 74, ENTER, EDIT, *Value*, ENTER
075	Remote #3 Value	FUNC, 75, ENTER, EDIT, *Value*, ENTER
076	# of Pulse Reduction Steps	FUNC, 76, ENTER, EDIT, *Value*, ENTER
077	% of Voltage Red Per Pulse Step	FUNC, 77, ENTER, EDIT, *Value*, ENTER
Required for Voltage Limit Mode		
080	Voltage Limit Mode	FUNC, 80, ENTER, EDIT, Scroll - *Off*; *High Limit Only*; *High/Low Limits*, IVVC High Limit Only, IVVC High/Low Limit, ENTER
081	High Voltage Limit	FUNC, 81 ENTER, EDIT, *Value*, ENTER
082	Low Voltage Limit	FUNC, 82, ENTER, EDIT, *Value*, ENTER

Multi-phase programming

When programming a control for multi-phase operation, there are a number of setting that configure the control for operation and a number that configure the control to function with the connected voltage regulators. It is important to identify the pertinent settings applying to the individual regulators and to the control and enter them correctly. Refer to **Section 6: Control Features: Multi-phase voltage regulation** and document *MZ225003EN CL-7 Multi-phase Control Reference* for guidance on programming the control for multi-phase operation.

All of the basic control and regulator operational information in this manual applies to controls and regulators whether they are in a single- or multi-phase configuration. When in the multi-phase configuration, the multi-phase LEDs (marked 1, 2 and 3), see **Figure 13**, can be used to identify to which of the regulators the parameters apply. When programming the multi-phase control, pay attention to the LEDs to insure that the parameters are being entered for the correct regulator. Pressing the forward arrow will cycle the display through each of the connected regulators.

Figure 13. Multi-phase LEDs and forward arrow

Programming and reconfiguring for different voltage systems

Reconfiguring a voltage regulator for a new system voltage requires more than just programming the control. System voltage changes will require control programming, ratio correction transformer (RCT) connection changes and in some cases, a change in the control winding (PT) tap connection inside the regulator tank through the hand-hole cover.

Refer to the regulator nameplate voltage chart for information on programming and reconfiguring the regulator. The Internal PT Ratio, RCT connection and Overall PT Ratio can be found for common system Load Voltages. If the desired system voltage is not show on the nameplate, refer to **Allowable system voltages and calculation of overall PT ratio** in this section of this manual. Instructions for setting Regulator Configuration (FC 41) can be found in the **Determination of leading or lagging in delta-connected regulators** in this section of this manual.

⚠ WARNING

Explosion Hazard. Bypass a regulator with the line energized only if the position indicator, the neutral light, and the control tap position indicate neutral and the voltage measured between the source and load bushings using an approved voltmeter is zero. If both neutral indicators do not indicate neutral or there is a voltage between the source and load bushings, the line should be de-energized to avoid shorting part of the series winding and resultant high circulating current. Failure to comply can result in death or personal injury and equipment damage. VR-T206.1

Steps for changing system voltage

1. Remove the nameplates from the unit and move the pins to the desired Load Volts.
2. Refer to the nameplate; if the Control Winding Taps must be changed the voltage regulator must be de-energize. Refer to the section **Removal from Service** in document *MN225008EN VR-32 Voltage Regulator with Quik-Drive Tap-Changer Installation, Operation and Maintenance Instructions* for detailed instructions.
3. Open the hand-hole cover and reconfigure the control winding connections on the terminal board on top of the tap changer.
   a. Move the PT tap connection (E tap) to the correct position. The terminal is bladed and should easily pull off and then slide onto the new connection point (E1, E2 or E3).
   b. If the regulator is equipped with an internal differential PT (IDPT) there will be a reference to a P tap on the nameplate for the control winding tap. Reconnect the P tap as required (P1, P2 or P3).
4. Replace and secure the hand-hole cover.

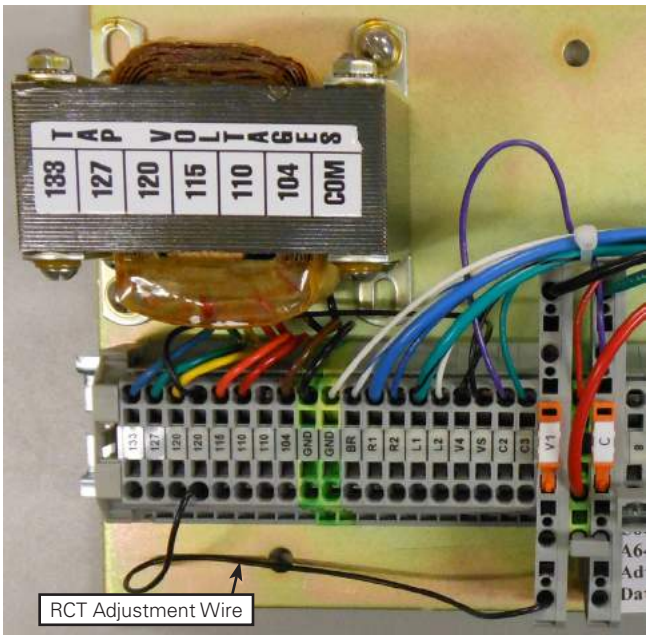


Figure 14. Ratio correction transformer showing wire for voltage adjustment

5. The control should be powered down for the next step. To do so:
   a. Move the CONTROL FUNCTION switch to OFF
   b. Move the POWER switch to OFF.
   c. On the back panel, Open the V1 and V6 (if present) switches and close the C switch (see **Figure 14**).
6. Connect the RCT as required for the desired system voltage.
   a. Standard Short Back Panel – Move the single black wire connected below TB3 to the correct RCT connection point (see **Figure 14**)
   b. Full Back Panel – Move the looped tagged black wire connected on the left side of the RCT terminal board.
   c. IDPT RCT – If there is a second RCT for the IDPT, move the looped tagged white/brown wire connected on the left side of the RCT2 terminal board.
7. Power the control for programming:
   a. Internal Power – If the regulator is connected to system power, close the V1 and V6 (if present) switches and open the C switch and move the POWER switch to INTERNAL.
   b. External Power – Refer to **Section 1: Control Front Panel: Connecting power to external source terminals** for detailed instructions on applying power to the external source terminals. Once power has been connected, move the POWER switch to INTERNAL.

8. Program the control as required for the new system voltage:
   a. Set FC 41 to for the system configuration (Wye, Delta Leading, Delta Lagging).
   b. Set FC 43 to the desired Load Volts.
   c. Set FC 44 to the Overall Pot. Ratio as shown on the nameplate for the corresponding Load Volts or as determined for voltages other than shown on the nameplate.
   d. Set FC 44↓ to the Internal PT Ratio as shown on the nameplate for the corresponding Load Volts or as determined for voltages other than shown on the nameplate.
9. Complete any other programming as required. Refer to **Table 3** and **Table 4** for guidance on typical settings.

Allowable system voltages and calculation of overall PT ratio

If the system voltage is other than those listed on the nameplate, it can be determined if there is sufficient ratio correction available from the control winding (internal PT) taps and the Ratio Correction Transformer (RCT) taps to allow the CL-7 control and motor to function properly. The general guideline is that the overall PT ratio is sufficient if the voltage delivered to the control for the nominal voltage conditions is in the range of 115–125 V.

To determine the voltage delivered to the control, use the following procedure:

1. Calculate the desired PT ratio.

   Desired PT Ratio = Desired system voltage ÷ 120 V
2. Choose the internal PT ratio on the nameplate closest to the desired PT Ratio.
3. Calculate the actual voltage at the output of the internal PT.

   Internal PT Output Voltage = Desired system voltage ÷ Selected Internal PT Ratio
4. Choose the RCT tap (133, 127, 120, 115, 110, 104) closest to the internal PT output voltage.
5. Given the RCT input tap, use **Table 5** to determine the RCT ratio.
6. Calculate the control input voltage.

   Control Input Voltage = Internal PT Output Voltage ÷ (RCT Ratio)
7. Calculate the overall PT ratio.

   Overall PT Ratio = Internal PT Ratio x (RCT Ratio)

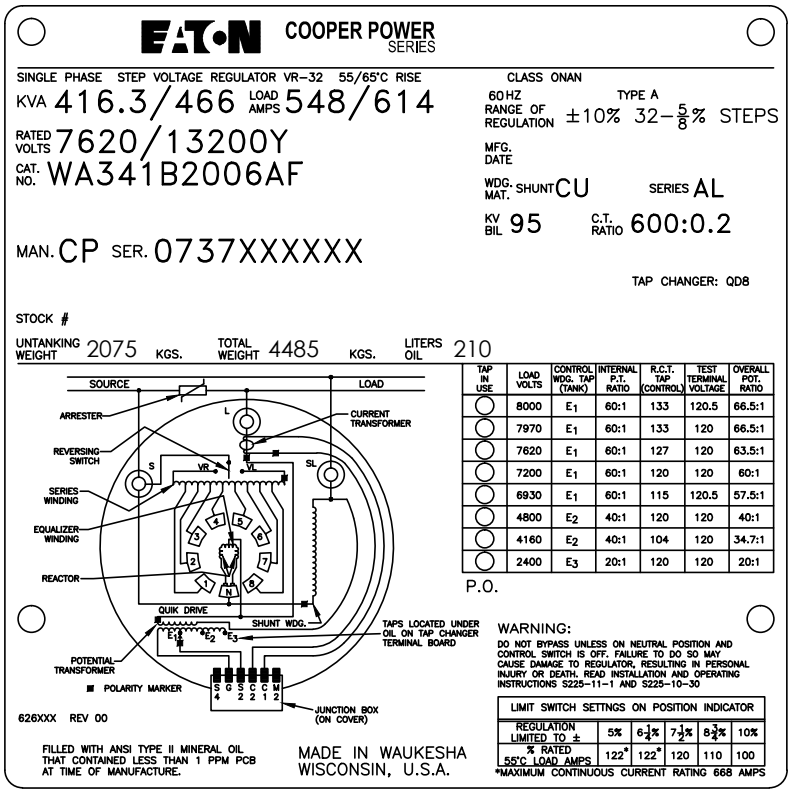
EXAMPLE: If a 60 Hz, 7620 V regulator is to be used on a system with a nominal voltage of 2500 V, the following is determined:

1. 2500 V ÷ 120 V = 20.8
2. Choose 20:1 for the internal PT ratio.
3. Internal PT output voltage = 2500 V ÷ 20 = 125 V
4. Best RCT input tap is 127.
5. RCT ratio is 1.058.
6. Control input V = 125 ÷ 1.058 = 118 V

   This is within allowable range.
7. Overall PT ratio = 20 x 1.058 = 21.2:1

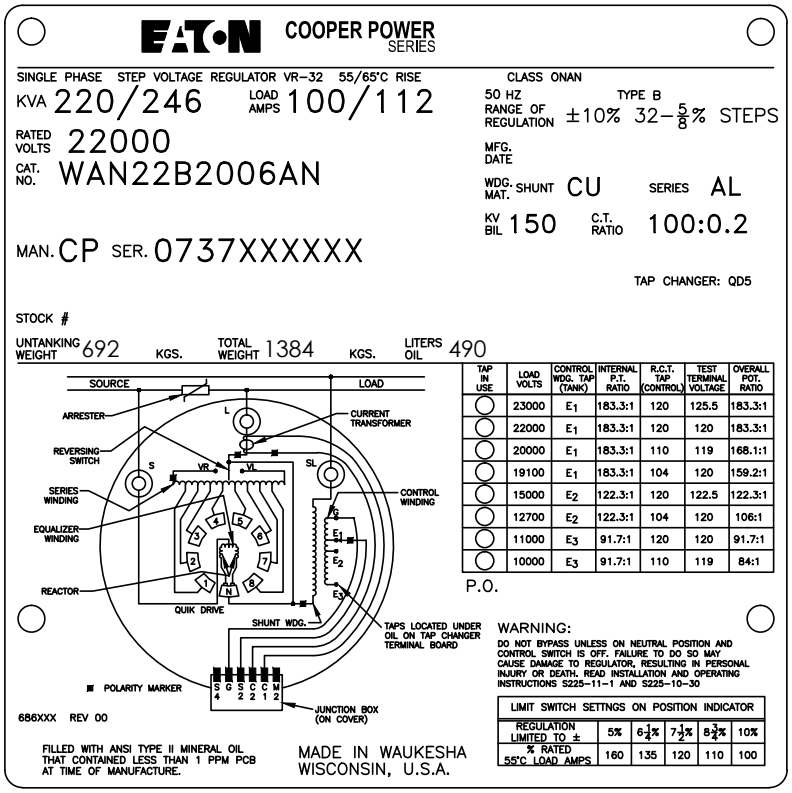
Table 5. RCT ratios

RCT Input Tap	RCT Ratio
133	1.108
127	1.058
120	1.000
115	0.958
110	0.917
104	0.867



TAP IN USE	LOAD VOLTS	CONTROL WDG. TAP (TANK)	INTERNAL P.T. RATIO	R.C.T. TAP (CONTROL)	TEST TERMINAL VOLTAGE	OVERALL POT. RATIO
○	8000	E_1	60:1	133	120.5	66.5:1
○	7970	E_1	60:1	133	120	66.5:1
○	7620	E_1	60:1	127	120	63.5:1
○	7200	E_1	60:1	120	120	60:1
○	6930	E_1	60:1	115	120.5	57.5:1
○	4800	E_2	40:1	120	120	40:1
○	4160	E_2	40:1	104	120	34.7:1
○	2400	E_3	20:1	120	120	20:1

LIMIT SWITCH SETTNGS ON POSITION INDICATOR					
REGULATION LIMITED TO ±	5%	6 1/4%	7 1/2%	8 3/4%	10%
% RATED 55°C LOAD AMPS	122*	122*	120	110	100



TAP IN USE	LOAD VOLTS	CONTROL WDG. TAP (TANK)	INTERNAL P.T. RATIO	R.C.T. TAP (CONTROL)	TEST TERMINAL VOLTAGE	OVERALL POT. RATIO
○	23000	E_1	183.3:1	120	125.5	183.3:1
○	22000	E_1	183.3:1	120	120	183.3:1
○	20000	E_1	183.3:1	110	119	168.1:1
○	19100	E_1	183.3:1	104	120	159.2:1
○	15000	E_2	122.3:1	120	122.5	122.3:1
○	12700	E_2	122.3:1	104	120	106:1
○	11000	E_3	91.7:1	120	120	91.7:1
○	10000	E_3	91.7:1	110	119	84:1

LIMIT SWITCH SETTNGS ON POSITION INDICATOR					
REGULATION LIMITED TO ±	5%	6 1/4%	7 1/2%	8 3/4%	10%
% RATED 55°C LOAD AMPS	160	135	120	110	100

Figure 15. Nameplates, 60 Hz regulator and 50 Hz regulator shown

Determination of leading or lagging in delta-connected regulators

For a regulator to operate properly when connected phase to phase, it is necessary for the control to be programmed with the correct regulator configuration in FC 41. It must be determined whether it is connected leading or lagging. The control aids the operator in making this determination.

1. Regulator must be installed.
2. POWER switch must be set to **INTERNAL**.
3. **V1** knife switch (and **V6**, if present) must be closed.
4. Knife switch C must be open. Current must be flowing.
5. CONTROL FUNCTION switch may be in any position (**AUTO/REMOTE-OFF-LOCAL MANUAL**).
6. For regulator #1, set FC 41 to Delta Lagging and record the Power Factor, FC 13.
7. For the same regulator, set FC 41 to Delta Leading and record the Power Factor.
8. Repeat steps 6 and 7 for each regulator in the bank.
9. For each regulator, one of the two power factor values will be reasonable and the other will be unreasonable.
10. Set the Regulator Configuration (FC 41) to the value which produced the reasonable power factor. See **Table 6**.

For one regulator: Set FC 41 to the value which produced the reasonable power factor.

For two regulators in open delta: See the example in **Table 6**. In an open delta connection, one of the regulators will always be leading and the other lagging. The reasonable power factor for each regulator should be very close to the typical power factor of the system. In this example, regulator #1 is the lagging unit and regulator #2 is the leading unit.

For three regulators in closed delta: In closed delta, all three regulators are either leading or lagging, depending on how they are connected relative to generator phase rotation. Set FC 41 of all three regulators to the value which produced the reasonable power factor.

Table 6. Sample power factor values for regulators connected in open delta configuration

	Recorded power factor (FC 13)	
Configuration (FC 41)	**Reg. #1**	**Reg. #2**
Delta Lagging	0.94*	-0.77
Delta Leading	0.17	0.93*

* Reasonable power factor values.

Section 4: Control operation

Automatic operation

In the automatic mode of operation, the POWER switch will be set on **INTERNAL** and the CONTROL FUNCTION switch will be placed on **AUTO/REMOTE**. The regulator is assumed energized from the primary circuit. If the sequential mode of operation (the standard mode set at FC 42) is selected, the control response on Eaton's Cooper Power series voltage regulator is as follows:

1. As the primary voltage moves to a level which represents an out-of-band condition, the sensing voltage will correspondingly reflect the same results on the 120 V (or 240 V) base. Assuming the voltage dropped low, a lower than normal signal will appear at the printed circuit board input terminals.
2. The signal is transformed and converted into a digital format for use by the microprocessor.
3. The microprocessor, recognizing the voltage condition as low and out-of-band, issues an output which activates the Out-of-Band Low indicator and starts an internal timer, which is equivalent to the time-delay setting.
4. During the time-out period, the voltage is continually sensed and sampled. Should the voltage momentarily move into band, the Out-of-Band Low indicator is deactivated and the timer is reset.
5. At the end of the time-delay period, the microprocessor issues an output which causes the raise triac to be activated.
6. The tap-changer motor begins to turn as a result of triac closure, and a cam on the tap-changer closes the raise holding switch. The holding switch now provides an alternate source for the motor current, which passes through the input terminals on the circuit board.
7. The microprocessor now recognizes that current is flowing in the holding switch circuit. The raise triac is deactivated.
8. As a result of the triac being deactivated, the motor current is now carried solely by the holding switch circuit. When the motor rotation is complete, the holding switch opens as a result of the cam action and the motor stops.
9. The microprocessor recognizes that the tap change is now complete by detecting that motor current is no longer flowing. The operations counter and tap position indication are incremented. A 2-second pause then occurs, allowing the sensing voltage to stabilize after motor operation.
10. At the end of this pause, if the voltage is still out-of-band, another output is issued to reactivate the raise triac, thus starting another tap change sequence. If the voltage is in-band, the **OUT-OF-BAND LOW** indicator is turned off and the time-delay timer is reset.

    This sequence is altered slightly if the voltage-averaging or time-integrating mode of operation are selected. These characteristics are described in **Control operating modes** in this section of the manual.

Manual operation

In the manual mode of operation, the POWER switch can be set on either **INTERNAL** or **EXTERNAL** and the control switch will be placed on **LOCAL MANUAL**. If the external position is chosen, an external source must be applied to the terminals on the control. This should be a nominal 120 Vac source (or other ac voltage as indicated by a decal) and should not be a direct current to alternating current (dc-to-ac) inverter.

Operation of the momentary toggle **RAISE/LOWER** switch applies power through the position indicator limit switch contacts directly to the tap-changer motor. As the tap-changer motor cam rotates, the holding switch is closed, as described above in the **Automatic operation** section. This holding-switch current is sensed by the circuit board, and the operations counter and tap position indicator are appropriately updated.

Tap change operation will continue as long as the **RAISE/LOWER** switch is held in either the raise or lower position and the ADD-AMP™ limit switch is not activated to open the circuit.

Self-test

There are three events which trigger the self-test routine: the initial control power-up, operator entry of self-test mode using FC 91, or detection of a firmware problem. Refer to **Section 8: Troubleshooting** for more information on control self-test.

Security system

The security (password) system implemented on the CL-7 control is structured into four levels. This permits selective access to the various parameters as dictated by the active security level. Most function codes may be read (accessed) at the View level, the base (unsecured) level. The security level required to change or reset each parameter is listed in **Table 7**. The security access codes for levels 1, 2, and 3 have been programmed into the control at the factory. These codes may be changed by the user according to **Table 7**. A secure password may consist of any combination of letters, numbers, and special characters which include the following requirements:

- A minimum of five and maximum of 10 non-blank characters.
- A minimum of 5 letters
- At least one upper case letter.
- At least one special character (#, /, ? or !)
- A letter in the first and last position.

Access into the system is accomplished by entering the appropriate security code at FC 99.The user has the option of overriding (inhibiting) one or more levels of security by choosing the appropriate Security Override Code at FC 92. Choices at FC 92 are View (no override), override Operate level, override Modify and Operate levels, and override the Operate, Modify, and Admin levels.

The values of the three security codes, FC 96, FC 97, and FC 98, may be read only at the Admin level.

IMPORTANT

If the Admin security password is changed and forgotten, it cannot be retrieved. This is to meet international security guidelines which prohibit back-door access to security passwords. In order to reset a lost Admin password, the control must be returned to the factory for reprogramming.

Remote security override

The remote security override feature allows for a temporary override of control security through SCADA. This can be used in cases where local operators are not provided with passwords, but are required to make local changes using the HMI.

Two function code settings configure and enable the feature either through HMI or SCADA, but the feature can only be activated by sending an analog value (Operate=1, Modify=2, Admin=3) through SCADA to override the present security level to the level specified. The remote override timer is set at FC 199 to specify the length of the override in hours and the feature is enables at FC 199↓.

Once the override is activated, it will continue for the duration specified by the remote override timer and then revert back to the previous security level. The timer information is stored in non-volatile memory enabling the override to continue after a power cycle unless the timer has expired while power was off. If the timer is changed when the override is in place, the timeout period will restart.

If the user enters a valid password from the front panel while the remote security override is enabled, the control will use the entered password and the remote security override feature will be disabled.

Table 7. Security codes

Security level	Accessible at function code	Factory-programmed code	Functions available at the active code
View	No code required	No Code Required	Read all parameters except security (FC 96, FC 97, & FC 98)
Operate	96	Operate	Read all parameters as described above,and reset all demand metering and tap position maximum and minimum values and date/times
Modify	97	Modify	Read all parameters as described above, reset all demand meter and tap position maximum and minimum values and date/times, and change any operational or setup parameter
Admin	98	Admin	Read, reset, or change any parameter

Basic control operations

Set voltage

The set voltage is the voltage level to which the control will regulate on the 120 V or 240 V base. Since the control performs ratio correction in the firmware, this value will typically be set for 120.0 V/240.0, unless it is desired to operate at a voltage level higher or lower than nominal. For proper operation, the ratio-correcting transformer, located on the back panel of the control enclosure, must also be set for the correct tap as shown on the regulator nameplate.

Bandwidth

The bandwidth is defined as that total voltage range, around the set voltage, which the control will consider as a satisfied condition. As an example, a 2 V bandwidth on a 120 V set voltage means the time delay timer will not activate until the voltage is below 119 V or above 121 V. When the voltage is in-band, the band edge indicators are off and the timer (time delay) is off. Selection of a small bandwidth will cause more tap changes to occur, but will provide a more tightly regulated line. Conversely, a larger bandwidth results in fewer tap changes, but at the expense of better regulation. Selection of the bandwidth and time-delay settings should be made recognizing the interdependence of these two parameters.

Time delay

The time delay is the period of time (in seconds) that the control waits from when the voltage first goes out-of-band to the time when a tap change is issued. If a rapid response is required, a shorter setting should be used. If several devices on the same line are to be coordinated (cascaded), different time-delay settings will be required to allow the devices to operate in the desired sequence. Proceeding from the source, each device should have a longer time delay than the preceding device. A minimum 15-second difference between regulators located on the same phase on the same feeder is recommended. The delay allows the upstream device to perform its operations prior to the downstream device reacting. The time-delay setting of a voltage-minimizing, activated capacitor control should be set the same as a regulator control. Alternate time delays are available with the voltage limiter feature. Refer to **Section 6: Control Features: Voltage limiter** for more information.

Line drop compensation, resistance and reactance settings

Quite often regulators are installed some distance from the theoretical load center (the location at which the voltage is to be regulated). This means the load will not be served at the desired voltage level due to the losses (voltage drop) on the line between the regulator and the load. Furthermore, as the load increases, line losses also increase, causing the lowest voltage condition to occur during the time of heaviest loading.

To provide the regulator with the capability to regulate at a projected load center, the control has line-drop-compensation elements within it. This circuitry usually consists of a current transformer (CT), which produces a current proportional to the load current, and resistive (R) and reactive (X) elements through which this current flows. As the load increases, the resulting CT current flowing through these elements produces voltage drops, which simulate the voltage drops on the primary line.

Within the control, the input current is sampled and is used in a computer algorithm which calculates the respective resistive and reactive voltage drops based upon the line-drop-compensation values programmed into the control at FC 4 and FC 5 (or FC 54 and FC 55 for reverse power flow conditions). This is an accurate and economical means of developing the compensated voltage.

To select the proper R and X values, the user must know several factors about the line being regulated.

Regulator configuration

The control is designed to operate on wye (star)-connected and delta-connected regulators. Regulators connected line-to-ground (wye) develop potentials and currents suitable for direct implementation in the control. Regulators connected line-to-line (delta) develop a potential-to-current phase shift which is dependent upon whether the regulator is defined as leading or lagging. The phase shift must be known by the control to permit accurate calculations for correct operation. This is accomplished by entering the proper option at FC 41: Wye, Delta Lagging, or Delta Leading. See **Section 3: Initial Control Programming: Determination of leading or lagging in delta-connected regulators** for more information on setting this parameter.

Control operating modes

The CL-7 control supports three modes in which the control responds to out-of-band conditions, permitting use of the mode that best fits the application. The three modes are Sequential, Time Integrating, and Voltage Averaging. The mode setting can be selected by scrolling within FC 42 or through **Settings > Configuration** in the menu structure.

Sequential mode

This is the standard mode of response. When the load voltage goes out-of-band, the time-delay circuit is activated. At the end of the time delay, a tap change is initiated. After each tap change, a 2-second pause occurs to permit the control to sample the voltage again. This sequence continues until the voltage is brought into band, at which time the timing circuit is reset. Whenever the voltage goes in-band, the timer is reset.

Time-integrating mode

When the load voltage goes out-of-band, the time-delay circuit is activated. At the end of the time-out, a tap change is initiated. After each tap change, a 2-second pause occurs to permit the control to sample the voltage again. If the voltage is still out-of-band, another tap change is performed. This sequence continues until the voltage is brought

into band. When the voltage goes in-band, the timer is decremented at the rate of 1.1 seconds for every second elapsed, until it reaches zero.

Voltage-averaging mode

When the load voltage goes out-of-band, the time-delay circuit is activated. During this time-delay period, the microprocessor monitors and averages the instantaneous load voltage. It then computes the number of tap changes required to bring the average voltage back to the set voltage level. When the time-delay period is complete, the computed number of tap changes are performed without any delay between them, up to a maximum of five consecutive tap changes, to avoid an accumulative error. The timer is not reset on voltage excursions in-band unless the voltage stays in-band for at least ten continuous seconds. An error-averaging characteristic is inherent with the voltage-averaging mode.

Note: To permit sufficient time for the microprocessor to average the voltage, the time-delay period must be 30 seconds or longer. If the time delay is set for less than 30 seconds, the control ignores the setting and uses 30 seconds.

System line voltage

The control performs ratio correction in the firmware, and, consequently, the primary voltage must be entered for the control to perform this calculation. This value is simply the nominal single-phase voltage supplied across the L and SL terminals. Regulators shipped from the factory are set for the voltage indicated by the pin on the nameplate, and this value is programmed into the control. If the regulator is installed on any other system voltage, this system voltage must be entered for proper operation.

Overall PT ratio

Since the control performs ratio correction in the firmware, the PT ratio for the voltage-sensing supply is required for the control to perform the calculation. The ratio to be programmed in the control is the Overall PT Ratio, which is a combination of the ratios of the PT in the tank and the RCT. For standard voltages shown on the regulator nameplate an Overall PT Ratio is listed. The Overall PT Ratio, which corresponds to the regulator's rated voltage, is set by the factory. If the regulator is installed on any other system voltage, the corresponding Overall PT Ratio is also required and must be determined. See **Section 3: Initial Control Programming: Allowable system voltages and calculation of overall PT ratio** for more information.

The voltage from the RCT is normally corrected to 120 V. However, when this voltage is other than 120 V, the control will calibrate the input voltage to a 120 V (or 240 V when FC 148 is set to 240 Volts) base and 120 V (or 240 V) will be displayed at FC 6. The voltage test terminals will continue to show the voltage as applied to the control from the RCT.

Internal PT ratio

The CL-7 control does not require a ratio correction transformer (RCT) for the internal differential PT (IDPT). If a regulator design includes an IDPT, but does not have a second RCT, the control is able to use the Internal PT ratio to determine the differential and source-side voltage. In order for this to work, the Internal PT ratio must be entered at FC 44↓ and the Vin PT Configuration (FC 146) must be set to Vdiff without RCT2. The Internal PT ratio is also used by the control to determine the source bushing voltage when the FC 146 is set to Vin and the the voltage regulator is equipped with a PT used to measure the voltage between the S and SL bushings.

Current transformer primary rating

The control is designed for 200 mA as the rated CT current and will meter to 800 mA with no loss of accuracy. Ratio correction is performed by the firmware, and, consequently, the CT primary rating must be entered. The CT primary rating is available on the regulator nameplate.

EXAMPLE: If a CT ratio 400/0.2 is indicated on the nameplate, then 400 must be entered at FC 45.

Delta-connected (line-to-line connected) regulators

When a regulator is connected line-to-line, the phase angle of the line current is 30 degrees displaced from the voltage impressed across the regulator. After setting the Regulator Configuration, FC 41, the correct relationship between the voltage and current is established. Setting the regulator Configuration to the incorrect delta value (lagging instead of leading, or vice versa), the phase angle will be in error 60 degrees.

See **Section 3: Initial Control Programming: Determination of leading or lagging in delta-connected regulators** for information on selecting the correct setting. Below are considerations concerning delta-connected regulators:

- The basic decision-making of the control when line-drop compensation is not used is not affected by the phase angle; therefore, operation will be correct even if FC 41 is set to either of the two incorrect values. This is true for forward and reverse operation.
- If line-drop compensation is used, the scaling of the R and X values is controlled by FC 41; therefore, it is important to correctly set FC 41 for the compensated voltage to be correctly determined.
- The following metering parameters will be correct only if the Regulator Configuration is correctly set: power factor, kVA, kW, kvar, demand kVA, demand kW, and demand kvar.

Note: The kVA, kW, kvar, demand kVA, demand kW, and demand kvar use the line-to-line voltage; therefore, they display the value at the regulator not on any one feeder. To determine the total three-phase value of any one of these parameters, each regulator value must be divided by √3 (1.732) before adding the three together.

Section 5: Control programming

Use the keypad to program the control. A Quik-Start™ setup is given for programming for basic regulation. Refer to **Section 1: Control front panel** for information on using the front panel.

Note: After turning on the control and the LCD displays **PASS**, press **ESC** for further keypad use.

Control functions with corresponding control function codes are accessed via the keypad. The menu system is structured with a main menu, and sub-menu levels, the last of which is the parameter. The parameters and other text information are displayed on the LCD screen.

Refer to **Table 9** for the nested menu of functions and parameters.

Refer to **Table 10** for a numerical listing of function codes (FC) and corresponding menu and parameter information.

Multiple menu items with the same function code are allowed; the first menu item listed is then the main function called up when that function code is entered at the keypad. Access multiple menu items within the same function code with the ↑↓ scrolling keys.

Quik-Start setup

Refer to **Table 8** for a quick start up for basic regulation. Please note the following Function Code information when using the Quik-Start settings.

99 Security Password must be entered before changes can be made to parameters.

39 Source Voltage Calculation must be set to On for reverse power flow operation if a source-side calculation is to be used instead of an internal differential potential transformer to determine source-side voltage.

140 Regulator Type must be set for Type A (Straight Design), Type B (Inverted Design), Type C (Type TX for regulators rated at 2.5 kV and greater than 875 A), or Type D (Type AX for regulators rated at 5.0 or 7.53 kV and greater than 875 A) when FC 39 is on.

41 Regulator Configuration must be programmed when a control change-out is required.

43 System Line Voltage must be programmed when a control change-out is required.

44 Overall PT Ratio must be programmed when a control change-out is required.

45 CT Primary Rating must be programmed when a control change-out is required.

49 Tap-Changer Type must be programmed when a control change-out is required.

50 Calendar/Clock must be programmed when a control change-out is required or if power has been lost for more than four (4) days.

69 Blocking Status must be set to Normal for the regulator to operate in the automatic mode.

Table 8. Quik-start set-up for basic regulation

Function code	Description	Instructions
Security		
099	Security	FUNC, 99, ENTER, *Password* (Admin), ENTER
Forward settings		
001	Forward Set Voltage	FUNC, 1, ENTER, EDIT, *Value*, ENTER
002	Forward Bandwidth	FUNC, 2, ENTER, EDIT, *Value*, ENTER
003	Forward Time Delay	FUNC, 3, ENTER, EDIT, *Value*, ENTER
004	Forward Line Drip Comp. Resistance	FUNC, 4, ENTER, EDIT, *Value,* ENTER
005	Forward Line Drip Comp. Reactance	FUNC, 5, ENTER, EDIT, *Value*, ENTER
Reverse settings		
056	Reverse Sensing Mode	FUNC, 56, ENTER, Scroll - Locked Forward; Locked Reverse; Reverse Idle; Bi-directional; Neutral Idle; Co-generation; React Bi-directional; Bias Bi-directional, Bias Co-generation; Reverse Co-generation, ENTER
039	Source Voltage Calculation	FUNC, 39, ENTER, EDIT, Scroll - *On or Off,* ENTER
140	Regulator Type	FUNC, 140, ENTER, EDIT, Scroll - *Type A; Type B; Type C; Type D,* ENTER
044	Internal PT Ratio	FUNC, 44, ENTER, Down Arrow, EDIT, Value, ENTER
146	Vin PT Configuration	FUNC, 146, ENTER, EDIT, Scroll - Vdiff without RCT2; Vin Mode; Vdiff with RCT2, ENTER
051	Reverse Set Voltage	FUNC, 51, ENTER, EDIT, *Value,* ENTER
052	Reverse Bandwidth	FUNC, 52, ENTER, EDIT, *Value,* ENTER
053	Reverse Time Delay	FUNC, 53, ENTER, EDIT, *Value,* ENTER
054	Reverse Line Drip Comp. Resistance	FUNC, 54, ENTER, EDIT, *Value,* ENTER
055	Reverse Line Drip Comp. Reactance	FUNC, 55, ENTER, EDIT, *Value,* ENTER
Configurations		
041	Regulator Configuration	FUNC, 41, ENTER, EDIT, Scroll - *Wye; Delta Lagging; Delta Leading,* ENTER
042	Control Operation Mode	FUNC, 42, ENTER, EDIT, Scroll - *Sequential; Time-Integrating; Voltage-Averaging,* ENTER
043	System Line Voltage	FUNC, 43, ENTER, EDIT, *Value,* ENTER
044	Overall PT Ratio	FUNC, 44, ENTER, EDIT, *Value,* ENTER
045	C.T. Primary Rating	FUNC, 45, ENTER, EDIT, *Value,* ENTER
049	Tap-Changer Type	FUNC, 49, ENTER, EDIT, Scroll - *Cooper QD8; Cooper QD5; Cooper QD3; Cooper Spring Drive; Cooper Direct Drive; Siemens; General Electric; Howard; LTC-Reinhausen, ITB; Toshiba; User-Defined,* ENTER
050	System Calendar and Clock	FUNC, 50, ENTER, EDIT, *Month, Day, Year, Hour, Minute,* ENTER
069	Auto Operation Blocking Status	FUNC, 69, ENTER, EDIT, Scroll - Normal; Blocked, ENTER
Voltage reduction		
070	Voltage Reduction Mode	FUNC, 70, ENTER, EDIT, *Scroll - Off; Local/Digital Remote; Remote/Latch, Remote/Pulse,* ENTER
072	Local/Digital Reduction Value	FUNC, 72, ENTER, EDIT, *Value,* ENTER
073	Remote #1 Value	FUNC, 73, ENTER, EDIT, *Value,* ENTER
074	Remote #2 Value	FUNC, 74, ENTER, EDIT, *Value*, ENTER
075	Remote #3 Value	FUNC, 75, ENTER, EDIT, *Value*, ENTER
076	# of Pulse Reduction Steps	FUNC, 76, ENTER, EDIT, *Value*, ENTER
077	% of Voltage Red Per Pulse Step	FUNC, 77, ENTER, EDIT, *Value*, ENTER
Voltage limiter		
080	Voltage Limiter Mode	FUNC, 80, ENTER, EDIT, Scroll - Off; *High Limit Only; High/Low Limit; IVVC High Limit Only; IVVC High/Low Limits,* ENTER
081	High Voltage Limit	FUNC, 81, ENTER, EDIT, *Value*, ENTER
082	Low Voltage Limit	FUNC, 82, ENTER, EDIT, *Value*, ENTER

Function menu

Refer to **Table 9** for the nested menu structure: Main Menu, Sub-Menus, and Parameter

Table 9. Function menu

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*SETTINGS	*Forward Direction			Forward Set Voltage	001
				Forward Bandwidth	002
				Forward Time Delay	003
				Fwd Line Drop Comp. Resistance	004
				Fwd Line Drop Comp. Reactance	005
	*Reverse Direction			Reverse Set Voltage	051
				Reverse Bandwidth	052
				Reverse Time Delay	053
				Rev Line Drop Comp. Resistance	054
				Rev Line Drop Comp. Reactance	055
	*Configuration			Control Identification	040
				Regulator Type	140
				Tap Changer Type	049
				Regulator Configuration	041
				Control Operating Mode	042
				System Line Voltage	043
				Overall P.T. Ratio	044
				Internal P.T. Ratio	044
				C.T. Primary Rating	045
				Rated Load Current	045
				Adaptive ADD-AMP 5% Limit	045
				Adaptive ADD-AMP 6 1/4% Limit	045
				Adaptive ADD-AMP 7 1/2% Limit	045
				Adaptive ADD-AMP 8 3/4% Limit	045
				Demand Time Interval	046
				P.I. ADD-AMP High Limit	144
				P.I. ADD-AMP Low Limit	145
				Vin P.T. Configuration	146
				TPI Sense Method	147
				Neutral Sync Retry Count	147
				Motor Power Source Selection	147
				Nominal Sec Load Voltage	148
				Regulator Identification	141
				Serial Number	142

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*SETTINGS (Cont.)	*Calendar/Clock			System Calendar and Clock	050
				UTC Time Zone	050
				Date Format	942
				Time Format	943
	_Multi-Phase Config			Multi-Phase Feature	200
				Multi-Phase Mode	201
				Multi-Phase VRs Configured	202
				Multi-Phase Lead Regulator	203
				VR1 Tap Wait Timer	204
				VR2 Tap Wait Timer	204
				VR3 Tap Wait Timer	204
				Multi-Phase Retry Count	205
				Multi-Phase Retry Delay	206
				Multi-Phase Total Deviation	207
				Timer To Max Deviation Mode	208
				Timer To Alt Mode	209
				Max Deviation Alt Mode	210
				Sequencing Interval	211
				Multi-Phase DeltaCalc Mode	212
*FEATURES	*Auto-Block Status			Auto Operation Blocking Status	069
				Block Before Remote Tap	169
	*Reverse Power Mode			Reverse Sensing Mode	056
				Reverse Current Sense Threshold	057
				Bias Co-Gen Alt Mode	058
	*Source Side Voltage Calc			Source Voltage Calculation	039
	*Voltage Limiter			Voltage Limiter Mode	080
				High Voltage Limit	081
				Low Voltage Limit	082
				Voltage Limiter Fast Resp. Delay	083
				Voltage Limiter Delay	084
				Time Between Taps	085
	*Voltage Reduction			Voltage Reduction Mode	070
				Reduction In Effect	071
				Local/Digital Reduction Value	072
				Remote #1 Value	073
				Remote #2 Value	074
				Remote #3 Value	075
				# of Pulse Reduction Steps	076
				% of Voltage Red Per Pulse Step	077
				Present Voltage Reduction Step	078

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*FEATURES (Cont.)	*Tap To Neutral			Tap To Neutral	170
	*Tap To Target			Tap to Target	171
				Target Tap Position	172
	*SOFT-ADD-AMP			SOFT-ADD-AMP Limits	079
				SOFT-ADD-AMP High Limit	175
				SOFT-ADD-AMP Low Limit	176
	*Alternate Config	*Alternate Config Mode		Alternate Config Mode	450
				Alternate Config State	451
				Alternate Config Selection	452
				ARL Timer Period	453
		*Alternate Configuration 1		Forward Set Voltage	460
				Forward Bandwidth	461
				Forward Time Delay	462
				Fwd Line Drop Comp. Resistance	463
				Fwd Line Drop Comp. Reactance	464
				Reverse Set Voltage	465
				Reverse Bandwidth	466
				Reverse Time Delay	467
				Rev Line Drop Comp. Resistance	468
				Rev Line Drop Comp. Reactance	469
				Control Operating Mode	470
				Reverse Sensing Mode	471
				Reverse Current Sense Threshold	472
				Auto Operation Blocking Status	473
				Voltage Reduction Mode	474
				Local/Digital Reduction Value	475
				Remote #1 Value	476
				Remote #2 Value	477
				Remote #3 Value	478
				# of Pulse Reduction Steps	479
				% of Voltage Red Per Pulse Step	480
				Present Voltage Reduction Step	481
				SOFT-ADD-AMP Limits	182
				SOFT-ADD-AMP High Limit	483
				SOFT-ADD-AMP Low Limit	484
				Voltage Limiter Mode	485
				High Voltage Limit	486
				Low Voltage Limit	487
				Voltage Limiter Fast Resp. Delay	488
				Voltage Limiter Delay	489
				Time Between Taps	490
				Tap To Neutral	491
				Bias Co-Gen Alt mode	492

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*FEATURES (Cont.)	*Alternate Config (Cont.)	*Alternate Configuration 2		Forward Set Voltage	500
				Forward Bandwidth	501
				Forward Time Delay	502
				Fwd Line Drop Comp. Resistance	503
				Fwd Line Drop Comp. Reactance	504
				Reverse Set Voltage	505
				Reverse Bandwidth	506
				Reverse Time Delay	507
				Rev Line Drop Comp. Resistance	508
				Rev Line Drop Comp. Reactance	509
				Control Operating Mode	510
				Reverse Sensing Mode	511
				Reverse Current Sense Threshold	512
				Auto Operation Blocking Status	513
				Voltage Reduction Mode	514
				Local/Digital Reduction Value	515
				Remote #1 Value	516
				Remote #2 Value	517
				Remote #3 Value	518
				# of Pulse Reduction Steps	519
				% of Voltage Red Per Pulse Step	520
				Present Voltage Reduction Step	521
				SOFT-ADD-AMP Limits	522
				SOFT-ADD-AMP High Limit	523
				SOFT-ADD-AMP Low Limit	524
				Voltage Limiter Mode	525
				High Voltage Limit	526
				Low Voltage Limit	527
				Voltage Limiter Fast Resp. Delay	528
				Voltage Limiter Delay	529
				Time Between Taps	530
				Tap to Neutral	531
				Bias Co-Gen Alt Mode	532

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*FEATURES (Cont.)	*Alternate Config (Cont.)	_Alternate Configuration 3		Forward Set Voltage	550
				Forward Bandwidth	551
				Forward Time Delay	552
				Fwd Line Drop Comp. Resistance	553
				Fwd Line Drop Comp. Reactance	554
				Reverse Set Voltage	555
				Reverse Bandwidth	556
				Reverse Time Delay	557
				Rev Line Drop Comp. Resistance	558
				Rev Line Drop Comp. Reactance	559
				Control Operating Mode	560
				Reverse Sensing Mode	561
				Reverse Current Sense Threshold	562
				Auto Operation Blocking Status	563
				Voltage Reduction Mode	564
				Local/Digital Reduction Value	565
				Remote #1 Value	566
				Remote #2 Value	567
				Remote #3 Value	568
				# of Pulse Reduction Steps	569
				% of Voltage Red Per Pulse Step	570
				Present Voltage Reduction Step	571
				SOFT-ADD-AMP Limits	572
				SOFT-ADD-AMP High Limit	573
				SOFT-ADD-AMP Low Limit	574
				Voltage Limiter Mode	575
				High Voltage Limit	576
				Low Voltage Limit	577
				Voltage Limiter Fast Resp. Delay	578
				Voltage Limiter Delay	579
				Time Between Taps	580
				Tap to Neutral	581
				Bias Co-Gen Alt Mode	582

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*FEATURES (Cont.)	*Leader/Follower			Leader/Follower	410
				Leader/Follower State	411
				Leader/Follower Mode	412
				Leader/Follower Designation	413
				Follower Devices Configured	414
				Leader/Follower Tap Wait Timer	415
				Leader/Follower Timeout	416
				Leader/Follower Retry Delay	417
				Leader/Follower Retries	418
				Leader/Follower Monitor	420
				L/F Average Comp Volt Secondary	421
				Max Deviation	422
				Timer To Alt Mode	423
				Timer To Max Deviation Mode	424
				Max Deviation Alt Mode	425
	*Calibration			Voltage Calibration	047
				Current Calibration	048
				Reset Calibration	150
	*Fault Detection			Fault Detect Enabled	640
				Fault Detect In Effect	641
				Reset All Fault Detect Durations	642
				Fault Detect Level1 Threshold	645
				Fault Detect Level1 Recovery	646
				Fault Level1 Threshold Timer	647
				Fault Level1 Recovery Timer	648
				Duration of Last Level1	649
				Duration of Longest Level1	649
				Fault Detect Level2 Threshold	650
				Fault Detect Level2 Recovery	651
				Fault Level2 Threshold Timer	652
				Fault Level2 Recovery Timer	653
				Duration of Last Level2	654
				Duration of Longest Level2	654
				Fault Detect Level3 Threshold	655
				Fault Detect Level3 Recovery	656
				Fault Level3 Threshold Timer	657
				Fault Level3 Recovery Timer	658
				Duration of Last Level3	659
				Duration of Longest Level3	659

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*FEATURES (Cont.)	*Voltage Sag Monitoring			Voltage Sag Monitoring	600
				Level1 Threshold	601
				Level1 Recovery	602
				Level1 Threshold Timer Value	602
				Level1 Recovery Timer Value	604
				Duration of Last Level1	605
				Duration of Longest Level1	606
				Level2 Threshold	611
				Level2 Recovery	612
				Level2 Threshold Timer Value	613
				Level2 Recovery Timer Value	614
				Duration of Last Level2	615
				Duration of Longest Level2	616
				Level3 Threshold	621
				Level3 Recovery	622
				Level3 Threshold Timer Value	623
				Level3 Recovery Timer Value	624
				Duration of Last Level3	625
				Duration of Longest Level3	626
				Voltage Sag In Effect	631
				Reset All Volt Sag Durations	632
	*User Inputs			User Defined HMI Func1 Activate	700
				User Defined HMI Func2 Activate	701
				User Defined HMI Func3 Activate	702
				User Defined HMI Func4 Activate	703
	*Auto Tap Dead Phase			Auto Tap Dead Phase mode	220
				Tap Dead Phase	221
				Delay Timer	222
	*Battery			Battery Voltage and Current	190
				Test Battery	191
				Battery Test Results	191
	_Advanced Features			Sequence of Events	151
				Data Profiler	152
				Status Alarms	153
				Data Alarms	154
				Interval OPS Counters	107
				Automatic Battery Test	192

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*COUNTERS	*Operations Counter			Total Operations	000
				Last Counter Change	100
				Enable Interval Counters	107
				Last 24 Hours Operations	101
				Last 30 Days Operations	102
				Current Month Operations	103
				Last Month Operations	104
				Current Year Operations	105
				Last Year Operations	106
*METERING	*Instantaneous			Load Voltage Secondary	006
				Source Voltage Secondary	007
				Compensated Volt. Secondary	008
				Load Current Primary	009
				Load Voltage Primary kV	010
				Source Voltage Primary kV	011
				Present Tap Position	012
				Percent Regulation	112
				Power Factor	013
				kVA Load	014
				kW Load	015
				kvar Load	016
				Line Frequency	017
				Voltage THD	018
				Voltage 2nd-15th Harmonic	018
				Current THD	019
				Current 2nd-15th Harmonic	019
				Energy kW-h Forward	125
				Energy kW-h Reverse	125
				Energy kvar-h Forward	126
				Energy kvar-h Reverse	126
				Phase Angle	130
				Load Current Real	131
				Load Current Reactive	131
				Average Load Volt. Secondary	132
				Average Source Volt. Secondary	132
				Average Comp Volt. Secondary	132
				Average Load Current Primary	132
				Average Present Tap Position	132
				Average Maximum Tap Position	132
				Average Minimum Tap Position	132
				Total kVA Load	133

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*METERING (Cont.)	*Instantaneous (Cont.)			Total kW Load	133
				Total kvar Load	133
				Motor Voltage	139
				Load Voltage Secondary (L-N)	750
				Load Voltage Secondary (L-L)	751
				Source Voltage Secondary (L-N)	752
				Source Voltage Secondary (L-L)	753
				Load Voltage Primary (L-N)	754
				Load Voltage Primary (L-L)	755
				Source Voltage Primary (L-N)	756
				Source Voltage Primary (L-L)	757
				Load Voltage Angle (L-N)	760
				Load Voltage Angle (L-L)	761
				Source Voltage Angle (L-N)	762
				Source Voltage Angle (L-L)	763
	*Forward Demand			Forward Load Voltage High	020
				Forward Load Voltage Low	020
				Forward Load Voltage Present	020
				Fwd Compensated Voltage High	021
				Fwd Compensated Voltage Low	021
				Fwd Compensated Voltage Present	021
				Forward Load Current High	022
				Forward Load Current Low	022
				Forward Load Current Present	022
				Power Factor at Max Forward kVA	023
				Power Factor at Min Forward kVA	023
				Forward kVA Load High	024
				Forward kVA Load Low	024
				Forward kVA Load Present	024
				Forward kW Load High	025
				Forward kW Load Low	025
				Forward kW Load Present	025
				Forward kvar Load High	026
				Forward kvar Load Low	026
				Forward kvar Load Present	026
				Fwd Load Current Real High	134
				Fwd Load Current Real Low	134
				Fwd Load Current Real Present	134
				Fwd Load Current Reactive High	134
				Fwd Load Current Reactive Low	134
				Fwd Load Current Reactive Present	134

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*METERING (Cont.)	*Forward Demand (Cont.)			Maximum Tap Position	027
				Maximum Percent Regulation	127
				Minimum Tap Position	028
				Minimum Percent Regulation	128
				Forward Source Voltage High	029
				Forward Source Voltage Low	029
				Forward Source Voltage Present	029
	*Reverse Demand			Reverse Load Voltage High	030
				Reverse Load Voltage Low	030
				Reverse Load Voltage Present	030
				Rev Compensated Voltage High	031
				Rev Compensated Voltage Low	031
				Rev Compensated Voltage Present	031
				Reverse Load Current High	032
				Reverse Load Current Low	032
				Reverse Load Current Present	032
				Power Factor at Max Reverse kVA	033
				Power Factor at Min Reverse kVA	033
				Reverse kVA Load High	034
				Reverse kVA Load Low	034
				Reverse kVA Load Present	034
				Reverse kW Load High	035
				Reverse kW Load Low	035
				Reverse kW Load Present	035
				Reverse kvar Load High	036
				Reverse kvar Load Low	036
				Reverse kvar Load Present	036
				Rev Load Current Real High	135
				Rev Load Current Real Low	135
				Rev Load Current Real Present	135
				Rev Load Current Reactive High	135
				Rev Load Current Reactive Low	135
				Rev Load Current Reactive Present	135
				Reverse Source Voltage High	037
				Reverse Source Voltage Low	037
				Reverse Source Voltage Present	037
	_Master Reset			Master Reset	038
*ALARMS	*Alarms Active Unacknowledged			(Unacknowledged Active Alarms)	---
	_Alarms Active Acknowledged			(Acknowledged Active Alarms)	---
*SEQUENCE OF EVENTS				(Events Log)	---
*USB LAST LOAD FAILED SETTINGS				(Load Settings Failed Log)	---

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*COMMUNICATIONS	*Comm Port #1	*Comm Port #1 Configuration		Protocol / Port Type	800
				LoopShare Communications	800
				ProView NXG Session	800
				ProView NXG Address	800
				Ethernet Switch On Comm Port #1	800
				Serial Bridge Mode	800
		*Serial Configuration		Serial Baud Rate	801
				Serial Parity	801
				Serial CTS Support	801
				Serial Enable Delay	801
				Serial Tx Disable Delay	801
				Serial Echo Mode	801
		*Network Configuration		IP Address	802
				Subnet Mask	802
				Gateway	802
				MAC Address	802
		*DNP3 Basic		DNP RBE Master	810
				DNP IED Slave	810
				DNP IED Slave 2	810
				DNP User Map Selection	810
		*DNP3 Network		DNP Network Protocol Type	811
				DNP Accept From Any IP	811
				DNP Accept From IP Address	811
				DNP Destination Port Number	811
				DNP Listening Port Number	811
				DNP Use Port From Request	811
				Initial Unsol UDP Dest Port	811
				DNP Keep Alive Timeout	811
				DNP Outbound Port Type	811
				DNP Static UDP Source Port	811
				DNP Static TCP Source Port	811
		*IEC 60870-5-101		IEC101 Link Address	812
				IEC101 Common Address	812
				IEC101 Link Address Size	812
				IEC101 Common Address Size	812
				IEC101 Object Address Size	812
				IEC101 Cause of Transmit Size	812
				8IEC101 Single Command Op Mode	812
				IEC101 Select Before Exec Time	812
				IEC101 User Map Selection	812

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*COMMUNICATIONS (Cont.)	*Comm Port #1 (Cont.)	*IEC 60870-5-104		IEC104 Server Listen Port	813
				IEC104 Common Address	813
				IEC104 Single Command Op Mode	813
				IEC104 Select Before Exec Time	813
				IEC104 Response Timeout (t1)	813
				IEC104 Ack/No Data (t2)	813
				IEC104 Idle Test (t3)	813
				IEC104 Max Transmit (k)	813
				IEC104 Max Receive (w)	813
				IEC104 User Map Selection	813
		*2179		2179 Master Address	815
				2179 Ignore Master Address	815
				2179 Device Address	815
				2179 SBO Select Timeout	815
				2179 User Map Selection	815
				2179 Dead Sync Timeout	815
				2179 Master Time Format	815
		_Modbus		Modbus Device Address	816
				Modbus User Map Selection	816
				Modbus Listening Port Number	816
	*Comm Port #2	*Comm Port #2 Configuration		Protocol / Port Type	830
				LoopShare Communications	830
				ProView NXG Session	830
				ProView NXG Address	830
		*Serial Configuration		Serial Baud Rate	831
				Serial Parity	831
				Serial CTS Support	831
				Serial Tx Enable Delay	831
				Serial Tx Disable Delay	831
				Serial Echo Mode	831
		*Network Configuration		IP Address	832
				Subnet Mask	832
				Gateway	832
				MAC Address	832
		*DNP3 Basic		DNP RBE Master	840
				DNP IED Slave	840
				DNP IED Slave 2	840
				DNP User Map Selection	840
		*DNP3 Network		DNP Network Protocol Type	841
				DNP Accept From Any IP	841
				DNP Accept From IP Address	841
				DNP Destination Port Number	841

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*COMMUNICATIONS (Cont.)	*Comm Port #2 (cont.)	*DNP3 Network (Cont.)		DNP Listening Port Number	841
				DNP Use Port From Request	841
				Initial Unsol UDP Dest Port	841
				DNP Keep Alive Timeout	841
				DNP Outbound Port Type	841
				DNP Static UDP Source Port	841
				DNP Static TCP Source Port	841
		*IEC 60870-5-101		IEC101 Link Address	842
				IEC101 Common Address	842
				IEC101 Link Address Size	842
				IEC101 Common Address Size	842
				IEC101 Object Address Size	842
				IEC101 Cause of Transmit Size	842
				IEC101 Single Command Op Mode	842
				IEC101 Select Before Exec Time	842
				IEC101 User Map Selection	842
		*IEC 60870-5-104		IEC104 Server Listen Port	843
				IEC104 Common Address	843
				IEC104 Single Command Op Mode	843
				IEC104 Select Before Exec Time	843
				IEC104 Response Timeout (t1)	843
				IEC104 Ack/No Data (t2)	843
				IEC104 Idle Test (t3)	843
				IEC104 Max Transmit (k)	843
				IEC104 Max Receive (w)	843
				IEC104 User Map Selection	843
		*2179		2179 MasterAddress	845
				2179 IgnoreMaster Address	845
				2179 Device Address	845
				2179 SBO Select Timeout	845
				2179 User Map Selection	845
				2179 Dead Sync Timeout	845
				2179 Master Time Format	845
		_Modbus		Modbus Device Address	846
				Modbus User Map Selection	846
				Modbus Listening Port Number	846

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*COMMUNICATIONS (Cont.)	*TCP/IP Re-init			TCP IP Socket Re-Init	803
				TCP IP Socket Re-Init Timeout	803
	*LoopShare			LoopShare Comms State	860
				LoopShare Comm Table Assignment	861
				LoopShare Comm Tx Delay	862
				LoopShare Comm Timeout	863
	*I/O Control	*Aux Module 1		Activate Contact Output 1	089
				Activate Contact Output 2	089
				Activate Contact Output 3	089
				Activate Contact Output 4	089
		_Aux Module 2		Activate Contact Output 1	089
				Activate Contact Output 2	089
				Activate Contact Output 3	089
				Activate Contact Output 4	089
	_I/O Status	*Contact Inputs	*Aux Module 1	(Contact status by point)	090
			_Aux Module 2	(Contact status by point)	090
		_Contact Outputs	*Aux Module 1	(Contact status by point)	090
			_Aux Module 2	(Contact status by point)	090

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*DIAGNOSTICS	*Test LEDs			(No Items)	---
	*Control			Firmware Version	920
				Firmware Database Version	921
				FPGA Version	922
				Digital Hardware Revision	923
				BootUtility Version	924
				BootLoader Version	925
				USB Device Connected	088
				Factory Mode	088
				Extended Comms Status	088
				Config. Logic Equation Error	088
				Self-Test	091
				Last Self-Test Results	091
	*Communications			Comm Port #1 Tx Messages	260
				Comm Port #1 Rx Messages	261
				Comm Port #1 Rx Errors	262
				Comm Port #2 Tx Messages	263
				Comm Port #2 Rx Messages	264
				Comm Port #2 Rx Errors	265
	*Maintenance			Contact Duty Cycle Monitor	333
				PMT™ Mode A State	300
				PMT Mode A Countdown Delay	301
				PMT Mode A Time Delay	302
				PMT Mode A Issue Test	303
				PMT Mode B State	320
				PMT Mode B Countdown Delay	321
				PMT Mode B Time Delay	322
				PMT Mode B Start Time	323
				PMT Mode B Stop Time	324
				PMT Mode B Max Deviation	325
				PMT Mode B Current Limit	327
				PMT Mode B Issue Test	328
	*Sync Counters			Tap Position Sync Count	110
	_Metering PLUS			Comp Voltage	---
				Load Voltage	---
				Load Current	---
				Tap Position	---
				LF TPI TRG STATUS	---
				Max Deviation	---
				Reg TPI CompV BandE	---
				sV Src Load Comp	---

Table 9. Function menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Sub-Menu	Level 4 Sub-Menu	Parameter	Function Code
*MENU SYSTEM	*Security Access			Security Override	092
				Password "Operate"	096
				Password "Modify"	097
				Password "Admin"	098
				Remote Security Override Timer	199
				Remote Security Override Mode	199
	*Language			Language Selection	941
	*Date and Time Format			Date Format	942
				Time Format	943
	_Hot Keys			Key Mapping Selection	944
*USB MEMORY DRIVE				USB Memory Drive Save All Data	950
				USB Memory Drive Save Custom All	950
				USB Memory Drive Save Cust Basic	950
				USB Memory Drive Save Custom Alt	950
				USB Memory Drive Save Custom Adv	950
				USB Memory Drive Save Custom Comm	950
				USB Memory Drive Load Config Data	951
				USB Memory Drive Upgrade Firmware	952
				USB Memory Drive Remove Device	953
				USB Memory Drive Settings to .CSV	954
				USB Memory Drive Metering to .CSV	954
_TURN DISPLAY OFF				(No Items)	---

Function codes

Refer to **Table 10** for a numerical listing of the function codes. The table accurately represents the display of each function code and identifies the security level for read, edit, and reset, the factory setting, and the low and high limits for keyed in entries. This is followed by a description and, where appropriate, a list of scrolling choices, examples, and related functions and features for each function code.

Table 10. Function codes

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
000 Total Operations XXXXXX	---	View	Admin	NA	0	0	999999
•On an Eaton's Cooper Power series voltage regulator, the total operations counter is activated by detecting tap-changer motor operation, which is determined by sensing current flow in the holding switch circuit. •It may also be incremented through operations counter circuitry on non-Eaton's Cooper Power series manufactured tap changers. •The total operations counter is written into non-volatile memory after every count. •Access other operations counters at FC 100–FC 107.							
001 Forward Set Voltage XXX.X Volts	Volts	View	Modify	NA	120.0	100.0	135.0
•The forward set voltage is the voltage level to which the control will regulate, on the 120 V or 240 V base, during forward power flow. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1). •If FC 148 Nominal Load Voltage is set to 240 Volts, limits are expanded (doubled). •If FC 148 is set to System Line Voltage, this setting must be set in terms of the system line voltage. For example, on a 7200 V system, with a desired set voltage 1% above the nominal voltage, the setting would be 7272.							
002 Forward Bandwidth X.X Volts	Volts/%	View	Modify	NA	2.0	1.0	6.0
•The bandwidth is defined as the total voltage range, around the set voltage, which the control will consider as a satisfied (in-band) condition, during forward power flow. •Example: A bandwidth of 3.0 V and a set voltage of 120 V will establish a low edge of 118.5 V and a high edge of 121.5 V. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1). •If FC 148 Nominal Load Voltage is set to 240 Volts, limits are expanded (doubled). •If FC 148 is set to System Line Voltage, this setting must be set as a percentage of the set voltage.							
003 Forward Time Delay XXX Seconds	Seconds	View	Modify	NA	45	5	180
•The time delay is the period of time that the control waits, from when the voltage first goes out-of-band to when a tap change is initiated, during forward power flow. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
004 Fwd Line Drop Comp. Resistance XX.X Volts	Volts/%	View	Modify	NA	0.0	-96.0	96.0
•The resistive line-drop compensation value is used to model the resistive line voltage drop between the regulator and the center of regulation. •The control uses this parameter, in conjunction with the regulator configuration (FC 41) and the load current, to calculate and regulate to the compensated voltage (displayed at FC 8) during forward power flow. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1). •If FC 148 Nominal Load Voltage is set to 240 Volts, limits are expanded (doubled). •If FC 148 is set to System Line Voltage, this setting must be set as a percentage of the set voltage.							
005 Fwd Line Drop Comp. Reactance XX.X Volts	Volts/%	View	Modify	NA	0.0	-96.0	96.0
•The reactive line-drop compensation value is used to model the reactive line drop voltage between the regulator and the center of regulation. •The control uses this parameter, in conjunction with the regulator configuration (FC 41) and the load current, to calculate and regulate to the compensated voltage (displayed at FC 8) during forward power flow. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1 •If FC 148 Nominal Load Voltage is set to 240 Volts, limits are expanded (doubled). •If FC 148 is set to System Line Voltage, this setting must be set as a percentage of the set voltage.							
006 Load Voltage Secondary XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•This is the fundamental RMS voltage, referred to the secondary, which appears at the output (load) terminals of the regulator. •Since ratio correction is performed by the firmware, this parameter is scaled according to the inputs at FC 43 (System Line Voltage) and FC 44 (Overall PT Ratio) •During reverse power operation, the control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
007 Source Voltage Secondary XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•This is the fundamental RMS voltage, referred to the secondary, which appears at the input (source) terminals of the regulator. •Since ratio correction is performed by the firmware, this parameter is scaled according to the inputs at FC 43 (System Line Voltage) and FC 44 (Internal PT Ratio). •During forward power operation, the control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
008 Compensated Volt. Secondary XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•This is the calculated voltage at the center of regulation, referred to the secondary. •This is based on the resistive compensation setting (FC 4 or FC 54), reactive compensation setting (FC 5 or FC 55), and the load current. •This is the voltage that the regulator is regulating during either forward or reverse power flow. •During reverse power operation, the control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
009 Load Current Primary XXX.X Amps	Amps	View	NA	NA	NA	NA	NA
•This is the fundamental RMS current flowing in the primary circuit. •This parameter is scaled according to the CT primary rating which is entered at FC 45. •During reverse power operation, the control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
010 Load Voltage Primary kV XX.XX kVolts	KV	View	NA	NA	NA	NA	NA
•This is the fundamental RMS voltage, referred to the primary, which appears at the output (load) terminals of the regulator. •During reverse power operation, the control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
011 Source Voltage Primary kV XX.XX kVolts	KV	View	NA	NA	NA	NA	NA
•This is the fundamental RMS voltage, referred to the primary, which appears at the input (source) terminals of the regulator. •Since ratio correction is performed by the firmware, this parameter is scaled according to the inputs at FC 43 (System Line Voltage) and FC 44 (Internal PT ratio). •During forward power operation, the control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
012 Present Tap Position -XX	Tap	View	3	NA	NA	-16	16
•This is the present position of the tap-changer. •The tap position indication is synchronized at the neutral position, as indicated by the neutral light circuit. Tap positions are displayed from -16 to 16, corresponding to 16 Lower (regulator bucking) to 16 Raise (regulator boosting), respectively. •See **Section 6: Control Features: Tap position indication (TPI).** •See Percent Regulation, FC 112.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
013 Power Factor -X.XXX	---	View	NA	NA	NA	NA	NA

- This is the power factor of the primary circuit, as represented by the phase difference between the line current and voltage.
- Lagging current, or inductive loads, are designated by an implied (+) sign, and leading current, or capacitive loads, are designated by a (-) sign. Refer to Figures 5-1 and 5-2.

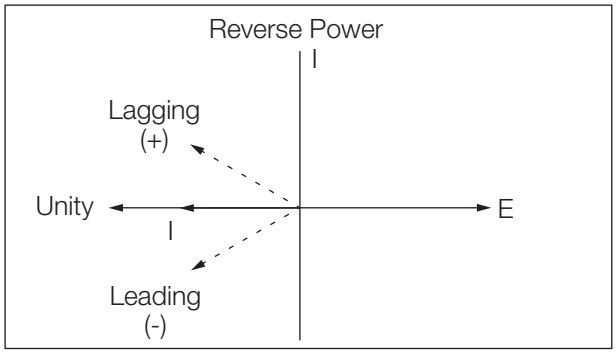


Figure 16. Reverse power vector diagram

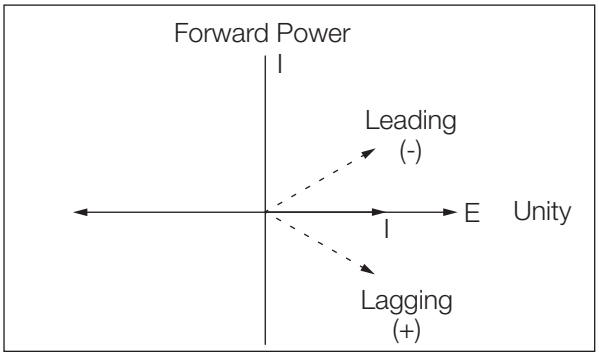


Figure 17. Forward power vector diagram

014 kVA Load XXXX.X kVA	KVA	View	NA	NA	NA	NA	NA

- This is the total kilovolt-amperes drawn by the load, as calculated by the product of the load-voltage primary kV (FC 10) times the primary load current (FC 9). See Figure 18.

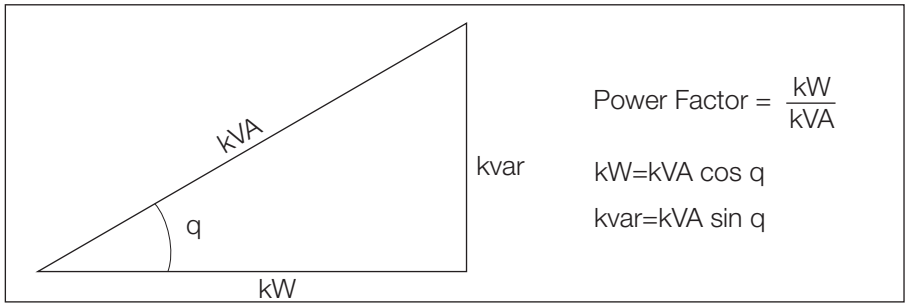


Figure 18. Power triangle

015 kW Load XXXX.X kW	KW	View	NA	NA	NA	NA	NA

- This is the total kilowatts (true power) consumed by the load.
- This is calculated by the product of the power factor (FC 13) times the kVA load (FC 14). See Figure 18.
- During reverse power operation, the control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
016 kvar Load XXXX.X kvar	Kvar	View	NA	NA	NA	NA	NA
•This is the total kilovolt-amperes reactive (reactive power) drawn by the load. The reactive power adds to losses on the line, yet does not do any work. See Figure 18. •During reverse power operation, the control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
017 Line Frequency XX.XX Hz	Hz	View	NA	NA	NA	NA	NA
•This is the frequency of the power line, as measured by the control. •The control is capable of operating on systems from 45 to 65 Hz with no loss of accuracy in its measurements.							
018 Voltage THD XX.X %	%	View	NA	NA	NA	NA	NA
•The total harmonic distortion (THD) is displayed after entering FC 18. •The total harmonic distortion is computed as the RSS (square root of the sum of the squares) of the individual harmonic values. •This is displayed as a percentage of the fundamental RMS voltage. •Example: 120.0 V of 60 Hz fundamental (power line frequency), with a reading of 0.5 at the 7th harmonic (420 Hz), is 0.6 V RMS.							
018 Voltage 2nd Harmonic XX.X %	%	View	NA	NA	NA	NA	NA
•2nd through 15th harmonic values are displayable. •Use the arrow keys to scroll through the 2nd through 15th harmonic.							
019 Current THD XX.X %	%	View	NA	NA	NA	NA	NA
•The total harmonic distortion is computed as the RSS (square root of the sum of the squares) of the individual harmonic values. •This is displayed as a percentage of the fundamental RMS voltage. •Example: 200 A of 60 Hz fundamental (power line frequency), with a reading of 1.9 at the 5th harmonic (300 Hz), is 3.8 A RMS.							
019 Current 2nd Harmonic XX.X %	%	View	NA	NA	NA	NA	NA
•The values of the 2nd through 15th harmonic values are displayable. •Use the arrow keys to scroll through the 2nd through 15th harmonic.							
020 Forward Load Voltage High XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the highest secondary output voltage of the regulator since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the highest secondary output voltage is displayed.							
020 Forward Load Voltage Low XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the lowest secondary output voltage of the regulator since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the lowest secondary output voltage is displayed.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
020 Forward Load Voltage Present XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•This is the present reading of secondary output voltage of the regulator, as a demand value, according to the demand time interval at FC 46							
021 Fwd Compensated Voltage High XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the highest value of the calculated secondary voltage at the center of regulation since the last reset, as a demand value, according to the demand time interval at FC 46. •The forward line-drop compensation settings for resistance and reactance (FC 4 and FC 5) are used in calculating this value. •Date and time of the occurrence of the highest compensated voltage is displayed.							
021 Fwd Compensated Voltage Low XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the lowest value of the calculated secondary voltage at the center of regulation since the last reset, as a demand value, according to the demand time interval at FC 46. •The forward line-drop compensation settings for resistance and reactance (FC 4 and FC 5) are used in calculating this value. •Date and time of the occurrence of the lowest compensated voltage is displayed.							
021 Fwd Compensated Voltage Present XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•This is the present value of the calculated secondary output voltage of the load center, as a demand value, according to the demand time interval at FC 46. •The forward line-drop compensation settings for resistance and reactance (FC 4 and FC 5) are used in calculating this value.							
022 Forward Load Current High XXX.X Amps MM-DD-YYYY HH:MM:SS	Amps	View	NA	Operate	Reset*	NA	NA
•This is the highest value of the load current since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the highest load current is displayed.							
022 Forward Load Current Low XXX.X Amps MM-DD-YYYY HH:MM:SS	Amps	View	NA	Operate	Reset*	NA	NA
•This is the lowest value of the load current since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the lowest load current is displayed.							
022 Forward Load Current Present XXX.X Amps	Amps	View	NA	NA	NA	NA	NA
•This is the present reading of the load current as a demand value, according to the demand time interval at FC 46.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
023 Power Factor at Max Forward kVA X.XXX MM-DD-YYYY HH:MM:SS	---	View	NA	NA	"-----" (Invalid)	NA	NA
•This is the instantaneous power factor of the load at the first occurrence of the maximum kVA demand value, since last reset. •Date and time of the occurrence of the maximum kVA demand value is displayed. •Note: This parameter is associated with the maximum kVA demand; therefore, it cannot be reset independent of that parameter.							
023 Power Factor at Min Forward kVA X.XXX MM-DD-YYYY HH:MM:SS	---	View	NA	NA	"-----" (Invalid)	NA	NA
•This is the instantaneous power factor of the load at the first occurrence of the minimum kVA demand value since last reset. •Date and time of the occurrence of the minimum kVA demand value is displayed. •Note: This parameter is associated with the minimum kVA demand; therefore, it cannot be reset independent of that parameter.							
024 Forward kVA Load High XXXX.X kVA MM-DD-YYYY HH:MM:SS	kVA	View	NA	Operate	Reset*	NA	NA
•This is the highest value of the load kVA since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the highest kVA load is displayed.							
024 Forward kVA Load Low XXXX.X kVA MM-DD-YYYY HH:MM:SS	kVA	View	NA	Operate	Reset*	NA	NA
•This is the lowest value of the load kVA since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the lowest kVA load is displayed.							
024 Forward kVA Load Present XXXX.X kVA	kVA	View	NA	NA	NA	NA	NA
•This is the present value of the load kVA, as a demand value, according to the demand time interval at FC 46.							
025 Forward kW Load High XXXX.X kW MM-DD-YYYY HH:MM:SS	kW	View	NA	Operate	Reset*	NA	NA
•This is the highest value of the load kW since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the highest kW load is displayed.							
025 Forward kW Load Low XXXX.X kW MM-DD-YYYY HH:MM:SS	kW	View	NA	Operate	Reset*	NA	NA
•This is the lowest value of the load kW since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the lowest kW load is displayed.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
025 Forward kW Load Present XXXX.X kW	kW	View	NA	NA	NA	NA	NA
•This is the present value of the load kW, as a demand value, according to the demand time interval at FC 46.							
026 Forward kvar Load High XXXX.X kvar MM-DD-YYYY HH:MM:SS	kvar	View	NA	Operate	Reset*	NA	NA
•This is the highest value of the load kvar since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of when the highest value occurred is displayed.							
026 Forward kvar Load Low XXXX kvar MM-DD-YYYY HH:MM:SS	kvar	View	NA	Operate	Reset*	NA	NA
•This is the lowest value of the load kvar since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of when the lowest value occurred is displayed.							
026 Forward kvar Load Present XXXX.X kvar	kvar	View	NA	NA	NA	NA	NA
•This is the present value of the load kvar, as a demand value, according to the demand time interval at FC 46.							
027 Maximum Tap Position -XX MM-DD-YYYY HH:MM:SS	Tap	View	NA	Operate	Reset*	NA	NA
•This is the highest tap position that the regulator has reached since last reset. •The maximum position and associated date and time can be reset using the ENTER key or via master reset, FC 38. This parameter is not reset by the drag-hand reset switch. •Date and time of the occurrence of the maximum tap position is displayed.							
028 Minimum Tap Position -XX MM-DD-YYYY HH:MM:SS	Tap	View	NA	Operate	Reset*	NA	NA
•This is the lowest tap position that the regulator has reached since last reset. •The minimum position and associated date and time can be reset using the ENTER key or via master reset, FC 38. This parameter is not reset by the drag-hand reset switch. •Date and time of the occurrence of the minimum tap position is displayed.							
029 Forward Source Voltage High XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the maximum source voltage of the regulator since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the highest source voltage is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
029 Forward Source Voltage Low XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the minimum source voltage of the regulator since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the lowest source voltage is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
029 Forward Source Voltage Present XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•This is the present value of the source voltage, as a demand value, according to the demand time interval at FC 46. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
030 Reverse Load Voltage High XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the maximum value of the secondary output voltage of the regulator during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the highest load voltage is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
030 Reverse Load Voltage Low XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the minimum value of the secondary output voltage of the regulator during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the lowest load voltage is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
030 Reverse Load Voltage Present XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•This is the present value of the secondary output voltage of the regulator during reverse power flow, as a demand value, according to the demand time interval at FC 46. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
031 Rev Compensated Voltage High XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the highest value of the calculated secondary voltage at the center of regulation during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •The reverse line-drop compensation settings for resistance and reactance (FC 54 and FC 55) are used in calculating this value. •Date and time of the occurrence of the highest compensated voltage is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
031 Rev Compensated Voltage Low XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the lowest value of the calculated secondary voltage at the load center during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •The reverse line-drop compensation settings for resistance and reactance (FC 54 and FC 55) are used in calculating this value. •Date and time of the occurrence of the lowest compensated voltage is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
031 Rev Compensated Voltage Present XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•This is the present value of the calculated secondary voltage at the load center during reverse power flow, as a demand value, according to the demand time interval at FC 46. •The reverse line-drop compensation settings for resistance and reactance (FC 54 and FC 55) are used in calculating this value. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
032 Reverse Load Current High XXX.X Amps MM-DD-YYYY HH:MM:SS	Amps	View	NA	Operate	Reset*	NA	NA
•This is the highest value of the load current during reverse power flow since the last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the highest load current is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
032 Reverse Load Current Low XXX.X Amps MM-DD-YYYY HH:MM:SS	Amps	View	NA	Operate	Reset*	NA	NA
•This is the lowest value of the load current during reverse power flow since the last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the lowest load current is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
032 Reverse Load Current Present XXX.X Amps	Amps	View	NA	NA	NA	NA	NA
•This is the present value of the load current during reverse power flow, as a demand value, according to the demand time interval at FC 46. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
033 Power Factor at Max Reverse kVA X.XXX MM-DD-YYYY HH:MM:SS	---	View	NA	NA	"-----" (Invalid)	NA	NA
•This is the instantaneous power factor of the load at the first occurrence of the maximum kVA demand value since the last reset, during reverse power flow. •Note: This parameter is associated with the maximum kVA demand; therefore, it cannot be reset independent of that parameter. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
033 Power Factor at Min Reverse kVA X.XXX MM-DD-YYYY HH:MM:SS	---	View	NA	NA	"-----" (Invalid)	NA	NA
•This is the instantaneous power factor of the load at the first occurrence of the minimum kVA demand value during reverse power flow since last reset. •Note: This parameter is associated with the minimum kVA demand; therefore, it cannot be reset independent of that parameter. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
034 Reverse kVA Load High XXXX.X kVA MM-DD-YYYY HH:MM:SS	kVA	View	NA	Operate	Reset*	NA	NA
•This is the highest value of the load kVA during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the highest kVA load is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
034 Reverse kVA Load Low XXXX.X kVA MM-DD-YYYY HH:MM:SS	kVA	View	NA	Operate	Reset*	NA	NA
•This is the lowest value of the load kVA during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence the lowest kVA load is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
034 Reverse kVA Load Present XXXX.X kVA	kVA	View	NA	NA	NA	NA	NA
•This is the present value of the load kVA during reverse power flow, as a demand value, according to the demand time interval at FC 46. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
035 Reverse kW Load High XXXX.X kW MM-DD-YYYY HH:MM:SS	kW	View	NA	Operate	Reset*	NA	NA
•This is the highest value of the load kW during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the highest kW load is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
035 Reverse kW Load Low XXXX kW MM-DD-YYYY HH:MM:SS	kW	View	NA	Operate	Reset*	NA	NA
•This is the lowest value of the load kW during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the lowest kW load is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
035 Reverse kW Load Present XXXX.X kW	kW	View	NA	NA	NA	NA	NA
•This is the present value of the load kW during reverse power flow, as a demand value, according to the demand time interval at FC 46. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
036 Reverse kvar Load High XXXX.X kvar MM-DD-YYYY HH:MM:SS	kvar	View	NA	Operate	Reset*	NA	NA
•This is the highest value of the load kvar during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the highest kvar load is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
036 Reverse kvar Load Low XXXX.X kvar MM-DD-YYYY HH:MM:SS	kvar	View	NA	Operate	Reset*	NA	NA
•This is the lowest value of the load kvar during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the lowest kvar load is displayed. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
036 Reverse kvar Load Present XXXX.X kvar	kvar	View	NA	NA	NA	NA	NA
•This is the present value of the load kvar during reverse power flow, as a demand value, according to the demand time interval at FC 46. •The control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
037 Reverse Source Voltage High XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the highest value of the primary input voltage of the regulator during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the highest source voltage is displayed.							
037 Reverse Source Voltage Low XXX.X Volts MM-DD-YYYY HH:MM:SS	Volts	View	NA	Operate	Reset*	NA	NA
•This is the lowest value of the primary input voltage of the regulator during reverse power flow since last reset, as a demand value, according to the demand time interval at FC 46. •Date and time of the occurrence of the lowest source voltage is displayed.							
037 Reverse Source Voltage Present XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•This is the present value of the primary input voltage of the regulator during reverse power flow, as a demand value, according to the demand time interval at FC 46.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
038 Master Reset	---	View	NA	Operate	NA	NA	NA
•Only demand metering forward and reverse; maximum and minimum raise and lower; tap position values and associated time/date stamps are reset to their corresponding present demand values at FC 38. •To reset, press ENTER and then ENTER again to confirm. •If the present demand value or tap position is in an invalid state, indicated by dashes, the high and low values will also become invalid and will display dashes. •Individual maximum and minimum values and their date/time stamps (see FC 20–FC 37, FC 127, FC 128, FC 134, and FC 135) may be reset to the present demand value: access the appropriate function code on display, press ENTER and then Enter again to confirm. •Successful master reset is indicated by the word (Done) appearing on the display. •See **Section 5: Control Programming: Special functions.**							
039 Source Side Voltage Calc. On	---	View	Modify	NA	On	NA	NA
•The source side voltage is calculated based on tap position and the regulator type (see FC 140). •Options include: Off; On. •The source voltage calculation provides accuracy to ±1.5% maximum error. •When calculated values are used, the LCD will display (CALCULATED). •If source voltage is sensed, it will take precedence over the calculated voltage.							
040 Control Identification 12345	---	View	Modify	NA	12345	0	99999
•This provision is made for entry of a number to uniquely identify each control. •The serial number of the control, as shown on the decal on the back of the front panel, is entered at the factory. However, any other number within the limits defined above may be chosen instead.							
041 Regulator Configuration Wye	---	View	Modify	NA	"-----" (Invalid)	NA	NA
•The control is designed to operate on wye-connected or delta-connected three-phase systems. Options include: Wye (star); Delta-lagging; Delta-leading. •Regulators connected line-to-ground (wye or star) develop potentials and currents suitable for direct implementation in the control. •Regulators connected line-to-line (delta) develop a potential-to-current phase shift which is dependent upon whether the regulator is defined as leading or lagging. This phase shift must be known by the control to permit accurate calculations for correct operation. •See **Section 3: Initial Control Programming: Determination of leading or lagging in delta-connected regulators.** •Note: See Reference Bulletin R225-10-1 for a discussion of delta connections.							
042 Control Operating Mode Sequential	---	View	Modify	NA	Sequential	NA	NA
•This parameter determines the manner in which the control responds to out-of-band conditions. •The available options are: Sequential; Time Integrating; Voltage Averaging. •For detailed information, see **Section 4: Control Operation: Control operating modes.** •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
043 System Line Voltage XXXXX Volts	Volts	View	Modify	NA	"-----" (Invalid)	1200	36000
•The control is designed to operate on primary system voltages from 1200 V to 36000 V. •Ratio correction is performed by the firmware and consequently, the primary voltage must be entered for this calculation. •Example: A regulator installed on a 7200 V system (line-to-neutral) would have 7200 entered. •Example: A regulator installed open or closed delta on an 11000 V system (line-to-line) would have 11000 entered. •Note: The line voltage rating is available on the regulator nameplate and is summarized in **Table 14** and **Table 15** for most regulator ratings.							
044 Overall P.T. Ratio XXX.X	---	View	Modify	NA	"-----" (Invalid)	10.0	300.0
•The control is designed to operate on primary system voltages from 1200 V to 36000 V. Ratio correction is performed by the firmware, and, consequently, the overall potential transformer (PT) ratio must be entered for this calculation. •Note: The overall PT ratio is available on the regulator nameplate and is summarized in **Table 14** and **Table 15** for most regulator ratings. •Example: A 13800 V regulator, installed on a 7970 V system, would have 7970 entered at FC 43 and 63.7 entered at FC 44. The control will then define the 125.1 V (output from the back panel ratio correction transformer) as the 120-base voltage, and 120 V is displayed at FC 6. If FC 148 is set to a 240 V base, the control will define the 125.1 V as the 240 V base and 240 V will be displayed at FC 6.							
044 Internal P.T. Ratio XXX.X	---	View	Modify	NA	"-----" (Invalid)	10.0	300.0
•The internal PT ratio for the applicable system voltage from the nameplate voltage chart. •When a voltage regulator is equipped with an Internal Differential PT (IDPT), but not with second Ratio Correction Transformer (RCT2), the control will use the internal PT ratio to calculate the source voltage from the IDPT voltage input. •When FC 146 Vin P.T. Configuration is set to Vin, the control will use the Internal P.T. Ratio when determining the source-bushing voltage. •While FC 146 Vin P.T. Configuration is set to Vdiff with RCT2, the text (INVALID VIN CONFIG) will be displayed when attempting to edit this parameter.							
045 C.T. Primary Rating XXXX Amps	Amps	View	Modify	NA	"-----" (Invalid)	25	4000
•The control is designed for 200 mA as the rated current transformer (CT) output current, and will meter to 800 mA with no loss of accuracy. •Ratio correction is performed by the firmware and consequently the CT primary rating must be entered. The CT primary rating is available on the regulator nameplate. •Example: A 7620 V, 328 A regulator (250 kVA) would have a C.T. rating of 400:0.2 and therefore, 400 is entered.							
045 Rated Load Current XXXX Amps	Amps	View	Modify	NA	"-----" (Invalid)	25	4000
•This is the 55 °C rated load current of the regulator. This information can be found on the unit nameplate.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
045 Adaptive ADD-AMP 5% Limit XXX %	%	View	Modify	NA	100	100	160
•Adaptive ADD-AMP setting found in the Limit Switch Settings chart on the nameplate at the 5% Level. •SOFT-ADD-AMP (FC 70) must be set to Adaptive to activate this feature.							
045 Adaptive ADD-AMP 6 1/4% Limit XXX %	%	View	Modify	NA	100	100	160
•Adaptive ADD-AMP setting found in the Limit Switch Settings chart on the nameplate at the 6 1/4% Level. •SOFT-ADD-AMP (FC 79) must be set to Adaptive to activate this feature.							
045 Adaptive ADD-AMP 7 1/2% Limit XXX %	%	View	Modify	NA	100	100	160
•Adaptive ADD-AMP setting found in the Limit Switch Settings chart on the nameplate at the 7 1/2% Level. •SOFT-ADD-AMP (FC 79) must be set to Adaptive to activate this feature.							
045 Adaptive ADD-AMP 8 3/4% Limit XXX %	%	View	Modify	NA	100	100	160
•Adaptive ADD-AMP setting found in the Limit Switch Settings chart on the nameplate at the 8 3/4% Level. •SOFT-ADD-AMP (FC 79) must be set to Adaptive to activate this feature.							
046 Demand Time Interval XX.X Minutes	Minutes	View	Modify	NA	15.0	0.1	60.0
•This is the time period during which the demand integral is performed for all demand metering readings. •Demand readings represent the values which produce actual heating effects in electrical equipment and do not respond to the continuous fluctuations which occur on the line.							
047 Voltage Calibration XXX.X Volts	Volts	View	Admin	NA	See Note	110.0	130.0
•The voltage which the control actually measures is displayed at FC 47. In the example given in FC 44 description, FC 47 would indicate 125.1 V when FC 6 indicated 120 V. •To calibrate, this value is compared to a reference voltmeter and if different, is changed to display the correct value. •Note: A default calibration factor is programmed into non-volatile memory at the factory; adjustments should not be necessary in the field. •See **Section 8: Troubleshooting: Control calibration.** •In addition to the low and high limits, the user must enter a value that is within 5% of the displayed value.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
048 Current Calibration XXX.X mAmps	MilliAmp	View	Admin	NA	See Note	100.0	400.0
•The current which the control actually measures in mA, is displayed at FC 48. •The control is designed for 200 mA as the rated CT secondary output current and will meter to 800 mA with no loss of accuracy. •To calibrate, this value is compared to a reference ammeter and, if different, is changed to display the correct value. •Note: A default calibration factor is programmed into non-volatile memory at the factory; adjustments should not be necessary. •See **Section 8: Troubleshooting: Control calibration.** •In addition to the low and high limits, the user must enter a value that is within 5% of the displayed value.							
049 Tap Changer Type Cooper QD8	---	View	Modify	NA	"-----" (Invalid)	NA	NA
•This function code identifies the tap-changer type. Changing this function code changes the control's sampling rate to accommodate varying tap-changer types. •Options include: Eaton's Cooper Power series QD8; Eaton's Cooper Power series QD5; Eaton's Cooper Power series QD3; Eaton's Cooper Power series Spring Drive; Eaton's Cooper Power series Direct Drive; Siemens; General Electric; Howard; LTC Reinhausen; ITB, Toshiba, User Defined.							
050 System Calendar and Clock MM-DD-YYYY HH:MM:SS	---	View	Modify	NA	See Note	NA	NA
•Editing is always in the format MM-DD-YYYY and with the 24 Hour clock. •Note: The default is Jan. 1, 1970. •Refer to **Section 6: Control Features: Calendar/clock.**							
050 UTC Time Zone GMT-05:00	---	View	NA	NA	NA	NA	NA
•Used to set the time zone with respect to Greenwich Mean Time. The options include: GMT-12:00 to GMT-01:00; Greenwich Mean Time; GMT+01:00 to GMT+13:00. •This cannot be edited via the keypad; use of ProView NXG interface software is required for editing.							
051 Reverse Set Voltage XXX.X Volts	Volts	View	Modify	NA	120.0	100.0	135.0
•The set voltage is the voltage level to which the control will regulate on the 120 V or 240 V base during reverse power flow. •See FC 1 and **Section 6: Control Features: Reverse power operation.** •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1). •If FC 148 Nominal Load Voltage is set to 240 Volts, limits are expanded (doubled). •If FC 148 is set to System Line Voltage, this setting must be set in terms of the system line voltage. For example, on a 7200 V system, with a desired set voltage 1% above the nominal voltage, the setting would be 7272.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
052 Reverse Bandwidth X.X Volts	Volts/%	View	Modify	NA	2.0	1.0	6.0
•The bandwidth is defined as that total voltage range, around the set voltage, which the control will consider as a satisfied (in-band) condition during reverse power flow. •Example: A bandwidth of 3.0 V and a set voltage of 120.0 V will establish a low limit of 118.5 V and a high limit of 121.5 V. •See FC 2 and **Section 6: Control Features: Reverse power operation.** •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1). •If FC 148 Nominal Load Voltage is set to 240 Volts, limits are expanded (doubled). •If FC 148 is set to System Line Voltage, this setting must be set as a percentage of the set voltage.							
053 Reverse Time Delay XXX Seconds	Seconds	View	Modify	NA	45	5	180
•The time delay is the period of time (in seconds) that the control waits, from the time when the voltage first goes out-of-band to the time when a tap change is initiated during reverse power flow. •See FC 3 and **Section 6: Control Features: Reverse power operation.** •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
054 Rev Line Drop Comp. Resistance XX.X Volts	Volts/%	View	Modify	NA	0.0	-96.0	96.0
•The resistive line-drop compensation value is used to model the resistive line voltage drop between the regulator and the center of regulation. •The control uses this parameter, in conjunction with the regular configuration (FC 41) and the load current, to calculate and regulate to the compensated voltage (displayed at FC 8) during the reverse power flow. •See FC 4 and **Section 6: Control Features: Reverse power operation.** •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1). •If FC 148 Nominal Load Voltage is set to 240 Volts, limits are expanded (doubled). •If FC 148 is set to System Line Voltage, this setting must be set as a percentage of the set voltage.							
055 Rev Line Drop Comp. Reactance XX.X Volts	Volts/%	View	Modify	NA	0.0	-96.0	96.0
•The reactive line-drop compensation value is used to model the reactive line drop voltage between the regulator and the center of regulation. •The control uses this parameter, in conjunction with the regulator configuration (FC 41) and the load current, to calculate and regulate to the compensated voltage (displayed at FC 8) during the reverse power flow. •See FC 5 and **Section 6: Control Features: Reverse power operation.** •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1). •If FC 148 Nominal Load Voltage is set to 240 Volts, limits are expanded (doubled). •If FC 148 is set to System Line Voltage, this setting must be set as a percentage of the set voltage.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
056 Reverse Sensing Mode Locked Forward	---	View	Modify	NA	Locked Forward	NA	NA
•The control offers ten different response characteristics for power flow operation. See **Section 6: Control Features: Reverse power operation** for more information on the reverse sensing modes. •Options include: Locked Forward; Locked Reverse; Reverse Idle; Bi-directional; Neutral Idle; Co-generation; Reactive Bi-directional; Bias Bi-directional; Bias Co-Generation; Reverse Co-Generation. •The current threshold set at FC 57 must be exceeded for some modes to function. •If an alternate configuration is active, the fourth LCD line displays which alternate is active, e.g. (ALT CONFIG 1).							
057 Reverse Current Sense Threshold X %	%	View	Modify	NA	1	1	5
•This is the percentage used to determine the current threshold at which the control recognizes current flow direction. Below the threshold, the current flow is considered to be indeterminate. •This threshold is programmable as a percentage of the rated CT primary rating. •Example: A regulator utilizing a CT with a 400:0.2 ratio with a 1% threshold would have a current threshold of 4 A. The Load Current Metering-PLUS screen would also display the 4 A threshold. •The metering of the control switches on a fixed 1% threshold, independent of FC 57. •If an alternate configuration is active, the fourth LCD line displays which alternate is active, e.g. (ALT CONFIG 1).							
058 Bias Co-Gen Alt Mode Locked Reverse	---	View	Operate	NA	Locked Reverse	NA	NA
•This setting is used in conjunction with the Reverse Sensing Mode (FC 56) of Bias Co-Generation only. The setting goes into effect when operating in that mode and when the control determines that a reversal of current has occurred on the system that is due to a switching operation, a true reversal of power. Under these circumstances, the control will revert to the mode of operation specified in this setting. •Options include: Locked Reverse; Neutral Idle; Reverse Co-Generation.							
069 Auto Operation Blocking Status Normal	---	0	Modify	NA	Normal	NA	NA
•This feature enables blocking of automatic operation locally and via SCADA communications. •Options include: Normal; Blocked. •Normal refers to normal automatic operation. Blocked refers to a state when automatic operation is inhibited. •Example: This function can be used to perform a desired amount of voltage reduction and then disable the tap-changer (inhibit additional operations) for an indefinite time period. •If FC 69 has been set to Blocked using SCADA, the operator may override the SCADA system by changing FC 69 from Blocked to Normal. •Refer to **Section 6: Control Features: Supervisory control and data acquisition (SCADA)** for additional information concerning the SCADA interaction with the control. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
070 Voltage Reduction Mode Off	---	View	Modify	NA	Off	NA	NA
•The control has three voltage reduction modes available. Options include: Off; Local/ Digital Remote; Remote/Latch; Remote/Pulse. •Refer to **Section 6: Control Features: Voltage reduction**. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
071 Reduction In Effect XX.X %	%	View	NA	NA	NA	NA	NA
•This is the percentage of voltage reduction currently active. •See **Section 6: Control Features: Voltage reduction.** •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
072 Local/Digital Reduction Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•Voltage reduction can be enabled by setting FC 70 to Local/Digital Remote and entering a value at FC 72 either locally through the keypad or remotely using SCADA. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
073 Remote #1 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•Three levels of remotely latched voltage reduction are available. These voltage reduction values are activated when FC 70 is set to Remote/Latch and the appropriate input terminals are latched. •This programs the percentage of voltage reduction for Remote/Latch level #1. •See **Section 6: Control Features: Analog SCADA** for more information. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
074 Remote #2 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•See information for FC 73. •This programs the percentage of voltage reduction for Remote/Latch level #2. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
075 Remote #3 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•See information for FC 73. •This programs the percentage of voltage reduction for Remote/Latch level #3. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
076 # of Pulse Reduction Steps XX	---	View	Modify	NA	0	0	10
•Up to ten steps of remotely activated voltage reduction are available. The voltage reduction steps are activated when FC 70 is set to Remote/Pulse and a momentary pulse is applied to the appropriate input terminal. •FC 76 defines the number of steps selected for pulsed voltage reduction. The percentage of voltage reduction of each step is defined at FC 77. •See **Section 6: Control Features: Analog SCADA** for more information. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
077 % of Voltage Red Per Pulse Step XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•This defines the percentage of voltage reduction which will be applied for each step of pulsed voltage reduction selected at FC 76. •See **Section 6: Control Features: Analog SCADA** for more information. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
078 Present Voltage Reduction Step XX	---	View	NA	NA	NA	NA	NA
•Displays the current step when Remote/Pulse voltage reduction is active. •If alternate configuration is active, the fourth LCD line displays which one is active, i.e. (ALT CONFIG 1).							
079 SOFT-ADD-AMP Limits Off	---	View	Modify	NA	Off	NA	NA
•This parameter enables the Soft ADD-AMP feature. Options include: Off; On; Remote Override; Cfg Logic Active; Adaptive. •See **Section 6: Control Features: Soft ADD-AMP feature.** •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
080 Voltage Limiter Mode Off	---	View	Modify	NA	Off	NA	NA
•The control has voltage-limiting capabilities for both high-voltage and low-voltage conditions. Options include: Off; High limit only; High/low limits; IVVC High Limit Only; IVVC High/Low Limits. •See **Section 6: Control Features: Voltage limiter.** •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1)							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
081 High Voltage Limit XXX.X Volts	Volts/%	View	Modify	NA	130.0	105.0	135.0
•The high voltage limit for Voltage Limiter. •When the voltage-limiting function is activated (FC 80), the control will prevent the output voltage of the regulator from exceeding this value. •See **Section 6: Control Features: Voltage limiter.** •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1). •If FC 148 Nominal Load Voltage is set to 240 Volts, limits are expanded (doubled). •If FC 148 is set to System Line Voltage, this setting must be set as a percentage of the set voltage.							
082 Low Voltage Limit XXX.X Volts	Volts/%	View	Modify	NA	105.0	105.0	135.0
•The low voltage limit for Voltage Limiter. •When the voltage-limiting function is activated (FC 80 high and low limit active), the control will prevent the output voltage of the regulator from dropping below this value. •See **Section 6: Control Features: Voltage limiter.** •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1). •If FC 148 Nominal Load Voltage is set to 240 Volts, limits are expanded (doubled). •If FC 148 is set to System Line Voltage, this setting must be set as a percentage of the set voltage.							
083 Voltage Limiter Fast Resp. Delay XX Seconds	Seconds	View	Modify	NA	3	1	60
•When the load voltage reaches the Voltage Limiter limits plus 3 volts, this is the period of time the control will delay before reacting to bring the load voltage back within the Voltage Limiter limits. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1)							
084 Voltage Limiter Delay XX Seconds	Seconds	View	Modify	NA	10	1	60
•The period of time the control will delay before reacting to bring the load voltage back within the Voltage Limiter limits. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
085 Time Between Taps XX Seconds	Seconds	View	Modify	NA	0	0	10
•For Voltage Limiter, the delay between completing a tapping operation and sending the signal for the next tapping operation when Voltage Limiter limits have been exceeded. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
088 USB Device Connected 0	---	View	NA	NA	NA	NA	NA
•Provides a display of 0 when a USB memory device is not connected and 1 when a USB memory device is connected.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
088 Factory Access Mode Disabled	---	View	Modify	NA	Disabled	NA	NA
•This function is used to diagnose the control when an extended communications module is in use. •Available options include: Disabled; Enabled.							
088 Extended Comms Status 0x0 (RUNNING OK)	---	View	NA	NA	NA	NA	NA
•Provides the status of an extended communications card. •(NOT AVAILABLE) indication is displayed if the extended communications card is not present. •(RUNNING OK) indication is displayed if the extended communications card is present and operating properly. •(FAILURE)-0x0 indication is displayed if the extended communications card is present and indicating a failure code.							
088 Config. Logic Equation Error X	---	View	NA	NA	NA	NA	NA
•Provide a display of 0 when there are no configurable logic errors and 1 when one or more configurable logic errors exist.							
089 Activate Contact Output 1 X	---	View	Modify	NA	NA	0	1
•Enables activation of discrete output contact 1. •If value is 0, it can be changed to 1 and then back 0. •If value is 1 because its activation is being driven by a logic equation, attempting to change it to 0 will display (CANNOT OVERRIDE).							
089 Activate Contact Output 2 X	---	View	Modify	NA	NA	0	1
•See description of Activate Contact Output 1.							
089 Activate Contact Output 3 X	---	View	Modify	NA	NA	0	1
•See description of Activate Contact Output 1.							
089 Activate Contact Output 4 X	---	View	Modify	NA	NA	0	1
•See description of Activate Contact Output 1.							
090 CI1 = Inactive CI2 = Inactive CI3 = Inactive CI4 = Inactive	---	View	NA	NA	NA	NA	NA
•Provides a status of the auxiliary input contacts and will display the status as Inactive or Active.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
090 CO1 = Inactive CO2 = Inactive CO3 = Inactive CO4 = Inactive	---	View	NA	NA	NA	NA	NA
•Provides a status of the auxiliary output contacts and will display the status as Inactive or Active.							
091 Self-Test	---	NA	NA	NA	NA	NA	NA
•Access this parameter to initiate a self-test. •While on the Self-Test screen press ENTER and then ENTER again to confirm. Results are displayed when the self-test is complete. Press Escape for further keypad use. •Refer to Power-Up/Reset Conditions in this section of the manual for more information.							
091 Last Self-Test Results 0xXXXXXXXX	---	View	NA	NA	NA	NA	NA
•This display is entered at the FC 91 Self-Test screen by pressing the down arrow before activating the self-test. This information is primarily intended to be used as a means of transmitting diagnostic error codes through SCADA. This same information can be viewed at FC 95 in a readable format. •The display for this parameter is a 32-bit value displayed in hexadecimal format. The value corresponds to the results of the FC 91 self-test. •To decipher the hexadecimal value, convert the hex number to a binary number. Each digit of the binary number will correspond to a bit in the chart below. For example, a hex number of 208 would correspond to a binary number of 0000000001000001000. Reading the binary number from right to left provide a 1 at bit 3 (the forth digit) and bit 9 (the 10th digit). These bits correspond to diagnostic errors of "VR1 Input Voltage Missing" and "VR1 No Neutral Sync Signal". •0x00000001 – bit 0, Non-Volatile Setting (CRC error at system startup) •0x00000002 – bit 1, Frequency Detection •0x00000004 – bit 2, Data Acquisition •0000000008 – bit 3, VR1 Input Voltage Missing •0x00000010 – bit 4, VR2 Input Voltage Missing •0x00000020 – bit 5, VR3 Input Voltage Missing •0000000040 – bit 6, VR1 OUTPUT VOLTAGE MISSING •0x00000080 – bit 7, VR2 Output Voltage Missing •0x00000100 – bit 8, VR3 Output Voltage Missing •0x00000200 – bit 9, VR1 No Neutral Sync Signal •0x00000400 – bit 10, VR2 No Neutral Sync Signal •0x00000800 – bit 11, VR3 No Neutral Sync Signal •0x00001000 – bit 12, Clock Needs Setting •0x00002000 – bit 13, Factory Calibration Required •0x00004000 – bit 14, Configuration Values Required •0x00008000 – bit 15, Battery Test •0x00010000 – bit 16, VR1 Motor Trouble •0x00020000 – bit 17, VR3 Motor Trouble •0x00040000 – bit 18, VR3 Motor Trouble							
092 Security Override View	---	View	Admin	NA	View	NA	NA
•This is the control security override parameter. Options for security override are: View; Operate; Modify; Admin. •Entering the Admin level security code at FC 99 will permit the security parameters to be modified. •See **Section 4: Control Operation: Security system.**							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
(095) Self-Test Complete xx-xx-xxxx x:xx:xxa (Pass)	---	View	NA	NA	NA	NA	NA
•This function code will display the results of the last self-test.							
096 Password "Operate" XXXXXXXXXX	---	Admin	Admin	NA	Operate	NA	NA
•The alphanumeric security code for the Operate security level is displayed here. •Entry of the Admin level security code at FC 99 enables viewing and editing of this password. •Entry of this alphanumeric code at FC 99 permits the user to change/reset parameters marked as Operate level security (i.e. demand and tap position readings). •See **Section 4: Control Operation: Security system.**							
097 Password "Modify" XXXXXXXXXX	---	Admin	Admin	NA	Modify	NA	NA
•The alphanumeric security code for the Modify security level is displayed here. •Entry of the Admin level security code at FC 99 enables viewing and editing of this password. •Entry of this alphanumeric code at FC 99 permits the user to change/reset parameters marked as Modify level security (i.e. control settings, configuration, and clock) and Operate level security (i.e. demand and tap position readings). •See **Section 4: Control Operation: Security system.**							
098 Password "Admin" XXXXXXXXXX	---	Admin	Admin	NA	Admin	NA	NA
•The alphanumeric security code for the Admin security level is displayed here. •Entry of the Admin level security code at FC 99 enables viewing and editing of this password. •Entry of this alphanumeric code at FC 99 permits the user to change/reset any parameter. •Note: If the level Admin code is changed by the user, the new value should be recorded and kept in a safe place. If lost, security codes can be retrieved with a USB memory device and ProView NXG software, with the ProView NXG software via a PC directly connected to the control, or with the remote communications system. •See **Section 4: Control Operation: Security system.**							
099 Enter Password ----------	---	Admin	Admin	NA	Admin	NA	NA
•This is the function code used to access the menu location where security codes are entered for access to the system. •Scrolling to this level is not allowed. •See **Section 4: Control Operation: Security system.**							
100 Last Counter Change XXXXX MM-DD-YYYY HH:MM:SS	---	View	NA	NA	NA	NA	NA
•This displays the time and date since the Total Operations counter (FC 0) was last changed, as well as the quantity of operations entered at the last change.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
101 Last 24 Hours Operations XXXXX MM-DD-YYYY HH:MM:SS	---	View	NA	Admin	Reset* to 0	NA	NA
•Number of operations in last 24 hours (updated hourly and on every tap change). •This counter is reset by pressing ENTER and then ENTER again to confirm.							
102 Last 30 Days Operations XXXXX MM-DD-YYYY HH:MM:SS	---	View	NA	Admin	Reset* to 0	NA	NA
•Number of operations in last 30 days (updated daily and on every tap change). •This counter is reset by pressing ENTER and then ENTER again to confirm.							
103 Current Month Operations XXXXX MM-DD-YYYY HH:MM:SS	---	View	NA	Admin	Reset* to 0	NA	NA
•Number of operations since the beginning of the current month (updated on every tap change and reset when the clock's month changes). •This counter is reset by pressing ENTER and then ENTER again to confirm.							
104 Last Month Operations XXXXX MM-DD-YYYY HH:MM:SS	---	View	NA	Admin	Reset* to 0	NA	NA
•Number of operations during the last calendar month (updated on every tap change and reset when the clock's month changes). •If reset, this counter will remain zero until the month changes. •This counter is reset by pressing ENTER and then ENTER again to confirm.							
105 Current Year Operations XXXXX MM-DD-YYYY HH:MM:SS	---	View	NA	Admin	Reset* to 0	NA	NA
•Number of operations since January 1st of the current year (updated on every tap change and reset when the clock's year changes). •This counter is reset by pressing ENTER and then ENTER again to confirm.							
106 Last Year Operations XXXXX MM-DD-YYYY HH:MM:SS	---	View	NA	Admin	Reset* to 0	NA	NA
•Number of operations during the last calendar year (updated on every tap change and reset when the clock's year changes). •If reset, this counter will remain zero until the year changes. •This counter is reset by pressing ENTER and then ENTER again to confirm.							
107 Enable Interval Counters Enabled	---	View	Admin	NA	Enabled	NA	NA
•This is used to enable operations counters corresponding to FC 101 to FC 106. Options include: Enabled; Disabled.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
110 Tap Position Sync Counter XXXXX MM-DD-YYYY HH:MM:SS	---	View	NA	Admin	Reset* to 0	NA	NA
•A count of the number of times the control tap position indication (TPI) was synchronized either at neutral or when the regulator was able to tap up or down when TPI was at 16R or 16L respectively. •This counter is reset by pressing ENTER and then ENTER again to confirm.							
112 Percent Regulation XX.X %	%	View	NA	NA	NA	NA	NA
•This is the actual percentage that the regulator is actively boosting (raising) or bucking (lowering) the input (source) voltage. •When the regulator output voltage is greater than the input voltage (regulator boosting), the sign is implied (+). When the output voltage is lower than the input voltage, the sign is implied (-). •Tap position indication is calculated as follows: % regulation = [(output/input) - 1] x 100. •During reverse power operation, the control requires source voltage from a differential or source potential transformer or from the source voltage calculation (see FC 39) to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
125 Energy kW-h Forward XXXX.X kW-h	KW-h	View	NA	Operate	Reset* to 0	NA	NA
•This is the total forward energy, measured in kilowatt hours. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
125 Energy kW-h Reverse XXXX.X kW-h	KW-h	View	NA	Operate	Reset* to 0	NA	NA
•This is the total reverse energy, measured in kilowatt hours. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
126 Energy kvar-h Forward XXXX.X kvar-h	Kvar-h	View	NA	Operate	Reset* to 0	NA	NA
•This is the total forward energy, measured in kvar. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
126 Energy kvar-h Reverse XXXX.X kvar-h	Kvar-h	View	NA	Operate	Reset* to 0	NA	NA
•This is the total reverse energy, measured in kvar. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
127 Maximum Percent Regulation XX.X % MM-DD-YYYY HH:MM:SS	%	View	NA	Operate	Reset*	NA	NA
•This is the highest percentage that the regulator has raised the input voltage since last reset. •The control requires an input voltage from a differential or source potential transformer to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
128 Minimum Percent Regulation XX.X % MM-DD-YYYY HH:MM:SS	%	View	NA	Operate	Reset*	NA	NA
•This is the highest percentage that the regulator has lowered the input voltage since last reset. •The control requires an input voltage from a differential or source potential transformer to obtain this parameter. Lack of this voltage will result in the parameter displaying dashes.							
130 Phase Angle XXX.X Degrees	Degrees	View	NA	NA	NA	NA	NA
•The instantaneous metering display of the angle by which the sine curve of the voltage in a circuit element leads or lags the sine curve of the current.							
131 Load Current Real XXXX.X Amps	Amps	View	NA	NA	NA	NA	NA
•The instantaneous metering display of the real portion of the load current.							
131 Load Current Reactive XXXX.X Amps	Amps	View	NA	NA	NA	NA	NA
•The instantaneous metering display of the reactive portion of the load current. •The instantaneous metering display of the averaged secondary load voltage when in multi-phase operation.							
132 Average Source Volt. Secondary XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•The instantaneous metering display of the averaged secondary source voltage when in multi-phase operation.							
132 Average Comp Volt. Secondary XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•The instantaneous metering display of the averaged secondary compensated voltage for all phases when in multi-phase operation.							
132 Average Load Current Primary XXX.X Volts	Amps	View	NA	NA	NA	NA	NA
•The instantaneous metering display of the averaged primary load current when in multi-phase operation.							
132 Average Present Tap Position XX	---	View	NA	NA	NA	NA	NA
•The instantaneous metering display of the average present tap position for all phases when in multi-phase operation.							
132 Average Maximum Tap Position XX MM-DD-YYYY HH:MM:SS	---	View	NA	NA	NA	NA	NA
•The instantaneous metering display of the average present tap position for all phases when in multi-phase operation. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
132 Average Minimum Tap Position XX MM-DD-YYYY HH:MM:SS	---	View	NA	NA	NA	NA	NA
•The instantaneous metering display of the average minimum tap position for all phases when in multi-phase operation. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
133 Total kVA Load XXXX.X kVA	kVA	View	NA	NA	NA	NA	NA
•The instantaneous metering display of the sum of the apparent power for all phases when in multi-phase operation.							
133 Total kW Load XXXX.X kW	kW	View	NA	NA	NA	NA	NA
•An instantaneous metering display of the sum of the real power for all phases when in multi-phase operation.							
133 Total kvar Load XXXX.X kvar	kvar	View	NA	NA	NA	NA	NA
•An instantaneous metering display of the sum of the reactive power for all phases when in multi-phase operation.							
134 Fwd Load Current Real High XXX.X Amps MM-DD-YYYY HH:MM:SS	Amps	View	NA	Operate	Reset*	NA	NA
•Demand metering high value for the real portion of the current for forward power flow with date and time of earliest occurrence. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
134 Fwd Load Current Real Low XXX.X Amps MM-DD-YYYY HH:MM:SS	---	View	NA	NA	NA	NA	NA
•Demand metering low value for the real portion of the current for forward power flow with date and time of earliest occurrence. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
134 Fwd Load Current Real Present XXX.X Amps	---	View	NA	NA	NA	NA	NA
•Demand metering present value for the real portion of the current for forward power.							
134 Fwd Load Current Reactive High XXX.X Amps MM-DD-YYYY HH:MM:SS	Amps	View	NA	Operate	Reset*	NA	NA
•Demand metering high value for the reactive portion of the current for forward power flow with date and time of earliest occurrence. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
134 Fwd Load Current Reactive Low XXX.X Amps MM-DD-YYYY HH:MM:SS	---	View	NA	NA	NA	NA	NA
•Demand metering low value for the reactive portion of the current for forward power flow with date and time of earliest occurrence. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
134 Fwd Load Current Reactive Present XXX.X Amps MM-DD-YYYY HH:MM:SS	---	View	NA	NA	NA	NA	NA
•Demand metering present value for the reactive portion of the current for forward power.							
135 Rev Load Current Real High XXX.X Amps MM-DD-YYYY HH:MM:SS	Amps	View	NA	Operate	Reset*	NA	NA
•Demand metering high value for the real portion of the current for reverse power flow with date and time of earliest occurrence. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
135 Rev Load Current Real Low XXX.X Amps MM-DD-YYYY HH:MM:SS	Amps	View	NA	Operate	Reset*	NA	NA
•Demand metering low value for the real portion of the current for reverse power flow with date and time of earliest occurrence. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
135 Rev Load Current Real Present XXX.X Amps	Amps	View	NA	NA	NA	NA	NA
•Demand metering present value for the real portion of the current for reverse power flow.							
135 Rev Load Current Reactive High XXX.X Amps MM-DD-YYYY HH:MM:SS	Amps	View	NA	Operate	Reset*	NA	NA
•Demand metering high value for the reactive portion of the current for reverse power flow. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
135 Rev Load Current Reactive Low XXX.X Amps MM-DD-YYYY HH:MM:SS	Amps	View	NA	Operate	Reset*	NA	NA
•Demand metering low value for the reactive portion of the current for reverse power flow with date and time of earliest occurrence. •This is reset to zero by pressing ENTER and then ENTER again to confirm.							
135 Rev Load Current Reactive Present XXX.X Amps	Amps	View	NA	NA	NA	NA	NA
•Demand metering present value for the reactive portion of the current for reverse power flow.							
139 Motor Voltage XXX.X Amps	Volts	View	NA	NA	NA	NA	NA
•The instantaneous metering display of the motor voltage detected by the control.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
140 Regulator Type Type B	---	View	Modify	NA	"-----" (Invalid)	NA	NA
•Regulator type defines the regulator type based on ANSI standards. Options include: Type A; Type B; Type C; Type D. •Type A – Series regulator design •Type B – Inverted regulator design •Type C – Series duplex transformer design or Series TX. Used on Eaton's Cooper Power series voltage regulator with voltage rating of 2.5 kV and current ratings above 875 A. •Type D – Series duplex auto transformer design or Series AX. Used on Eaton's Cooper Power series voltage regulators with voltage rating of 5.0 kV and 7.62 kV and current rating above 875 A. •Note: The regulator type is included on Eaton's Cooper Power series nameplates.							
141 Regulator Identification ----------	---	View	Modify	NA	-----	NA	NA
•A 20-character alphanumeric identification that can be applied to each regulator controlled. •For a multi-phase configuration, each regulator can have its own identification.							
142 Serial Number -------	---	View	NA	NA	NA	NA	NA
•This function code will display the control serial number. The serial number is also displayed on a smaller sticker near the bottom on the left side of the control. •This function code is not editable.							
144 P.I. ADD-AMP High Limit XX	---	View	Modify	NA	16	NA	NA
•The physical location of the high P.I. limit switch on the position indicator is entered here. The allowable values are 16, 14, 12, 10, or 8. •This setting is informational only and must be set by the user.							
145 P.I. ADD-AMP Low Limit -XX	---	View	Modify	NA	-16	NA	NA
•The physical location of the low P.I. limit switch on the position indicator is entered here. The allowable values are -16, -14, -12, -10, or -8. •This setting is informational only and must be set by the user.							
146 Vin P.T. Configuration Vdiff without RCT2	---	View	Modify	NA	Vdiff w/o RCT2	NA	NA
•This defines the configuration of the PT for the source-side voltage. Options include: Vdiff with RCT2; Vdiff without RCT2; Vin Mode. •The Vdiff modes are used when the regulator is provided with an internal differential PT with or without a ratio correction transformer, or if the Source Voltage Calculator (FC 39) is used to calculate the source voltage. •The Vin Mode is selected when a PT is connected between the source bushing and the reference voltage to measure the source voltage. When the Vin setting is selected, the control will use the Internal P.T. Ratio set at FC 44↓ to determine the source voltage. •See **Section 6: Control Features: Source-side voltage.**							
147 TPI Sense Method Incremental	---	View	Modify	NA	Incremental	NA	NA
•Function used for LTC applications. The options are: Incremental; Measured.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
147 Neutral Sync Retry Count X	---	View	Modify	NA	3	0	5
•If the control tap-position indication (TPI) is at 1R or 1L and the control taps toward the neutral position but does not detect neutral, the control will keep the tap-position indication at 1R or 1L and allow attempts to tap down or up to synchronize TPI with the actual tap position. This parameter is the number of allowable attempts to synchronize to neutral.							
147 Motor Power Source Selection V-Sense	---	View	Modify	NA	V-Sense	NA	NA
•The control confirms motor power before a tap command can be initiated. This setting will designate which circuit will be checked to confirm the presence of power for the motor. •The Options are: V-Sense (motor is powered by the sense circuit); V-Motor (motor is powered by the motor circuit).							
148 Nominal Sec Load Voltage 120 Volts	---	View	Modify	NA	120 Volts	NA	NA
•The option to display the control voltage at either a 120 V or 240 V base, or using the system voltage. Options are: 120 volts; 240 volts; System Line Voltage. •When the System Line Voltage setting is selected using the control HMI, it will automatically update the display of all affected settings using the system voltage base. •When the System Line Voltage Setting is selected while changing setting using ProView NXG software, this setting must first be applied to the control. Once it is applied, the affected setting will be set to the default values using the system voltage base. The setting must then be set to the desired values.							
150 Reset Calibration	---	View	Admin	NA	NA	NA	NA
•This function allows for the resetting of voltage and current calibration factors set at FC 47 and FC 48 to the factory defaults.							
151 Sequence of Events Enabled	---	View	Admin	NA	Enabled	NA	NA
•The parameter enables the control to record Sequence of Events data. •See **Section 7: Advanced Control Features: Sequence of events (SOE)** for more information.							
152 Data Profiler Enabled	---	View	Admin	NA	Enabled	NA	NA
•The parameter enables the control to record Data Profiler data. •See **Section 7: Advanced Control Features: Data profiler** for more information.							
153 Status Alarms Enabled	---	View	Admin	NA	Enabled	NA	NA
•The parameter enables the Status Alarms feature of the control. •See **Section 7: Advanced Control Features: Alarms** for more information.							
154 Data Alarms Enabled	---	View	Admin	NA	Enabled	NA	NA
•The parameter enables the Data Alarms feature of the control. •See **Section 7: Advanced Control Features: Alarms** for more information.							
169 Block Before Remote Tap Off		View	Modify	NA	Off	NA	NA
•This setting will disable remote tapping operations unless the Auto Operation Blocking Status (FC 69) is set to Blocked. The settings options are: Off; On.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
170 Tap To Neutral Off	---	View	Modify	NA	Off	NA	NA
•This setting will enable the Tap To Neutral Feature. Once the feature is enabled, it can be activated using analog inputs, digital SCADA, or configurable logic. •Options include: Off; On.							
171 Tap To Target Off	---	View	Modify	NA	Off	NA	NA
•This setting will enable the Tap To Target Feature. Once the feature is enabled, it can be activated using analog inputs, digital SCADA, or configurable logic. •Options include: Off; On.							
172 Target Tap Position 0	---	View	Admin	NA	0	-16	16
•When the Tap To Target feature is enabled, this setting identifies the target tap position. •For multi-phase voltage regulators, individual target tap positions can be entered for each phase by scrolling through the phase setting using the right arrow button.							
175 SOFT-ADD-AMP High Limit XX	---	View	Modify	NA	16	NA	NA
•Soft ADD-AMP restricts the range of regulation using firmware logic as opposed to the hardware on the tap position indicator. The high limit is set here. The allowable values are 16, 14, 12, 10, or 8. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
176 SOFT-ADD-AMP Low Limit -XX	---	View	Modify	NA	-16	NA	NA
•Soft ADD-AMP restricts the range of regulation using firmware logic as opposed to the hardware on the tap position indicator. The low limit is set here. The allowable values are -16, -14, -12, -10, or -8. •If an alternate configuration is active, the fourth LCD line displays which one is active, e.g. (ALT CONFIG 1).							
190 Battery Voltage And Current VBat = XX.XX Volts IBat = -X.XX Amps	Volts, Amps	View	NA	NA	NA	NA	NA
•When a battery is connected to the control and being used to maintain control function, this will display the voltage and current readings of the battery.							
191 Test Battery	---	View	NA	NA	NA	NA	NA
•This parameter initiates a battery test. •Pressing the ENTER key causes the (CONFIRM) message to be displayed on the forth line of LCD. Pressing the ENTER key again initiates the battery testing mode.							
191 Battery Test Results VBat = XX.XX Volts IBat = -X.XX Amps	Volts, Amps	View	NA	NA	NA	NA	NA

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
•When a battery is connected to the control, this will display the voltage and current readings of the battery found while running the battery test routine.							
192 Automatic Test Battery Disabled	---	View	Modify	NA	Disabled	NA	NA
•When enabled, a battery test will automatically be run within 60 seconds of power-up and then 12 hours after the last battery test. The options are: Disabled; Enabled.							
194 Factory Default	---	NA	NA	Admin	NA	NA	NA
•This feature will reset all control settings, parameters, data, and metering information back to the factory default. •The reset includes passwords. •This parameter is not found in the nested menu, and can only be found using the function code.							
199 Remote Security Override Timer XX Hours	Hours	View	Admin	NA	0	0	24
•This parameter is the time that the security override will be active once enabled.							
199 Remote Security Override Mode Disabled	---	View	View	NA	Disabled	NA	NA
•The security level can be temporarily overridden remotely. This parameter is used to enable or disable the feature. The options are: Disable; Enable.							
200 Multi-phase Feature Off	---	View	Modify	NA	Off	NA	NA
•Enables the control for multi-phase operation. The options are: Off; On.							
201 Multi-phase Mode Independent	---	View	Modify	NA	Independ.	NA	NA
•Sets the mode of multi-phase operation on the control when the multi-phase mode has been turned on. Options are: Independent; Lead Phase Reg.; Voltage Averaging; Max Deviation Advanced Independent. •See **Section 6: Control Features: Multi-phase voltage regulation** for more information.							
202 Multi-phase VRs Configured X	---	View	Modify	NA	2	2	3
•The number of voltage regulators configured for multi-phase operation. The available settings are 2 and 3.							
203 Multi-phase Lead Regulator VR1	---	View	Modify	NA	VR1	NA	NA
•Assigns the lead regulator for certain multi-phase operation modes. The available settings are: VR1; VR2; VR3. •See **Section 6: Control Features: Multi-phase voltage regulation** for more information.							
204 VR1 Tap Wait Timer XXXXX mSec	MilliSec	View	Modify	NA	0	0	10000

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
•Sets a VR1 wait timer for use with the Multi-phase modes that require a gang operation (meaning that all tap changers must be on the same position). For ganged tap-changer operation, the tapping operations of the connected regulators must be synchronized if more than one tap-changer type is used. If, for example, the fast Quik-drive is ganged with a slow spring-drive, the control will not be able to keep the voltage regulators on the same position unless the Quik-drive is slowed down to switch at the same time as the spring-drive.							
204 VR2 Tap Wait Timer XXXXX mSec	MilliSec	View	Modify	NA	0	0	10000
•See explanation for FC 204 VR1 Tap Wait Timer.							
204 VR3 Tap Wait Timer XXXXX mSec	MilliSec	View	Modify	NA	0	0	10000
•See explanation for FC 204 VR1 Tap Wait Timer.							
205 Multi-phase Retry Count XX	---	View	Modify	NA	3	1	10
•A count of the number of attempts to resend a tap-change command by the control when a tap-change operation was not sensed in certain multi-phase operating modes.							
206 Multi-phase Retry Delay XX Seconds	Seconds	View	Modify	NA	5	5	60
•The delay between attempts to resend a tap-change command by the control when a tap-change operation was not sensed in certain multi-phase operating modes.							
207 Multi-phase Total Deviation XX	---	View	Modify	NA	32	0	32
•The maximum deviation in tap position between regulators operating in the Max Deviation multi-phase mode.							
208 Timer To Max Deviation Mode XXX Hours	Hours	View	Modify	NA	168	0	168
•Defines the amount of time that the connected regulators will remain in the Max Deviation Alternate Mode before reverting to the standard Max Deviation operation.							
209 Timer To Alt Mode XXXX Seconds	Seconds	View	Modify	NA	60	10	3600
•Defines the amount of time that the connected regulators are permitted to remain at the configured Max Deviation value before the control will revert to the Max Deviation Alternate mode of operation.							
210 Max Deviation Alt Mode Ganged Mode	---	View	Modify	NA	Off	NA	NA
•The configured fall back mode of operation for a group of connected regulators if they remain at the user configured Max Deviation value for the time defined at FC 209. The options are: Off; Tap To Neutral; Ganged Mode; Historical Tap Pos. •See **Section 6: Control Features: Multi-phase voltage regulation** for more information on the options.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
211 Sequencing Interval XX Seconds	Seconds	View	Modify	NA	5	0	60
•The sequence interval for the multi-phase display and status LEDs on the control HMI. The LEDs will alternately display the status of each connected device for the specified interval.							
212 Multi-Phase DeltaCalc Mode Off	---	View	Modify	NA	Off	NA	NA
•Enables the DeltaCalc feature on a multi-phase control. •The settings options are: Off; Basic; Advanced. •See **Section 6: Control Features: DeltaCalc feature** for more information on this parameter.							
220 Auto Tap Dead Phase mode Disabled		View	Modify	NA	Disabled	NA	NA
•This setting will enable Tap-Dead-Phase functionality for a multi-phase control. Using this function, the control will use power from powered phases to operate the tap changer of dead phases. •The settings options include: Disabled, Tap To Neutral, Ganged Mode.							
221 Tap Dead Phase Inactive		View	NA	NA	NA	NA	NA
•This will display the operational status of the Auto Tap Dead Phase mode function, either Inactive or Active.							
222 Delay Timer 15 Seconds	Seconds	View	Modify	NA	15	1	180
•When a condition occurs that would enable the Auto Tap Dead Phase mode, the activation of the function will be delayed for this period of time.							
260 Com 1 Tx Messages XXXXX	---	View	NA	Operate	Reset* to 0	NA	NA
•Count of Transmitted Messages from Com 1.							
261 Com 1 Rx Messages XXXXX	---	View	NA	Operate	Reset* to 0	NA	NA
•Count of Received Messages from Com 1.							
262 Com 1 Rx Errors XXXXX	---	View	NA	Operate	Reset* to 0	NA	NA
•Count of Receive Errors from Com 1.							
263 Com 2 Tx Messages XXXXX	---	View	NA	Operate	Reset* to 0	NA	NA
•Count of Transmitted Messages from Com 2.							
264 Com 2 Rx Messages XXXXX	---	View	NA	Operate	Reset* to 0	NA	NA
•Count of Received Messages from Com 2.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
265 Com 2 Rx Errors XXXXX	---	View	NA	Operate	Reset* to 0	NA	NA
•Count of Receive Errors from Com 2.							
300 PMT Mode A State Off	---	View	Modify	NA	Off	NA	NA
•The Preventive Maintenance Tapping (PMT) feature Mode A will automatically raise and lower the tap-changer to wipe contact blades. The options include: Off; On.							
301 PMT Mode A Countdown Delay XX Days	Days	View	NA	NA	NA	NA	NA
•This is the time remaining until the next PMT Mode A operation.							
302 PMT Mode A Time Delay XX Days	Days	View	Modify	NA	7	1	99
•This is the user-defined period of time between PMT Mode A operations.							
303 PMT Mode A Issue Test	---	NA	Modify	NA	NA	NA	NA
•The user can force the PMT Mode A operation independent of the time-delay setting. •The test is initiated by pressing ENTER and then ENTER again to confirm the command.							
320 PMT Mode B State Off	---	View	Modify	NA	Off	NA	NA
•The Preventive Maintenance Tapping (PMT) feature Mode B will automatically raise and lower the tap-changer to wipe reversing contact blades. The PMT feature Mode B is turned off or on here. The options include: Off; On.							
321 PMT Mode B Countdown Delay XX Days	Days	View	NA	NA	NA	NA	NA
•This is the time remaining until the next PMT Mode B operation.							
322 PMT Mode B Time Delay XX Days	Days	View	Modify	NA	7	1	99
•This is the user-defined period of time between PMT Mode B operations.							
323 PMT Mode B Start Time MM:SS	---	View	Modify	NA	22:00	00:00	23:59
•When the PMT feature Mode B is turned on (FC 320), operation is enabled only within a specified time period. The starting time is set here.							
324 PMT Mode B Stop Time MM:SS	---	View	Modify	NA	02:00	00:00	23:59
•The PMT Mode B operation is disabled after the stopping time set here.							
325 PMT Mode B Max Deviation XX	---	View	Modify	NA	8	1	16
•This is the maximum number of tap positions beyond neutral for which PMT Mode B is enabled.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
327 PMT Mode B Current Limit XXX %	%	View	Modify	NA	50	0	160
•The PMT Mode B is enabled at or below the current limit setting, defined as a percentage of the CT primary rating.							
328 PMT Mode B Issue Test	---	NA	Modify	NA	NA	NA	NA
•The user can force the PMT Mode B operation independent of the time-delay setting. •The test is initiated by pressing ENTER and then ENTER again to confirm the command.							
333 Contact Duty Cycle Monitor XX.XXX %	%	View	NA	NA	NA	NA	NA
•The contact life Duty Cycle Monitor function represents the amount of life consumed, for the worst-case contact, displayed as a percentage of total life. Individual contact wear levels can be interrogated via the ProView NXG software.							
410 Leader/Follower Off	---	View	Modify	NA	Off	NA	NA
•This will turn On or Off Leader/Follower feature. The options include: Off; On.							
411 Leader/Follower State Not Ready	---	View	NA	NA	NA	NA	NA
•This is the state of the Leader/Follower function. Display include: Ready; Not Ready; Active; Inactive; Unable To Operate; Loss Of Comms; Unknown.							
412 Leader/Follower Mode Lead Phase Reg.	---	View	Modify	NA	Lead Phase Reg.	NA	NA
•Designates the mode of operation for the Leader/Follower feature. Options include: Lead Phase Reg.; Volt Averaging Reg.; Max Deviation. •See **Section 7: Advanced Control Features: Leader/follower scheme** for more information of the various modes of operation.							
413 Leader/Follower Designation Follower 1	---	View	Modify	NA	Follower 1	NA	NA
•This is the Leader/Follower table designation for each connected regulator. The options include: Leader; Follower 1; Follower 2.							
414 Follower Devices Configured 1	---	View	Modify	NA	1	1	2
•The number of follower devices connected in a Leader/Follower scheme. The allowable options are 1 or 2.							
415 Leader/Follower Tap Wait Timer XXXXX mSec	MilliSec	View	Modify	NA	0	0	10000
•Sets a wait timer for use with Leader/Follower gang operation. Gang operation means that all tap changers must be on the same position. For ganged tap-changer operation, the tapping operations of the connected regulators must be synchronized if more than one tap-changer type is used. If, for example, the fast Quik-drive is ganged with a slow spring-drive, the control will not be able to keep the voltage regulators on the same position unless the Quik-drive is slowed down to switch at the same time as the spring-drive.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
416 Leader/Follower Timeout XX Seconds	Seconds	View	Modify	NA	3	0	60
•The length of time in seconds before the Leader returns to starting tap position if a Follower device does not tap.							
417 Leader/Follower Retry Delay XX Seconds	Seconds	View	Modify	NA	5	5	60
•The length of time in seconds before the leader retries to initiate a tapping operation if an initial attempt failed.							
418 Leader/Follower Retries XX	---	View	Modify	NA	3	1	10
•Designates the maximum number of tap command retries attempted by the Leader when a follower does not tap.							
420 Leader/Follower Monitor Powerup	---	View	NA	NA	NA	NA	NA
•Displays the state of the Leader/Follower scheme. Display options include: Powerup; Initializing; Disabled; Leader Active; Leader Inactive; Feedback Pending; Feedback Received; Feedback Late; Sync Retry Delay; Retry Delay; Unable to Operate; Follower Ready; Follower Tap Issued; Follower Not Ready.							
421 L/F Average Comp Volt Secondary XXX.X Volts	Volts	View	NA	NA	NA	NA	NA
•Displays the average compensated voltage among regulators connected in a Leader/Follower scheme.							
422 Max Deviation XX	---	View	Modify	NA	32	0	32
•The maximum deviation in tap position between regulators operating in the Max Deviation Leader/Follower mode.							
423 Timer To Alt Mode XXXX Seconds	Seconds	View	Modify	NA	60	10	3600
•Defines the amount of time that the connected regulators are permitted to remain at the configured Max Deviation value before the control will revert to the Max Deviation Alternate mode of operation.							
424 Timer To Max Deviation Mode XXX Hours	Hours	View	Modify	NA	168	0	168
•Defines the amount of time that the connected regulators will remain in the Max Deviation Alternate Mode before reverting to the standard Max Deviation operation.							
425 Max Deviation Alt Mode Ganged Mode	---	View	Modify	NA	Ganged Mode	NA	NA
•The configured fall back mode of operation for a group of connected regulators if they remain at the user configured Max Deviation value for the time defined at FC 424. The options are: Off; Tap To Neutral; Ganged Mode; Historical Tap Pos. •See **Section 7: Advanced Control Features: Leader/follower scheme** for more information on the options.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
450 Alternate Config Mode Off	---	View	Modify	NA	Off	NA	NA
•This will turn on Alternate Configurations and designate a mode of operation. The options are: Off; On; ARLH; ARLC; Config Logic; Enhanced ARLH; Enhanced ARLC. •Selecting "On" will enable the basic Alternate Configuration settings selected at FC 452. •See **Section 6: Control Features: Auto-restore local (ARL)** for more information on the ARL settings. •Selecting Config Logic will enable Alternate Configuration settings to be enabled or disabled using configurable logic equations.							
451 Alternate Config State Inactive	---	View	NA	NA	NA	NA	NA
•Displays the alternate configuration that is currently active. Display options include: Alt Config 1 Active; Alt Config 2 Active; Alt Config 3 Active; ARLC Active; ARLH Active.							
452 Alternate Config Selection Alt Config 1	---	View	Modify	NA	Off	NA	NA
•Allows for the selection of basic alternate configuration settings when FC 450 is set to "On". Options include: Alt Config 1; Alt Config 2; Alt Config 3; Config Logic.							
453 ARL Timer Period XX Minutes	Minutes	View	Modify	NA	15	1	32767
•This sets the Auto Restore Local (ARL) time period. •ARL is an alternate configurations feature that enables a control center to make changes to the voltage regulator operation settings while actively communicating with the control. When ARL is active, this parameter establishes the period in which a communications or heartbeat signal must be received by the control to keep ARL active. If the signal is not received, the control will revert back to the control settings locally stored.							
460 Forward Set Voltage XXX.X Volts	Volts	View	Modify	NA	120.0	100.0	135.0
•Forward Set Voltage for Alternate Configuration 1.							
461 Forward Bandwidth X.X Volts	Volts	View	Modify	NA	2.0	1.0	6.0
•Forward Bandwidth for Alternate Configuration 1.							
462 Forward Time Delay XXX Seconds	Seconds	View	Modify	NA	45	5	180
•Forward Time Delay for Alternate Configuration 1.							
463 Fwd Line Drop Comp. Resistance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Forward Line Drop Compensation Resistance for Alternate Configuration 1.							
464 Fwd Line Drop Comp. Reactance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Forward Line Drop Compensation Reactance for Alternate Configuration 1.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
465 Reverse Set Voltage XXX.X Volts	Volts	View	Modify	NA	120.0	100.0	135.0
•Reverse Set Voltage for Alternate Configuration 1.							
466 Reverse Bandwidth X.X Volts	Volts	View	Modify	NA	2.0	1.0	6.0
•Reverse Bandwidth for Alternate Configuration 1.							
467 Reverse Time Delay XXX Seconds	Seconds	View	Modify	NA	45	5	180
•Reverse Time Delay for Alternate Configuration 1.							
468 Rev Line Drop Comp. Resistance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Reverse Line Drop Compensation Resistance for Alternate Configuration 1.							
469 Rev Line Drop Comp. Reactance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Reverse Line Drop Compensation Reactance for Alternate Configuration 1.							
470 Control Operating Mode Sequential	---	View	Modify	NA	Sequential	NA	NA
•The Control Operating Mode for Alternate Configuration 1.							
471 Reverse Sensing Mode Locked Forward	---	View	Modify	NA	Locked Forward	NA	NA
•The Reverse Sensing Mode for Alternate Configuration 1.							
472 Reverse Current Sense Threshold X %	%	View	Modify	NA	1	1	5
•The Reverse Current Sense Threshold for Alternate Configuration 1.							
473 Auto Operation Blocking Status Normal	---	View	Modify	NA	Normal	NA	NA
•The Auto Operation Blocking Status for Alternate Configuration 1.							
474 Voltage Reduction Mode Off	---	View	Modify	NA	Off	NA	NA
•The Voltage Reduction Mode for Alternate Configuration 1.							
475 Local/Digital Reduction Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Local/Digital Reduction Value for Alternate Configuration 1.							
476 Remote #1 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote latch #1 Voltage Reduction Value for Alternate Configuration 1.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
477 Remote #2 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote latch #2 Voltage Reduction Value for Alternate Configuration 1.							
478 Remote #3 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote latch #3 Voltage Reduction Value for Alternate Configuration 1.							
479 # of Pulse Reduction Steps XX	---	View	Modify	NA	0	0	10
•The Remote Pulse Voltage Reduction number of steps for Alternate Configuration 1.							
480 % of Voltage Red Per Pulse Step XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote Pulse Voltage Reduction % per step for Alternate Configuration 1.							
481 Present Voltage Reduction Step XX	---	View	NA	NA	NA	NA	NA
•The Remote Pulse Voltage Reduction Present Voltage Reduction Step for Alternate Configuration 1.							
482 SOFT-ADD-AMP Limits Off	---	View	Modify	NA	Off	NA	NA
•The SOFT-ADD-AMP Limits feature enabled for Alternate Configuration 1.							
483 SOFT-ADD-AMP High Limit XX	---	View	Modify	NA	16	NA	NA
•The SOFT-ADD-AMP High Limit for Alternate Configuration 1.							
484 SOFT-ADD-AMP Low Limit XX	---	View	Modify	NA	-16	NA	NA
•The SOFT-ADD-AMP Low Limit for Alternate Configuration 1.							
485 Voltage Limiter Mode Off	---	View	Modify	NA	Off	NA	NA
•Voltage Limiter Mode enabled for Alternate Configuration 1.							
486 High Voltage Limit XXX.X Volts	Volts	View	Modify	NA	130.0	120.0	135.0
•The Voltage Limiter High Limit for Alternate Configuration 1.							
487 Low Voltage Limit XXX.X Volts	Volts	View	Modify	NA	105.0	105.0	120.0
•The Voltage Limiter Low Limit for Alternate Configuration 1.							
488 Voltage Limiter Fast Resp. Delay XX Seconds	Seconds	View	Modify	NA	3	1	60
•The Voltage Limiter Fast Resp. Delay for Alternate Configuration 1.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
489 Voltage Limiter Delay XX Seconds	Seconds	View	Modify	NA	10	1	60
•The Voltage Limiter Delay for Alternate Configuration 1.							
490 Time Between Taps XX Seconds	Seconds	View	Modify	NA	0	0	10
•The Voltage Limiter Time Between Taps for Alternate Configuration 1.							
491 Tap To Neutral Off	---	View	Modify	NA	Off	NA	NA
•The Tap to Neutral setting for Alternate Configuration 1.							
492 Bias Co-Gen Alt Mode Locked Reverse	---	View	Modify	NA	Locked Reverse	NA	NA
•The Bias Co-generation Alt Mode setting for Alternate Configuration 1. See FC 58.							
500 Forward Set Voltage XXX.X Volts	Volts	View	Modify	NA	120.0	100.0	135.0
•Forward Set Voltage for Alternate Configuration 2.							
501 Forward Bandwidth X.X Volts	Volts	View	Modify	NA	2.0	1.0	6.0
•Forward Bandwidth for Alternate Configuration 2.							
502 Forward Time Delay XXX Seconds	Seconds	View	Modify	NA	45	5	180
•Forward Time Delay for Alternate Configuration 2.							
503 Fwd Line Drop Comp. Resistance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Forward Line Drop Compensation Resistance for Alternate Configuration 2.							
504 Fwd Line Drop Comp. Reactance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Forward Line Drop Compensation Reactance for Alternate Configuration 2.							
505 Reverse Set Voltage XXX.X Volts	Volts	View	Modify	NA	120.0	100.0	135.0
•Reverse Set Voltage for Alternate Configuration 2.							
506 Reverse Bandwidth X.X Volts	Volts	View	Modify	NA	2.0	1.0	6.0
•Reverse Bandwidth for Alternate Configuration 2.							
507 Reverse Time Delay XXX Seconds	Seconds	View	Modify	NA	45	5	180
•Reverse Time Delay for Alternate Configuration 2.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
508 Rev Line Drop Comp. Resistance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Reverse Line Drop Compensation Resistance for Alternate Configuration 2.							
509 Rev Line Drop Comp. Reactance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Reverse Line Drop Compensation Reactance for Alternate Configuration 2.							
510 Control Operating Mode Sequential	---	View	Modify	NA	Sequential	NA	NA
•The Control Operating Mode for Alternate Configuration 2.							
511 Reverse Sensing Mode Locked Forward	---	View	Modify	NA	Locked Forward	NA	NA
•The Reverse Sensing Mode for Alternate Configuration 2.							
512 Reverse Current Sense Threshold X %	%	View	Modify	NA	1	1	5
•The Reverse Current Sense Threshold for Alternate Configuration 2.							
513 Auto Operation Blocking Status Normal	---	View	Modify	NA	Normal	NA	NA
•The Auto Operation Blocking Status for Alternate Configuration 2.							
514 Voltage Reduction Mode Off	---	View	Modify	NA	Off	NA	NA
•The Voltage Reduction Mode for Alternate Configuration 2.							
515 Local/Digital Reduction Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Local/Digital Reduction Value for Alternate Configuration 2.							
516 Remote #1 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote latch #1 Voltage Reduction Value for Alternate Configuration 2.							
517 Remote #2 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote latch #2 Voltage Reduction Value for Alternate Configuration 2.							
518 Remote #3 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote latch #3 Voltage Reduction Value for Alternate Configuration 2.							
519 # of Pulse Reduction Steps XX	---	View	Modify	NA	0	0	10
•The Remote Pulse Voltage Reduction number of steps for Alternate Configuration 2.							
520 % of Voltage Red Per Pulse Step XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote Pulse Voltage Reduction % per step for Alternate Configuration 2.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
521 Present Voltage Reduction Step XX	---	View	NA	NA	NA	NA	NA
•The Remote Pulse Voltage Reduction Present Voltage Reduction Step for Alternate Configuration 2.							
522 SOFT-ADD-AMP Limits Off	---	View	Modify	NA	Off	NA	NA
•The SOFT-ADD-AMP Limits feature enabled for Alternate Configuration 2.							
523 SOFT-ADD-AMP High Limit XX	---	View	Modify	NA	16	NA	NA
•The SOFT-ADD-AMP High Limit for Alternate Configuration 2.							
524 SOFT-ADD-AMP Low Limit XX	---	View	Modify	NA	-16	NA	NA
•The SOFT-ADD-AMP Low Limit for Alternate Configuration 2.							
525 Voltage Limiter Mode Off	---	View	Modify	NA	Off	NA	NA
•Voltage Limiter Mode enabled for Alternate Configuration 2.							
526 High Voltage Limit XXX.X Volts	Volts	View	Modify	NA	130.0	120.0	135.0
•The Voltage Limiter High Limit for Alternate Configuration 2.							
527 Low Voltage Limit XXX.X Volts	Volts	View	Modify	NA	105.0	105.0	120.0
•The Voltage Limiter Low Limit for Alternate Configuration 2.							
528 Voltage Limiter Fast Resp. Delay XX Seconds	Seconds	View	Modify	NA	3	1	60
•The Voltage Limiter Fast Resp. Delay for Alternate Configuration 2.							
529 Voltage Limiter Delay XX Seconds	Seconds	View	Modify	NA	10	1	60
•The Voltage Limiter Delay for Alternate Configuration 2.							
530 Time Between Taps XX Seconds	Seconds	View	Modify	NA	0	0	10
•The Voltage Limiter Time Between Taps for Alternate Configuration 2.							
531 Tap To Neutral Off	---	View	Modify	NA	Off	NA	NA
•The Tap to Neutral setting for Alternate Configuration 2.							
532 Bias Co-Gen Alt Mode Locked Reverse	---	View	Modify	NA	Locked Reverse	NA	NA
•The Bias Co-generation Alt Mode setting for Alternate Configuration 2. See FC 58.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
550 Forward Set Voltage XXX.X Volts	Volts	View	Modify	NA	120.0	100.0	135.0
•Forward Set Voltage for Alternate Configuration 3.							
551 Forward Bandwidth X.X Volts	Volts	View	Modify	NA	2.0	1.0	6.0
•Forward Bandwidth for Alternate Configuration 3.							
552 Forward Time Delay XXX Seconds	Seconds	View	Modify	NA	45	5	180
•Forward Time Delay for Alternate Configuration 3.							
553 Fwd Line Drop Comp. Resistance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Forward Line Drop Compensation Resistance for Alternate Configuration 3.							
554 Fwd Line Drop Comp. Reactance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Forward Line Drop Compensation Reactance for Alternate Configuration 3.							
555 Reverse Set Voltage XXX.X Volts	Volts	View	Modify	NA	120.0	100.0	135.0
•Reverse Set Voltage for Alternate Configuration 3.							
556 Reverse Bandwidth X.X Volts	Volts	View	Modify	NA	2.0	1.0	6.0
•Reverse Bandwidth for Alternate Configuration 3.							
557 Reverse Time Delay XXX Seconds	Seconds	View	Modify	NA	45	5	180
•Reverse Time Delay for Alternate Configuration 3.							
558 Rev Line Drop Comp. Resistance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Reverse Line Drop Compensation Resistance for Alternate Configuration 3.							
559 Rev Line Drop Comp. Reactance XX.X Volts	Volts	View	Modify	NA	0.0	-96.0	96.0
•Reverse Line Drop Compensation Reactance for Alternate Configuration 3.							
560 Control Operating Mode Sequential	---	View	Modify	NA	Sequential	NA	NA
•The Control Operating Mode for Alternate Configuration 3.							
561 Reverse Sensing Mode Locked Forward	---	View	Modify	NA	Locked Forward	NA	NA
•The Reverse Sensing Mode for Alternate Configuration 3.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
562 Reverse Current Sense Threshold X %	%	View	Modify	NA	1	1	5
•The Reverse Current Sense Threshold for Alternate Configuration 3.							
563 Auto Operation Blocking Status Normal	---	View	Modify	NA	Normal	NA	NA
•The Auto Operation Blocking Status for Alternate Configuration 3.							
564 Voltage Reduction Mode Off	---	View	Modify	NA	Off	NA	NA
•The Voltage Reduction Mode for Alternate Configuration 3.							
565 Local/Digital Reduction Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Local/Digital Reduction Value for Alternate Configuration 3.							
566 Remote #1 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote latch #1 Voltage Reduction Value for Alternate Configuration 3.							
567 Remote #2 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote latch #2 Voltage Reduction Value for Alternate Configuration 3.							
568 Remote #3 Value XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote latch #3 Voltage Reduction Value for Alternate Configuration 3.							
569 # of Pulse Reduction Steps XX	---	View	Modify	NA	0	0	10
•The Remote Pulse Voltage Reduction number of steps for Alternate Configuration 3.							
570 % of Voltage Red Per Pulse Step XX.X %	%	View	Modify	NA	0.0	0.0	10.0
•The Remote Pulse Voltage Reduction % per step for Alternate Configuration 3.							
571 Present Voltage Reduction Step XX	---	View	NA	NA	NA	NA	NA
•The Remote Pulse Voltage Reduction Present Voltage Reduction Step for Alternate Configuration 3.							
572 SOFT-ADD-AMP Limits Off	---	View	Modify	NA	Off	NA	NA
•The SOFT-ADD-AMP Limits feature enabled for Alternate Configuration 3.							
573 SOFT-ADD-AMP High Limit XX	---	View	Modify	NA	16	NA	NA
•The SOFT-ADD-AMP High Limit for Alternate Configuration 3.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
574 SOFT-ADD-AMP Low Limit XX	---	View	Modify	NA	-16	NA	NA
•The SOFT-ADD-AMP Low Limit for Alternate Configuration 3.							
575 Voltage Limiter Mode Off	---	View	Modify	NA	Off	NA	NA
•Voltage Limiter Mode enabled for Alternate Configuration 3.							
576 High Voltage Limit XXX.X Volts	Volts	View	Modify	NA	130.0	120.0	135.0
•The Voltage Limiter High Limit for Alternate Configuration 3.							
577 Low Voltage Limit XXX.X Volts	Volts	View	Modify	NA	105.0	105.0	120.0
•The Voltage Limiter Low Limit for Alternate Configuration 3.							
578 Voltage Limiter Fast Resp. Delay XX Seconds	Seconds	View	Modify	NA	3	1	60
•The Voltage Limiter Fast Resp. Delay for Alternate Configuration 3.							
579 Voltage Limiter Delay XX Seconds	Seconds	View	Modify	NA	10	1	60
•The Voltage Limiter Delay for Alternate Configuration 3.							
580 Time Between Taps XX Seconds	Seconds	View	Modify	NA	0	0	10
•The Voltage Limiter Time Between Taps for Alternate Configuration 3.							
581 Tap To Neutral Off	---	View	Modify	NA	Off	NA	NA
•The Tap to Neutral setting for Alternate Configuration 3.							
582 Bias Co-Gen Alt Mode Locked Reverse	---	View	Modify	NA	Locked Reverse	NA	NA
•The Bias Co-generation Alt Mode setting for Alternate Configuration 3. See FC 58.							
600 Voltage Sag Monitoring Off		View	Modify	NA	Off	NA	NA
•This will turn on or turn off the voltage sag monitor feature on the control. •The settings options include: On; Off							
601 Level1 Threshold 70.0 %	%	View	Modify	NA	70.0	50.0	70.0
•The level 1 voltage sag set point given as a percentage Demand Metering value of Forward Load Voltage Present or Reverse Load Voltage Present as applicable. •A voltage sag below this level for the duration of the value of the Level 1 Threshold Timer Value (FC 603) will cause the control to record a Level 1 sag event.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
602 Level1 Recovery 75.0 %	%	View	Modify	NA	75.0	71.0	100.0
•After a level 1 voltage sag has occurred, this is the level at which the voltage is said to have recovered from the sag. This value is given as a percentage Demand Metering value of Forward Load Voltage Present or Reverse Load Voltage Present as applicable. •A voltage recovery above this level for the duration of the value of the Level 1 Recovery Timer Value (FC 604) will cause the control to record a Level 1 recovery event.							
603 Level1 Threshold Timer Value 20 mSec	mSec	View	Modify	NA	20	30000	20
•The minimum time duration that must be met in order to record a Level 1 sag event.							
604 Level1 Recovery Timer Value 20 mSec	mSec	View	Modify	NA	20	30000	20
•The minimum time duration that must be met by a sag recovery in order to record a level 1 sag recovery.							
605 Duration of Last Level1 0 Cycles MM-DD-YYYY HH:MM:SSp	Cycles	View	NA	Operate	NA	NA	NA
•A date and time stamped record of the duration of the last level 1 voltage sag recorded in cycles. •The duration is the time between the point at which a sag event reaches the threshold timer value and the recovery has reached the recovery timer value. •This is reset to 0 and the current date and time by entering the appropriate security level and pressing ENTER.							
606 Duration of Longest Level1 0 Cycles MM-DD-YYYY HH:MM:SSp	Cycles	View	NA	Operate	NA	NA	NA
•A date and time stamped record of the longest duration recorded for the Duration of Last Level1 (FC 605) voltage sag. •This is reset to 0 and the current date and time by entering the appropriate security level and pressing ENTER.							
611 Level2 Threshold 80.0 %	%	View	Modify	NA	80.0	50.0	80.0
•The level 2 voltage sag set point given as a percentage Demand Metering value of Forward Load Voltage Present or Reverse Load Voltage Present as applicable. •A voltage sag below this level for the duration of the value of the Level 2 Threshold Timer Value (FC 613) will cause the control to record a Level 2 sag event.							
612 Level2 Recovery 85.0 %	%	View	Modify	NA	85.0	81.0	100.0
•After a level 2 voltage sag has occurred, this is the level at which the voltage is said to have recovered from the sag. This value is given as a percentage Demand Metering value of Forward Load Voltage Present or Reverse Load Voltage Present as applicable. •A voltage recovery above this level for the duration of the value of the Level 2 Recovery Timer Value (FC 614) will cause the control to record a Level 2 recovery event.							
613 Level2 Threshold Timer Value 500 mSec	mSec	View	Modify	NA	500	20	30000
•The minimum time duration that must be met in order to record a Level 2 sag event.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
614 Level2 Recovery Timer Value 500 mSec	mSec	View	Modify	NA	500	20	30000
•The minimum time duration that must be met by a sag recovery in order to record a level 2 sag recovery.							
615 Duration of Last Level2 0 Cycles MM-DD-YYYY HH:MM:SSp	Cycles	View	NA	Operate	NA	NA	NA
•A date and time stamped record of the duration of the last level 2 voltage sag recorded in cycles. •The duration is the time between the point at which a sag event reaches the threshold timer value and the recovery has reached the recovery timer value. •This is reset to 0 and the current date and time by entering the appropriate security level and pressing ENTER.							
616 Duration of Longest Level2 0 Cycles MM-DD-YYYY HH:MM:SSp	Cycles	View	NA	Operate	NA	NA	NA
•A date and time stamped record of the longest duration recorded for the Duration of Last Level 2 (FC 615) voltage sag. •This is reset to 0 and the current date and time by entering the appropriate security level and pressing ENTER.							
621 Level3 Threshold 90.0 %	%	View	Modify	NA	90.0	50.0	90.0
•The level 3 voltage sag set point given as a percentage Demand Metering value of Forward Load Voltage Present or Reverse Load Voltage Present as applicable. •A voltage sag below this level for the duration of the value of the Level 3 Threshold Timer Value (FC 623) will cause the control to record a Level 3 sag event.							
623 Level3 Threshold Timer Value 10000 mSec	mSec	View	Modify	NA	10000	20	30000
•The minimum time duration that must be met in order to record a Level 3 sag event.							
624 Level3 Recovery Timer Value 10000 mSec	mSec	View	Modify	NA	10000	20	30000
•The minimum time duration that must be met by a sag recovery in order to record a level 3 sag recovery.							
625 Duration of Last Level3 0 Cycles MM-DD-YYYY HH:MM:SSp	Cycles	View	NA	Operate	NA	NA	NA
•A date and time stamped record of the duration of the last level 3 voltage sag recorded in cycles. •The duration is the time between the point at which a sag event reaches the threshold timer value and the recovery has reached the recovery timer value. •This is reset to 0 and the current date and time by entering the appropriate security level and pressing ENTER.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
626 Duration of Longest Level3 0 Cycles MM-DD-YYYY HH:MM:SSp	Cycles	View	NA	Operate	NA	NA	NA
•A date and time stamped record of the longest duration recorded for the Duration of Last Level 3 (FC 625) voltage sag. •This is reset to 0 and the current date and time by entering the appropriate security level and pressing ENTER.							
631 Voltage Sag In Effect None	---	View	NA	NA	NA	NA	NA
•During a voltage sag event, this will display the level attained by the event as Level 1, Level 2, or Level 3.							
632 Reset All Volt Sag Durations	---	View	NA	Operate	NA	NA	NA
•Pressing ENTER after providing the appropriate security level will reset all sag monitor duration records to 0 with the current date and time stamp.							
640 Fault Detect Off	---	View	Modify	NA	Off	NA	NA
•This setting will enable the Fault Detect Feature. •Options include: Off; On.							
641 Fault Detect In Effect None	---	View	NA	NA	NA	NA	NA
•When the control has detected a fault based upon the set Fault Detect parameters, this parameter will display the level of fault detect that is in effect at the moment. •Possible displays: Level 1; Level 2; Level 3.							
642 Reset All Fault Detect Durations	---	View	NA	Admin	NA	NA	NA
•This parameter will reset all Fault Detect longest and latest duration parameters for all three levels of fault detect. After the reset, the duration will display 0 Cycles with the date and time stamp of the reset. •On a multi-phase control it will reset the durations for all phases.							
645 Fault Detect Level1 Threshold 600 Amps	Amps	View	Modify	NA	600	5	16000
•This setting defines the current level which must be exceeded for a Level 1 Fault to be recorded by the control. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							
646 Fault Detect Level1 Recovery 599 Amps	Amps	View	Modify	NA	599	4	16000
•This setting defines the level below which current must fall for a Level 1 Fault Recovery to be recorded. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
647 Fault Level1 Threshold Timer 20 mSec	mSec	View	Modify	NA	20	20	30000
•This setting defines the minimum time duration over which the Level 1 Fault Detect Threshold Current must occur for a fault to be recorded. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							
648 Fault Level1 Recovery Timer 20 mSec	mSec	View	Modify	NA	20	20	30000
•This setting defines the minimum time duration over which the Level 1 Fault Detect Recovery Current must occur for a fault recovery to be recorded. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							
649 Duration of Last Level1 0 Cycles 01/01/1970 12:00:00a	Cycles	View	NA	Operate	NA	NA	NA
•A display with date and time stamped of the duration in cycles of the last recorded Level 1 fault since last reset. •On a multi-phase the right arrow is used to scroll to the display for each phase.							
649 Duration of Longest Level1 0 Cycles 01/01/1970 12:00:00a	Cycles	View	NA	Operate	NA	NA	NA
•A display with date and time stamped of the duration of the longest recorded Level 1 fault since last reset. •On a multi-phase the right arrow is used to scroll to the display for each phase.							
650 Fault Detect Level2 Threshold 500 Amps	Amps	View	Modify	NA	500	5	16000
•This setting defines the current level which must be exceeded for a Level 2 Fault to be recorded by the control. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							
651 Fault Detect Level2 Recovery 499 Amps	Amps	View	Modify	NA	499	4	16000
•This setting defines the level below which current must fall for a Level 2 Fault Recovery to be recorded. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							
652 Fault Level2 Threshold Timer 500 mSec	mSec	View	Modify	NA	500	20	30000
•This setting defines the minimum time duration over which the Level 2 Fault Detect Threshold Current must occur for a fault to be recorded. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							
653 Fault Level2 Recovery Timer 500 mSec	mSec	View	Modify	NA	500	20	30000
•This setting defines the minimum time duration over which the Level 2 Fault Detect Recovery Current must occur for a fault recovery to be recorded. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
654 Duration of Last Level2 0 Cycles 01/01/1970 12:00:00a	Cycles	View	NA	Operate	NA	NA	NA
•A display with date and time stamped of the duration in cycles of the last recorded Level 2 fault since last reset. •On a multi-phase the right arrow is used to scroll to the display for each phase.							
654 Duration of Longest Level2 0 Cycles 01/01/1970 12:00:00a	Cycles	View	NA	Operate	NA	NA	NA
•A display with date and time stamped of the duration of the longest recorded Level 2 fault since last reset. •On a multi-phase the right arrow is used to scroll to the display for each phase.							
655 Fault Detect Level3 Threshold 400 Amps	Amps	View	Modify	NA	400	5	16000
•This setting defines the current level which must be exceeded for a Level 3 Fault to be recorded by the control. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							
656 Fault Detect Level3 Recovery 399 Amps	Amps	View	Modify	NA	399	4	16000
•This setting defines the level below which current must fall for a Level 3 Fault Recovery to be recorded. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							
657 Fault Level3 Threshold Timer 1000 mSec	mSec	View	Modify	NA	1000	20	30000
•This setting defines the minimum time duration over which the Level 3 Fault Detect Threshold Current must occur for a fault to be recorded. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							
658 Fault Level3 Recovery Timer 1000 mSec	mSec	View	Modify	NA	1000	20	30000
•This setting defines the minimum time duration over which the Level 3 Fault Detect Recovery Current must occur for a fault recovery to be recorded. •On a multi-phase the right arrow is used to scroll to the setting for each phase.							
659 Duration of Last Level3 0 Cycles 01/01/1970 12:00:00a	Cycles	View	NA	Operate	NA	NA	NA
•A display with date and time stamped of the duration in cycles of the last recorded Level 3 fault since last reset. •On a multi-phase the right arrow is used to scroll to the display for each phase.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
659 Duration of Longest Level3 0 Cycles 01/01/1970 12:00:00a	Cycles	View	NA	Operate	NA	NA	NA
•A display with date and time stamped of the duration of the longest recorded Level 3 fault since last reset. •On a multi-phase the right arrow is used to scroll to the display for each phase.							
700 User Defined HMI Func1 Activate Off	---	View	Modify	NA	Off	NA	NA
•This is used in conjunction with the configurable logic input User HMI Function 1 ON. •This provides and HMI means of enabling or disabling configurable logic. By setting this to "On", the configurable logic input User HMI Function 1 ON becomes active. •The settings options include: On; Off							
701 User Defined HMI Func2 Activate Off	---	View	Modify	NA	Off	NA	NA
•This is used in conjunction with the configurable logic input User HMI Function 2 ON. •This provides and HMI means of enabling or disabling configurable logic. By setting this to "On", the configurable logic input User HMI Function 2 ON becomes active. •The settings options include: On; Off							
702 User Defined HMI Func3 Activate Off	---	View	Modify	NA	Off	NA	NA
•This is used in conjunction with the configurable logic input User HMI Function 3 ON. •This provides and HMI means of enabling or disabling configurable logic. By setting this to "On", the configurable logic input User HMI Function 3 ON becomes active. •The settings options include: On; Off							
703 User Defined HMI Func4 Activate Off	---	View	Modify	NA	Off	NA	NA
•This is used in conjunction with the configurable logic input User HMI Function 4 ON. •This provides and HMI means of enabling or disabling configurable logic. By setting this to "On", the configurable logic input User HMI Function 4 ON becomes active. •The settings options include: On; Off							
750 Load Voltage Secondary (L-N) ----- Volts	Volts	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Load Voltage Secondary from Line to Neutral. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							
751 Load Voltage Secondary (L-L) ----- Volts	Volts	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Load Voltage Secondary from Line to Line. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
752 Source Voltage Secondary (L-N) ----- Volts	Volts	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Source Voltage Secondary from Line to Neutral. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							
753 Source Voltage Secondary (L-L) ----- Volts	Volts	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Source Voltage Secondary from Line to Line. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							
754 Load Voltage Primary (L-N) ----- kVolts	kVolts	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Load Voltage Primary from Line to Neutral. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							
755 Load Voltage Primary (L-L) ----- kVolts	kVolts	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Load Voltage Primary from Line to Line. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							
756 Source Voltage Primary (L-N) ----- kVolts	kVolts	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Source Voltage primary from Line to Neutral. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							
757 Source Voltage Primary (L-L) ----- kVolts	kVolts	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Source Voltage Primary from Line to Line. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							
760 Load Voltage Angle (L-N) ----- Degrees	Degrees	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Load Voltage Angle from Line to Neutral. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
761 Load Voltage Angle (L-L) ----- Degrees	Degrees	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Load Voltage Angle from Line to Line. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							
762 Source Voltage Angle (L-N) ----- Degrees	Degrees	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Source Voltage Angle from Line to Neutral. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							
763 Source Voltage Angle (L-L) ----- Degrees	Degrees	View	NA	NA	NA	NA	NA
•This is a Delta Calc instantaneous metering value for the Source Voltage Angle from Line to Line. •On a multi-phase control, the metering values for each phase can be viewed by scrolling with the right arrow.							
800 Protocol / Port Type Serial DNP	---	View	Modify	NA	Serial DNP	NA	NA
•Protocol and Port setting for Com 1. Not all options are resident on the control, some will require additional hardware to enable. The available protocol options will display according to port type. •Possible options for a particular configuration include: Disabled; DNP / Serial; DNP / Ethernet; IEC 101 / Serial; IEC 104 / Ethernet; 2179 / Serial; Modbus / Serial; Modbus / Ethernet.							
800 LoopShare Communications Disabled	---	View	Modify	NA	Disabled	NA	NA
•This will enable or disable LoopShare Communications for Com 1. The options include: Disabled; Enabled.							
800 ProView NXG Session Disabled	---	View	Modify	NA	Disabled	NA	NA
•This will enable or disable sessions with ProView NXG for Com 1. The options include: Disabled; Enabled.							
800 ProView NXG Address XXXXX	---	View	Modify	NA	65519	0	65519
•The Com 1 address for communications with ProView NXG is set here.							
800 Ethernet Switch On Com 1 Disabled	---	View	Modify	NA	Disabled	NA	NA
•This will enable or disable the Ethernet switch when it is available on Com 1. The options include: Disabled; Enabled.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
800 Serial Bridge Mode Disabled	---	View	Modify	NA	Disabled	NA	NA
•This parameter enables the Serial Bridge communications mode. The options include: Disabled; Enabled. •The Serial Bridge feature enables the use of a RS-232 communications card to facilitate a connection between a master station and a local serial FO communications loop for DNP3 protocol. This functionality is similar to that available on the CL-6 control using the serial RS-232/FO communications board.							
801 Serial Baud Rate 9600 BPS	---	View	Modify	NA	9600 BPS	NA	NA
•This is the Com 1 Serial Communications Baud Rate setting. The options available are: 300 BPS; 600 BPS; 1200 BPS; 2400 BPS; 4800 BPS; 9600 BPS; 19200 BPS; 38400 BPS; 57600 BPS; 115200 BPS.							
801 Serial Parity None	---	View	Modify	NA	None	NA	NA
•This sets for Com 1 the data parity parameter to be used on the serial communications channel. •The available options are: None; Odd; Even							
801 Serial CTS Support Disabled	---	View	Modify	NA	Disabled	NA	NA
•This setting determines for Com 1 if CTS/RTS handshaking will be used to control the serial communications channel. •The available options are: Disabled; Enabled							
801 Serial Tx Enable Delay XXXX mSec	MilliSec	View	Modify	NA	5	0	3000
•For Com 1, when the control is set for transmit control handshaking, a delay may be required between the time when the transmission is enabled to when data is transmitted. •Example: If the transmit enable were used as a keying device for a transmitter or modem, a “warm-up” period may be necessary before data can be transmitted. •See Figure 19.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
801 Serial Tx Disable Delay XXXX mSec	MilliSec	View	Modify	NA	5	0	3000
•For Com 1, when the control is set for transmit control handshaking, a delay may be required between the time when the data transmission is terminated and the transmit enable signal is disabled. •See Figure 19.							
801 Serial Echo Mode Disabled	---	View	Modify	NA	Disabled	NA	NA
•When serial communications is active, this parameter will enable or disable the echo mode for Com 1. •Options include: Disabled; Enabled							
802 IP Address XXX.XXX.XXX.XXX	---	View	Modify	NA	NA	NA	NA
•The Com 1 IP Address setting.							
802 Subnet Mask XXX.XXX.XXX.XXX	---	View	Modify	NA	NA	NA	NA
•The Com 1 Subnet Mask setting.							
802 Gateway XXX.XXX.XXX.XXX	---	View	Modify	NA	NA	NA	NA
•The Com 1 Gateway setting.							
802 MAC Address XX:XX:XX:XX:XX:XX	---	View	NA	NA	NA	NA	NA
•The Com 1 MAC Address setting.							
803 TCP IP Socket Re-Int. Disabled	---	View	Admin	NA	Disabled	NA	NA
•This enables a feature that will reinitiate the TCP/IP communications socket periodically.							
803 TCP IP Socket Re-Int Timeout 24 Hours	Hours	View	Admin	NA	24	1	336
•This sets the period between TCP/IP socket resets.							

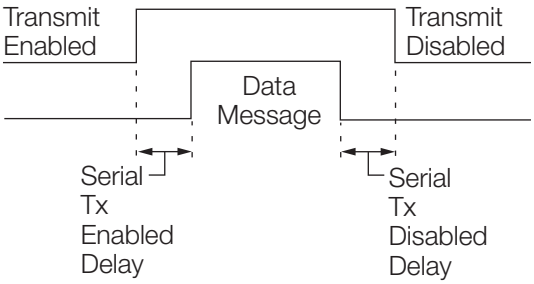


Figure 19. Data transmission from the CL-7 control to the communication system for handshaking applications

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
810 DNP RBE Master XXXXX	---	View	Modify	NA	1234	0	65519
•This is the Com 1 setting for the DNP3 device number to be used as the destination for any unsolicited reports by DNP3 events.							
810 DNP IED Slave XXXXX	---	View	Modify	NA	1	0	65519
•This is the Com 1 setting for the DNP3 device number to be assigned to the connected CL-7 control.							
810 DNP IED Slave 2 XXXXX	---	View	Modify	NA	65519	0	65519
•This is the Com 1 setting for the DNP3 device number to be assigned to the connected CL-7 control. •Communications to this address must always use the Default DNP map.							
810 DNP User Map Selection CL-7 Default	---	View	Modify	NA	CL-7 Default	NA	NA
•The selection of the active DNP map for Com 1. The available options are: User 1; User 2; CL-7 Default; CL-7 Default Events; CL-7 Advanced; CL-6 Default; CL-6 Default Events; CL-7 3Ph Default; CL-7 3Ph Default Evt; CL-7 3Ph Advanced.							
811 DNP Network Protocol Type Listening End Point	---	View	Modify	NA	Listening End Point	NA	NA
•This sets the DNP network type for Com 1. •The available options are: Listening End Point; Dual End Point; UDP.							
811 DNP Accept From Any IP Enabled	---	View	Modify	NA	Enabled	NA	NA
•This is the Com 1 setting that controls whether or not DNP3 requests will be honored from hosts other than the one defined in the next set of fields. •The available options are: Disabled; Enabled							
811 DNP Accept From IP Address XXX.XXX.XXX.XXX	---	View	Modify	NA	NA	NA	NA
•This is the Com 1 setting that allows the user to input a specific IP address from which to accept DNP3 requests. This is also used as the destination IP to establish a connection when a Dual End Point connection is initiated by the control.							
811 DNP Destination Port Number XXXXX	---	View	Modify	NA	20000	1	65535
•This is the Com 1 setting that defines the IP port number to which outgoing DNP3 messages are addressed when a UDP End Point is configured, unless DNP Use Source Port From Request is Enabled. This port number is also used for outgoing TCP connections when a Dual End Point is configured.							
811 DNP Listening Port Number XXXXX	---	View	Modify	NA	20000	1	65535
•This is the Com 1 setting that defines the IP port number that will be monitored for incoming DNP3 requests when a TCP Listening End Point is configured; responses will be sent using the source port from the incoming request.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
811 DNP Use Port From Request Enabled	---	View	Modify	NA	Enabled	NA	NA
•This is the Com 1 setting that enables the control to use the source IP port number from the last request as the destination port number. •The available options are: Disabled; Enabled							
811 Initial Unsol UDP Dest Port XXXXX	---	View	Modify	NA	20000	1	65535
•This sets the destination UDP port to which the initial unsolicited null message will be addressed when a UDP End Point is configured.							
811 DNP Keep Alive Timeout XXXXX Seconds	---	View	Modify	NA	3600	1	65535
•This is the Com 1 setting for the time after which a DNP3 Data Link Layer status request will be sent if no message is received from the master (enter 0 to disable).							
811 DNP Outbound Port Type Ephemeral Port	---	View	Modify	NA	Ephemeral Port	NA	NA
•This parameter will set the type of port used for outbound DNP messages. Options include: Ephemeral Port; Static Port. •If set to Ephemeral, the control will use a "random" port from the typical range of ephemeral/temporary non-reserved ports for outbound connections in dual endpoint mode or outbound datagrams in UDP endpoint mode. •If set to the configured static TCP source port is used for outbound connections in dual endpoint mode or outbound datagrams in UDP endpoint mode.							
811 DNP Static UDP Source Port XXXXX	---	View	Modify	NA	20000	1	65534
•This defines a static source port to be used for outbound DNP3 UDP datagrams to the master when the DNP Outbound Port Type is set to static.							
811 DNP Static TCP Source Port XXXXX	---	View	Modify	NA	20000	1	65534
•This defines a static source port to be used for outbound DNP3 TCP socket connections to the master when the DNP Outbound Port Type is set to static.							
812 IEC101 Link Address XXXXX	---	View	Modify	NA	2	0	See note
•This is the Com 1 setting that assigns a unique identifier to the individual slave instance running on the device. •If Link Address Size is 1, Link Address high value is 255 •If Link Address Size is 2, Link Address high value is 65535							
812 IEC101 Common Address XXXXX	---	View	Modify	NA	2	0	See note
•This is the Com 1 setting that identifies the station address, where the station is comprised of all of a device's links. •If Common Address Size is 1, Common Address high value is 255 •If Common Address Size is 2, Common Address high value is 65535							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
812 IEC101 Link Address Size X	---	View	Modify	NA	1	1	2
•This is the Com 1 setting for the number of octets to be used for the value of the link address.							
812 IEC101 Common Address Size X	---	View	Modify	NA	1	1	2
•This is the Com 1 setting for the number of octets to be used in the value of the common address.							
812 IEC101 Object Address Size X	---	View	Modify	NA	2	1	3
•This is the Com 1 setting for the number of octets to be used in the value of the object address.							
812 IEC101 Cause of Transmit Size X	---	View	Modify	NA	1	1	2
•This is the Com 1 setting for the number of octets to be used in the cause of transmission indication.							
812 IEC101 Single Command Op Mode SBE	---	View	Modify	NA	SBE	NA	NA
•This is the Com 1 setting that defines if the control will respond directly (Direct mode) to Single Command Operation commands or if a "select" is required before "execution" (SBE mode). •The available options are: Direct; SBE.							
812 IEC101 Select Before Exec Time XXXXX mSec	MilliSec	View	Modify	NA	5000	0	65535
•This is the Com 1 setting that determines the amount of time that can elapse between a "select" and "execute" command for Single Command Operations in systems that employ a select-before-execute mode.							
812 IEC101 User Map Selection CL-7 Default	---	View	Modify	NA	CL-7 Default	NA	NA
•The selection of the active IEC101 map for Com 1. The available options are: User 1; User 2; CL-7 Default; CL-7 Default Events; CL-7 Advanced; CL-6 Default; CL-6 Default Events; CL-7 3Ph Default; CL-7 3Ph Default Evt; CL-7 3Ph Advanced.							
813 IEC104 Server Listen Port XXXXX	---	View	Modify	NA	2404	1	65535
•This is the Com 1 setting for the IP port number that will be monitored for connections.							
813 IEC104 Common Address XXXXX	---	View	Modify	NA	2	1	65535
•This is the Com 1 setting that identifies the station address, where the station is comprised of all of a device's links for Com 1.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
813 IEC104 Single Command Op Mode SBE	---	View	Modify	NA	SBE	NA	NA
•This is the Com 1 setting that defines if the control will respond directly (Direct mode) to Single Command Operation commands or if a "select" is required before "execution" (SBE mode). •The available options are: Direct; SBE.							
813 IEC104 Select Before Exec Time XXXXX mSec	MilliSec	View	Modify	NA	5000	0	65535
•This is the Com 1 setting that determines the amount of time that can elapse between a "select" and "execute" command for Single Command Operations in systems that employ a select-before-execute mode.							
813 IEC104 Response Timeout (t1) XXXXX Seconds	Seconds	View	Modify	NA	15	1	255
•This is the Com 1 setting for the time-out value for the transmission of data or test messages.							
813 IEC104 Ack/No Data (t2) XXXXX Seconds	Seconds	View	Modify	NA	10	1	255
•This is the Com 1 setting for time-out before sending an ACK APDU if no data ACKs are received.							
813 IEC104 Idle Test (t3) XXXXX Seconds	Seconds	View	Modify	NA	20	1	255
•This is the Com 1 setting for the amount of time allowed to lapse before a test APDU is generated.							
813 IEC104 Max Transmit (k) XXXXX	---	View	Modify	NA	12	1	32767
•This is the Com 1 setting for the maximum number of unacknowledged data frames that are allowed to be in transit.							
813 IEC104 Max Receive (w) XXXXX	---	View	Modify	NA	8	1	32767
•This is the Com 1 setting for the maximum number of data frames to wait before acknowledging if no data ACKs are received (w should normally not exceed 2 K/3).							
813 IEC104 User Map Selection CL-7 Default	---	View	Modify	NA	CL-7 Default	NA	NA
•The selection of the active IEC104 map for Com 1. The available options are: User 1; User 2; CL-7 Default; CL-7 Default Events; CL-7 Advanced; CL-6 Default; CL-6 Default Events; CL-7 3Ph Default; CL-7 3Ph Default Evt; CL-7 3Ph Advanced.							
815 2179 Master Address XX	---	View	Modify	NA	0	0	31
•This is the Com 1 setting for the address, from 0 to 31, of the master station controlling and polling the RTU. •Configuration parameters for 2179 are displayed when the protocol is available.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
815 2179 Ignore Master Address Disabled	---	View	Modify	NA	Enabled	NA	NA
•This is the Com 1 setting that allows the device to accept commands and requests from masters other than that listed in the Master Device Address field. •The available options are: Disabled; Enabled.							
815 2179 Device Address XXXX	---	View	Modify	NA	1	0	2047
•This is the Com 1 setting that specifies the address, from 0 to 2047, of the RTU instance on the control.							
815 2179 Select Timeout XXXXXXX mSec	MilliSec	View	Modify	NA	5000	0	3600000
•This is the Com 1 setting that determines the amount of time that can elapse between a "select" and "operate" command for systems that employ select-before-operate commands.							
815 2179 User Map Selection CL-7 Default Event	---	View	Modify	NA	CL-7 Default	NA	NA
•The selection of the active 2179 protocol map for Com 1. The available options are: User 1; User 2; CL-7 Default; CL-7 Default Events; CL-7 Advanced; CL-6 Default; CL-6 Default Events; CL-7 3Ph Default; CL-7 3Ph Default Evt; CL-7 3Ph Advanced.							
815 2179 Dead Sync Timeout 10 Msec	Msec	View	Admin	NA	10	1	1000
•A period of time during which the received data line is idle, defining the end of the previous message. This idle time is the dead-line sync period. The control is now synchronized so that the next byte received is considered the beginning of a new message. This parameter is for Com 1.							
815 2179 Master Time Format Local	NA	View	Modify	NA	Local	NA	NA
•This selects the master time format for use with the 2179 protocol. This parameter is for Com 1. •Options include: Local; UTC.							
816 Modbus Device Address XXX	---	View	Modify	NA	1	1	247
•This is the Com 1 setting that specifies the address, from 1 to 247, of the RTU instance on the control. •Configuration parameters for Modbus are displayed when protocol is available.							
816 Modbus User Map Selection CL-7 Default	---	View	Modify	NA	CL-7 Default	NA	NA
•The selection of the active Modbus protocol map for Com 1. The available options are: User 1; User 2; CL-7 Default; CL-7 Default Events; CL-7 Advanced; CL-6 Default; CL-6 Default Events; CL-7 3Ph Default; CL-7 3Ph Default Evt; CL-7 3Ph Advanced.							
816 Modbus Listening Port Number XXXXX	---	View	Modify	NA	502	1	65534
•This defines the IP port number that will be monitored for incoming MODBUS TCP connections.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
830 Protocol / Port Type Serial DNP	---	View	Modify	NA	Serial DNP	NA	NA
•Protocol and Port setting for Com 2. Not all options are resident on the control, some will require additional hardware to enable. The available protocol options will display according to port type. •Possible options for a particular configuration include: Disabled; DNP / Serial; DNP / Ethernet; IEC 101 / Serial; IEC 104 / Ethernet; 2179 / Serial; Modbus / Serial; Modbus / Ethernet.							
830 LoopShare Communications Disabled	---	View	Modify	NA	Disabled	NA	NA
•This will enable or disable LoopShare Communications for Com 2. The options include: Disabled; Enabled.							
830 ProView NXG Session Disabled	---	View	Modify	NA	Disabled	NA	NA
•This will enable or disable sessions with ProView NXG for Com 2. The options include: Disabled; Enabled.							
830 ProView NXG Address XXXXX	---	View	Modify	NA	65519	0	65519
•The Com 2 address for communications with ProView NXG is set here.							
831 Serial Baud Rate 9600 BPS	---	View	Modify	NA	9600 BPS	NA	NA
•This is the Com 2 Serial Communications Baud Rate setting. The options available are: 300 BPS; 600 BPS; 1200 BPS; 2400 BPS; 4800 BPS; 9600 BPS; 19200 BPS; 38400 BPS; 57600 BPS; 115200 BPS.							
831 Serial Parity None	---	View	Modify	NA	None	NA	NA
•This sets for Com 2 the data parity parameter to be used on the serial communications channel. •The available options are: None; Odd; Even.							
831 Serial CTS Support Disabled	---	View	Modify	NA	Disabled	NA	NA
•This setting determines for Com 2 if CTS/RTS handshaking will be used to control the serial communications channel. •The available options are: Disabled; Enabled.							
831 Serial Tx Enable Delay XXXX mSec	MilliSec	View	Modify	NA	5	0	3000
•For Com 2, when the control is set for transmit control handshaking, the user may require a delay between the time when the transmission is enabled to when data is transmitted. •Example: If the transmit enable were used as a keying device for a transmitter or modem, a "warm-up" period may be necessary before data can be transmitted. •See Figure 20.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
831 Serial Tx Disable Delay XXXX mSec	MilliSec	View	Modify	NA	5	0	3000
•For Com 2, when the control is set for transmit control handshaking, the user may require a delay between the time when the data transmission is terminated and the transmit enable signal is disabled. •See Figure 20.							
831 Serial Echo Mode Disabled	---	View	Modify	NA	Disabled	NA	NA
•When serial communications is active, this parameter will enable or disable the echo mode for Com 2. •Available options are: Disabled; Enabled.							
832 IP Address XXX.XXX.XXX.XXX	---	View	Modify	NA	NA	NA	NA
•The Com 2 IP Address setting.							
832 Subnet Mask XXX.XXX.XXX.XXX	---	View	Modify	NA	NA	NA	NA
•The Com 2 Subnet Mask setting.							
832 Gateway XXX.XXX.XXX.XXX	---	View	Modify	NA	NA	NA	NA
•The Com 2 Gateway setting.							
832 MAC Address XX:XX:XX:XX:XX:XX	---	View	NA	NA	NA	NA	NA
•The Com 2 MAC Address setting.							
840 DNP RBE Master XXXXX	---	View	Modify	NA	1234	0	65519
•This is the Com 2 setting for the DNP3 device number to be used as the destination for any unsolicited reports generated by DNP3 events.							
840 DNP IED Slave XXXXX	---	View	Modify	NA	1	0	65519
•This is the Com 2 setting for the DNP3 device number to be assigned to the connected CL-7 control.							

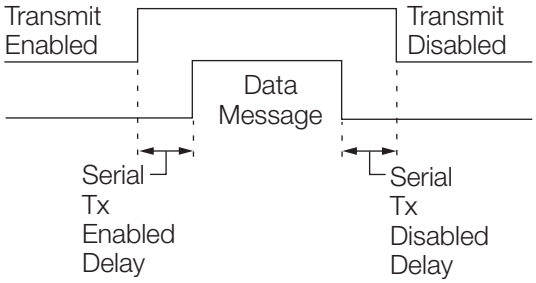


Figure 20. Data transmission from the CL-7 control to the communication system for handshaking applications

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
840 DNP IED Slave 2 XXXXX	---	View	Modify	NA	65519	0	65519
•This is the Com 2 setting for the DNP3 device number to be assigned to the connected CL-7 control. •Communications to this address must always use the Default DNP map.							
840 DNP User Map Selection CL-7 Default	---	View	Modify	NA	CL-7 Default	NA	NA
•The selection of the active DNP map for Com 2. The available options are: User 1; User 2; CL-7 Default; CL-7 Default Events; CL-7 Advanced; CL-6 Default; CL-6 Default Events; CL-7 3Ph Default; CL-7 3Ph Default Evt; CL-7 3Ph Advanced.							
841 DNP Network Protocol Type Listening End Point	---	View	Modify	NA	Listening End Point	NA	NA
•This sets the DNP network type for Com 2. •The available options are: Listening End Point; Dual End Point; UDP.							
841 DNP Accept From Any IP Enabled	---	View	Modify	NA	Enabled	NA	NA
•This is the Com 2 setting that controls whether or not DNP3 requests will be honored from hosts other than the one defined in the next set of fields. •The available options are: Disabled; Enabled.							
841 DNP Accept From IP Address XXX.XXX.XXX.XXX	---	View	Modify	NA	NA	NA	NA
•This is the Com 2 setting that allows the user to input a specific IP address from which to accept DNP3 requests. This is also used as the destination IP to establish a connection when a Dual End Point connection is initiated by the control.							
841 DNP Destination Port Number XXXXX	---	View	Modify	NA	20000	1	65535
•This is the Com 2 setting that defines the IP port number to which outgoing DNP3 messages are addressed when a UDP End Point is configured, unless DNP Use Source Port From Request is Enabled. This port number is also used for outgoing TCP connections when a Dual End Point is configured.							
841 DNP Listening Port Number XXXXX	---	View	Modify	NA	20000	1	65535
•This is the Com 2 setting that defines the IP port number that will be monitored for incoming DNP3 requests when a TCP Listening End Point is configured; responses will be sent using the source port from the incoming request.							
841 DNP Use Port From Request Enabled	---	View	Modify	NA	Enabled	NA	NA
•This is the Com 2 setting that enables the control to use the source IP port number from the last request as the destination port number. •Available options are: Disabled; Enabled.							
841 Initial Unsol UDP Dest Port XXXXX	---	View	Modify	NA	20000	1	65535
•This sets the destination UDP port to which the initial unsolicited null message will be addressed when a UDP End Point is configured.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
841 DNP Keep Alive Timeout XXXXX Seconds	---	View	Modify	NA	3600	1	65535
•This is the Com 2 setting for the time after which a DNP3 Data Link Layer status request will be sent if no message is received from the master (enter 0 to disable).							
841 DNP Outbound Port Type Ephemeral Port	---	View	Modify	NA	Ephemeral Port	NA	NA
•This parameter will set the type of port used for outbound DNP messages. Options include: Ephemeral Port; Static Port. •If set to Ephemeral, the control will use a "random" port from the typical range of ephemeral/temporary non-reserved ports for outbound connections in dual endpoint mode or outbound datagrams in UDP endpoint mode. •If set to the configured static TCP source port is used for outbound connections in dual endpoint mode or outbound datagrams in UDP endpoint mode.							
841 DNP Static UDP Source Port XXXXX	---	View	Modify	NA	20000	1	65534
•This defines a static source port to be used for outbound DNP3 UDP datagrams to the master when the DNP Outbound Port Type is set to static.							
841 DNP Static TCP Source Type XXXXX	---	View	Modify	NA	20000	1	65534
•This defines a static source port to be used for outbound DNP3 TCP socket connections to the master when the DNP Outbound Port Type is set to static.							
842 IEC101 Link Address XXXXX	---	View	Modify	NA	2	0	See note
•This is the Com 2 setting that assigns a unique identifier to the individual slave instance running on the device. •If Link Address Size is 1, Link Address high value is 255 •If Link Address Size is 2, Link Address high value is 65535							
842 IEC101 Common Address XXXXX	---	View	Modify	NA	2	0	See note
•This is the Com 2 setting that identifies the station address, where the station is comprised of all of a device's links. •If Common Address Size is 1, Common Address high value is 255 •If Common Address Size is 2, Common Address high value is 65535							
842 IEC101 Link Address Size X	---	View	Modify	NA	1	1	2
•This is the Com 2 setting for the number of octets to be used in the value of the link address.							
842 IEC101 Common Address Size X	---	View	Modify	NA	1	1	2
•This is the Com 2 setting for the number of octets to be used in the value of the common address.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
842 IEC101 Object Address Size X	---	View	Modify	NA	2	1	3
•This is the Com 2 setting for the number of octets to be used in the value of the object address.							
842 IEC101 Cause of Transmit Size X	---	View	Modify	NA	1	1	2
•This is the Com 2 setting for the number of octets to be used in the cause of transmission indication.							
842 IEC101 Single Command Op Mode SBE	---	View	Modify	NA	SBE	NA	NA
•This is the Com 2 setting that defines if the control will respond directly (Direct mode) to Single Command Operation commands or if a "select" is required before "execute" (SBE mode). •The available options are: Direct; SBE.							
842 IEC101 Select Before Exec Time XXXXX mSec	MilliSec	View	Modify	NA	5000	0	65535
•This is the Com 2 setting that determines the amount of time that can elapse between a "select" and "execute" command for Single Command Operations in systems that employ a select-before-execute mode.							
842 IEC101 User Map Selection CL-7 Default	---	View	Modify	NA	CL-7 Default	NA	NA
•The selection of the active IEC101 map for Com 2. The available options are: User 1; User 2; CL-7 Default; CL-7 Default Events; CL-7 Advanced; CL-6 Default; CL-6 Default Events; CL-7 3Ph Default; CL-7 3Ph Default Evt; CL-7 3Ph Advanced.							
843 IEC104 Server Listen Port XXXXX	---	View	Modify	NA	2404	1	65535
•This is the Com 2 setting for the IP port number that will be monitored for connections.							
843 IEC104 Common Address XXXXX	---	View	Modify	NA	2	1	65535
•This is the Com 2 setting that identifies the station address, where the station is comprised of all of a device's links.							
843 IEC104 Single Command Op Mode SBE	---	View	Modify	NA	SBE	NA	NA
•This is the Com 2 setting that defines if the control will respond directly (Direct mode) to Single Command Operation commands or if a "select" is required before "execution" (SBE mode). •The available options are: Direct; SBE.							
843 IEC104 Select Before Exec Time XXXXX mSec	MilliSec	View	Modify	NA	5000	0	65535
•This is the Com 2 setting that determines the amount of time that can elapse between a "select" and "execute" command for Single Command Operations in systems that employ a select-before-execute mode.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
843 IEC104 Response Timeout (t1) XXXXX Seconds	Seconds	View	Modify	NA	15	1	255
•This is the Com 2 setting for the time-out value for the transmission of data or test messages.							
843 IEC104 Ack/No Data (t2) XXXXX Seconds	Seconds	View	Modify	NA	10	1	255
•This is the Com 2 setting for a time-out before sending an ACK APDU if no data ACKs are received.							
843 IEC104 Idle Test (t3) XXXXX Seconds	Seconds	View	Modify	NA	20	1	255
•This is the Com 2 setting for the amount of time allowed to lapse before a test APDU is generated.							
843 IEC104 Max Transmit (k) XXXXX	---	View	Modify	NA	12	1	32767
•This is the Com 2 setting for the maximum number of unacknowledged data frames that are allowed to be in transit.							
843 IEC104 Max Receive (w) XXXXX	---	View	Modify	NA	8	1	32767
•This is the Com 2 setting for the maximum number of data frames to wait before acknowledging if no data ACKS are received (w should normally not exceed 2 K/3).							
843 IEC104 User Map Selection CL-7 Default	---	View	Modify	NA	CL-7 Default	NA	NA
•The selection of the active IEC104 map for Com 2. The available options are: User 1; User 2; CL-7 Default; CL-7 Default Events; CL-7 Advanced; CL-6 Default; CL-6 Default Events; CL-7 3Ph Default; CL-7 3Ph Default Evt; CL-7 3Ph Advanced.							
845 2179 Master Address XX	---	View	Modify	NA	0	0	31
•This is the Com 2 setting for master address, from 0 to 31, of the master station controlling and polling the RTU. •Configuration parameters for 2179 are displayed when protocol is available.							
845 2179 Ignore Master Address Disabled	---	View	Modify	NA	Enabled	NA	NA
•This is the Com 2 setting that allows the device to accept commands and requests from masters other than that listed in the Master Device Address field. •Available options are: Disabled; Enabled.							
845 2179 Device Address XXXX	---	View	Modify	NA	1	0	2047
•This is the Com 2 setting that specifies the address, from 0 to 2047, of the RTU instance on the control.							
845 2179 Select Timeout XXXXXXX mSec	MilliSec	View	Modify	NA	5000	0	3600000
•This is the Com 2 setting that determines the amount of time that can elapse between a "select" and "operate" command for systems that employ select-before-operate commands.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
845 2179 User Map Selection CL-7 Default Event	---	View	Modify	NA	CL-7 Default	NA	NA
•The selection of the active 2179 protocol map for Com 2. The available options are: User 1; User 2; CL-7 Default; CL-7 Default Events; CL-7 Advanced; CL-6 Default; CL-6 Default Events; CL-7 3Ph Default; CL-7 3Ph Default Evt; CL-7 3Ph Advanced.							
845 2179 Dead Sync Timeout 10 Msec	Msec	View	Admin	NA	10	1	1000
•A period of time during which the received data line is idle, defining the end of the previous message. This idle time is the dead-line sync period. The control is now synchronized so that the next byte received is considered the beginning of a new message. This parameter is for Com 2.							
845 2179 Master Time Format Local	NA	View	Modify	NA	Local	NA	NA
•This selects the master time format for use with the 2179 protocol. This parameter is for Com 2. •Options include: Local; UTC.							
846 Modbus Device Address XXX	---	View	Modify	NA	1	1	247
•Specifies the address from 1 to 247, of the RTU instance on the control for Com 2. •Configuration parameters for Modbus are displayed when protocol is available.							
846 Modbus User Map Selection CL-7 Default	---	View	Modify	NA	CL-7 Default	NA	NA
•The selection of the active Modbus protocol map for Com 2. The available options are: User 1; User 2; CL-7 Default; CL-7 Default Events; CL-7 Advanced; CL-6 Default; CL-6 Default Events; CL-7 3Ph Default; CL-7 3Ph Default Evt; CL-7 3Ph Advanced.							
846 Modbus Listening Port Number XXXXX	---	View	Modify	NA	502	1	65534
•This defines the IP port number that will be monitored for incoming MODBUS TCP connections.							
860 LoopShare Comms State Active	---	View	NA	NA	NA	NA	NA
•This is the state of LoopShare Communications. It will display either Active or Inactive.							
861 LoopShare Comm Table Assignment Passive	---	View	Modify	NA	Passive	NA	NA
•This is the device in the LoopShare Table. The options include: VR1; VR2; VR3; Passive.							
862 LoopShare Comm Tx Delay XXXXX mSec	MilliSec	View	Modify	NA	0	0	10000
•This is the delay between the time a device receives an updated LFDT and when the device passes it along.							
863 LoopShare Comm Timeout XX Seconds	Seconds	View	Modify	NA	3	1	60
•This is the LoopShare communications timeout time.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
920 Firmware Version X.X.X	---	View	NA	NA	NA	NA	NA
•A display of the firmware version currently active on the control.							
921 Firmware Database Version X	---	View	NA	NA	NA	NA	NA
•A display of the firmware Database version currently installed on the control.							
922 FPGA Version X.X.X	---	View	NA	NA	NA	NA	NA
•A display of the FPGA version currently installed on the control.							
923 Digital Hardware Revision X	---	View	NA	NA	NA	NA	NA
•A display of the Digital Hardware Revision of the control.							
924 BootUtility Version X.X.X	---	View	NA	NA	NA	NA	NA
•A display of the BootUtility version currently installed on the control.							
925 BootLoader Version X.X.X	---	View	NA	NA	NA	NA	NA
•A display of the BootLoader version currently installed on the control.							
941 Language Selection English	---	View	Modify	NA	English	NA	NA
•This setting allows the user to select the language to display. Options include: English; Spanish; French; Portuguese.							
942 Date Format MM-DD-YYYY	---	View	Modify	NA	MM-DD-YYYY	NA	NA
•This setting allows the user to select how the date format will be displayed. •Options include: MM-DD-YYYY; DD-MM-YYYY; YYYY-MM-DD.							
943 Time Format 12 Hour AM/PM	---	View	Modify	NA	12 Hour AM/PM	NA	NA
•This setting allows the user to select whether time will be displayed on the 12-hour or the 24-hour scale. Options include: 12 Hour AM/PM; 24 Hour.							
944 Key Mapping Selection Cl-7 Advanced	---	View	Modify	NA	CL-7 Advanced	NA	NA
•This setting allows for the selection of one of the preprogrammed keypad mapping configurations or to select the custom user option. The options are: CL-7 Advanced; CL-7 Basic; Standard Platform; Custom User. •To program the Custom User option, ProView NXG Software must be used.							
950 USB Memory Drive Save All Data	---	View	View	NA	NA	NA	NA
•This is a command to write control data to a USB memory device. Refer to **Section 7: Advanced Control Features: USB memory device.**							
950 USB Memory Drive Save Custom All	---	View	View	NA	NA	NA	NA
•This command saves all settings from a control onto a USB memory device. Using the custom option will include the control ID in the file name as a default.							

Table 10. Function codes (continued)

Parameter	Unit of Measure	Security Level			Default Value	Key Entry Limit	
		To Read	To Write	To Reset		Low	High
950 USB Memory Drive Save Cust Basic	---	View	View	NA	NA	NA	NA
•This command saves the group of settings defined as the Basic settings from a control onto a USB memory device. Using the custom option will include the control ID in the file name as a default.							
950 USB Memory Drive Save Custom Alt	---	View	View	NA	NA	NA	NA
•This command saves the group of settings defined as the Alternate Configuration settings from a control onto a USB memory device. Using the custom option will include the control ID in the file name as a default.							
950 USB Memory Drive Save Custom Adv	---	View	View	NA	NA	NA	NA
•This command saves the group of settings defined as the Advanced Features settings from a control onto a USB memory device. Using the custom option will include the control ID in the file name as a default.							
950 USB Memory Drive Save Custom Comm	---	View	View	NA	NA	NA	NA
•This command saves the group of settings defined as Communications settings from a control onto a USB memory device. Using the custom option will include the control ID in the file name as a default.							
951 USB Memory Drive Load Config Data	---	View	Modify	NA	NA	NA	NA
•Use this function to load a control settings file from a USB storage device onto a control. •Pressing ENTER will bring up a list of available settings files. Use of the scroll arrows allows for the selection of the desired file. Pressing ENTER with the desired file on the display will bring up CONFIRM on the display. Pressing ENTER again will load the setting from the file into the control.							
952 USB Memory Drive Upgrade Firmware	---	View	Admin	NA	NA	NA	NA
•Use this function to upgrade control firmware using a USB drive through the HMI. •Note that control parameter settings are retained after the upgrade process, but it is a good idea to save a settings file onto a USB drive before a firmware upgrade, using FC950 (Save Custom All) as a precaution.							
953 USB Memory Drive Remove Device	---	View	View	NA	NA	NA	NA
•Use this function to prepare the control for removal of the USB memory device. Make sure leave the memory device in the control until the green USB Drive LED has gone out.							
954 USB Memory Drive Settings to .CSV	---	View	NA	NA	NA	NA	NA
•This feature enables a user to save a .CSV file onto a USB memory device inserted into the USB DRIVE on the front of the control. The file will contain the settings information for most of the control operation settings. The .CSV file can be opened using a spreadsheet program for viewing.							
954 USB Memory Drive Metering to .CSV	---	View	NA	NA	NA	NA	NA
•This feature enables a user to save a .CSV file onto a USB memory device inserted into the USB DRIVE on the front of the control. The file will all of the Instantaneous and Demand metering on the control at the time of the save operation. The .CSV file can be opened using a spreadsheet program for viewing.							

Special functions

Use these functions to perform commands through the menu or function code system.

Master reset – FC 38

Initial press reset message

Entering FC 38 or accessing this command via the menu system will cause the LCD to display the following message:

```
038 Master Reset
```

While the Master Reset screen is displayed, pressing the **ESC** key causes the LCD to exit the viewing of this command and to display the previous sub-menu items. Or, pressing the **ENTER** key will request a (CONFIRM) before resetting all demand metering and tap position maximum and minimum values.

```
038 Master Reset


       (CONFIRM)
```

Confirm message

While the (CONFIRM) message is displayed: pressing the **ESC** key causes the LCD to display the initial Master Reset screen; pressing the **ENTER** key causes the execution of the command. Once the command has been executed, it will return to the original Master Rest screen.

Enter security code – FC 99

A security code must be entered to enable parameter editing at the appropriate level. Entering FC 99...

```
Function Code

                  _99
```

...causes the menu system to enter the security code mode:

```
Security Code
              -------
```

This function code does not have an item in the nested-menu system and can only be accessed by using the function code.

Self-test - FC 91

After pressing **FUNC, 91 ENTER** and accessing the FC 91 display, press **ENTER** again to select the option and again to confirm. When the self-test is complete, the LCD displays the Self-Test Complete screen. Press **ESC** for further keypad use.

Test LEDs

Access this under the Diagnostic menu. With the cursor selecting "Test LEDs" press the **ENTER** key and the front panel LEDs will blink three times. The Neutral Light LEDs do not blink.

Turn display off

Access this from the Main Menu (Level 1). With the cursor selecting TURN DISPLAY OFF press the **ENTER** key and the LCD display will turn off. To turn on the LCD display, press any button in the keypad.

Alarms

Use the nested menu to access the lists of acknowledged and unacknowledged system alarms. No security code is needed to display an alarm; a security code is needed to acknowledge an alarm.

- ALARMS > Alarms Active Unacknowledged

  This displays a list of active, unacknowledged system alarms.

- ALARMS > Alarms Active Acknowledged

  This displays a list of active, acknowledged system alarms.

This section covers Alarm displays; for more information on programming alarms, see the Alarms section of document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide*.

If there are no unacknowledged active alarms available, the LCD displays the following message:

```
No Unacknowledged
Active Alarms
```

If there are no acknowledged active alarms available, the LCD displays the following message:

```
No Acknowledged
Active Alarms
```

An actual alarm display example:

```
Supervisory State
Active
01/25/2013 11:35:58a
      (MORE...↓)
```

Status and data alarms

For a complete list and descriptions of the available Status and Data Alarms section of document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide*.

Instantaneous metering and counter quantities

For most Instantaneous Metering quantities, there are two data alarms available: One that can be triggered for a high threshold value and one that can be triggered for a low threshold value. For counter quantities, there will be only one data alarm that will be triggered for a high threshold.

Maintenance quantities

See **Section 7: Advanced Control Features: Duty cycle monitor** for more information on these alarms.

- Contact Life Level 1 Exceeded
- Contact Life Level 2 Exceeded

Sequence of events (SOE)

Use the Sequence of Events menu item to access a list of events. No security code is needed to display events; a security code is needed to acknowledge an event.

This section covers displaying the SOE; for more information on programming SOE and a complete list of available events, see the Sequence of Events section of document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide*.

The event labels can use 2 LCD lines for a total of up to 40 characters.

If there are no events available, the LCD displays the following message:

```
There Are No Events.
```

An SOE example:

```
VR1 Control Switch
Auto/Remote
01/25/2013 11:35:58a
      (MORE...↓)
```

When accessed through the keypad, only the last 50 events will be displayed. If there are many events (100+) that have not been read via the front panel, it may take a few seconds. While this is occurring the following message, indicating that events are being read, may appear before displaying the latest events:

```
Events...
```

Power-up/reset conditions

When the system first comes up and no error conditions are detected, the LCD displays the following message:

```
Self-Test Complete.
(Date/Time Shown)

        (PASS)
```

If error conditions are detected, the LCD will display error message similar to those that follow:

```
Self-Test Complete.
Factory Calibration
Required!
(ATTENTION...MORE  ↓)
```

```
Self-Test Complete.
Data Acquisition!

 (FAILURE...MORE  ↓)
```

```
Self-Test Complete.
Configuration Value
Required!
(ATTENTION...MORE  ↓)
```

If the "Configuration Value Required!" message appears, refer to **Section 3: Initial control programming**. Perform basic programming steps and then initiate a self-test.

```
Self-Test Complete.
Clock Needs Setting!

(ATTENTION...MORE  ↓)
```

```
Self-Test Complete.
VR1 Input Voltage
Missing!
(ATTENTION...MORE  ↓)
```

```
Self-Test Complete.
VR1 Output Voltage
Missing!
 (FAILURE...MORE  ↓)
```

```
Self-Test Complete.
VR1 No Neutral
Sync Signal!
  (ATTENTION...LAST)
```

Consult **Section 8: Troubleshooting** or contact your Eaton representative for assistance with specific self-test messages.

Indication messages

The fourth line of the LCD is used to provide messages associated with menu mode indications. These indication messages can be defined with up to 20 characters.

Displayed during Self-Test message:

- (PASS)
- (ATTENTION)
- (ATTENTION...MORE↓)
- (ATTENTION...LAST↓)
- (FAILURE)
- (FAILURE...MORE↓)
- (FAILURE...LAST↓)

Displayed when an invalid function code is entered:

- (INVALID FUNCTION)

Displayed when and invalid security code is entered:

- (INVALID SECURITY)

Displayed when a parameter cannot be read, written, or reset because the proper security code has not been entered:

- (IMPROPER SECURITY)

Displayed when setting a password that is too weak:

- (PASSWORD TOO WEAK)

Displayed when edit mode is active:

- (EDIT)
- (CONFIRM) (also displayed to prompt the user when issuing a command from the menu system)

Displayed when a value that has been entered is out the valid range:

- (VALUE TOO HIGH)
- (VALUE TOO LOW)
- (OUT OF RANGE)
- (TIMEOUT)
- (NEG ACKNOWLEDGE)
- (INVALID DATE)
- (INVALID TIME)

Displayed when listing alarms or events:

- (MORE...↓)
- (LAST...↓)

Displayed when an alarm is to be acknowledged or unacknowledged by the user:

- (ACKNOWLEDGE)
- (UNACKNOWLEDGE)

Displayed when accessing USB Memory Drive operations:

- (NO FILES FOUND)
- (READING FILES...)
- (REPLACE FILE)
- (LOADING...)
- (LOAD COMPLETE)
- (LOAD FAILED)
- (SAVING...)
- (SAVE COMPLETE)
- (SAVE FAILED)
- (UPGRADING...)
- (UPGRADE COMPLETE)
- (UPGRADE FAILED)
- (REMOVING...)
- (OK TO REMOVE)
- (REMOVE FAILED)
- (USB NOT CONNECTED)
- (CANCELLING...)
- (CANCEL COMPLETE)

Displayed when indicating that the values for "Load Voltage Secondary" and "Source Voltage Secondary" have been derived by the control:

- (CALCULATED)

Displayed when indicating that alternate configuration is active:

- (ALT CONFIG 1)
- (ALT CONFIG 2)
- (ALT CONFIG 3)

Displayed when indicating that changing Internal PT ratio is not applicable because Vin PT configuration is invalid:

- (INVALID VIN CONFIG)

Displayed when indicating inconsistencies between the neutral signal and Tap Position value entered by the user:

- (TAP AT NEUTRAL)
- (TAP NOT AT NEUTRAL)
- (MEASURED TP ACTIVE)

Displayed when testing the battery:

- (TESTING...)
- (ATTENTION)

Displayed when contact output cannot be overridden:

- (CANNOT OVERRIDE)

Displayed when accessing Extended Comms Status:

- (NOT AVAILABLE)
- (RUNNING OK)
- (FAILURE)

Displayed when accessing Metering PLUS screens for LoopShare:

- (LOOPSHARE INACTIVE)

Displayed when performing a firmware upgrade:

- Do Not Remove Drive (USB Drive)
- Restoring Settings

Section 6: Control features

Calendar/clock

Integral to several functions of the control is an internal real-time calendar/clock. The clock maintains the year, month, day, hour, minute and seconds, within 1 second. The display format is user-selectable (see FC 942 and FC 943). The control time is synchronized to the system frequency when powered by AC. When ac power is lost, the clock maintains time for approximately four (4) days, by using a crystal oscillator and a capacitor as the power source. Twenty minutes on ac power is required to fully charge the capacitor.

The LCD displays the current date and time at the end of the self-test when the front panel is turned on. However, upon power-up after extended loss of power, the control clock time and date will default to midnight, January 1, 1970.

The date and time can be read and set at FC 50. When setting, all of the digits must be entered using the standard 24-hour format (MM/DD/YYYY hh:mm). If an error is made while entering the values, backspace using the left arrow key.

Time zone settings are available. ProView NXG software is required to select a time zone setting; available time zones are all with respect to Greenwich Mean time. The time zone setting can be viewed using FC 50 and pressing the down arrow key once.

Metering

The control has extensive metering capabilities, which are categorized as Instantaneous, Forward Demand, and Reverse Demand.

Instantaneous metering

Instantaneous metering values are refreshed once each second. The information may be accessed using the front panel HMI under the METERING menu. See **Table 9** for a list of available metering values under this menu. See **Table 10** in **Section 5: Control programming** for more information on the function codes.

Demand metering

The control provides forward and reverse demand metering information for numerous parameters. When applicable, the present value, high value since last reset and low value since last reset are recorded. For the low and high values, the earliest time and date of occurrence are also recorded.

Additionally, the power factor at kVA-high demand and kVA-low demand are recorded. All demand metering values are stored in non-volatile memory separately for forward and reverse power conditions.

Demand metering values may be accessed using the keypad under the METERING menu; see **Table 9** for a list of available metering values under this menu.

See **Table 10** in **Section 5: Control programming** for information on the function codes associated with demand metering.

Demand task operation

The demand metering function is based upon a sliding window concept, or moving integral. The algorithm implemented simulates the response of a thermal demand meter which will reach 90% of its final value after one demand interval in response to a step function input. See **Figure 21**.

The task works like this:

1. For three (3) minutes after a power outage or power reversal, no demands are calculated. This allows the utility system to stabilize from the event which created the outage or power reversal.
2. At three (3) minutes, the present demands (for the appropriate power direction) are set to their corresponding instantaneous value and the integration algorithm begins according to the programmed demand interval at FC 46.
3. At fifteen (15) minutes or at the demand time interval (whichever is longer), the high/low demand values begin to track the present demand, similar to drag hands. All demand values are calculated continuously and, if a change has occurred, the high/low demands are stored in the non-volatile memory every fifteen (15) minutes. This prevents loss of data during a power interruption or outage.

Notice that the provisions are made to reset any demand value individually using the **ENTER** key, or all demand values can be reset simultaneously by entering FC 38. High and low values will be set to their corresponding present demand value, and the dates and times will be set to the present date/time.

Two conditions can cause the present demands to be invalid: The power has just been applied (within the 3-minute freeze period) or the power flow has changed direction. If the control is metering in the forward direction, the reverse present demands will be invalid; if metering in the reverse direction, the forward present demands will be invalid.

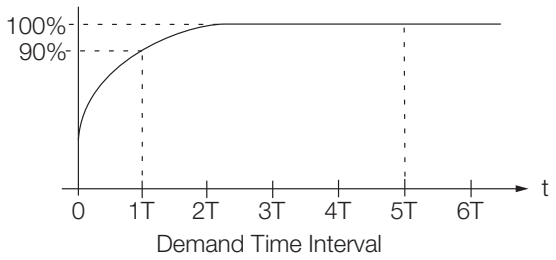


Figure 21. Demand time interval response

Tap position indication (TPI)

The control has the ability to track the position of the tap-changer. The TPI function senses the status of the motor and neutral light circuits and does not require source (input) voltage. The present tap position is stored at FC 12.

EXAMPLES: "8" at FC 12 indicates 8 raise and "-7" indicates 7 lower.

The TPI function is synchronized to the position of the tap-changer by running the regulator to the neutral position. To manually set the present tap position: Access Admin security level; access FC 12; use the **EDIT** key to change to the desired value.

The maximum tap position since last reset (upper drag-hand value of the present tap position) and its date and time are stored at FC 27. The minimum tap position since last reset (lower drag hand value of the present tap position) and its date and time are stored at FC 28.

The TPI drag hand values and dates/times are reset to the present values by the master reset, FC 38, or by resetting each of the values individually. The drag hand reset switch resets the drag hands of the position indicator only, not TPI. All TPI values are stored in non-volatile memory.

The following conditions could occur if the present tap position was manually set incorrectly:

- The present tap position value will go to invalid "---" if the present tap position is 0 (zero, neutral) but no neutral signal is detected. For example, this condition will occur if a replacement control with present tap position set to "0" is installed on a regulator which is not in the neutral position.
- If the TPI function detects a successful upward tap and the prior value of FC 12 was "16", or a successful downward tap is detected and the prior value of FC 12 was "–16," the prior value will be maintained.

The display will show a diagnostic error message upon power-up when: (1) the present tap position value prior to power-up is "---" (invalid) and the regulator is not in neutral position; (2) The present tap position prior to power-up is "0" and the regulator is not in the neutral position. [This condition will cause the present tap position value to go to invalid ("----")]; and (3) During automatic or manual operation the present tap position changes to "0", but a neutral signal is not received. The **No Neutral Sync** signal is an attention signal, not a failure signal.

The TPI will satisfy the diagnostics routine upon power-up when: (1) The regulator is in neutral and the present tap position is "0"; (2) The present tap position is not "0" and the regulator is not in neutral, including when the tap position is not set correctly; and (3) When the regulator is in neutral and the present tap position is not "0" (TPI will self-correct and reset the tap position).

Source-side voltage

Without a source voltage input, some functions will indicate dashes when displayed. There are three methods for supplying a source-side voltage to the CL-7 control: Internal Differential Potential Transformer (IDPT), source-side PT, or source-side voltage calculation.

Differential voltage

The voltage regulator may be designed and ordered with an Internal Differential PT (IDPT). The IDPT will be included in the schematic on the voltage regulator nameplate and labeled Series Winding Potential Transformer. An IDPT supplies the voltage difference between the source and load bushings of the voltage regulator. This differential voltage is then combined with the load voltage to provide the source-side voltage. When using an IDPT on an Eaton's Cooper Power series voltage regulator, the source voltage accuracy is within ± 1%.

As a standard, a second ratio correction transformer (RCT2) is not supplied on regulators equipped with an IDPT. The control will use the internal PT ratio entered at FC 44↓ and the input voltage from the IDPT to determine the differential voltage between the source and the load bushings. The setting at FC 146 must be set to Vdiff without RCT2 for this configuration.

If an RCT2 is supplied, the Overall PT Ratio entered at FC 44 and the input voltage from the IDPT are used to determine the differential voltage. The setting at FC 146 must be set to Vdiff with RCT2 for this configuration.

Source voltage

A source-side PT may be used to supply a directly measured source voltage. When using a source-side PT, the user must change Vin PT Configuration, FC 146, from the default Vdiff without RCT2 to Vin Mode. Some manufactures use a source PT as a standard. Using an external source-side PT may be desirable if the voltage regulators are in a closed-delta configuration. In a closed delta, the source voltage and percent regulation will only reflect the true system source values if an external source voltage or DeltaCalc feature is used. Voltage regulator performance is not affected by the difference between metering parameters when using an external source PT: the accuracy of the source voltage is dependent upon the accuracy of the PT. When FC 146 is set to Vin, the control will use the Internal P.T. Ratio (FC 44↓) to determine the measured source bushing voltage.

Source-side voltage calculation

The CL-7 control has the ability to calculate the source-side voltage without an IDPT or source PT. When this feature is turned on at FC 39, the control will use the load voltage from the main PT, the regulator type (Type A, Type B, Type C or Type D), the tap position, and the internal impedance of the regulator to calculate the source-side voltage. This calculated source voltage is accurate to within ±1.5%. Only the regulator type needs to be programmed into the control;

the other values are already available.

On the control back panel, when no source or differential PT are present, the connection that would be the input for one of these PTs if they were present is tied to the load-side PT input. When the load and source PT inputs are tied and the values are the same, the control interprets that as meaning that the calculation is required. If the inputs are not tied when there is no source-side PT signal, the control will attempt to read the source-side voltage and will provide an errant value. Often, this value will be in the range of 40 volts. If the source-voltage value is displaying errantly and there is no source PT, check to make sure the source and load PT inputs (terminals V7 and VS) are tied together.

Reverse power operation

Most voltage regulators are installed in circuits with well-defined power flow from source to load. However, some circuits have interconnections or loops in which the direction of power flow through the regulator may change. For optimum utility system performance, a regulator installed on such a circuit should have the capability of detecting reverse power flow and of sensing and controlling the voltage, regardless of the power flow direction.

The control has full reverse power capabilities. For fully automatic reverse operation, the source voltage must be available to the control. Refer to **Section 6: Control Features: Source-side voltage** in this section of the manual.

The control offers nine different response characteristics for forward and reverse power detection and operation. These characteristics are user-selectable by programming the Reverse Sensing Mode (FC 56). The nine modes are Locked Forward, Locked Reverse, Reverse Idle, Bi-directional, Neutral Idle, Co-generation, Reactive Bi-directional, Bias Bi-directional, and Bias Co-generation.

This section will separately explain each mode of operation. Since the control retains the reverse metered demand values separate from the forward metered values, the metering will also be explained for each mode.

In determining power direction the control uses one of two methods, depending upon the reverse sensing mode in use and the current level detected. In most cases, the control senses the real component of the current, then determines the current direction and magnitude in that direction.

Power direction may also be determined using a test-tapping routine under certain conditions when the "Bias" reverse sensing modes are employed.

When the conditions indicate power is flowing in reverse, the following parameters assume new values and the control operation is affected accordingly:

Load Voltage	Now sensed from what was previously the source voltage supply.
Source Voltage	Now sensed from what was previously the load voltage supply.
Load Current	In the forward direction, the current is used directly as measured. In the reverse direction, the current is scaled to reflect the ratio difference between the source and load side of the regulator, according to this formula[Q]:

$$\text{Reverse Load Current} = \frac{\left(\begin{array}{c}\text{Forward}\\ \text{Load}\\ \text{Current}\end{array}\right)\left(\begin{array}{c}\text{Source}\\ \text{Voltage}\\ \text{Supply}\end{array}\right)}{\text{Load Voltage Supply}}$$

[Q]Where source voltage supply and load voltage supply are in the reverse direction.

Based upon the new metered reverse values, the kVA, kW, kvar, and % buck/boost are now calculated.

Locked forward mode

The Lock Forward setting is intended for applications where reverse power flow is not possible. When the control is set for Locked Forward, a measured voltage from the load bushing is required, but a source voltage is not required.

METERING: Always determined in the forward direction, regardless of power flow direction. If reverse power occurs, the metering functions remain on the normal load side of the regulator—no reverse demand readings will occur.

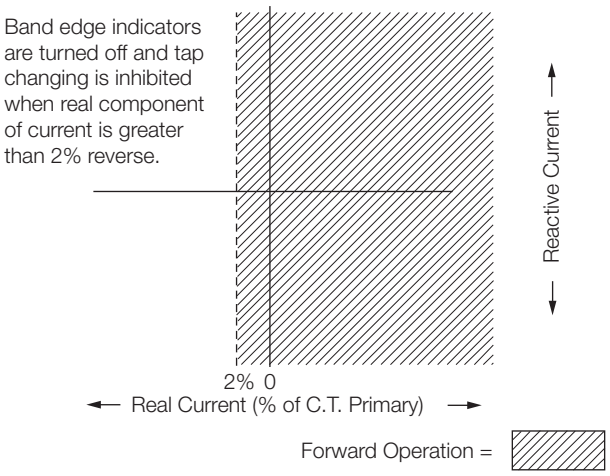


Figure 22. Locked forward mode operation

OPERATION: See **Figure 22**. Voltage regulation always occurs in the direction from the source bushing to the load bushing. Voltage regulation operation will use the forward direction settings at FC 1, FC 2, FC 3, FC 4, and FC 5.

Voltage regulation operation will occur down to a zero current condition because the reverse current sense threshold is not applied. As a safeguard, the locked forward setting is programmed to prevent voltage regulation runaway in the event reverse power flow does occur. If reverse current exceeds 2% of the CT primary, the control idles on the last tap position held and the band edge indicators will turn off. The control will also go into an auto tap blocking state and display Rev Pwr Mode on the Load Current Metering-PLUS screen. As the current flow returns to a level above the 2% safeguard, normal forward operation resumes.

Locked reverse mode

The Lock Reverse setting is intended for applications where forward power flow is not possible. When the control is set for Locked Reverse, a measured or calculated voltage from the source bushing is required. A voltage from the load bushing is also required for the measurement and calculation methods of determining the source bushing voltage.

METERING: Always determined in the reverse direction, regardless of power flow direction. If forward power occurs, the metering functions remain on the source-bushing side of the regulator and no forward demand readings will occur.

OPERATION: See **Figure 23**. Voltage regulation always occurs in the direction from the load bushing to the source bushing. Voltage regulation operation will use the reverse direction settings at FC 51, FC 52, FC 53, FC 54, and FC 55.

Voltage regulation operation will occur down to a zero current condition because the reverse current sense threshold is not applied. As safeguard, the locked reverse setting is programmed to prevent voltage regulation runaway in the event forward power flow does occur. If forward current exceeds 2% of the CT primary rating, the control idles on the last tap position held and the band edge indicators will turn off. The control will also go into an auto tap blocking state and display Rev Pwr Mode on the Load Current Metering-PLUS screen. As the current flow returns to a level above the 2% safeguard, normal reverse operation resumes.

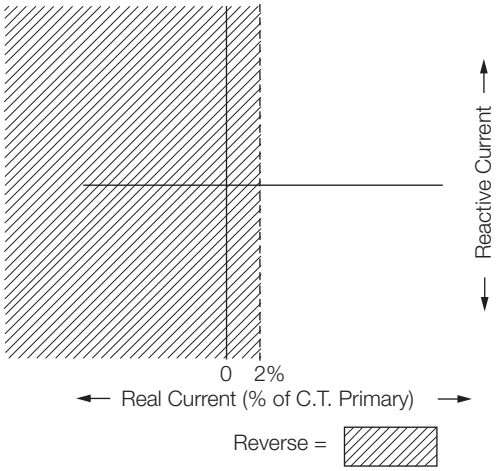


Figure 23. Locked reverse mode operation

Reverse idle mode

The Reverse Idle setting is recommended for applications where reverse power is possible but the source bushing voltage cannot be determined and reverse power regulation is not required. When the control is set for Reverse Idle, a measured or calculated source voltage would be needed for metering only.

METERING: See **Figure 24**. A threshold level of 1% (.002 A) of the full load CT secondary current of .200 A is used in setting the power direction. The metering will be forward until the current exceeds the 1% threshold in the reverse direction. At this time, the various parameters use the reverse settings and the Reverse Power indicator turns on. The control continues metering in reverse until the current exceeds the 1% threshold in the forward direction, and then the parameter scaling reverts back to normal and the Reverse Power indicator turns off.

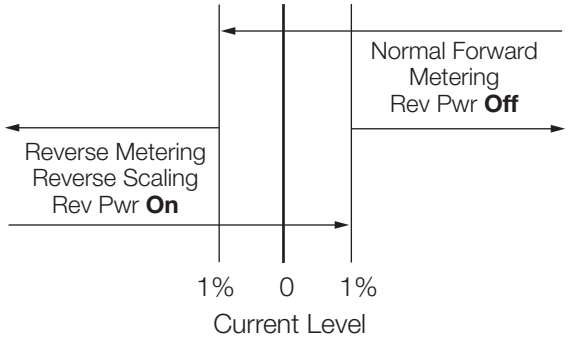


Figure 24. Reverse idle metering

OPERATION: See **Figure 25**. When the control is set to the Reverse Idle mode, the control will regulate in the forward direction (from source bushing to load bushing) when the real component of system load current exceeds a threshold value determined using the Reverse Current Sense Threshold setting (FC 57).

When the the real component of system load current falls below the threshold, the control will go into an auto tap blocking state and idle on the tap position held before the threshold was crossed. The operational timer (time delay) will reset on any excursion below this threshold. While below the threshold, the control will display Rev Pwr Mode on the Load Current Metering-PLUS screen. As the current flow again exceeds the threshold, normal forward operation resumes.

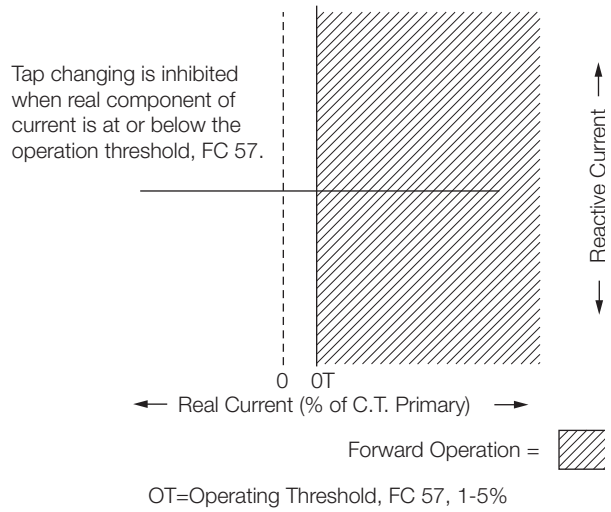


Figure 25. Reverse idle mode* operation

* Tap changing is inhibited and band edge indicators are turned off.

Bi-directional mode

The Bi-directional setting for Reverse Sensing Mode is recommended for applications where forward and reverse power are possible. The setting is not recommended for applications in which the reverse power is due to a co-generational facility. It is also not recommended for applications with load currents in the forward or reverse direction that do not meet the current sense threshold.

When the control is set for Bi-directional, a measured or calculated voltage from the source bushing is required for reverse power operation and metering.

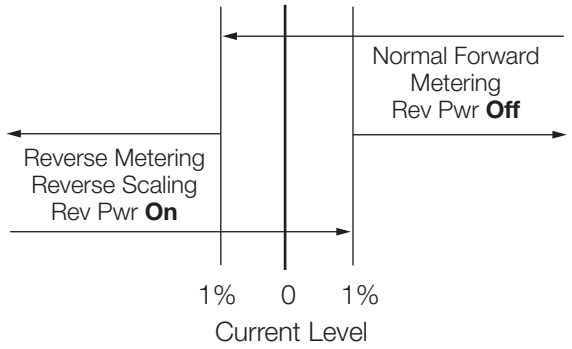


Figure 26. Bi-directional, neutral idle and reactive bi-directional metering

METERING: See **Figure 26**. A threshold level of 1% (.002 A) of the full load CT secondary current of .200 A is used in setting the power direction. The metering will be forward until the current exceeds the 1% threshold in the reverse direction. At this time, the various parameters use the reverse settings and the Reverse Power indicator turns on. The control continues metering in reverse until the current exceeds the 1% threshold in the forward direction, and then the parameter scaling reverts back to normal and the Reverse Power indicator turns off.

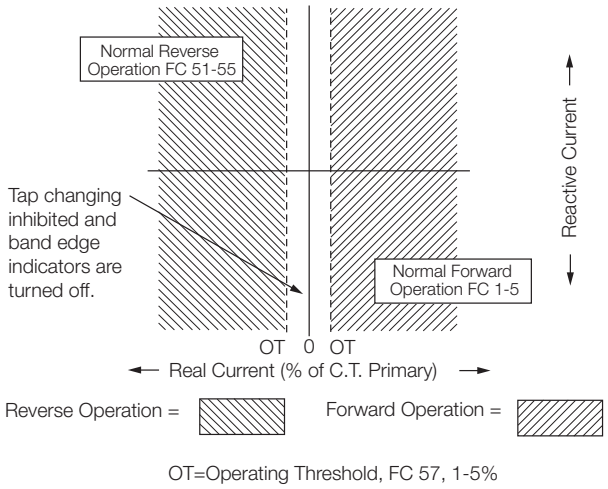


Figure 27. Bi-directional mode operation

OPERATION: See **Figure 27**. When the control is set to the Bi-directional mode, it will regulate in the forward direction (from source bushing to load bushing) when the real component of system load current in the forward direction exceeds a threshold value determined using the Reverse Current Sense Threshold setting (FC 57).

The control will regulate in the reverse direction (from load bushing to source bushing) when the real component of system load current in the reverse direction exceeds the threshold value.

When the the real component of system load current falls between the forward and reverse threshold values:

- Auto operation will be inhibited and the control will idle on the tap position held before the threshold was crossed.
- The band-edge indicator LEDs will not illuminate, even when the compensated voltage is out of band.
- The operational timer (time delay) will reset.
- As the current flow again exceeds the threshold in either direction, auto operation will resume in that direction.

Neutral idle mode

The Neutral Idle setting is recommended for applications where reverse power is possible but the source bushing voltage cannot be determined and reverse power regulation is not required. When the control is set for Neutral Idle, a measured or calculated source voltage would be needed for metering only.

METERING: See **Figure 26**. A threshold level of 1% (.002 A) of the full load CT secondary current of .200 A is used in setting the power direction. The metering will be forward until the current exceeds the 1% threshold in the reverse direction. At this time, the various parameters use the reverse settings and the Reverse Power indicator turns on. The control continues metering in reverse until the current exceeds the 1% threshold in the forward direction, and then the parameter scaling reverts back to normal and the Reverse Power indicator turns off.

OPERATION: See **Figure 28**. When the control is set to the Neutral Idle mode, the control will regulate in the forward direction (from source bushing to load bushing) when the real component of system load current, in the forward direction, exceeds the current threshold value determined using the Reverse Current Sense Threshold setting (FC 57).

When the real component of system load current, in the reverse direction, exceeds the current threshold value for 10 continuous seconds, the control will tap to neutral. Neutral position is determined using control tap position. If the tap position is not valid, neutral is determined using percent regulation (buck and boost).

When the real component of current is in the region between the forward and reverse thresholds, the control idles on the tap position held before the forward threshold was crossed. While tapping to the neutral position, if the current falls below the reverse threshold, the control continues to tap until neutral position is reached.

On any excursion below the forward threshold, the operational timer (time delay) is reset and the band edge indicators turn off.

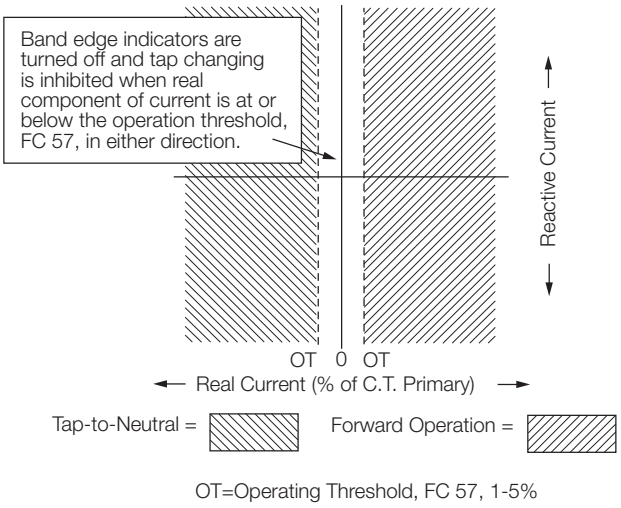


Figure 28. Neutral idle mode* operation

* Band edge indicators are turned off.

Co-generation mode

The Co-generation setting is intended for applications where distributed generation is present on the load bushing side of the voltage regulator, and where reverse power as a result of feeder switching is not possible. When the control is set for co-generation, a measured voltage from the load bushing is required, but a source voltage is not required. See **Figure 29**.

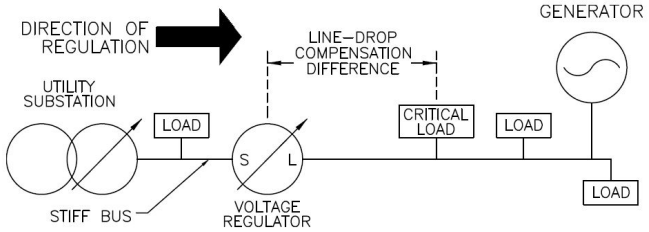


Figure 29. Co-generation regulation points

METERING: See **Figure 30**. Always operates in the forward direction except that load center voltage is calculated based upon the reverse line-drop compensation settings (FC 54 and FC 55) when the fixed 1% reverse metering threshold is exceeded. The Reverse Power indicator turns on when this reverse threshold is crossed. The forward line-drop compensation settings (FC 4 and FC 5) are used when the current exceeds the fixed 1% forward metering threshold. The demand values acquired during reverse power flow are stored as reverse metered data, but the values are not scaled (to reflect the other side of the regulator) since the operating direction of the regulator never truly reverses.

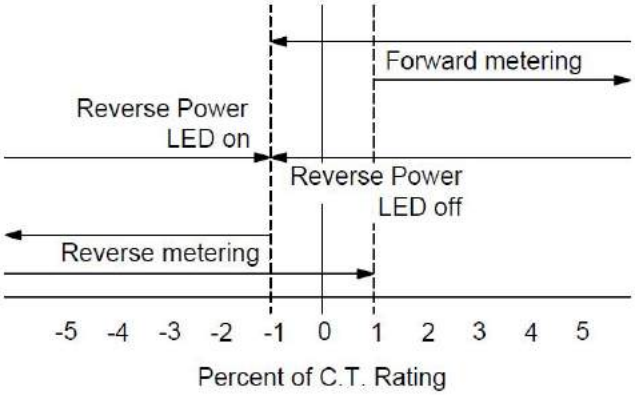


Figure 30. Co-generation metering

OPERATION: See **Figure 31**. The control always regulates voltage in the forward direction. The control will regulate in the forward direction, but will use the reverse settings for set voltage (FC 51), bandwidth (FC 52), time delay (FC 53), and line-drop compensation (FC 54 and FC 55) when the real component of the current is above the fixed 1% reverse metering threshold. The control will continue to use the reverse settings until the real component of the current is above the fixed 1% forward metering threshold.

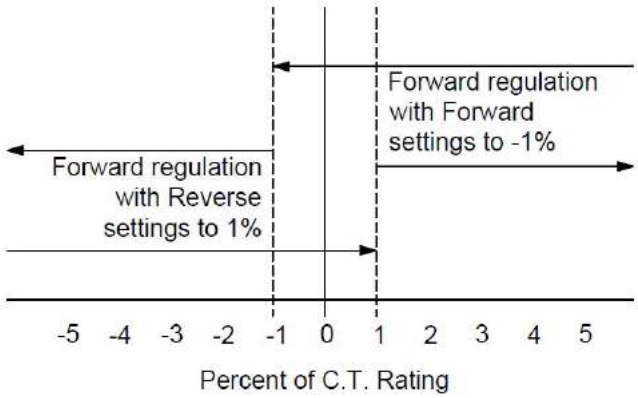


Figure 31. Co-generation mode operation

Reactive bi-directional mode

When FC 56 is set for Reactive Bi-directional, source voltage is required, either measured or calculated.

This mode is recommended for installations where reverse power flow may occur and the real component of the current is below the operator-defined threshold (FC 57), except where the source of reverse power is a co-generation facility or independent power producer.

METERING: See **Figure 32**. A threshold level of 1% (.002 A) of the full load CT secondary current of .200 A is used in setting the power direction. The metering will be forward until the current exceeds the 1% threshold in the reverse direction. At this time, the various parameters use the reverse settings and the Reverse Power indicator turns on. The control continues metering in reverse until the current exceeds the 1% threshold in the forward direction, then the parameter scaling reverts back to the normal and Reverse Power indicator turns off.

OPERATION: See **Figure 32**. The control determines which settings (forward/reverse) to use by sensing the real and reactive components of the current. The control operates in the forward direction whenever the magnitude of the reactive component of the current exceeds the operator-defined threshold (FC 57) in the negative direction. The control also operates in the forward direction if the magnitude of the real component of the current exceeds the operator-defined threshold (FC 57) in the positive direction while the magnitude of the reactive component of the current is between the operator-defined thresholds (FC 57). The control operates in the reverse direction using the reverse settings at FC 51, FC 52, FC 53, FC 54, and FC 55 whenever the magnitude of the reactive component of the current exceeds the operator-defined threshold (FC 57) in the positive direction. The control also operates in the reverse direction if the magnitude of the real component of the current exceeds the operator-defined threshold (FC 57) in the negative direction while the magnitude of the reactive component of the current is between the operator-defined thresholds (FC 57).

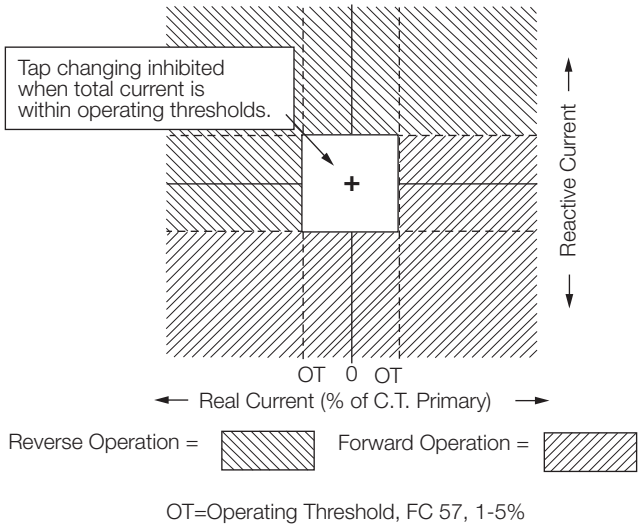


Figure 32. Reactive bi-directional mode operation

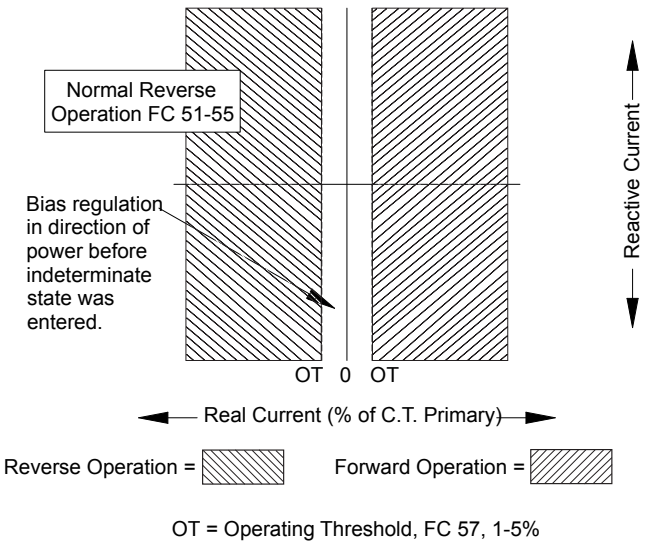


Figure 33. Bias bi-directional mode operation

Bias bi-directional mode

When FC 56 is set for Bias Bi-directional, a source voltage is required, either measured or calculated. This mode is an option for installations where reverse power flow may occur except where the source of reverse power is a co-generation facility or independent power producer. This mode is similar in operation to the Bi-Directional Mode, but includes a mechanism to enable voltage regulation when current flow is below the current sense threshold and current flow direction cannot be reliably determined because of CT accuracy limitations.

METERING: When current direction is above the current threshold in the forward direction or below it in the reverse direction, metering will be recorded in the direction of current flow. When current flow is under the current thresholds for forward and reverse power, the control will use a mechanism that includes tapping and sampling changes in voltage to look for an out-of-band condition. Metering will be recorded for the current direction last determined by the sampling mechanism to be correct.

OPERATION: See **Figure 33**. In Bias Bi-directional Mode, the control shall function in the power flow direction it was in before entering the indeterminate state. If the control was in the forward power direction before it entered the indeterminate state, it shall use forward settings to determine if it is out of band. If the control was in the reverse power direction before it entered the indeterminate state, it shall use reverse settings to determine if it is out of band.

Any time the control is in the indeterminate state and transitions from an in-band to an out-of-band condition, it will make two quick steps to determine if it is tapping in the correct direction for the flow of power. The two quick steps will be in the appropriate direction based upon the last known power direction.

Note: In the context of this discussion, the quick raise steps would be in the clockwise direction on the position indicator and quick lower steps would be in the counter-clockwise direction.

The control shall confirm it is tapping in the correct direction if any one of following conditions is met:

- Load bushing voltage increases one percent or more of the nominal secondary voltage after two quick raise taps if the control is out of band low and was in the forward direction before it entered the indeterminate state, or
- Load bushing voltage is unchanged or increases less than one percent of the nominal secondary voltage after two quick raise taps if the control is out of band high and was in the reverse direction before it entered the indeterminate state, or

- Load bushing voltage decreases one percent or more of the nominal secondary voltage after two quick lower taps if the control is out of band high and was in the forward direction before it entered the indeterminate state, or
- Load bushing voltage is unchanged or decreases less than one percent of the nominal secondary voltage after two quick lower taps if the control is out of band low and was in the reverse direction before it entered the indeterminate state.

If the control determines the regulator is not tapping in the correct direction after two quick taps, the control shall make two quick taps back to its original position and then make the needed taps in the opposite direction to bring the compensated voltage in band.

When the control is in an indeterminate state and needs to tap, two quick raise taps it will be inhibited if the current tap position is 15 or 16. When the control is in an indeterminate state and needs to tap, two quick lower taps it will be inhibited if the current tap position is -15 or -16.

When the control is in an indeterminate state and needs to tap, two quick raise or lower taps shall be inhibited if control determines that two quick taps will violate any of the following limits:

- Soft ADD-AMP limits
- P.I. ADD-AMP limits
- Leader/Follower Max Deviation limits
- Voltage limiting (i.e. two quick taps will exceed the limits)

Bias Co-Generation mode

When FC 56 is set for Bias Co-Generation, a source voltage is required, either measured or calculated.

The traditional Co-Generation mode of operation assumes that the primary power source is supplied by a utility substation on the source-side, physical S bushing, of the voltage regulator and that this supply is stiff. In this scenario, the co-generation facility is located on the load-side, physical L bushing, of the voltage regulator and the power generated supplements the stiff bus. Voltage regulation will always be in the forward direction, away from the stiff bus toward the co-gen facility. See **Figure 29**.

It is possible however, that a co-gen facility is connected to a loop configured distribution system containing disconnect and tie switches to isolate and recover sections of the system. In this scenario, a true power reversal can occur through the voltage regulator due to a switch reconfiguration. The traditional Co-Generation mode is not able to react to a current reversal due to a switch reconfiguration. If a reversal does occur when the control is set to Co-Gen mode, the regulator would continue to attempt forward voltage regulation and tap changer runaway is likely.

Bias Co-Generation is able to distinguish between reverse power due to co-generation (**Figure 34**) and true reverse power flow due to switch reconfiguration (**Figure 35**).

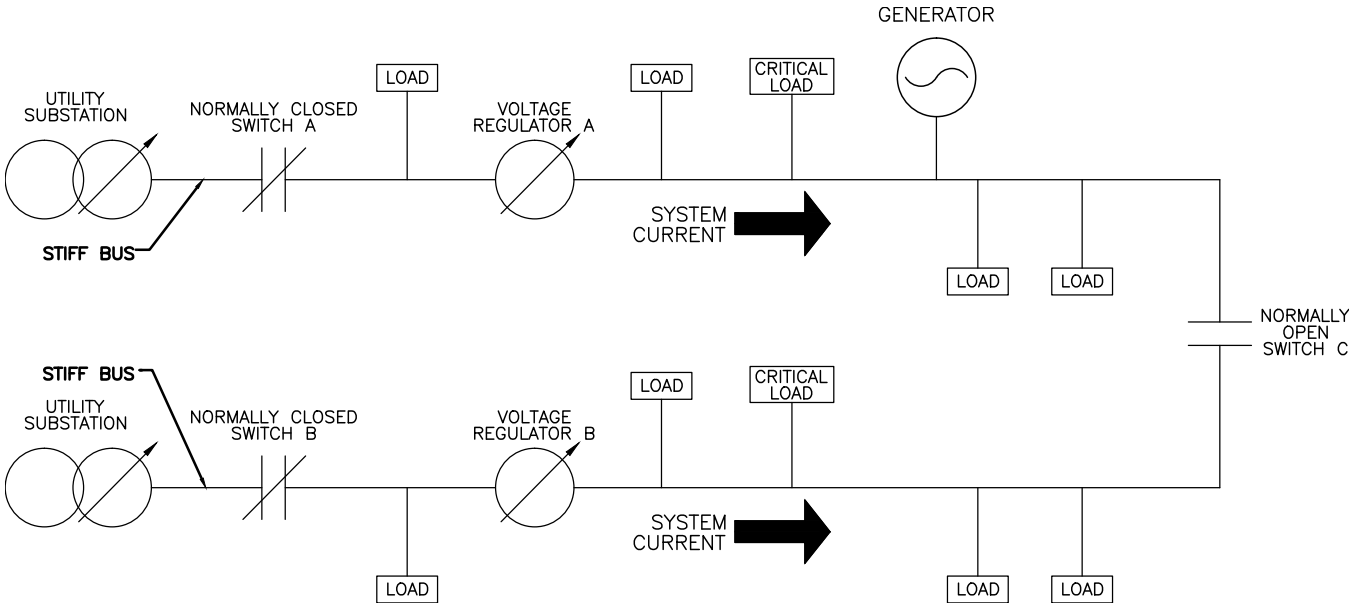


Figure 34. Loop configured system with Co-Gen facility. Tie switch is open; stiff bus on the source bushings of the regulators and true current flow from source bushing to load bushing.

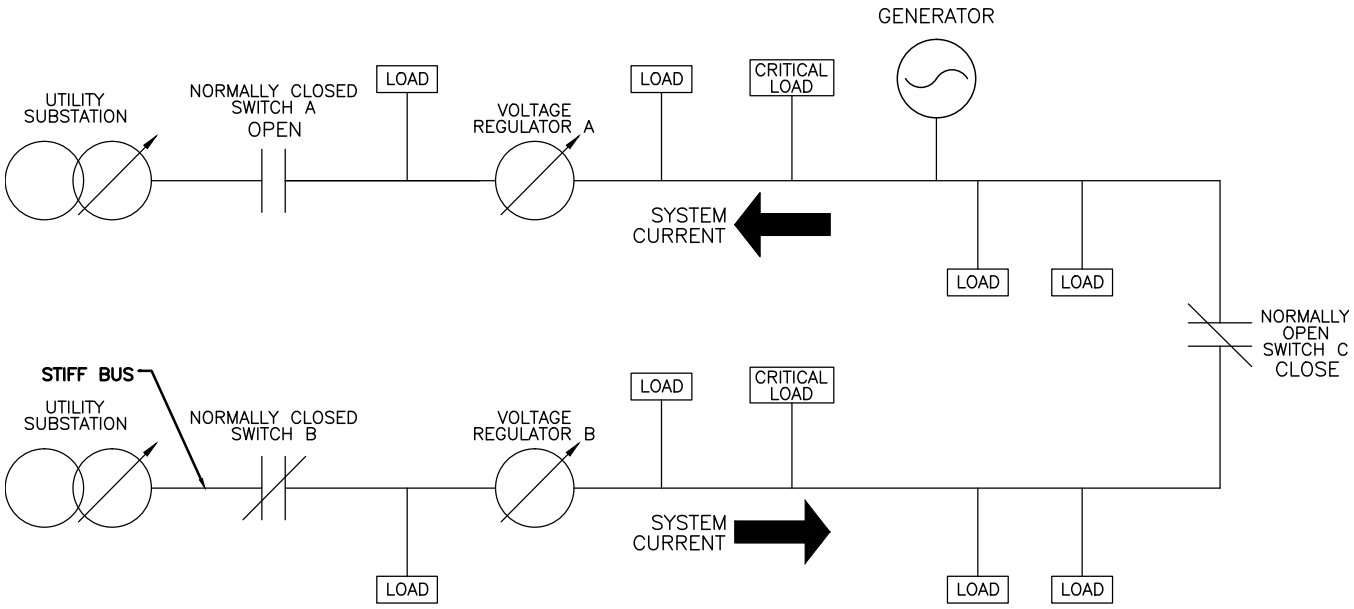


Figure 35. Loop configured system with Co-Gen facility. Tie switch is closed. Stiff bus on the load bushing of voltage regulator A with true current flow from load to source. Stiff bus on the source bushing of voltage regulator B with true current flow from source to load.

METERING: In a co-generation environment, when current level is above the Reverse Current Sense Threshold in the forward direction, metering will be recorded for forward current flow. When current flow is below the Reverse Current Sense Threshold in the forward direction, the control will use a test tap strategy and sample changes in voltage to determine a true current flow direction. Metering will be recorded for the current direction last determined by the sampling mechanism to be correct. See **Figure 36**.

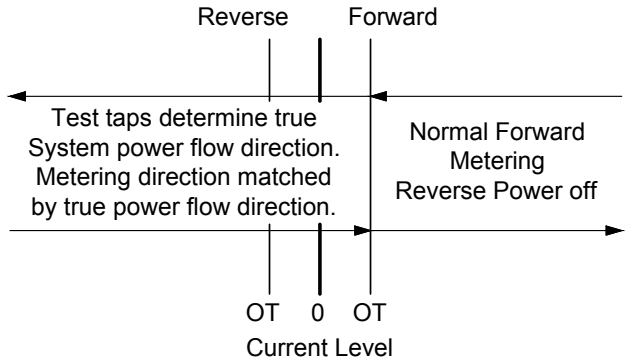


Figure 36. Bias co-generation metering

OPERATION: When the control is set for Bias Co-Generation, if the current flow exceeds the Reverse Current Sense Threshold in the forward direction, the control will regulate voltage as normal for forward current flow. If the current flow drops below the Reverse Current Sense Threshold, the control must determine current direction. To do this, it will use a test tap strategy similar to the Bias Bi-directional mode. The control will utilize two quick test taps and sample changes in voltage. The current flow direction will be indicated by the direction of voltage change seen during the test taps.

If the test tapping and sampling determines a reverse power flow is due to co-generation, the control will perform forward voltage regulation using reverse settings for set voltage (FC 51), bandwidth (FC 52), time delay (FC 53), and line drop compensation (FC 54 and FC 55). If the test tapping and sampling determines that a true current reversal has occurred, the control will begin to operate in an alternate bias co-gen mode as selected by the user. The alternate bias co-gen modes are 1) Locked Reverse, 2) Neutral Idle , and 3) Reverse Co-generation. In this case, it will also use the basic reverse power settings (FC 51 - FC 55). See **Figure 37**.

Because reverse power through the regulator is possible in a co-generation scenario without a true current flow reversal, the control must continue to use the test tap and sampling strategy to determine current flow whenever the current flow in the forward direction is below the Reverse Current Sense Threshold.

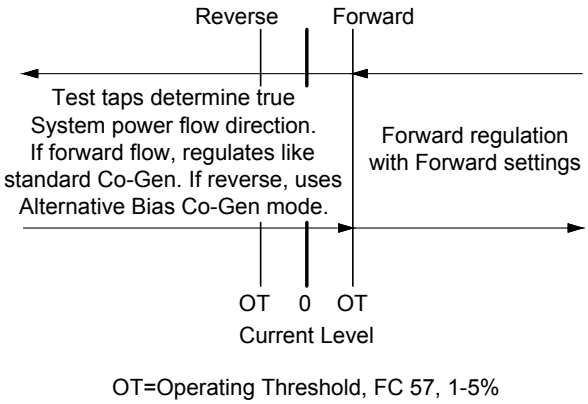


Figure 37. Bias co-generation operation

Reverse Co-generation mode

The stand-alone use of the Reverse Co-generation mode is intended for applications where normal voltage regulation is occurring in the reverse direction (on the source bushing side of the voltage regulator), distributed generation is also present on the source-bushing side of the voltage regulator, and forward power flow as a result of feeder switching is not possible. When the control is set for Reverse Co-generation, a source-bushing voltage, either measured or calculated, is required. See **Figure 38**.

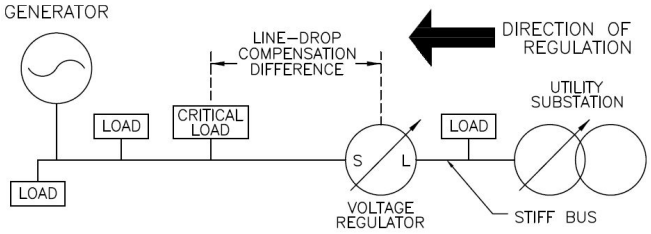


Figure 38. Reverse co-generation regulation points

This mode of operation can also be used in conjunction with the Bias Co-generation mode as a Bias Co-Gen Alt Mode. In this use, the control is able to properly respond to co-generation facilities on both side of a regulator installed on a loop-configured system where power flow can be reversed due to feeder switching.

METERING: See **Figure 39**. Always regulates in the reverse direction except that load center voltage is calculated based upon the forward line-drop compensation settings (FC 4 and FC 5) when the fixed 1% forward metering threshold is exceeded. The reverse power indicator turns off when the forward metering threshold is exceeded. The reverse line-drop compensation settings (FC 54 and FC 55) are used when the current exceeds the fixed 1% reverse metering threshold. The demand values acquired during forward power flow are stored as forward metered data, but the values are not scaled (to reflect the other side of the regulator) since the direction of voltage regulation never truly reverses to the forward direction.

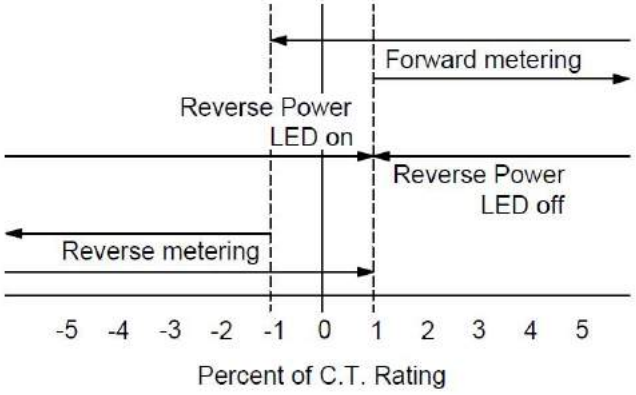


Figure 39. Reverse co-generation metering

OPERATION: See **Figure 40**. The control always regulates voltage in the reverse direction. The control will use the reverse settings for set voltage (FC 52), bandwidth (FC 52), time delay (FC53) and line-drop compensation (FC 54 and FC 55) when the real component of the current is beyond 1% fixed reverse metering threshold, but will use the forward settings (FC 1, FC 2, FC3, FC 4, and FC5) when the real component of the current is beyond the fixed 1% forward metering threshold. As the current transitions between reverse and forward, the settings used will transition as shown in **Figure 40**.

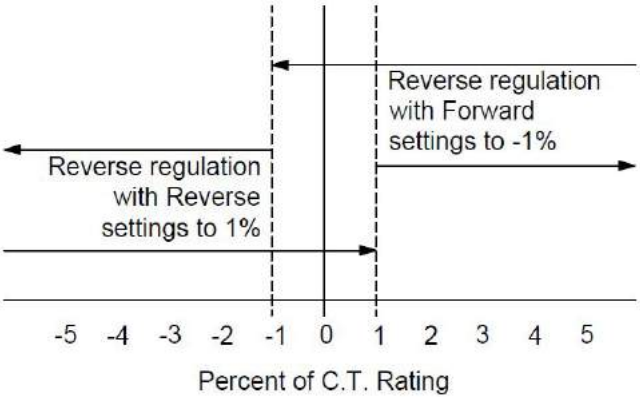


Figure 40. Reverse co-generation operation

Multi-phase voltage regulation

The CL-7 voltage regulator control is capable of controlling up to three (3) voltage regulators with the use of a single control. In order to function in a multi-phase configuration, the control must be equipped with a multi-phase module attached to the bottom of the base control. It must also be installed into a control box configured with a back panel and connections for multiple voltage regulators.

Figure 41. Multi-phase module with control switches, a neutral light, motor fuse and terminals for connected second and third regulators

Multi-phase parameters

Once the control and control box are configured, the multi-phase functionality is turned on using FC 200. Other multi-phase settings are required to designate the mode of operation (FC201), the number connected regulators (FC 202) and designation of a lead regulator (FC 203).

The Multi-phase Mode selection designates how the control will operate the regulators with respect to each other. The settings include:

- Independent – Connected units regulate voltage independently of each other;
- Lead Phase Regulation – Similar to Leader/Follower, the lead regulator determines the tap position for all phases based on conditions on the lead phase;
- Voltage Averaging – All regulators are gang operated and on the same tap position with the control regulating based upon the average load voltage of all connected regulators;
- Max Deviation – All connected regulators regulate independently, but within a sliding window of a maximum deviation of tap positions.
- Advanced Independent - Connected units regulate independent of each other and are also able to operate using individual settings values for Set Voltage, Bandwidth, Time Delay and Line Drop Compensation.

See document *MZ225003EN, CL-7 Multi-phase Control Reference* for detailed information on the multi-phase definitions and settings. Also see document *MN225015EN, CL-7 Regulator Control ProView NXG Software Programming Guide* for additional multi-phase operational and setup information.

Multi-phase control display

The CL-7 control is able to cycle through displays for settings and metering information. When in the multi-phase mode of operation, the LEDs number 1, 2 and 3 are used to designate which regulator information is being displayed on the LCD screen and status LEDs.

Figure 42. Multi-phase LEDs designate the regulator active on the display

Pressing the right arrow button will cycle through the displays for each connected regulator.

When in the multi-phase mode, after the LCD display goes into the power-save mode by powering down, the status LEDs on the control will automatically cycle through to display the status of all connected regulators. The setting for the cycle time is set at FC 211.

Multi-phase regulation settings

When the control is operating in the multi-phase mode, there are a number of settings that are considered to be control settings and still others that are specific to each connected voltage regulator and are considered to be *regulator settings*.

The *control settings* include the following:

- FC 1 to FC 5 and FC 51 to FC 55 – Forward and Reverse Direction Settings (when not in Advance Independent multi-phase mode)
- FC 40 – Control Identification
- FC 42 – Control Operating Mode
- FC 43 – System Line Voltage
- FC 46 – Demand Time Interval
- FC 148 – Nominal Sec Load Voltage
- FC 56 – Reverse Power Mode
- FC 80 – Voltage Limiter and other associated Voltage Limiter function codes
- FC 70 – Voltage Reduction Mode and other associated Voltage Reduction function codes
- FC 170 – Tap To Neutral
- FC 171 – Tap To Target
- FC 79 – Soft ADD-AMP and other associated other Soft ADD-AMP function codes

The *regulator settings* are set individually for each regulator. When entering the settings, scroll through the display for each regulator by pressing the right arrow key. The multi-phase LED with cycle through as the arrow is pressed and will indicate which regulator is active for each specific control parameter.

The regulator settings include:

- FC 1 to FC 5 and FC 51 to FC 55 – Forward and Reverse Direction Settings (when in Advance Independent multi-phase mode)
- FC 140 – Regulator Type
- FC 49 – Tap Changer Type
- FC 41 – Regulator Configuration
- FC 44 – Overall PT Ratio
- FC 44 – Internal PT Ratio
- FC 45 – CT Primary Rating
- FC 45 – Rated Load Current
- FC 45 – % C.T. Rating Level 4
- FC 45 – % C.T. Rating Level 3
- FC 45 – % C.T. Rating Level 2
- FC 45 – % C.T. Rating Level 1
- FC 144 – P.I. ADD-AMP High Limit
- FC 145 – P.I. ADD-AMP Low Limit
- FC 146 – Vin PT Configuration
- FC 141 – Regulator Identification
- FC 39 – Source Voltage Calculation

Auto tap dead phase

An advantage of using the multi-phase control is the Auto Tap Dead Phase feature. This feature enables the operation of the voltage regulator on a dead phase. When power is lost to one phase, power from the other phases can be used to operate the regulator on the dead phase. Enabling this option can be done either on the control HMI using FC 220 through FC 222 or using ProView NXG software.

The Auto Tap Dead Phase options are Tap To Neutral and Ganged Mode. The Tap To Neutral option will tap the dead phase regulator to the neutral position until power is restored. The Ganged Mode will gang operate the regulators, keeping them on the same tap position until power is restored. There is also a delay timer that will delay the operation of the dead phase for a user defined period of time.

DeltaCalc feature

The CL-7 Multi-Phase (MP) control opens up new applications unavailable with individual single-phase controls. The single control now has access to the metering and phasor information from all connected voltage regulators. This measured data can be used to calculate metering values unavailable on single-phase connected controls, without the addition of external metering transformers.

DeltaCalc settings

The DeltaCalc settings are accessible using the control HMI or through ProView NXG software. Since DeltaCalc is available only on the CL-7 MP control, the settings are associated with the other control multi-phase settings. Through the control HMI, FC 212 is used to select the DeltaCalc Mode. When the DeltaCalc feature is enabled, the control will determine whether the control is connected to an open or closed delta configured system based upon the number of VRs Configured (FC 202) and the System Configuration setting (FC 41). There are three options for the DeltaCalc parameter (Off, Basic, and Advanced), which are explained below.

DeltaCalc settings for open delta

For open delta configured systems, the DeltaCalc setting parameter of **Off** will result in traditional independent regulation of phases A and C without consideration of phase B voltages. The parameter settings of **Basic** and **Advanced** both result in the same voltage regulator operations as described in the next section.

Open delta voltage regulation

As an example, **Figure 43** shows the connection of two Type B voltage regulators connected in an open delta configuration. Similar operations as described here will also occur when DeltaCalc is applied to Type A regulators. It is clear in the figure that voltages are known between phase A and phase B. The voltages are also known between phase C and phase B. The load voltages are measured using control windings (S2 to G); the source voltages are determined with the addition of measured voltages between S4 and G or a source voltage calculation.

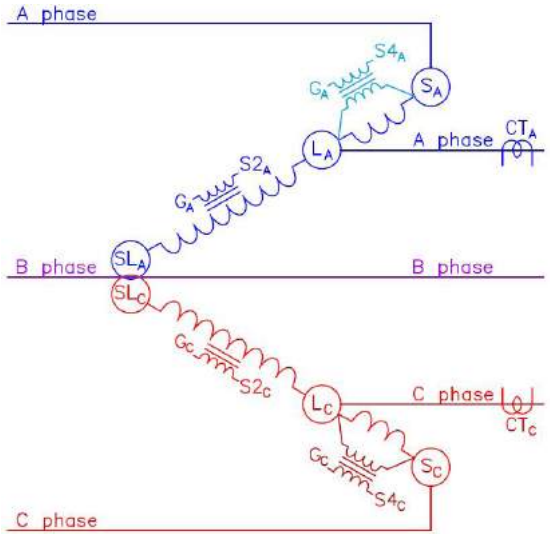


Figure 43. Two type B regulator connected in an open-delta

What would not traditionally be known when regulators are connected in open delta is the voltages between phases A and C. The DeltaCalc feature uses the known values and phasor math to calculate the phase A to C voltage. With this information, the control will make decisions about operating the voltage regulators to regulate the A to C voltage.

When a determination has been made that regulation is needed for A to C, the control will determine which connected voltage regulator is best able to affect regulation. The operation will then occur on one of the voltage regulators to bring the A to C voltage back into band. The MP control settings for VR3 (set voltage, bandwidth, time delay, LDC resistance, and LDC reactance) will be used for A to C regulation.

Open delta load amps

With the open-delta systems there has been no method of measuring the load current of the open phase. Using the DeltaCalc feature, the open phase load current is calculated based upon the known measured values of the adjacent phases.

Close delta voltage regulation

Figure 44 shows the connection of two Type B voltage regulators connected in a closed delta configuration. This figure is being used to illustrate how the DeltaCalc feature operates when applied to voltage regulators connected in a closed delta configuration. Similar operations as described here will also occur when DeltaCalc is applied to Type A regulators.

For closed delta connected regulators, without the DeltaCalc feature, reverse power regulation has presented a problem. **Figure 44** illustrates the problem. It can be seen in the figure that reverse regulation requires the control to have knowledge of the voltages between the adjacent S

bushings. For example, to regulate the voltage between phase A and phase C, the phase A regulator would have to have knowledge of the voltage between the SA and SC bushings. Before the MP control was available, the only method of obtaining this voltage would be to use a potential transformer positioned between the source bushings on the two adjacent voltage regulators.

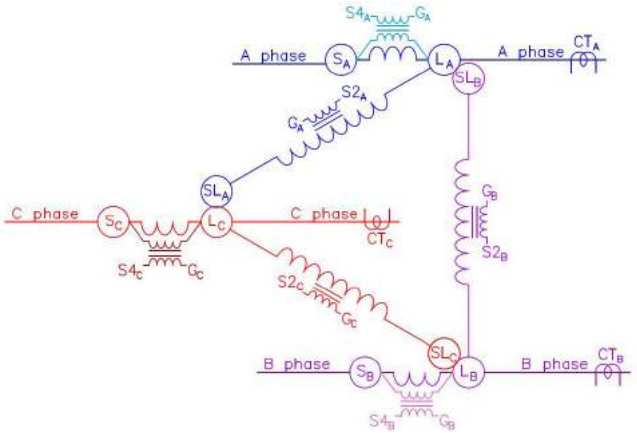


Figure 44. Three type B regulators connected in a closed-delta

Because the MP control is connected to all three regulators in the close delta arrangement, all data is known and available to the one control. Using the DeltaCalc feature, the control can now do accurate regulation for delta connected voltage regulators when power flow is in reverse.

DeltaCalc settings for closed delta

When using DeltaCalc with closed delta configured regulators, the three settings options available are **Off**, **Basic**, and **Advanced**. The **Off** setting will result in traditional closed delta voltage regulation for the three phases.

The **Basic** setting option enables the DeltaCalc feature to determine and use voltage information from adjacent voltage regulators to effectively perform voltage regulation in the reverse direction. For regulation in the forward direction, there is no difference between **Off** and the **Basic** DeltaCalc settings.

In addition to the functions performed in the **Basic** DeltaCalc operation, the **Advanced** setting enables the control to determine the best method of affecting regulation between the three phases for forward and reverse power operations. The control will analyze the out-of-band conditions between all phases and determine how to best operate the regulators to bring the voltages between all three phases back into band with the fewest number of tap-changer operations. Without the DeltaCalc feature, in-band stability will usually take a few extra operations as the control of a particular phase may be forced to respond to an out-of-band condition created by the operation of a regulator on an adjacent phase. The DeltaCalc feature will eliminate some of the back-and-forth tapping operations required to find stable in-band voltages between all three phases.

Voltage limiter

The voltage limiter feature is used to place both a high and low limit on the output voltage of the regulator. When enabled, it operates in either the forward or reverse directions and has one of the highest priorities of all operating functions. Voltage limiter is overridden only when Auto Operation Blocking Status (FC 69) is set to Blocked, when an operator takes local control or through an inter-connected SCADA system. When the voltage limiter IVVC (integrated volt/var control) settings are used, voltage limiter also takes priority over remote SCADA tapping operations. The purpose of the voltage limiter is to protect the consumer from abnormally high or low voltages resulting from:

- Large, rapid changes in transmission voltage
- Abnormal loading of the feeder
- Inaccurate regulator control settings (voltage level, bandwidth, and line-drop compensation)
- Heavy loading by the first customer while there is a leading power factor on the feeder
- Light loading at the first customer with heavy loading on the feeder at the same time

The appropriate high and low limits for the output voltage can be programmed into the control at FC 81 and FC 82, respectively. The feature is then activated by accessing FC 80 and entering the desired operation: Off; High Limit Only; High/Low Limits; IVVC High Limit Only; or IVVC High/Low Limits. If low-voltage limiting only is desired, FC 80 should be set for both high and low limiting and an extreme value programmed into FC 81 for the high limit (e.g.135) to prevent the high limit from activating.

As mentioned earlier, when one of the IVVC voltage limiter settings are selected at FC 80, the voltage limiter settings in the control take priority over SCADA controlled motor operations. IVVC software typically has the ability to enforce voltage limits, but this is not always the case. When IVVC software is not able to impose voltage limiter limits, these setting will impose the limits through the control.

The control has two response sensitivities and the response time for each sensitivity is configurable. If the output voltage exceeds either the high or low limit by 3 V or more, the control samples the voltage for the period time specified at FC 83 and then taps immediately to bring the voltage to the limit value. If the output voltage exceeds either the high or low limit by less than 3 V, the control samples the voltage for the period specified at FC 84 and then taps to bring the voltage to the limit value. The control uses the sequential method of tapping, with a time delay between the completion of one tapping operation and the beginning of the next set at FC 85, when bringing the voltage back to the limit value. Voltage Limiter High and Voltage Limiter Low LEDs on the front panel illuminate to indicate when either limit is active.

To avoid potential cycling of the regulator, set the high-and low-voltage limits at lest two volts above and below the upper and lower bandwidth limits. This will establish a "grey zone" between the high-and low-voltage limits and the

upper and lower band edges. When the output voltage is within this "grey zone", the control will not perform any tap changes the would take the output voltage over the limit. If the voltage is directly on the inner edge of the grey zone, the control will allow one tap change to permit the voltage to enter the grey zone by as much as 0.7 V.

Voltage reduction

An ideal application for system load management is at the distribution voltage regulator. Voltage reduction capabilities within the regulator control permit it to trigger the regulator to reduce voltage during situations where power demands surpass the available capacity and where there are extraordinary peak loads. The control offers three modes of voltage reduction: Local/Digital Remote, analog Remote/Latch, and analog Remote/Pulse. All modes operate for forward or reverse power flow conditions. For further information on the Local/Digital Remote mode, see below. Remote/Latch and Remote/Pulse are discussed in the **Analog SCADA** section starting later in this section.

All voltage reduction modes work by calculating an effective set voltage as follows:

Effective Set Voltage = Set Voltage x [1- (% reduction)]

Example: If the set voltage = 123 V and voltage reduction of 4.6% is active, the regulator will regulate the compensated voltage to 117.3 V, that is, tap down 5.7 V.

While any mode of voltage reduction is in effect, the Voltage Reduction indicator LED on the front panel will be illuminated. Voltage reduction occurs after a time out, as established by the time delay, FC 3 or FC 53, and the Control Operating Mode, FC 42. The percent reduction in effect is displayed at FC 71.

Local/digital remote mode

Voltage reduction can be performed by selecting the Local/Digital Remote mode of operation at FC 70 and then entering into FC 72 the amount of reduction required as a percentage of the set voltage. To turn voltage reduction off, set FC 70 to "Off" or set FC 72 to 0%. The settings may be changed at the front panel (Local) or through digital SCADA (Digital) to achieve the desired voltage reduction.

Soft ADD-AMP feature

This feature (FC 79) allows the user to set the regulator for the Soft ADD-AMP feature locally at the control as well as remotely through SCADA. The Soft ADD-AMP limits can be overridden by a local operator running the tap-changer in manual mode of operation. This is not the case for the "hard" ADD-AMP limit switches on the position indicator face. The Soft ADD-AMP feature can be overridden via digital SCADA if the ADD-AMP mode is set to Remote Override.

In addition to using to the standard Soft ADD-AMP setting using FC 79, Configurable Logic Activate ADD-AMP is available as an advance control feature. It allows the control to sense system and voltage regulator conditions and turn on the Soft ADD-AMP feature in reaction to specified conditions. Configurable Logic Activate ADD-AMP is controlled by the configurable logic capabilities of the CL-7 control. Configurable logic is described in more detail in document *MN225015EN, CL-7 Regulator Control ProView NXG Software Programming Guide*.

Adaptive ADD-AMP

Adaptive ADD-AMP is a form of the Soft ADD-AMP feature that enables the control to automatically adapt to the load being experienced by the regulator and limit the range of regulation in response. When limiting the range of regulation, the control adapts the voltage regulator current rating to meet changing current demands. The control supports four configurable Adaptive ADD-AMP tap position levels. To enable the feature the following control settings are required:

1. Enter the 55 °C AWR current rating of the regulator at FC 45↓.
2. Enter the Adaptive ADD-AMP values at FC 45↓. The levels can be found in the lower right corner of the unit nameplate in the chart labeled "Limit Switch Settings on Position Indicator." The levels correspond to the nameplate information as follows:
   - 5 % corresponds to position limits of ±8.
   - 6-1/4 % corresponds to position limits of ±10.
   - 7-1/2 % corresponds to position limits of ±12.
   - 8-3/4 % corresponds to position limits of ±14.
3. Set FC 79 SOFT-ADD-AMP Limits to Adaptive.

Supervisory control and data acquisition (SCADA)

With its tap-changer, potential transformer, and current transformer, the regulator is a likely candidate for a Supervisory Control and Data Acquisition system where the utility needs to have centralized voltage control for peak shaving, energy conservation, or other purposes.

Regulators can be connected to Analog SCADA systems where the regulator is controlled by contact closure and the feedback is via a voltage transducer connected to the voltage sensing circuit of the regulator control. The CL-7 control has a number of features which allow it to function well on these types of systems. For details, see **Analog SCADA** in this section.

The CL-7 control is also capable of real-time digital two-way communication. For details, see **Digital SCADA** in this section.

The control is also well suited to the user who does not have a SCADA system but does have a need for detailed information about the bus or feeder loading. For details, see **Data retrieval and settings uploading**.

Data retrieval and settings uploading

The CL-7 control is equipped with a USB (type B) PC data port. It allows for temporary connection to a PC. Using ProView NXG software, the connection allows the user to reset all metering and tap position maximum and minimum

values, upload settings which are specific to the control I.D. number, and view data. The entire control database may be downloaded.

Analysis of the data allows the user to verify the control settings and analyze the conditions of the feeder as follows:

- At the moment of the downloading (instantaneous metering)
- Maximum and minimum demand values since last reset (time-tagged demand metering)
- The profile of salient parameters (profile recorder)

For more information on connecting to the control and use of ProView NXG software, see document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide*.

Data retrieval and settings uploading can also be performed using a USB memory device and various associated function codes. See **Section 7: Advanced Control Features: USB memory device**.

Digital SCADA

Refer to **Section 7: Advanced Control Features: Communications** and document *MN225021EN, CL-7 Regulator Control Communications* for information on communications and physical interface.

Local operator security

Through the communications channel, the SCADA master may read the CL-7 control data points, write to certain data points, or reset certain data points. The technique of writing to a data point is used for performing operations such as changing settings like Set Voltage or Reverse Power Mode, inhibiting automatic operation, or controlling the tap-changer motor, etc. Following is a discussion of the levels of security used to protect the local operator.

Supervisory switch

The CL-7 control is equipped with a Supervisory Off switch. When this switch is not in the off condition (the switch LED is not illuminated), SCADA may perform the normal read, write, and reset activity. When the switch is in the off condition (the switch LED is illuminated), SCADA may only read the database. This affords protection to the local operator at the front panel, while allowing the system operator to maintain surveillance.

Control switch

If the local operator switches the CONTROL FUNCTION switch to either OFF or LOCAL MANUAL, the control internal circuitry prohibits SCADA from controlling the tap-changer motor. Resets and other writes are allowed.

Active control security level

If the local operator changes the control active security level to Operate level or above, or security override is set to override the Operate level or higher, this does not inhibit any SCADA activity. To inhibit SCADA writes and resets, the local operator should turn the Supervisory switch to Off.

Note: A local operator wishing to check automatic operation should check to make sure that the Blocking Status, FC 69, is set to Normal.

Note: Changes to any of the communications parameters take effect immediately.

Analog SCADA

The CL-7 control can be used with Analog SCADA systems. Three general purpose inputs accessed on the control connection terminal board have been programmed by default for use as inputs for voltage reduction, Tap-to-Neutral, and auto-tap blocking. Most back-panel configurations also have provisions for remote motor control and transducer connections.

Discrete voltage reduction

During voltage reduction, the control remains in the automatic mode. Standard, fixed configuration logic programmed into the control assigns General Purpose Input 1 (GPI 1) to be voltage reduction point 1. See **Figure 26** and **Figure 27** for the location of the physical connections. This point can be used as point 1 for the Remote/Latch mode of voltage reduction or as the single pulse point for the Remote/Pulse mode of voltage reduction. If a voltage reduction point 2 is desired for Remote/Latch or Remote/Pulse, GPI 2 or GPI 3 can be reassigned or an auxiliary I/O module can be added and a point assigned. A nominal 120 Vac must be supplied to the GPI point(s) to enable analog voltage reduction. For information on configurable Logic, reassignment of GPI points and assignment of auxiliary I/O points to voltage reduction, see document *MN225015EN, CL-7 Regulator Control ProView NXG Software Programming Guide*.

If dry contacts are to be used for analog voltage reduction, the voltage should be obtained at terminal V9 on the terminal board, an example connection is shown in **Figure 26**. This whetting voltage is only available when the control switch is in the Auto/Remote position. If whet contacts are used, the connections should be as shown in **Figure 27**.

The terminal board contacts assigned as GPIs are:

- GPI 1 is assigned to contact point 5.
- GPI 2 is assigned to contact point J.
- GPI 3 is assigned to contact point BR.

Analog remote/latching mode

This feature is set at FC 70. Up to three independent values of voltage reduction are possible. Levels 1, 2, and 3 are programmed at FC 73, FC 74, and FC 75, respectively. Voltage Reduction input 1 activates the voltage reduction programmed at FC 73; Voltage Reduction input 2 activates the voltage reduction programmed at FC 74; and latching both contacts activates the voltage reduction programmed at FC 75. Each of these function codes may be set from 0.1 to 10.0%. Read the section on **Discrete voltage reduction** above for information on the voltage reduction contact points.

Analog remote/pulse mode

This feature is set at FC 70. Voltage Reduction Point 1 is described in the **Discrete voltage reduction** section. The contact is pulsed (momentarily closed) rather than latched closed to activate this feature. Each closure and waiting period between closures is expected to be at least 0.25 seconds in duration.

The number of steps of pulsed reduction, up to 10, is programmed at FC 76. The percent reduction per step is programmed at FC 77. The present voltage reduction step is display at FC 78. Starting at zero percent reduction, every time Voltage Reduction Point 1 is pulsed, one step of reduction is added to the accumulated total. Pulsing to one step higher than the programmed number of steps returns the voltage reduction to zero. If Voltage Reduction Point 2 is assigned to one of the other GPI points or and auxiliary contact point, a pulse to that point returns voltage reduction immediately to zero.

EXAMPLE: If the number of steps is 3 and the percent per step is 1.5%, four successive pulses of voltage reduction will cause the following percentages of reduction: 1.5, 3.0, 4.5, and 0.

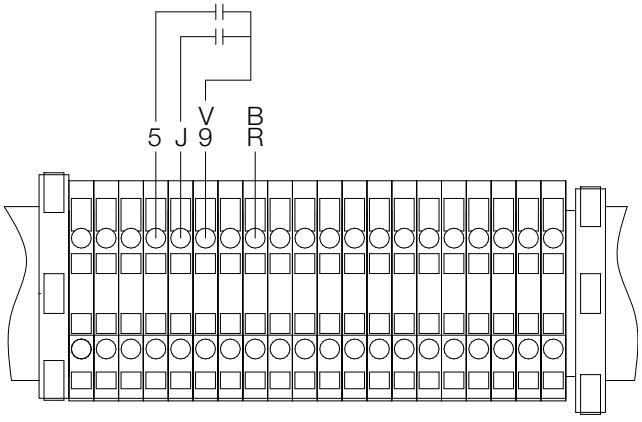


Figure 45. Dry contact connections for remote latching and pulse mode with Voltage Reduction Point 2 reassigned to GPI 2

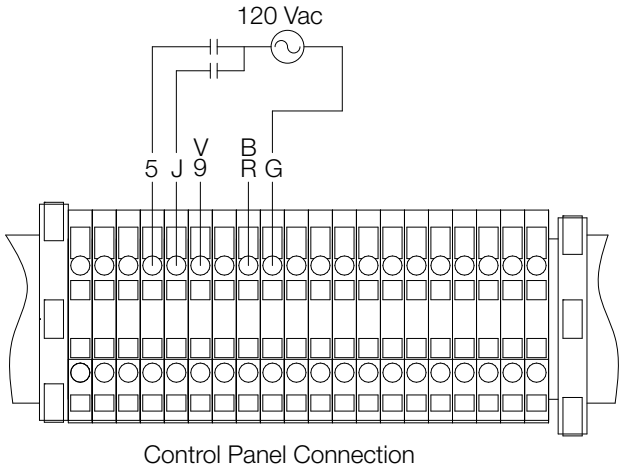


Figure 46. Whet contact connections for remote latching and pulse modes with Voltage Reduction Point 2 reassigned to GPI 2

Tap-to-Neutral

The Tap To Neutral Feature enables a user to tap a voltage regulator to neutral and then maintain that position for as long as desired. During this time, auto operation will be blocked. To utilize the Tap To Neutral feature, two elements are required.

The first required element is to enable Tap To Neutral. Enabling can be done by setting FC 170 on the control to On or by checking a Tap To Neutral box in ProView NXG. The second element required for Tap To Neutral is activation. Tap To Neutral is activated using either an analog input or digital SCADA data point.

As a default, GPI 2 (the J terminal on the control back panel) is used as the analog input to active the feature. Using a relay to close in 120 Vac or ground to the terminal will activate Tap To Neutral.

The digital SCADA point **Configurable Logic Output From SCADA Tap to Neutral Activate** can also be used to activate Tap To Neutral. This digital SCADA point can be found in the default CL-7 DNP map as binary output point 38 (BO-38). In the CL-7 MODBUS default map, the point can be found in Binary Input Registers point 21 (BI-21).

Tap-To-Target

Tap To Target is similar to Tap To Neutral except that with Tap To Target a regulator can be tapped to and held at any tap position until the feature is deactivated. As with Tap To Neutral, the feature must first be enabled and then activated. A third element is also require for Tap To Target and that is the target tap position.

Enabling Tap To Target can be done by setting FC 171 on the control to On or by checking a Tap To Target box in ProView NXG. Tap To Target can be activated using either an analog input or digital SCADA data point, or using configurable logic. The third element, target tap position, can be programmed using FC 172 or entered in the Tap To Neutral dialog box in ProView NXG.

As a default, there are no analog inputs assigned to activate the Tap To Target. An analog input can be assigned using configurable logic in ProView NXG. Assigning one of the General Purpose Inputs, GPI 1, GPI 2, or GPI 3 would provide a means to activate the feature by applying either 120 Vac or grounding the terminal board points on the back panel. The terminal board points are assigned as follows:

- GPI 1 is assigned to terminal 5
- GPI 2 is assigned to terminal J
- GPI 3 is assigned to terminal BR

Making an alternate assignment to a GPI terminal will deactivate its default fixed functionality.

To activate the feature using digital SCADA, use the data point **Configurable Logic Output From SCADA Tap to Target Activate**.

Remote motor control and auto-tap blocking

Standard, fixed configuration logic programmed into the control assigns General Purpose Input 3 (GPI 3) to be the input point for the External Auto Block Active output. Supplying 120 Vac to the point will inhibit auto-operation tapping until it is removed. When the motor is controlled remotely, it is necessary to inhibit automatic operation. As with the analog input points for voltage reduction, a whetting voltage from contact point V9 or a 120 Vac whet contact can be used to activate the auto-tap blocking feature.

Note: GPI 3 is assigned to contact point BR as a default.

To remotely raise or lower the tap-changer, the appropriate set of contacts are momentarily closed. Interposing relays can be used, such that raise and lower contact closure cannot occur simultaneously. See **Figure 41** for recommended connections on a standard back panel with the TB3 terminal board at the bottom of the control cabinet.

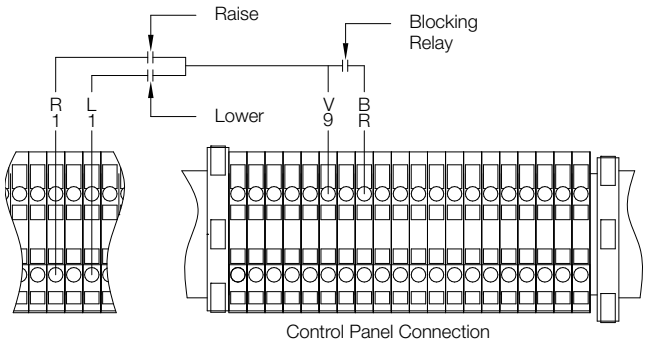


Figure 47. Auto-tap blocking and remote motor control connections shown on the standard back panel with a TB3 terminal board

Alternate configuration

The CL-7 control panel typically operates with one set of configuration settings that are programmed or changed through the keypad or one of the available communications channels using ProView NXG software. Alternate Configuration modes allow the CL-7 control to be programmed with three additional sets of configuration settings that can then be activated at FC 450. Which Alternate Configuration is active can be selected at FC 452. The Alternate Configuration state can be monitored at FC 451 and will display Alt Config 1 Active, Alt Config 2 Active, Alt Config 3 Active, ARLC Active or ALRH Active.

When an Alternate Configuration mode is activated using FC 450, a set of alternate configuration settings will become active and will be used as the basis for the operation of the control. The control parameters included in the set of Alternate Configuration settings can be seen in **Table 9** in the control menu **Features > Alternate Config**.

Alternate Configuration settings can be entered using two methods: 1) Set the individual Alternate Configuration settings using the control HMI (see **Table 10** for a list of applicable function codes). 2) Using ProView NXG software, enter the Alternate Configuration settings in the Alternate Configuration Setting dialog box and load the settings using one of the communications channels.

When the control is in the Alternate Configuration mode, the display for each of the affected control parameters will display the statement "(ALT CONFIG X)" at the bottom where X is the number of the active Alternate Configuration set. This will indicate that the alternate configuration setting is active and in use for control operation (see the example below).

```
001 Forward
  Set Voltage
    120.0 Volts
  (ALT CONFIG 1)
```

When the Metering-PLUS Comp Voltage button is pressed, it will display "Alt Config X Active" on the bottom line as shown in the example below.

```
Comp Voltage    120.0
Band      119.0-121.0
Using Func        1-5
Alt Config 1 Active
```

Auto-restore local (ARL)

Four additional functions enabled at FC 450 are Auto-Restore Local Heartbeat (ARLH), Auto-Restore Local Comms (ARLC), Enhanced ARLH, and Enhanced ARLC. When SCADA communications are being used to modify basic configuration settings, enabling Auto-Restore Local will allow the control to revert control settings modified through SCADA communications back to the original settings programmed into the control. With ARLH, the settings will revert when a heartbeat signal is lost or discontinued. For ARLC, the settings will revert when a communications signal is lost. The settings that are affected by ARL are the same as those listed for Alternate Configurations.

The difference between the ARL and Enhanced ARL has to do with the data points written to when performing SCADA control. For ARL, the data points written to are those used for the standard settings. For Enhanced ARL, SCADA will write to the Alt Configuration 1 data points.

When an ARL function is active, Alternate Config State (FC 451) will display either ARLH Active, ARLC Active, Enhanced ARLH Active, or Enhanced ARLH Active.

For more information on setting up ARL with SCADA communications, contact your Eaton representative.

Configurable logic

Alternate Configurations settings can be enabled using Configurable Logic. To enable Alternate Configuration settings using Configurable Logic, the Alternate Configuration setting (FC 450) must be set to Config Logic. Equations must then be created using ProView NXG software which program the conditions under which Alternate Configuration settings will become active. When Alternate Configuration settings are active due to Configurable Logic, the status at FC 451 will display Alt Config 1 Active, Alt Config 2 Active or Alt Config 3 Active.

For more information on enabling Alternate Configuration settings using Configurable Logic, refer to document *MN225015EN, CL-7 Regulator Control ProView NXG Software Programming Guide* or contact your Eaton representative.

Transducer connections

To monitor the load voltage (forward direction), a transducer, nominal 120 Vac input, may be connected as follows: Connect the transducer hot lead to terminal V4 and its ground lead to a G terminal. A current transducer, 200 mA input, may be connected on the standard short back panel as follows: Close knife switch C; remove the jumper between C2 and C3; connect the transducer hot lead to C2 and its ground lead to C3; and open knife switch C. For a terminal connection schematic, see **Figure 66**.

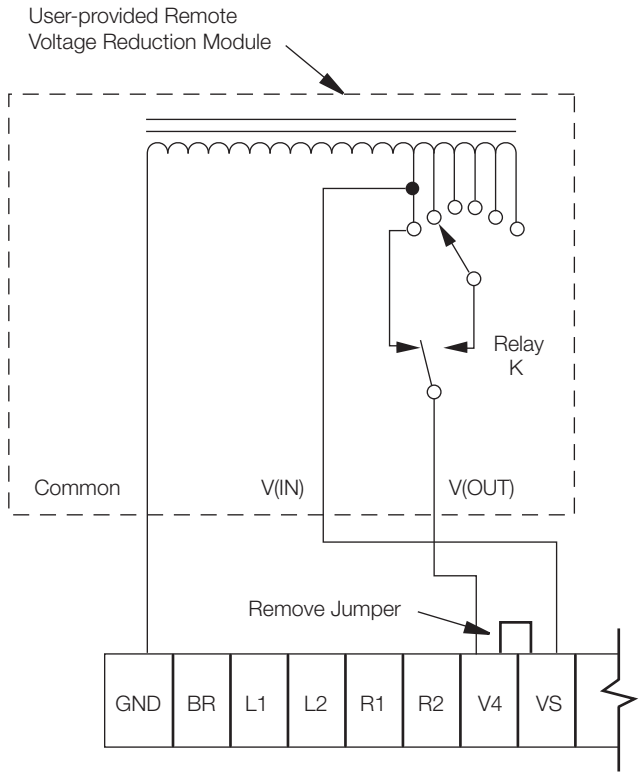


Figure 48. Typical user provided "Fooler Voltage" module

Fooler voltage scheme

Using this method, the voltage sensed by the control is raised, thereby "fooling" the control into reducing the voltage during its normal automatic operation. This method can be used with the CL-7 controls. A VR module, as shown in **Figure 42**, is usually supplied by the Remote Terminal Unit (RTU) manufacturer. The VR module is usually a tapped auto-transformer with a pulse-activated indexing relay. When connected to the control back panel as shown, the voltage sensed by the control is raised as the module is pulsed to higher taps.

Since this method keeps the control in automatic operation, Auto-Inhibiting is not used. An advantage of this method is that it can be applied to many different models of controls from many manufacturers. A disadvantage of this method is that while VR is activated, the measured load voltage is incorrect, as are all other calculated metering values which use the load voltage. To avoid the effects of metering inaccuracy, the Pulse Mode of VR should be used.

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Section 7: Advanced control features

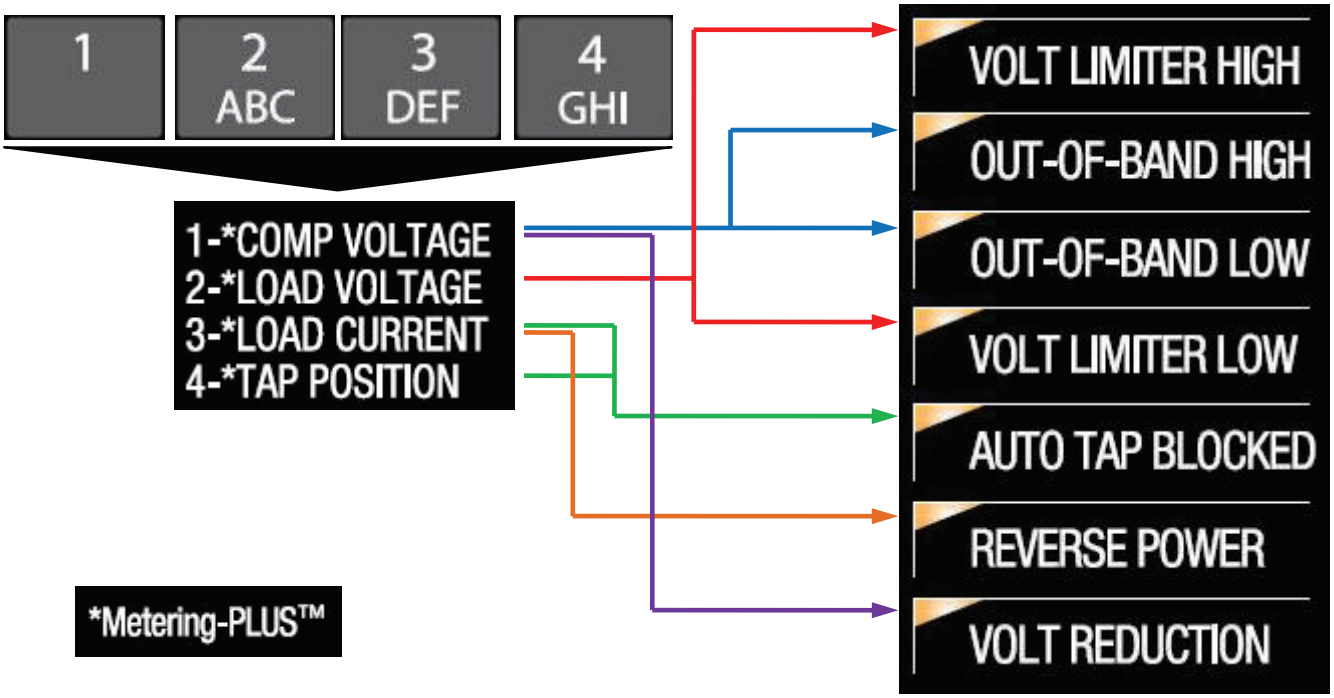


Figure 49. Operation analysis using Metering-PLUS feature

Metering-PLUS feature

The Metering-PLUS feature was designed to allow immediate access to basic control information. On the CL-7 control, the keypad can be configured to assign Hot-Key access to the Metering-PLUS displays. The Hot-Key assignments are shown on the right side of the control. As a default, the CL-7 control is programmed with the Metering-PLUS Comp Voltage, Load Voltage, Load Current and Tap Position screens being assigned as hot-keys to key numbers 1 through 4 respectively.

Compensated voltage

When the ***Comp Voltage** key is pressed, the LCD will display the following information.

The first line displays a live representation of the compensated voltage. The compensated voltage is also available at FC 8.

The second line is used to display the in-band compensated voltage range. The voltage range is dependent on four separate parameters: operating mode, metering power direction, set voltage, and bandwidth in the corresponding metering power direction.

The third line specifies the range of configurable function codes that are used to compute the in-band compensated voltage range and the corresponding time delay.

The Out-of-Band High and Out-of-Band Low LEDs are used to indicate an out-of-band condition.

EXAMPLE 1:

```
Comp Voltage    125.0
Band      119.0-121.0
Using Func        1-5
```

- Compensated Voltage = 125.0 V
- Fwd. Set Voltage = 120.0 V
- Fwd. Bandwidth = 2.0 V
- Control experiencing forward power flow as indicated by reference to FC 1-5.

EXAMPLE 2:

```
Comp Voltage    115.0
Band      108.0-112.0
Using Func      51-55
```

- Compensated Voltage = 115.0
- Rev. Set Voltage = 110.0 V
- Rev. Bandwidth = 4.0 V
- Control experiencing reverse power flow as indicated by reference to FC 51-55

Load voltage

When the ***Load Voltage** key is pressed, the LCD will display the following information:

The first line displays a live representation of the load voltage. The load voltage is also available at FC 6.

The second line displays the voltage limits to be applied by the Voltage-Limiting feature (see **Section 6: Control Features: Voltage limiter**). If a voltage range is displayed, a high and low limit is enabled. A single value implies that only the high limit is active.

The Voltage Limiter High and Voltage Limiter Low LEDs are used to indicate the voltage limiter is active.

EXAMPLE 1:

```
Load Voltage    115.0
Limiter   119.0-121.0
```

- Load Voltage = 115.0 V
- Voltage-Limiting Mode = High and Low Limits Active
- High Voltage Limit = 121.0 V
- Low Voltage Limit = 119.0 V

EXAMPLE 2:

```
Load Voltage    115.0
Limiter         121.0
```

- Load Voltage = 115.0 V
- Voltage-Limiting Mode = Only High Limit Active
- High Voltage Limit = 121.0 V

EXAMPLE 3:

```
Load Voltage    115.0
Limiter Off
```

- Load Voltage = 115.0 V
- Voltage-Limiting Mode = Off

Load current

When the ***Load Current** key is pressed, the LCD will display the following information:

The first line displays a live representation of the load current. The load current is also available at FC 9. This line also includes an abbreviation of the power flow direction: "Fwd" corresponds to Forward, "Rev" corresponds to Reverse.

The second line displays the current threshold. This is the point below which the control enters an indeterminate current flow state. See **Section 6: Control Features: Reverse power operation** in this manual for more information on the current threshold. The current threshold is the product of the CT Primary Rating, and the Reverse Threshold percentage.

Table 11. Blocking condition priorities

Priority (1=Highest)	Automatic blocking condition when…	LCD display text (Line 4)
1	Control Function switch is in Off or Local Manual position.	Blocked: Cntrl Switch
2	In Voltage Averaging or Ganged Max Deviation Alt Mode in multi-phase (MP) applications for non-lead phase devices in Lead Phase Regulation.	Blocked: Multiphase
3	A loss of communication occurs for a control working under Max Deviation mode in Leader Follower (L/F) applications.	Blocked: LS Inactive
4	Tap position becomes invalid in certain modes of Leader Follower or Multi-phase applications.	Blocked: Invalid Tap
5	In L/F the designation setting does not match LoopShare Table Assignment setting.	Blocked: MaxDev Confg
6	In L/F for Follower Devices.	Blocked: L/F Follower
7	In L/F for Leader in Unable to Operate state.	Blocked: L/F UTO
8	In L/F for Leader in Inactive State.	Blocked: L/F Inactive
9	In initialization process in MP or L/F applications or when retry count is exhausted if device failed to tap in MP applications.	Blocked: Synching
10	In L/F and tap positions is being determined by the Max Deviation Alt Mode of Historical Tap Pos.	Blocked: Historical
11	Tap-to-Neutral is active.	Blocked: Tap-To-Neutr
12	Blocking is enabled through Configurable Logic or Communications.	Blocked: CL or Comm
13	FC 69 is set to Blocked using keypad, software or SCADA.	Blocked: Func Code 69
14	Reverse power when in Locked Forward mode or forward power when in Locked Reverse mode.	Blocked: Rev Pwr Mode

EXAMPLE: A 328 A regulator utilizing a CT with a 400 A primary rating and a 3% reverse threshold value would yield a 12 A current threshold.

The third line displays the operating mode: Locked Forward, Locked Reverse, Reverse Idle, Bi-directional, Neutral Idle, Co-generation, Reactive Bi-directional, Bias Bi-directional, Bias Co-generation, or Reverse Co-generation.

If automatic operation is blocked, the fourth line displays the blocking condition. If multiple blocking conditions exist, the blocking condition with the highest precedence will be displayed. Refer to **Table 11** for the blocking condition priority levels.

EXAMPLE 1:

```
Load Current  600 Fwd
Current Threshold  12
Mode   Locked Forward
Blocked:   CL or Comm
```

- Load Current = 600 A
- Forward Power Flow
- Threshold Current = 12 A
- Locked Forward operating mode
- Auto blocking due to configurable logic condition or SCADA communications

EXAMPLE 2:

```
Load Current  200 Rev
Current Threshold   2
Mode   Bi-directional
```

- Load Current = 200 A
- Reverse Power Flow
- Threshold Current = 2 A
- Bi-directional operating mode
- Automatic tapping is not block

Tap position

When the ***Tap Position** key is pressed, the LCD will display the following information:

The first line displays the present tap position. Neutral tap position is represented as a "0". Tap positions lower than zero are denoted with a negative sign; tap positions above zero do not carry a sign.

The second line is used to indicate when the tap-changer has reached a Soft ADD-AMP limit or a user-configured Position Indicator (P.I.) ADD-AMP limit. In Example 1, the second line is blank because the tap-changer is not at an ADD-AMP limit.

If the Soft ADD-AMP feature is enabled, the third line is used to display the corresponding Soft ADD-AMP limits.

The fourth line is used to display the physical P.I. ADD-AMP settings corresponding to the physical position indicator.

Note: Physical ADD-AMP always takes precedence over soft.

EXAMPLE 1:

```
Tap Position        8

SOFT-ADD-AMP  -12, 14
P.I. ADD-AMP  -14, 16
```

- Present tap position = 8 Raise
- Soft ADD-AMP feature = On
- Soft ADD-AMP feature lower tap limit = -12
- Soft ADD-AMP feature upper tap limit = 14
- P. I. ADD-AMP lower tap limit = -14
- P. I. ADD-AMP upper tap limit = 16

EXAMPLE 2:

```
Tap Position      -12
At Limit
SOFT-ADD-AMP  -12, 14
P.I. ADD-AMP  -14, 16
```

- Present tap position = 12 Lower
- Tap-Changer at ADD-AMP Limit
- Soft ADD-AMP feature = On
- Soft ADD-AMP feature lower tap limit = -12
- Soft ADD-AMP feature upper tap limit = 14
- P. I. ADD-AMP lower tap limit = -14
- P. I. ADD-AMP upper tap limit = 16

EXAMPLE 3:

```
Tap Position        0


P.I. ADD-AMP  -14, 16
```

- Present tap position = Neutral
- Soft ADD-AMP feature = Off
- P. I. ADD-AMP lower tap limit = -14
- P. I. ADD-AMP upper tap limit = 16

EXAMPLE 4:

```
Tap Position       14
At Limit
SOFT-ADD-AMP  -12, 14
P.I. ADD-AMP  -14, 14
```

- Present tap position = 14
- Tap-Changer at ADD-AMP Limit
- Soft ADD-AMP feature = On
- Soft ADD-AMP feature lower tap limit = -12
- Soft ADD-AMP feature upper tap limit = 14
- P. I. ADD-AMP lower tap limit = -14
- P. I. ADD-AMP upper tap limit = 14

Note: Both the Soft ADD-AMP feature and the physical ADD-AMP settings on the Position Indicator will prevent any further lower tap changes. This conclusion is based on the assumption that the P.I. ADD-AMP configuration settings, entered by the user, match the physical position indicator limit settings.

EXAMPLE 5:

```
Tap Position       15
At Limit

P.I. ADD-AMP  -14, 12
```

- Present tap position = 15
- Tap-Changer above ADD-AMP Limit
- Soft ADD-AMP feature = Off
- P. I. ADD-AMP lower tap limit = -14
- P. I. ADD-AMP upper tap limit = 12

Note: User-configured upper "P.I. ADD-AMP" tap limit **does not** match the upper physical tap limit setting on the Position Indicator. Assuming the present tap position is correct, the physical upper P.I. limit switch must be at position 16.

This condition may occur if the user-configured P.I. ADD-AMP limits do not match the physical location of the P.I. ADD-AMP limit switches. In this example, the regulator is at tap position 15, yet the user-configured upper P.I. ADD-AMP limit is 12. The control will advance the tap-changer beyond the user-configured P.I. ADD-AMP limit settings provided the actual mechanical P.I. limit switches do not prevent the operation. If the tap-changer is at, or beyond, either user-configured "P.I. ADD-AMP" limit, **At Limit** will appear on the second line.

Figure 50. A USB memory device in the data port

USB memory device

The CL-7 control has a USB Drive (type A) data port located in the front of the control. This port allows the operator to import settings into the control or to save settings and data from the control. Also, firmware upgrades can be loaded using a USB memory device. Firmware is the software resident in the control that provides processing algorithms and functionality to the hardware. Firmware upgrades are supplied by the factory periodically to add control features and improve functions.

USB memory devices are readily available; any USB memory device will work that is USB 2.0 compatible, is formatted with the FAT32 file system, and has at least 250 MB free space.

Using the USB memory device inserted into the Data Port, the operator has the ability to easily transfer information to and from the control. When the USB memory device is properly seated and ready for use, the green LED above the port will illuminate. To properly remove the device, use FC 953 and wait until the green LED goes out.

If a USB device is not inserted and one of the USB functions is accessed, an error message (USB NOT CONNECTED) will appear on the display.

USB memory drive functions

Save all data, FC 950

The Save All Data function saves all of the data within the control (metering data, settings, configuration, etc.) in a file. The default name of the data file will be xxxxxALL.cl7 where the xxxxx corresponds to the control identification number found at FC 40. The name of the file can be modified as desired using the keypad.

EXAMPLE : 12345ALL.cl7
To use the function, insert a USB memory device, access FC 950 and press **ENTER**. The control LCD will display the default file name and the word (CONFIRM). The file name can be edited at this time. Press **ENTER** again to confirm and the save the file using the name displayed. While data is being saved, the LCD will display (SAVING...), and the control will write the data to a file on the device. If a file already exists on the memory device with the same name, the words (REPLACE FILE) will display; press the **ENTER** key to confirm saving over the existing file. Upon completion, the control will display (OK TO REMOVE) indicating that it is safe to remove the card without compromising the data. The green LED above the data port will also go out when it is safe to remove the device.

If the command is completed with errors, a (SAVE FAILED) message is displayed on the fourth line of the LCD. If the command is in progress and is aborted via the ESC key, a (CANCEL COMPLETED) message is displayed on the fourth line of the LCD.

Saving configuration settings, FC 950

There are several options available at FC 950 for saving configuration settings. The options can be access by entering the FC 950 parameter and then scrolling through the options using the up and down arrows on the keypad. The options that exist are:

- Custom and Standard All – Save all settings.
- Custom and Standard Basic - Save the basic control operation and configuration settings only.
- Custom and Standard Alt – Save the Alternate Configuration Settings only.
- Custom and Standard Adv – Save the Advanced Features settings only.
- Custom and Standard Comm – Save the communications settings only.

When the save option is used, a file will be created with the suffix .cl7. The designation ALL, BAS, ALT, ADV and COM will also be added as a default to the settings file name before the .cl7 suffix. It is recommended to keep these designations in place so that the types of setting contained in the file can be identified.

The only difference between custom and standard settings files is that the default name of the file created will contain either the control identification number found at FC 40 or the word "Standard" respectively. When using the custom saving options, the control also allows for editing of the file name.

EXAMPLES: 12345ALL.cl7
StandardBAS.cl7

To use the function, insert a USB memory device, access FC 950 and press the down arrow key to scroll through the save options. Press **ENTER**; this will bring up the default file name with the message (CONFIRM) on the bottom of the screen. For the custom save options, modify the file name if desired. Press **ENTER** to confirm. The LCD will display

(SAVING...), and the control will save the configuration data to the memory device. If a file already exists on the memory device with the same name, the words (REPLACE FILE) will display; press the **ENTER** key to confirm saving over the existing file. Upon completion, the control will display (OK TO REMOVE). The USB memory device may be removed after this message is displayed and the green LED light goes out.

If the command is completed with errors, a (SAVE FAILED) message is displayed on the fourth line of the LCD. If the command is in progress and is aborted via the ESC key, a (CANCEL COMPLETED) message is displayed on the fourth line of the LCD.

Loading configuration data, FC 951

Using FC 951 will allow the user to select among the configuration files located on a USB memory device and load the desired file. Any of the stored files with the .cl7 suffix can be selected and loaded.

An Admin level of security is required to perform this operation. After inserting a USB memory device, access FC 951. Press **ENTER**; this will bring up the first file name located on the device. If more than one .cl7 file is located on the device, a (More...↓) will appear on the screen. Use the down arrow to scroll to the desired file for loading. Press **ENTER** again and the control LCD will display (CONFIRM). Press **ENTER** again to confirm and begin loading the file. The LCD will display (LOADING...), and the control will load the configuration data from the memory device. Upon completion, the control will display (LOAD COMPLETE). The USB memory device may be removed after this message is displayed.

If the command is completed with errors, a (LOAD FAILED) message is displayed on the fourth line of the LCD. If the command is in progress and is aborted via the ESC key, a (CANCEL COMPLETE) message is displayed on the fourth line of the LCD.

Remove device, FC 953

It is always recommended that the USB memory device not be removed from the control while the green LED above the port is illuminated. To prepare the control for removal of the device, access FC 953 and press **ENTER**; (CONFIRM) will appear on the display. Pressing **ENTER** again will cause the message (OK TO REMOVE) to display and the green LED to go out. The device may now be safely removed.

.CSV files, FC 954

Comma-separated values (.CSV) files can be created and saved onto a USB memory device inserted into the USB DRIVE data port. The two types of files that can be created will contain either voltage regulation settings or metering data. Once the file has been saved onto a USB memory device, the file can then be opened using a spreadsheet program on a computer.

To create the .CSV files, begin by inserting a USB memory device into the control. Access FC 954 and press ENTER to bring up the Settings to .CSV option. Pressing ENTER again will bring up a line on the control LCD enabling the user to name the file and a prompt to CONFIRM the operation. Pressing ENTER again will create the settings file. Accessing FC 954 and pressing the down arrow once will provide access Metering to .CSV option.

Communications

Communicate with the CL-7 control using ProView NXG software or protocols such as DNP3 or IEC 60870. The ProView NXG software, used with a PC, can provide temporary local connection to the control.

Communication ports

There are two physical communications ports and a PC data port (USB type B) on the CL-7 control.

The PC data port is for use as a temporary local communication connection to the control. Connection is made to the PC data port by using a standard USB type A to USB type B cable (standard USB printer cable). When using ProView NXG software, a port configuration has been created to allow for easy connection. Clicking on the connect button will bring up a list of configured ports, click on **Data Ports (USB Direct)** to connect.

The communication ports Com 1 and Com 2 are for use as permanent communication connection to the control. Connection is made by using an optional communication accessory card inserted into the side of the control. A communications base card is also required. The port settings are configured using various function codes which can be found in the COMMUNICATIONS menu. See **Table 9** and **Table 10** for a list of communication parameters and descriptions.

For more detailed instructions on using ProView NXG software, see document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide.*

For more detailed instruction on communications settings, protocols and capabilities, see document *MN225021EN CL-7 Regulator Control Communications*.

Protocols

There are several protocols resident in the CL-7 control. The protocols include DNP3 (serial and IP), IEC 60870-5-101 and -104, Cooper 2179, Modbus RTU, and Modbus TCP. While only one protocol can be selected for a single Com port at a time, the two com ports can be set to different protocols. Both of the protocols are highly configurable.

Configurable logic

Configurable Logic is a powerful tool since it provides the user with the means to configure general logic equations. These logic equations can be used to perform discrete SCADA functions, modify control function, or add communications data points. Configurable Logic must be configured via the digital communications software, ProView NXG software.

Control functions codes can be used to enable configurable logic. See the information contained in **Table 10** for FC 700-703 more information on this functionality.

See document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide* for more information on programming configurable logic.

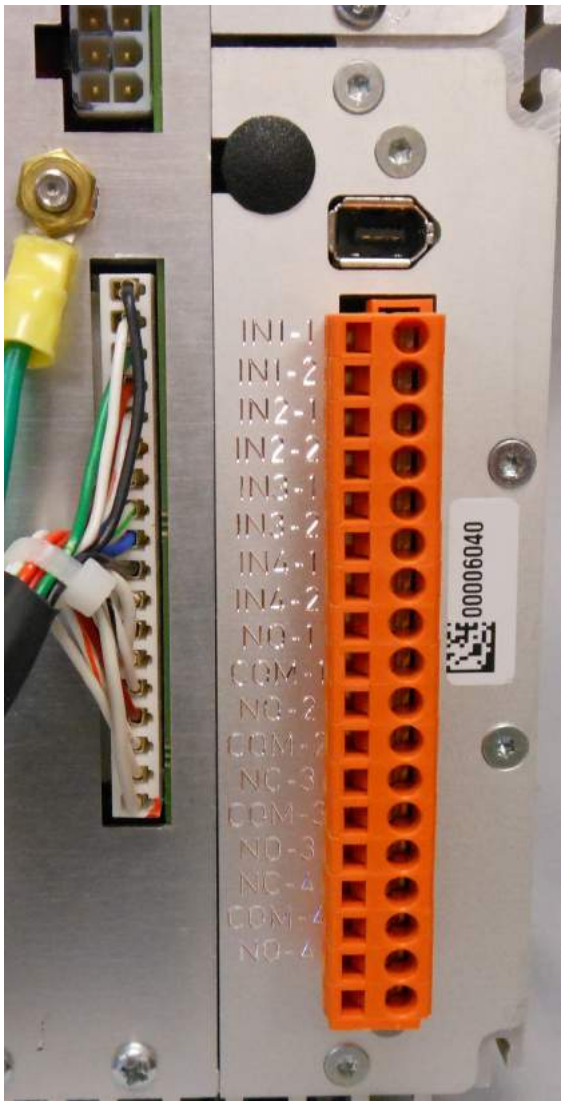


Figure 51. Optional I/O contact module connector

Auxiliary input and output

Up to two auxiliary I/O Modules can be added as options to the CL-7 control (**Figure 51**). The modules enable connection of contact-type input devices (switches, relays) and discrete indicating devices (relays, LEDs, lamps) to the control to effect local discrete inputs and outputs. The I/O module accessories can be used to supplement normal local control and status indicators.

Each contact I/O module option contains four (4) inputs and four (4) outputs. When added to a control, the modules require configuration to assign functionality to the input and output contacts. The module must also be mapped for the control to recognize it. Use ProView NXG software to configure logic and map the module. Refer to document *MN225015EN, CL-7 Regulator Control ProView NXG Software Programming Guide* for additional information on configuring the control and control logic.

The user can program the CL-7 control to use the discrete input states, as well as other internal logic conditions, to determine the operation of the control. Likewise, the user can program the CL-7 control to toggle the discrete output states based on internal control logic.

The input contacts can be activate using an ac or dc voltage; see **Table 12**, Contact I/O Option Module Input Ratings for more information on input activation limits. A whetting voltage can be supplied from the control; the whetting voltage connection can be made at terminal V9 on the lower terminal board on the back panel. See **Figure 52** for connection recommendations.

Output contacts 1 and 2 on the Contact I/O outputs are Form A (single-pole normally open) relay contacts; output contacts 3 and 4 are Form C (single-pole, double throw NO/NC) relay contacts. All four outputs are non-latching type. Refer to **Table 13** for output fusing recommendations.

Note: Latching is defined as an output that retains its status when control power is removed. Non-latching is defined as an output that returns to a default status when control power is removed.

Note: Following a firmware upgrade the Contact I/O module output relays will revert to the de-energized state. Additionally, the Contact I/O module may need to be remapped.

NOTICE

Equipment damage; misoperation. External leads must be shielded and the shield must be grounded at both ends. Terminate each lead with a 320 Vac, 160 Joules metal oxide varistor (MOV), or equivalent, at the remote end. Attach MOVs between the leads and ground. Failure to properly shield and protect leads can result in equipment damage and/or unintentional operation.

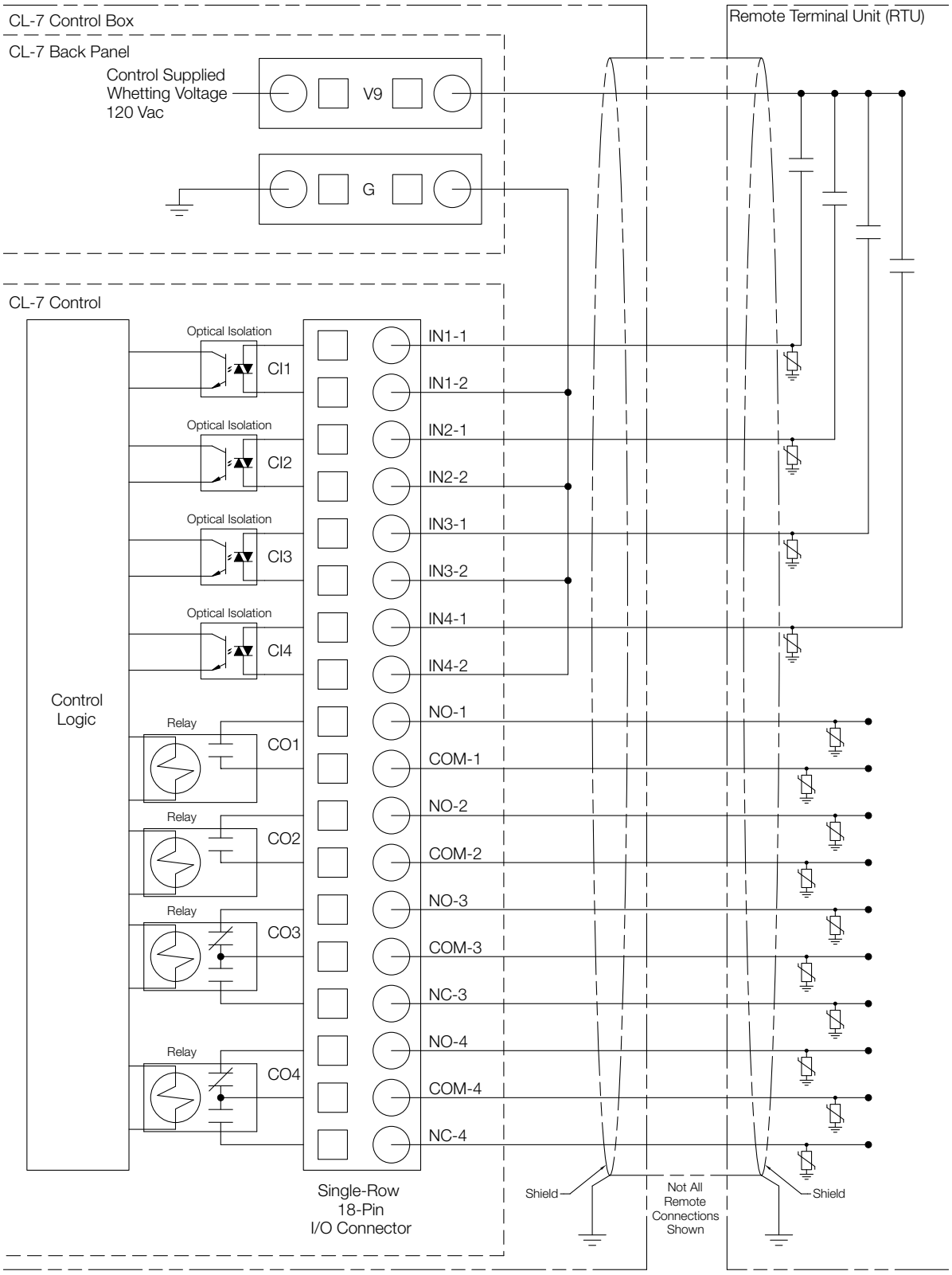


Figure 52. Customer connections to Contact I/O Module with shielding and surge protection. (I/O functionality is customizable using the Configurable Logic tool in ProView NXG software.)

Table 12. Contact I/O option module input ratings

Description	Rating
Minimum Detection Level:	10 V (ac rms or dc) (50 or 60 Hz) (Using control-supplied whetting Voltage is recommended)
Maximum Applied Voltage:	250 Vac, rms, or 125 Vdc
Nominal Input Loading:	2 mA per input (internally current limited)
Typical Control Response Time:	50 msec (Note: Regulation tasks take priority over input activity.)
Minimum Input Pulse Time:	250 msec
Minimum Transition Time between Pulse Inputs:	250 msec
Input Protection:	Shunting type using MOVs and capacitors. Optical Isolation from input to system. (1500 Vac, rms)
Hi-Pot Capability:	3.150 kV dc for 1 second, from one input set to the next or from one pin to chassis, but not across the two terminals of a single input (due to MOVs).

Table 13. Output ratings

Description	Rating
Maximum Switching Voltage:	250 Vac, rms or 125 Vdc
Maximum Switching Loading:	Refer to **Figure 53**.
Maximum Pickup Time:	8 msec (not including control response time)
Maximum Release Time:	15 msec (not including control response time)
Output Protection:	Shunting type using MOVs and capacitors. 1500 Vac, rms isolation between coil and contacts
Hi-Pot Capability:	3.150 kV dc for 1 second from one output to the next or from one pin to chassis, but not across two terminals of a single output (due to output protection).
Fusing:	Outputs are not internally fuse-protected. Customer-supplied fusing is recommended.

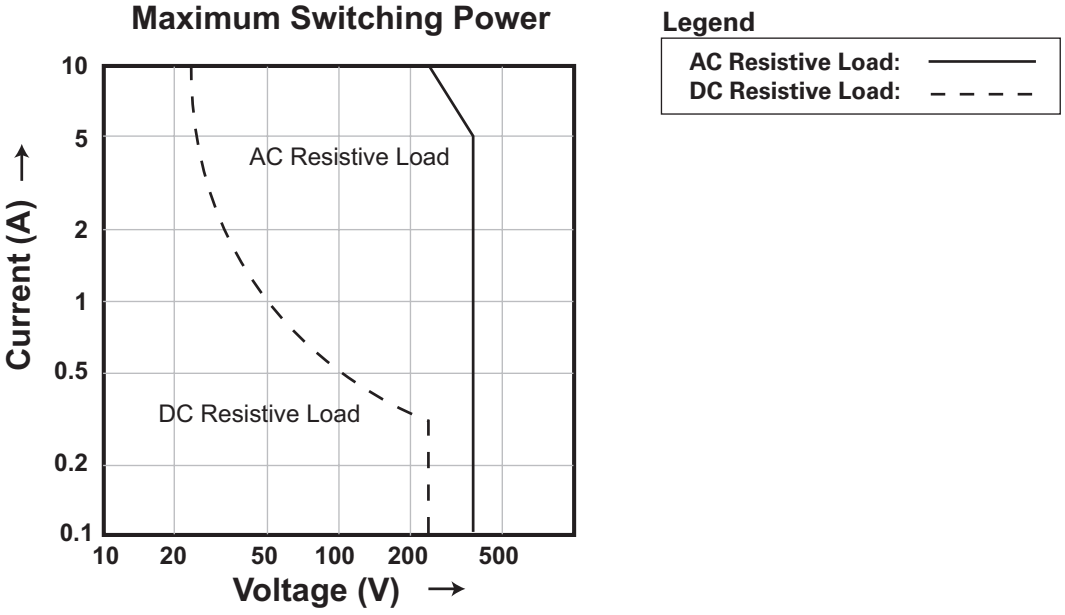


Figure 53. Maximum output switching graph

Alarms

An alarm is a binary (On/Off) flag that is activated when a user-defined condition is true. The status of an alarm can be viewed on the LCD display or through communications, including ProView NXG software. Alarms can only be configured via communications. See document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide* for information on configuring alarms.

The user can define the priority of an alarm to cause the Alarm LED, Warning LED, or no LED to be illuminated. The assigned priority of the alarm also determines the order in which the alarms are viewed via the display.

- Assigning a Priority of 0–50 will cause the Alarm LED to be illuminated when the alarm condition is active.
- Assigning a Priority of 51–100 will cause the Warning LED to be illuminated when the alarm condition is active.
- Assigning a Priority of 101–127 will not cause an LED to be illuminated, but the condition can be viewed on the LCD display or through communications while the alarm condition is active.

A timer can also be set for each alarm. This will allow the alarm to become active only after the alarm condition has existed and the period of time specified by the timer (in seconds) has expired. When an alarm becomes active, it is given the state of Unacknowledged. If the alarm is configured to illuminate an LED, the LED will flash as long as the alarm is Unacknowledged. To acknowledge an alarm the Operate security level is required. After entering the security code, enter Alarms > Alarms Active Unacknowledged using the front-panel menu; the unacknowledged alarms will display. Press the **ENTER** key to display (ACKNOWLEDGE) and **ENTER** again to complete the operation. If the alarm is configured to illuminate an LED and it has been acknowledged, the LED will be on continuously. The alarm will turn off whenever the alarm condition is no longer true.

The control can also record an event or take a profile snapshot whenever an alarm becomes active or inactive. The control contains two types of user-configurable alarms: Status Alarms and Data Alarms.

The **Status Alarm** type is activated based upon the condition of a binary (On/Off) parameter. By default, Status Alarms become active when the parameter is On. The alarm, however, can be inverted so that it becomes active when the parameter is Off. See document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide* for a complete list and definitions of available Status alarms.

EXAMPLE:
Configuring a Supervisory Active Alarm to be inverted with a Priority of 25 will cause the Alarm LED to flash whenever the Supervisory Switch is in the Off position.

The **Data Alarm** type is activated based upon the condition of an analog (numeric) parameter being above or below a threshold value. The operations counters and metering values are available as Data Alarms. See document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide* for a complete list and definitions of available Status alarms.

EXAMPLE: Configuring a Compensated Voltage Low Alarm with a Threshold of 115 V with a Priority of 75 will cause the Warning LED to flash whenever the compensated voltage is below 115 V.

Sequence of events (SOE)

An event is a time-stamped record of an alarm condition or control activity. The CL-7 control is designed to record a sequence of these events; event data is stored in non-volatile memory on the control. The last fifty events can be viewed via the front panel display using the top level nested menu item SEQUENCE OF EVENTS. The last 300+ events can be viewed using ProView NXG software.

Configuring SOE can only be done using software. There are a number of events that are pre-configured on every control. See document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide* for a list of available events and information on configuring SOE functionality.

Data profiler

The Data Profiler records the current state of parameters chosen by the user at regular intervals into non-volatile memory. The Data Profiler data can only be viewed using ProView NXG software. Configuring the Data Profiler must also be accomplished using the software. The user can choose to profile as many of the instantaneous and demand (present) parameters as desired. The sampling interval can be set from one (1) minute to one (1) day. The storage capacity for data is limited; the greater the number of parameters chosen and the shorter the sampling interval, the less overall time will pass before the record begins to be overwritten. In the software, a Trend Time will be displayed as the Profiler is configured which will be an estimate of the length of time data can be recorded before the oldest data is overwritten.

See document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide* for a list and description of available Data Profiler items and information on configuring Data Profiler functionality.

TIME-ON-TAP™ feature

The TIME-ON-TAP™ feature logs the percentage of time spent on each tap-changer position. The TIME-ON-TAP data is only viewable using ProView NXG software and is presented in bar graph format; see **Figure 54**.

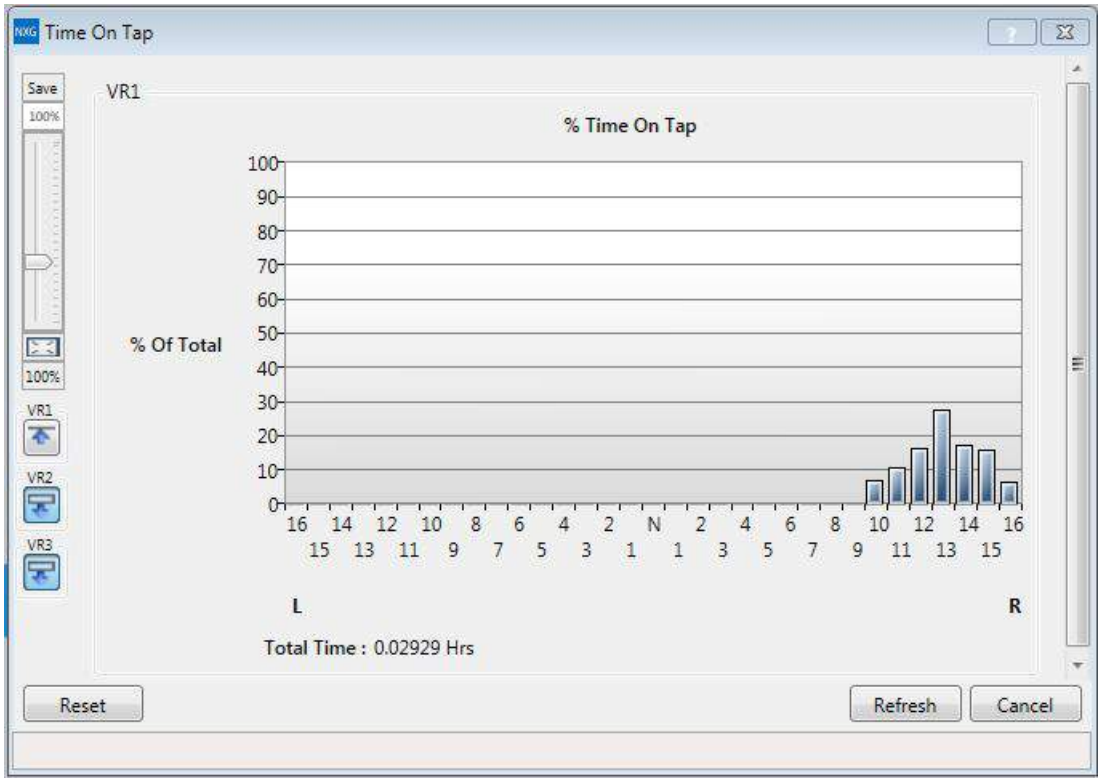


Figure 54. TIME-ON-TAP sample graph

Preventive maintenance tapping

Preventive Maintenance Tapping (PMT™) will automatically operate the tap-changer according to user-configured parameters. Under certain operating conditions, load tap-changer contacts can become susceptible to coking. The PMT feature will operate the tap-changer to wipe the contact blades and prevent build-up of carbon. There are two different types of preventive maintenance tapping available: **PMT Mode A** and **PMT Mode B**.

PMT Mode A

When enabled the control monitors tap position and, if it remains on any single tap position for a user-defined period of time (Time Delay, FC 302), the control will automatically raise the tap-changer one position, lower the tap-changer two positions, and then raise the tap-changer one position. When PMT Mode A is performed on a Quik-Drive tap-changer, this entire operation will take approximately one second. The user can monitor how much time is left prior to the maintenance tapping being performed at Countdown Delay, FC 301. To sample how the PMT Mode A functions, the user can use Issue Test, FC 303.

PMT Mode B

When enabled, the control monitors tap position and, if it does not pass through neutral for a user-defined period of time (Time Delay, FC 322), the control will automatically tap through and past neutral one position. This operates and wipes the blades of the reversing switch. It then returns the tap-changer to the original tap position. Due to the possible large fluctuation in voltage while maintenance is being performed, there are more configuration points in PMT Mode B than in Mode A. The user can determine the time of day that PMT Mode B is allowed to operate, so that maintenance can be performed at night. To limit the amount of allowable voltage-swing when performing maintenance, the user can input the maximum deviation. Also, the user can input a current limit so that maintenance is only performed under light load conditions. Additionally, a master slave mode is available so multiple units can act at once to keep the supply balanced for three-phase loads that are sensitive to imbalance. The user can monitor how much time is left prior to the maintenance tapping being performed at Countdown Delay, FC 321. To sample how the PMT Mode B functions, the user can use Issue Test, FC 328.

Duty cycle monitor

The Duty Cycle Monitor calculates the amount of life used for each arcing surface contact on the voltage regulator Quik-Drive tap-changer. The control uses the metering values, such as current, voltage, power factor, and tap position, and a detailed data on the internal design of the voltage regulator to calculate the interrupting current and recovery voltage. This is then related to the test data for the appropriate Quik-Drive tap-changer. The Duty Cycle Monitor functions only on voltage regulators with a Quik-Drive tap-changer.

FC 333 displays the worst-case value of life used, expressed as a percentage, to the third decimal point. This value may be used to generate two different Data Alarms. The first DCM Data Alarm is intended to be configured so that maintenance may be scheduled. The suggested setting is 75%. The second Data Alarm is intended to be set at a higher level, the suggested setting is 90%, in order to notify the user that a service outage due to contact failure may be imminent. For more information on Alarms, see the **Alarms** topic in this section of the manual.

A detailed percentage of life-used for each arcing contact is also available and can be viewed using ProView NXG software. When replacing a control on an existing voltage regulator, ProView NXG software must be used to enable and configure the Duty Cycle Monitor feature. Configuration values programmed in the software for the specific voltage regulator include the design number and an estimation of the amount of life already used.

Note: Duty Cycle Monitor is active only on Eaton's Cooper Power series regulators with Quik-Drive tap-changers.

Leader/follower scheme

The Leader/Follower Scheme is an electronic scheme designed to coordinate the operation of two or three individual single-phase step voltage regulators. This feature is primarily used by utilities and others needing three-phase voltage regulation within certain parameters.

A fiber optic intelligent loop scheme (LoopShare) is used between controls providing the communications necessary between phases to initialize a tap change and provide positive feedback in maintaining regulation within the desired parameters. The status and settings for LoopShare are found at FC 860 through FC 863. As a result of the communications between all phases, access to certain data from all phases is available at the display of all controls involved and by using ProView NXG software.

If configured as a Leader or Follower device, the CL-7 control can be operated in one of two Ganged modes or a Group Coordinated mode. All configuration and setting values associated with the connected equipment must be configured separately for all connected voltage regulators. Leader/Follower Operation works on the understanding that all equipment connected and run in the Leader/Follower configuration must maintain communications with the operating group.

This scheme can also be used for paralleling substation voltage regulators with a set of power transformers used for increasing capacity and providing a backup for maintaining regulated power. For more details on the various Leader/Follower schemes and configuring the feature, see document *MN225015EN CL-7 Regulator Control ProView NXG Software Programming Guide*.

Voltage sag monitoring

The voltage sag monitor compares the voltage regulator load voltage with a reference value and determines if the load voltage has dropped below a defined threshold level for a defined period of time. The concept is based on the voltage quality curve defined by the Computer Business Equipment Manufacturer's Association (CBEMA), which is meant as a guideline for the kind of voltage deviation that electronic equipment should withstand without failure. This feature as applied to the voltage regulator will be a limited subset of the CBEMA guideline.

With the feature enabled, the control compares the current load voltage against three unique voltage sag set points, with each set point containing both a voltage level (as a percent of the reference voltage) and minimum time duration of the voltage sag. When the control detects that the regulated voltage has fallen below the defined voltage level and stayed below that level for the defined duration, the control records the voltage sag as an event in the sequence of events recorder.

When the load voltage rises above a defined recovery voltage for a defined recovery period of time, the control resets the voltage sag monitor and records another event indicating that the voltage sag has ended. A date and time stamped record of the duration of the last and longest voltage sag for each voltage sag level is also recorded.

The reference voltage used to compare against the regulator load voltage is the Demand Metering value of Forward Load Voltage Present or Reverse Load Voltage Present as applicable.

Voltage sag monitor settings can be found using control nested menu FEATURES > Voltage Sag Monitoring or by accessing FC 600-606, 611-616, 621-262, 631, and 632. The feature can also be programmed and data viewed using ProView NXG software.

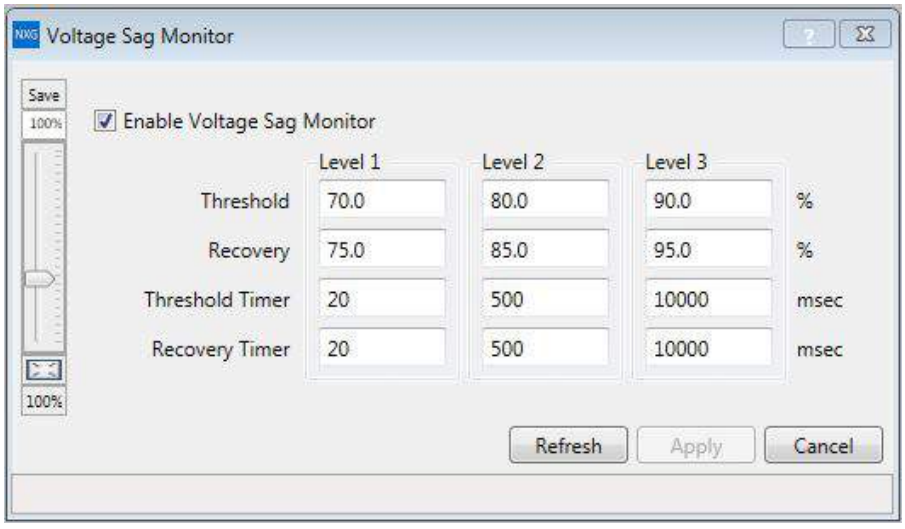


Figure 55. Setting the voltage sag monitor using ProView NXG software

Fault detection

The fault detection feature will compare system load current measured by the voltage regulator with a reference value, and determine if the load current rises above a defined fault current threshold level for a defined period of time.

The Fault Detection feature can be enabled using FC 640 on the control HMI or by checking a box in the Fault Detection dialog box in ProView NXG.

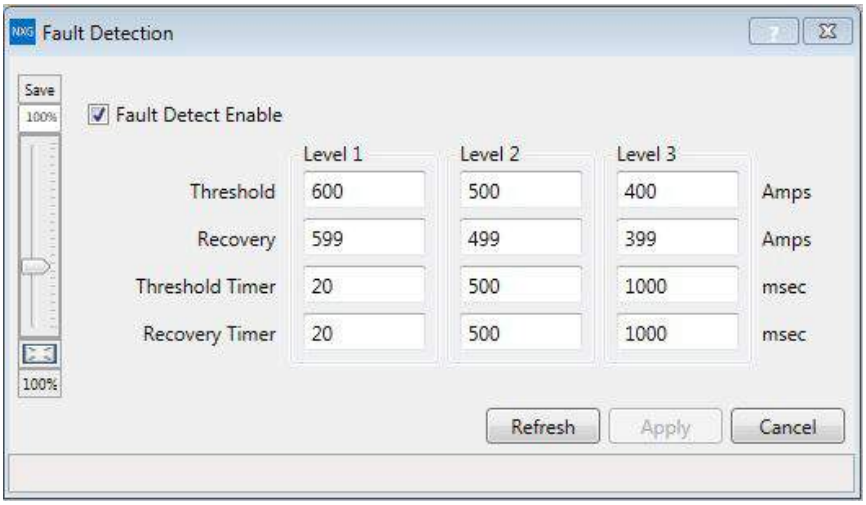


Figure 56. Fault Detection settings dialog box

The Fault Detection feature will enable the control to compare system currents against three unique fault current levels. Each fault current level contain both a current threshold in amps and threshold timer in milliseconds. When the control detects that the system current level has exceeded a defined fault current level and remains above that level for the time period defined by the Threshold Timer, the control will record the fault current as an event in the control's Sequence of Events recorder. When the fault current falls below the defined Recovery current level for the time period defined by the Recovery Timer, the control will reset Fault Detection and record another event indicating that the fault has ended. Fault Detection settings can be made using the dialog box shown above (**Figure 56**) in ProView NXG or through the control HMI using function codes found in the control nested menu **Features > Fault Detection**. There is one set of Fault Detection settings which applies to all three voltage regulators when using a multi-phase control.

It is also possible to record the total time duration of the fault events. The last fault event and longest fault event are recorded with a date and time stamp which can be viewed using the control HMI or in the Metering Fault Detection dialog box (**Figure 54**) in ProView NXG. Fault Detection event recording is available for up to three connected voltage regulators when using a multi-phase control.

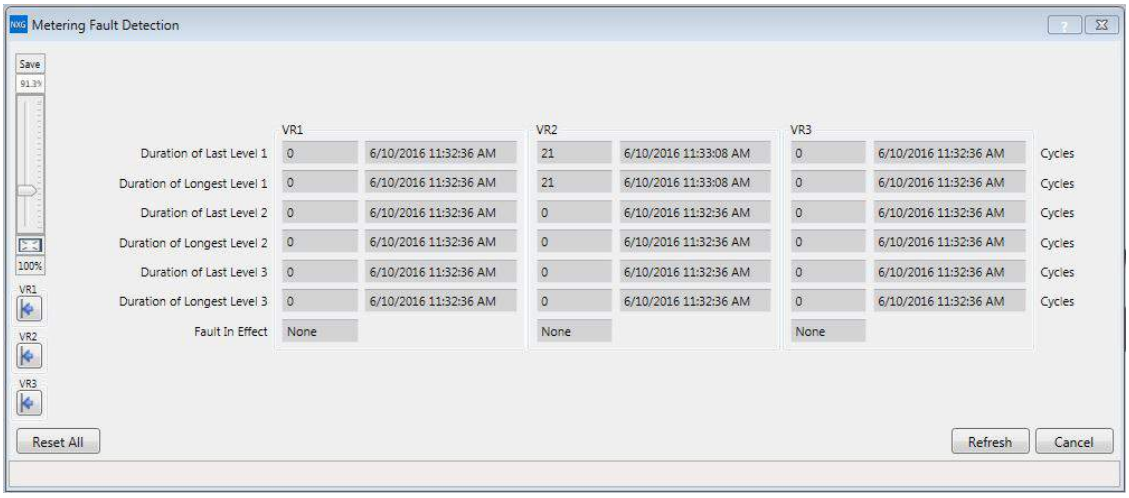


Figure 57. Metering Fault Detection dialog box

The Fault Detect feature can also be used in conjunction with Status Alarms. When levels of fault detection are included in the list of active alarms and one of the fault detection criteria are met, this condition will activate the alarm. The active alarm status can then be used to trigger profiler data recordings, illuminate an LED, or drive configurable logic.

Heater

The CL-7 control is equipped with a cabinet heater as a standard feature. The heater is incorporated into the control hardware and no action is required to enable or control the operation of the heater.

Battery options

The CL-7 control may be equipped with a 13 A-Hr, 24 Vdc battery backup. The purpose of the battery backup is to maintain power to the control when system power is lost. The battery is not intended to run the tap-changer.

When the control is equipped with battery backup, the function codes are used to monitor battery function. When the battery is in use, FC 190 will display battery current and voltage values. Use FC 191 to initiate a battery test and display the results. An automatic battery test can be enabled at FC 192 which will run a battery test within 60 seconds of power up of the control and then every 12 hours thereafter.

Battery test results may display a code when the test is not successfully passed. The codes are:

1 – Battery failed test

2 – A battery test was already running

3 – Battery test was blocked

4 – Battery test was not run

5 – Auto battery test disabled.

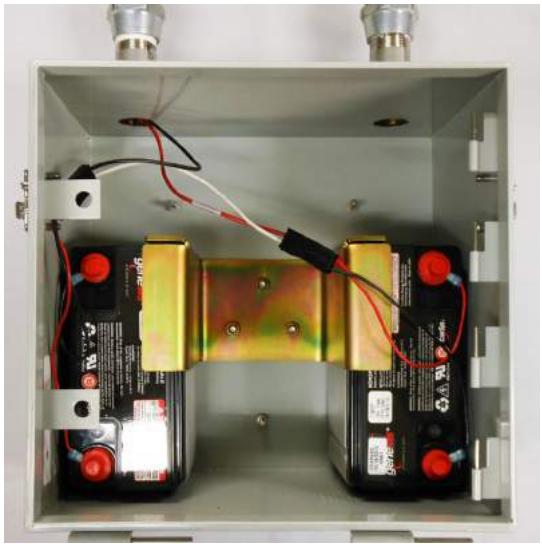


Figure 58. Auxiliary control box with backup batteries

Customer supplied battery power

The CL-7 control can be powered using a substation battery with a voltage of 48 to 125 Vdc. With this option, terminals will be provided on the back panel of the control to connect battery power. The terminals will be connected to the control DC power jumper (see **Figure 54**). If a substation batter option is not provided, the DC power jumper must be in place in order to power the control.

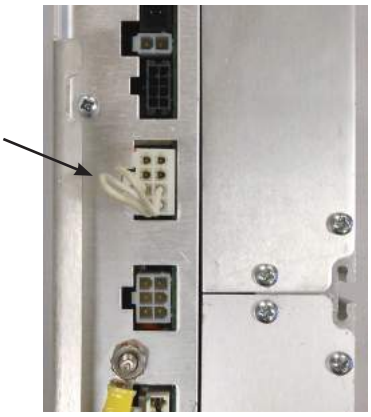


Figure 59. DC power jumper in place on side of control. This jumper must be in place to power the control when the substation battery option is not provided

DC power supply (13.5 Vdc)

An optional 13.5 Vdc power supply is available for the CL-7 control. The power supply is intended to provide an auxiliary source to power communications equipment. The unit has a max output of 1.48 A for 1 second and max power of 14 W continuous and 20 W peak.

Figure 58 shows the DC power supply installed in the side of a CL-7 control. Power connections can be made to the orange plug; the top plug is the negative terminal and the bottom plug is the positive terminal.

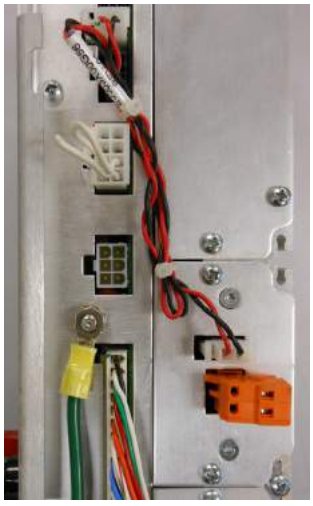


Figure 60. DC power supply (13.5 Vdc) installed in the side of a CL-7 control

Section 8: Troubleshooting

⚠ WARNING

Hazardous voltage. When troubleshooting energized equipment, protective gear must be worn to avoid personal contact with energized parts. Failure to comply can cause serious injury or death. VR-T213.0

When using the CL-7 control with an Eaton's Cooper Power series regulator, refer to document *MN225008EN VR-32 Voltage Regulator with Quik-Drive Tap-Changer Installation, Operation, and Maintenance Instructions* for additional information on the regulator operation and maintenance.

External check

Examine the power connections first. For example, verify that the load lead is connected to the load (L) bushing, the source lead is connected to the source (S) bushing and that the source-load lead is connected to the source-load (SL) bushing. Check for other potential problems, such as an open ground connection.

Defining the problem

Determine which of the following categories best describes the malfunction and follow the corresponding steps. Refer to the schematics in **Section 9: Appendix**, **Figure 62** through **Figure 67**, while diagnosing the problem.

Note: Parameter options accessed via menu or function code are shown in **bold**.

Settings of front panel switches are shown in **bold**.

Keypad directions are shown as follows: press keys as shown in **bold**; enter numbers as shown in italics.

Note: The typical control box will have a single terminal board (TB3) at the bottom of the back panel. Legacy control boxes, CRA control boxes and a very few new units will have two terminal boards, TB1 at the top and TB2 at the bottom. TB3 will include most of the same terminals as found on TB1 and TB2. Troubleshooting principles will apply to any back-panel configuration.

Control panel troubleshooting

No motor power

If the control panel powers up, but the motor will not run, first check the 6 A motor fuse on the control front panel. Remove the fuse from the control and check for continuity across the fuse. Spare fuses are shipped with each control and are located in the control box.

Note: Use only 125 V, 6 amp, fast-blow fuses of the proper current rating. Failure to do so may cause unnecessary fuse operation or insufficient protection of the regulator and control.

No control power

If the control will not power up at all, check the power to the control:

1. With a voltmeter, check the voltage between terminals **VS** and **G**. The voltage should approximate the set voltage. If the voltage is present at terminal **VS**, then the problem is in the control. Replace the control.
2. Check the voltage-disconnect knife switch **V1**, **V6** (if present), and the current shorting knife switch **C** on the back panel in the control enclosure. Close the **V1** and V6 switches if open. Open the CT shorting switch (**C**) if closed.
3. Check the voltage between **V1** and **G**. If the voltage is present at **V1**, then the problem could be in the wiring harness or ratio-correcting transformer. Check for loose connections or burnt wiring. Verify that the ratio-correcting transformer **RCT1** is on the correct tap for the regulated voltage as shown on the nameplate on the control enclosure door.
4. If voltage is not present, then the problem is either in the control cable, junction box connection, or inside of the regulator.

Self-test

The control hardware performs self-diagnostic physical and memory checks. There are two events which force the control into the self-test routine: (1) Power is turned on; (2) Operator entry of the self-test mode (FC 91).

The duration of this test sequence is approximately seven (7) seconds. At completion, the display will indicate **PASS** or display an error message if a problem is found. (See **Diagnostic Error Messages** in the next section of this manual). The messages will remain in the display until the operator presses the **ESC** key or, after 20 minutes, the display will automatically be turned off.

Note: After the self-test and the LCD displays **PASS**, press **ESC** key for further keypad use.

Diagnostic error messages

Upon running the self-test, if an error is detected, a diagnostic error message will be displayed and the red DIAG ERROR LED will illuminate until the self-test is rerun without error.

Note: The most common diagnostic errors can be rectified by changing parameters in the control. Review this section or call an Eaton representative for assistance.

A list of diagnostic error messages and explanations follows.

- Non-Volatile Settings Failed!—The firmware was unable to create, open, read or write the settings file.
- Frequency Detection Failed!—Detected system frequency is below 40 Hz or above 70 Hz.

- No Data Acquisition!—Data failed to be acquired over a 1 second time period (data is acquired every 512 microseconds, if no data is acquired in one second it indicates a problem).
- VR1 (2, 3) Input Voltage Missing!—The detected or measured source voltage secondary is below 40 volts for VR1 (2, 3).
- VR1 (2, 3) Output Voltage Missing!—The detected or measured load voltage secondary is below 40 volts for VR1 (2, 3).
- VR1 (2, 3) No Neutral Sync Signal!—The control tap position is set to neutral, but the neutral signal from the tap changer is not present for VR1 (2, 3).
- Clock Needs Setting!—The clock has lost power and must be reset.
- Factory Calibration Required!—Control calibrations are out of range.
- Configuration Value Required!—Control settings have not been set.
- Battery Test Failed!—The battery has failed and needs replacing.
- VR1 (2, 3) Motor Trouble!—Motor trouble was detected and the motor trouble state was set to true.

No neutral sync signal

Control not installed on regulator

This most often occurs when powering up a control on a workbench or when a control panel has been installed on a regulator on a tap position other than neutral. The **No Neutral Sync Signal** means the control did not have a neutral signal during the self-test while powering up. This can occur because there is no 120 V signal present on the neutral light input. To confirm this and clear the error message, perform the following:

1. Press ESC.
2. Func, 99, Enter, Admin (default), Enter.
3. Func, 12, Enter.
4. Edit, (some number from one to 16), Enter.
5. Initiate a self-test.

   Func, *91*, **Enter**, **Enter**, **Enter**.

   The **(No Neutral Sync Signal)** message should not reappear.

Control on Regulator

If the control is on a regulator and the **No Neutral Sync Signal** message appears during power up or self-test, or there is no neutral light, check the input signal between terminal **NL** and **G**. If the regulator is in neutral, there should be 120 V at the input. When 120 V is not present at terminal **NL** while on neutral, the neutral light on the control panel will be off.

If there is no neutral light and no neutral light signal at terminal **NL**, verify that the regulator is in neutral. For the regulator to be in neutral, the position indicator should be on neutral and if the regulator is energized there should not be a differential voltage between the source (S) bushing and the load (L) bushing.

When there is no neutral light and the regulator is powered up either by internal or external power, check these input points as follows:

- If there are **TB1** and **TB2** terminal boards, check the voltage between **TB2-NL** and **G**, located on the bottom terminal board on the control assembly back panel:

  If there is no voltage and there is voltage at **TB1-NL**, the problem is in the connections in the wiring harness on the back panel. If there is voltage on **TB2-NL** and no neutral light, the problem is in the control panel.

- **TB3-NL or TB1-NL if present** located on the top terminal board on the control assembly back panel:

  If there is no voltage, the problem can be in the connection at this terminal point, the control cable, the connection in the junction box, or inside the regulator.

- **JBB-NL**, located on the terminal board inside the junction box and **TCB-NL**, located on the tap changer:

  If there is no voltage, the problem is inside the regulator, either with connection point **JBB-NL** under the cover assembly, connection **TCB-NL** on the tap-changer, neutral light switch, or the neutral light actuator segments.

  On the current regulator design, the junction box terminal board consists of automotive-style plug connections. Check that the plugs are firmly installed. Disconnecting the plug on the top will allow for a probe to make contact to check the voltage.

No input voltage

The **Input Voltage Missing** message occurs when no input voltage is sensed or it cannot be calculated. The input voltage is the source voltage from a differential or source potential transformer. This voltage signal can also be calculated by the control if FC 39, Source Voltage Calculation is set to **On**, the regulator type is properly set at FC 140, and the tap position is present at FC 12.

When this message is indicated and the regulator has a differential transformer, check for a voltage between **V6** and **G**, if V6 is present. This voltage will be 0.0 V when the regulator is in neutral. The voltage will increase as the regulator is tapped up. When the regulator is at 16 raise, the voltage will be 11.5 to 12 Vac. If there is no input voltage shown at FC 7, Source Voltage Secondary, and the regulator has a differential transformer, the problem could be in the control, back panel connections, control cable, the junction box, the junction box terminal board under the cover, or the differential PT.

If there is not a differential PT on the regulator, turn FC 39 to **On**. This will supply the calculated voltage signal and when the self-test is rerun, the input voltage diagnostic error message will clear.

Indication messages when using edit key

The following indication messages can occur when using the **Edit** key:

- (**Improper Security**) message will display while attempting an edit function when changes are disabled by the security system. To enable, enter a higher security code at FC 99. To enter the Security Code key in:

  Func, *99*, **Enter**, *Security Code*, **Enter**.

  Proceed with function code value and setting changes.

- (**VALUE TOO LOW**) means the function value you have entered is below the acceptable limit.
- (**VALUE TOO HIGH**) means the function value you have entered is above the acceptable limit.

For more information, refer to **Section 5: Control Programming: Indication messages**.

Tap-changer operation troubleshooting

The regulator will not operate manually or automatically

1. Connect a voltmeter between **R1** and **G**. Set the CONTROL FUNCTION switch on **LOCAL MANUAL.**
2. Toggle the **RAISE** switch and measure the voltage between terminals **R1** and **G**. The voltage reading should approximate the set voltage setting.
3. Place the voltmeter hot lead on **L1**, then toggle the **LOWER** switch.
4. Measure the voltage between terminals **L1** and **G**. The voltage reading should approximate the set voltage value.
5. If correct voltage readings are obtained in Steps 2 and 4, the trouble may be in the position indicator, junction box, control cable, or motor capacitor. Refer to the junction box troubleshooting section in document *MN225008EN VR-32 Voltage Regulator with Quik-Drive Tap-Changer Installation, Operation, and Maintenance Instructions*.
6. If there is no voltage measurement in either Step 2 or 4, make a corresponding measurement (from **R3** to **G** and **L3** to **G**) on lower terminal board **TB2** or **TB3**.
7. If the voltages measured in Step 6 are approximately the set voltage value, then the fault is likely a loose connection or a faulty terminal on the back panel.
8. If Steps 2, 4, and 6 do not provide voltage readings, measure the voltage between **VM** and **G**. The reading should approximate the set voltage value.
9. If Step 8 does not yield a voltage measurement, check the voltage between **V1** and **G** at the voltage disconnect knife switch.

   A. If the set voltage value is approximately obtained, the V1 disconnect or the ratio-correcting transformer (RCT1) of the rear panel signal circuit is probably faulty.

   B. If voltage is not obtained, the trouble is in the control cable, junction box, or regulator tank. Refer to the junction box troubleshooting section of document *MN225008EN VR-32 Voltage Regulator with Quik-Drive Tap-Changer Installation, Operation, and Maintenance Instructions*. If the junction box checks are satisfactory, the trouble is in the regulator tank. See documents *S225-12-1 QD3 Quik-Drive Voltage Regulator Tap-Changer Manual, MN225012EN QD5 Quik-Drive Voltage Regulator Tap-Changer Manual*, and *MN225011EN QD8 Quik-Drive Voltage Regulator Tap-Changer Installation and Maintenance Instructions*.

Motor capacitor problem

A problem in the motor capacitor can prevent a regulator from operating manually or automatically. If the motor capacitor is in the control box, it can easily be removed and checked using a voltmeter with a capacitive setting. To check the motor capacitor if it is not accessible, use the following steps:

1. Connect a voltmeter from **R1** to **G**.
2. With the control powered up, place the **CONTROL FUNCTION** switch on **LOCAL MANUAL**.
3. Using the **RAISE/LOWER** switch, give a **raise** signal.
4. The voltmeter reading should approximate the set voltage.
5. With the voltmeter still connected between the **R1** terminal and **G**, give a **lower** signal.
6. The voltmeter should read a capacitive voltage. This voltage could be somewhere between 160 and 190 Vac.
7. A voltage reading between **R1** and **G** of 0 V or a mV reading while giving a lower signal is a sign of a bad capacitor.
8. To double check, place the voltmeter lead between **L1** and **G**.
9. Use the **RAISE/LOWER** switch, and give a **lower** signal.
10. The voltmeter reading should approximate the set voltage.
11. With the voltmeter still connected to between **L1** and **G**, give a **raise** signal.
12. The voltmeter should read a capacitive voltage. This voltage could be somewhere between 160 and 190 Vac.
13. A voltage reading between **L1** and **G** of 0 V or a mV reading while giving a lower signal is a sign of a bad capacitor.
14. If both the raise and lower circuit reads 0 V, or a mV reading, when there should be a capacitive voltage, then the motor capacitor is open. The capacitor will need to be replaced.
15. If 120 Vac is present between **R1** and **G** and **L1** and **G** when no raise or lower signal is provided, it is a sign of a shorted motor or capacitor.

Operation counter does not indicate tap change

If the operation counter does not indicate tap changes, check the following:

1. The voltage signal between **TB3-R1** and **L1** (or **TB2-R3** and **L3** is present) should be approximately 120 Vac when a tap change is made. When this voltage signal is applied, the control panel operation counter will be updated.
2. Measure the voltage at **R1** and **L1** (**R3** and **L3** if present) when the tap-changer is given a command to tap, in manual mode, by the **RAISE/LOWER** toggle switch. If the voltage signal is present, the problem is either in the control connector or the control.
3. If the voltage signal is not present at **R1** and **L1** (**R3** and **L3** if present), the problem could be in the back panel wiring harness connections at **TB1-R1** or **L1** (if they are present), the control cable, junction box connections, or the holding switch on the tap-changer.
4. Check the voltage signal at **TB1-R1** or **L1** (if they are present). If the signal is not present at these points or at **TB3-R1** or **L1**; keep tracing the signal back through the components back into the regulator.

Tap position out-of-sync

If the control loses sync with the position indicators (check FC 12, Present Tap Position), then check:

1. FC 49 Tap-Changer Type against the nameplate on the regulator. The nameplate indicates what type of tap-changer is on Eaton's Cooper Power series regulator. FC 49 must be set for the type of tap-changer (Spring Drive, Direct Drive, QD8, QD5, QD3).

   If the control is installed on a non-Eaton's Cooper Power series regulator, FC 49 should be set to match the manufacturer of the unit.
2. The control box ground—An improperly grounded control box can cause the control to loose tap tracking. The control box must have a solid ground to the ground lug on the side of the box, either from the tank ground pad or earth ground cable.
3. The tap position of the position indicator—When a control is installed on a unit in the field, the correct tap position must be entered in the control to match the position indicator tap position.

Regulator will not tap beyond a certain tap position

If the regulator will not tap beyond a certain tap position, check the limit switch settings on the position indicator. If the limits need to be adjusted, adjust upper and lower limits to allow proper regulation.

If the regulator will not tap beyond a certain position while in automatic operation, but will beyond this position manually, check the Soft ADD-AMP settings are FC 79, FC 175 and FC 176.

If the regulator does not tap beyond tap position 2 in the lower direction or -2 in raise direction, the problem may be the internal tap-changer logic switches. Call your Eaton representative for assistance.

The regulator operates manually but operates incorrectly when set on automatic

Manually run the regulator to the neutral position. Check for voltage between the bottom of the **V1** switch and **G**. This is the sensing circuit supplying voltage from the output of **RCT1** on the rear panel. If this voltage is more than 10% above or below the programmed voltage level setting of the control, then the source is beyond the range of the regulator. An absence of voltage would indicate a wiring problem such as an open somewhere in the control power supply. If these checks are correct, perform the following:

1. If the control will not operate automatically, verify that the band edge indicators are functioning. (These are the **OUT-OF-BAND HIGH** and **OUT-OF-BAND LOW** LEDs located on the front panel.) If they are not functioning, check FC 56, Reverse Sensing Mode. Set it to **Locked Forward** if it is not there already. Retry the automatic mode of operation.
2. Verify that FC 69, Auto Blocking is set to **Normal**. Retry the automatic mode of operation.
3. Measure the voltage from **VS** to **G** on **TB3** (or on the lower terminal board **TB2** if present).
   A. A measurement of approximately the set voltage value between **VS** and **G** indicates that the problem is in the control.
   B. If there is no voltage present between **VS** and **G**, the trouble is in the V1 disconnect or the ratio-correcting transformer of the back-panel circuit. Replace them.
4. Check the holding switch circuit.
   A. Verify that the tap-changer will complete a tap change by placing the **CONTROL FUNCTION** switch to **LOCAL Manual** and toggling the **Raise/Lower** switch in the desired direction.
   B. If the **Raise/Lower** switch must be held in the **Raise** or **Lower** position to complete a tap change, the problem is in the holding switch circuit. If the holding switch is not working, a Quik-Drive tap-changer will do multiple taps until the tap change time-out occurs.
   C. Check for voltage between **TB3-HS** and **G** (**TB1-HS** or **TB2-HS** if they are present and **G**). When TB1 and TB2 are present, if voltage is present at **TB1-HS** and not on **TB2-HS**, the problem is in the back panel wiring harness. Replace the orange **HS** lead from **TB1-HS** to **TB2-HS**. If no voltage is present at **TB3-HS** (or **TB1-HS** when present), the problem is in the control cable, junction box cover, or the holding switch (located inside the regulator) itself. Check cable continuity up to the junction box.

      If it appears normal, the problem is the holding switch. To replace the holding switch, see documents *S225-12-1 QD3 Quik-Drive Voltage Regulator Tap-Changer Manual, MN225012EN QD5 Quik-Drive Voltage Regulator Tap-Changer Manual*, and *MN225011EN QD8 Quik-Drive Voltage Regulator Tap-Changer Installation and Maintenance Instructions*. If all appears to be in order, the problem is most likely in the control, not in the holding switch.

Check FC 56, reverse sensing mode

When there is no load current and the regulator will not operate in automatic, check the **C** switch on the back panel. If the **C** switch is closed and FC 56 is set for **Bi-directional**, the regulator will not operate in automatic. The **C** switch should be open for normal operation.

Check FC 69, auto operation blocking status

1. Check the **CONTROL FUNCTION** switch. The switch should be on **AUTO/REMOTE**.
2. Verify that FC 69 is set to **Normal**. To check the FC 69 setting:

   FUNC, *69*, **ENTER**.
3. If not on **Normal** and resetting is blocked by the security feature, enter the security code via the keypad to change the blocking status:
   A. **FUNC**, *99*, **ENTER**; *Admin* (default), **ENTER**.
   B. **FUNC**,*69*, **ENTER**.
   C. **EDIT**, Scroll to **Normal**, **ENTER**.

Check FC 170, Tap-to-Neutral

1. Verify that FC 170 is set to **Off**. To check the FC 170 setting:

   FUNC, *170*, **ENTER**.
2. If not set to **Off** and resetting is blocked by the security feature, enter the security code via the keypad to change the blocking status:
   A. **FUNC**, *99*, **ENTER**; *Admin* (default), **ENTER**.
   B. **FUNC**,*170*, **ENTER**.
   C. **EDIT**, Scroll to **Off**, **ENTER**.

Testing with the voltage limiter ON and a limit value set

NOTICE

Equipment Damage. Be mindful of polarity when using an external source. Polarity reversal will result in control damage. VR-T201.0

When testing a regulator with external power, it is recommended that FC 80, Voltage Limiter Mode be set to **Off**.

When testing in the auto mode with the voltage limiter on, there may be problems getting the regulator to operate in either raise or lower direction if the external voltage is greater than the voltage limit settings.

No band indicators

If the band indicators are not working when the voltage is out-of-band, check the following:

1. Check FC 56, Reverse Sensing Mode. If FC 56 is set to **Lock Forward** and there is reverse power, the indicator will not display and the voltage will not regulate.
2. Check FC 57, Reverse Current Sense Threshold and ***Load Current** (*Metering PLUS). If the load current is less then the reverse threshold current, the indicators will not work and the regulator will not regulate.
3. If the regulator has been serviced and the current transformer circuit was involved, check the polarity of the current transformer. If the polarity is reversed, the band indicators will not display.

Metering troubleshooting

Load voltage secondary (output voltage), does not match the voltmeter test terminal voltage

When the output voltage at FC 6 is several volts different from the voltage at the voltmeter test terminals, verify that the following function code settings are per the nameplate:

1. Verify FC 43, System Line Voltage (Load Voltage) is set per the nameplate value.
2. Verify FC 44, Overall PT Ratio is set per the nameplate.
3. Verify **RCT** Control Tap located on the back panel of the control assembly is set per the nameplate.
4. Verify Control Winding **E** Tap and Differential Transformer P Taps, if present, are set per the nameplate. **E** taps are located on the terminal board on the tap-changer inside the tank. **P** taps may be located on the terminal board on the top of the tap-changer or on the differential potential transformer located on the side channel inside the regulator tank.

When all the settings are set per the nameplate, the regulator is in neutral, and the system line voltage or load voltage matches what is stated on the nameplate, the voltmeter test terminals on the control panel will read the value on the nameplate.

No load current

When there is no load current reading at FC 9, Load Current, Primary, or any of the metering components requiring current as part of the calculation, check the **C** switch on the back panel. The switch should be open. If the **C** is closed, the current transformer is shorted and no current reading is available.

Control calibration

⚠ WARNING

Explosion Hazard. Verify that both the neutral light and the position indicator hand indicate neutral when the tap-changer is physically in the neutral position. Lack of synchronization will cause an indefinite indication of NEUTRAL. Without both indications of neutral, bypassing of the regulator at a later time will not be possible, and the line must be de-energized to avoid shorting part of the series winding. Failure to comply can result in serious personal injury or death and equipment damage. VR-T212.0

NOTICE

Equipment Damage. Be mindful of polarity when using an external source. Polarity reversal will result in control damage. VR-T201.0

All controls are factory-calibrated and should not need to be recalibrated. However, calibration can be performed for both the voltage and current circuits using the steps that follow. The factory calibration can be restored using FC 150.

Voltage calibration

1. Connect an accurate true-RMS-responding voltmeter to the voltmeter terminal. This voltmeter should have a base accuracy of at least 0.1% with calibration traceable to the National Bureau of Standards.
2. Connect a stable 50/60 Hz voltage source (with less than 5% harmonic content) to the External Source terminals.
3. Set the POWER switch to **EXTERNAL**.
4. Adjust the voltage source to provide 120.0 Vac to the control, as read on the reference voltmeter.
5. Before calibration can be performed, Security Level 3 must be activated by entering the proper security code at FC 99, Security Code.

   FUNC, *99*, **ENTER**; *Admin* (default), **ENTER**.
6. *Access* FC 47, Voltage Calibration.

   FUNC, *47*, **ENTER**.
7. The display will show the voltage applied to the control. This should correspond to the reading on the reference voltmeter. If the control reading is significantly different, (0.6 volts or more), the calibration can be altered by pressing **EDIT**, keying in the correct voltage as displayed on the reference meter, and pressing **ENTER**. The voltage circuit is now calibrated.

Note: When installing an Eaton's Cooper Power series control on a non-Eaton's Cooper Power series voltage regulator, the control MUST have the calibration process performed. To calibrate the control on the non-Eaton's Cooper Power series regulator the internal power (System Voltage) must be applied.

Current calibration

1. Connect an accurate true-RMS-responding ammeter in series with the current source.
2. Connect a stable 60/50 Hz current source (with less than 5% harmonic content) to the reference ammeter and to the current input terminals **C1** and **C3** on **TB3** (or **TB2** if present) (**C1** is identified by a red wire, and **C3** is identified as the green wire).
3. To power the control, connect a 120 Vac voltage source to the EXTERNAL SOURCE terminals.
4. Place the power switch on **External Power**.
5. Adjust the current source to provide 0.200 A to the control, as read on the reference ammeter.
6. Before calibration can be performed, Security Level 3 must be activated by entering the proper security code at FC 99, Security Code. The default security code is "Admin".

   FUNC, *99*, **ENTER**; *Admin* (default), **ENTER**.
7. *Access* FC 48, Current Calibration.

   FUNC, *48*, **ENTER**.
8. The display will show the current applied to the control. This should correspond to the reading on the reference ammeter. If the control reading is significantly different (greater than 0.6 mA error), the calibration can be altered by pressing **EDIT**, then entering the correct current as displayed on the reference meter, followed by **ENTER**. The current circuit is now calibrated.

Section 9: Appendix

Table 14. VR-32 tap connections and voltage levels (60 Hz)

Regulator Voltage Rating	Nominal Single Phase Voltage	Ratio-Adjusting Data			Test Terminal Voltage **	Overall Potential Ratio **
		Internal Tap*	PT Ratio	RCT Tap		
1	2	3	4	5	6	7
2500	2500	-	20:1	120	125	20:1
	2400	-	20:1	120	120	20:1
5000	5000	E_1/P_1	40:1	120	125	40:1
	4800	E_1/P_1	40:1	120	120	40:1
	4160	E_1/P_1	40:1	104	120	34.7:1
	2400	E_2/P_2	20:1	120	120	20:1
7620	8000	E_1/P_1	60:1	133	120.5	66.5:1
	7970	E_1/P_1	60:1	133	120	66.5:1
	7620	E_1/P_1	60:1	127	120	63.5:1
	7200	E_1/P_1	60:1	120	120	60:1
	6930	E_1/P_1	60:1	115	120.5	57.5:1
	4800	E_2/P_2	40:1	120	120	40:1
	4160	E_2/P_2	40:1	104	120	34.7:1
	2400	E_3/P_3	20:1	120	120	20:1
13800	13800	E_1/P_1	115:1	120	120	115:1
	13200	E_1/P_1	115:1	115	120	110.2:1
	12470	E_1/P_1	115:1	104	125	99.7:1
	12000	E_1/P_1	115:1	104	125	99.7:1
	7970	E_2/P_2	57.5:1	133	125	63.7:1
	7620	E_2/P_2	57.5:1	133	120	63.7:1
	7200	E_2/P_2	57.5:1	120	120	57.5:1
	6930	E_2/P_2	57.5:1	120	120.5	57.5:1
14400	14400	E_1/P_1	120:1	120	120	120:1
	13800	E_1/P_1	120:1	115	120	115:1
	13200	E_1/P_1	120:1	110	120	110:1
	12000	E_1/P_1	120:1	104	115.5	104:1
	7970	E_2/P_2	60:1	133	120	66.5:1
	7620	E_2/P_2	60:1	127	120	63.5:1
	7200	E_2/P_2	60:1	120	120	60:1
	6930	E_2/P_2	60:1	115	120.5	57.5:1
19920	19920	E_1/P_1	166:1	120	120	166:1
	17200	E_1/P_1	166:1	104	119.5	143.9:1
	16000	E_2/P_2	120:1	133	120.5	133:1
	15242	E_2/P_2	120:1	127	120	127:1
	14400	E_2/P_2	120:1	120	120	120:1
	7960	E_3/P_3	60:1	133	120	66.5:1
	7620	E_3/P_3	60:1	127	120	63.5:1
	7200	E_3/P_3	60:1	120	120	60:1
34500	34500	E_1/P_1	287.5:1	120	120	287.5:1
	19920	E_2/P_2	165.5:1	120	120.5	165.5:1

* P taps are used with E taps only on regulators where an internal differential potential transformer is used in conjunction with the control winding to provide voltage supplies to the control. See nameplate for verification of this type of control supply.

** Test terminal voltage and overall potential ratio may vary slightly from one regulator to another. See the regulator nameplate for determining the exact values.

Table 15. VR-32 tap connections and voltage levels (50 Hz)

Regulator Voltage Rating	Nominal Single Phase Voltage	Ratio-Adjusting Data			Test Terminal Voltage **	Overall Potential Ratio **
		Internal Tap*	PT Ratio	RCT Tap		
1	2	3	4	5	6	7
6600	6930	-	55:1	127	119.1	58.2:1
	6600	-	55:1	120	120	55:1
	6350	-	55:1	115	120.5	52.7:1
	6000	-	55:1	110	119	50.4:1
	5500	-	55:1	104	115.4	47.7:1
11000	11600	E_1/P_1	91.7:1	127	119.5	96:1
	11000	E_1/P_1	91.7:1	120	120	91.7:1
	10000	E_1/P_1	91.7:1	110	119	84.1:1
	6930	E_2/P_2	55:1	127	119.1	58.2:1
	6600	E_2/P_2	55:1	120	120	55.1:1
	6350	E_2/P_2	55:1	115	120.5	52.7:1
	6000	E_2/P_2	55:1	110	119	50.4:1
	5500	E_2/P_2	55:1	104	115.4	47.7:1
15000	15000	E_1/P_1	120:1	120	125	120:1
	14400	E_1/P_1	120:1	120	120	120:1
	13800	E_1/P_1	120:1	115	120	115:1
	13200	E_1/P_1	120:1	110	120	110:1
	12000	E_1/P_1	120:1	104	115.4	104:1
	11000	E_2/P_2	92.7:1	120	118.7	91.8:1
	10000	E_2/P_2	92.7:1	110	117.7	84.1:1
	8600	E_3/P_3	72.9:1	120	118	72.9:1
22000	23000	E_1/P_1	183.4:1	127	118.5	194.1:1
	22000	E_1/P_1	183.4:1	120	120	183.4:1
	20000	E_1/P_1	183.4:1	110	119	168.1:1
	19100	E_1/P_1	183.4:1	104	120.2	158.9:1
	15000	E_2/P_2	122.3:1	120	122.6	122.3:1
	12700	E_2/P_2	122.3:1	104	119.8	106:1
	11000	E_3/P_3	91.7:1	120	120	91.7:1
	10000	E_3/P_3	91.7:1	110	119	84.1:1
33000	34500	E_1/P_1	275:1	127	118.5	291:1
	33000	E_1/P_1	275:1	120	120	275:1
	30000	E_1/P_1	275:1	110	119	252.1:1
	22000	E_2/P_2	183.3:1	120	120	183.3:1
	20000	E_2/P_2	183.3:1	110	119	168:1
	11600	E_3/P_3	91.7:1	127	119.5	97:1
	11000	E_3/P_3	91.7:1	120	120	91.7:1
	10000	E_3/P_3	91.7:1	110	119	84.1:1

* P taps are used with E taps only on regulators where an internal differential potential transformer is used in conjunction with the control winding to provide voltage supplies to the control. See nameplate for verification of this type of control supply.

** Test terminal voltage and overall potential ratio may vary slightly from one regulator to another. See the regulator nameplate for determining the exact values.

Table 16. ADD-AMP capabilities of 60 Hz ratings

		†Load Current Ratings (A)				
		Regulation Range (Wye and Open Delta)				
		±10%	±8.75%	±7.5%	±6.25%	±5%
Rated Volts	Rated kVA	Regulation Range (Closed Delta) ±15%	±13.1%	±11.3%	±9.4%	±7.5%
2500	50	200	220	240	270	320
	75	300	330	360	405	480
	100	400	440	480	540	640
	125	500	550	600	668	668
	167	668	668	668	668	668
	250	1000	1000	1000	1000	1000
	333	1332	1332	1332	1332	1332
	416.3	1665	1665	1665	1665	1665
5000	25	50	55	60	68	80
	50	100	110	120	135	160
	100	200	220	240	270	320
	125	250	275	300	338	400
	167	334	367	401	451	534
	250	500	550	600	668	668
	333	668	668	668	668	668
	416.3	833	833	833	833	833
7620*	38.1	50	55	60	68	80
	57.2	75	83	90	101	120
	76.2	100	110	120	135	160
	114.3	150	165	180	203	240
	167	219	241	263	296	350
	250	328	361	394	443	525
	333	438	482	526	591	668
	416.3	548	603	658	668	668
	500	656	668	668	668	668
	667	875	875	875	875	875
	833	1093	1093	1093	1093	1093
13800	69	50	55	60	68	80
	138	100	110	120	135	160
	207	150	165	180	203	240
	276	200	220	240	270	320
	414	300	330	360	405	480
	500	362	398	434	489	579
	552	400	440	480	540	640
	667	483	531	580	652	668
	833	604	664	68	668	668
14400	72	50	55	60	68	80
	144	100	110	120	135	160
	288	200	220	240	270	320
	333	231	254	277	312	370
	416	289	318	347	390	462
	432	300	330	360	405	480
	500	347	382	416	468	555
	576	400	440	480	540	640
	667	463	509	556	625	668
	720	500	550	600	668	668
	833	578	636	668	668	668
19920	100	50.2	55	60	68	80
	200	100.4	110	120	135	160
	333	167	184	200	225	267
	400	200.8	220	240	270	320
	500	250	275	300	338	400
	667	335	369	402	452	536
	833	418	460	502	564	668
	1000	502	552	602	668	668
34500	172.5	50	55	60	68	80
	345	100	110	120	135	160
	518	150	165	180	203	240
	690	200	220	240	270	320

Table 17. ADD-AMP capabilities of 50 Hz ratings

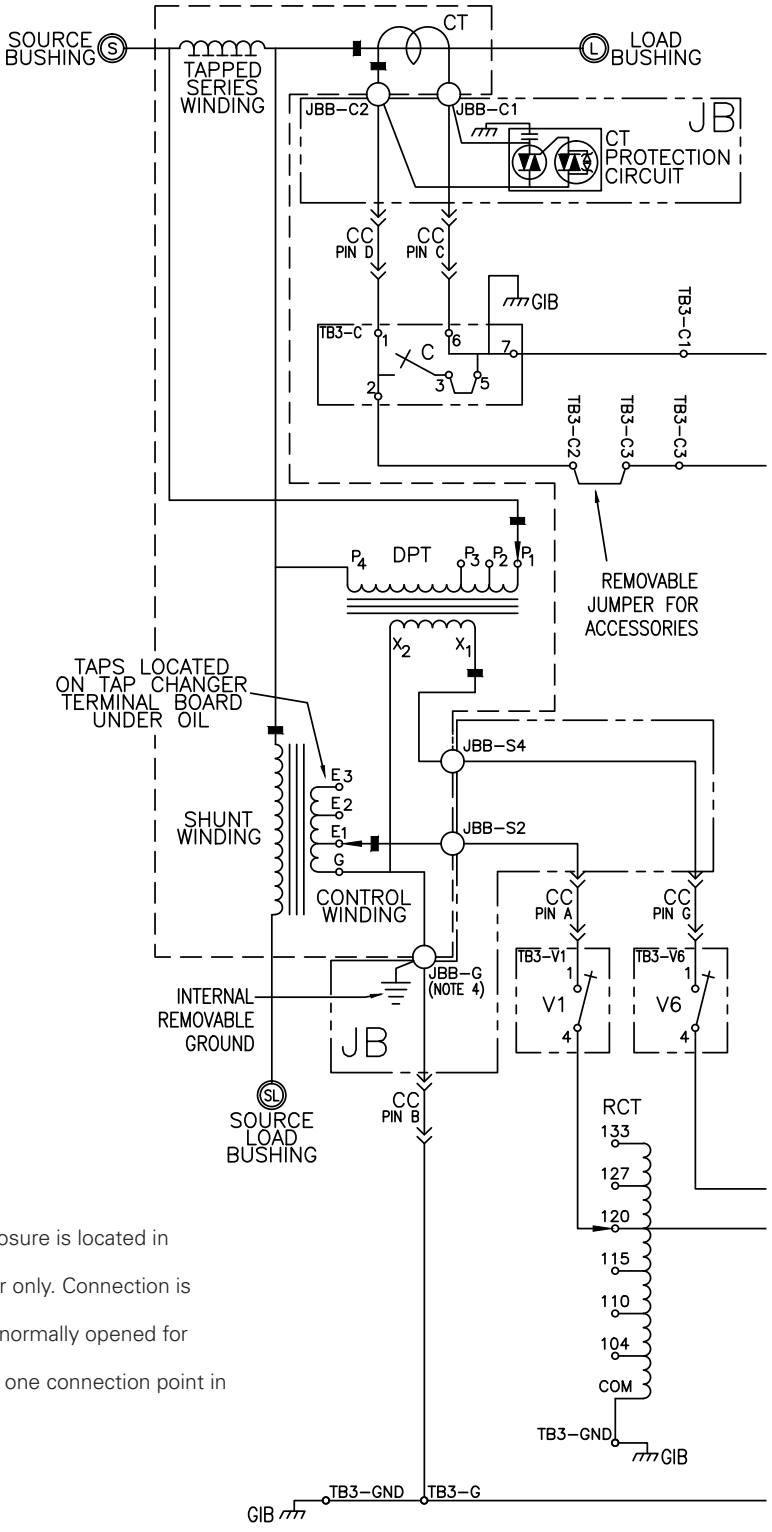
		†Load Current Ratings (A)				
		Regulation Range (Wye and Open Delta) ±10%	±8.75%	±7.5%	±6.25%	±5%
Rated Volts	Rated kVA	Regulation Range (Closed Delta) ±15%	±13.1%	±11.3%	±9.4%	±7.5%
6600	33	50	55	60	68	80
	66	100	110	120	135	160
	99	150	165	180	203	240
	132	200	220	240	270	320
	198	300	330	360	405	480
	264	400	440	480	540	640
	330	500	550	600	668	668
	396	600	660	668	668	668
11000	55	50	55	60	68	80
	110	100	110	120	135	160
	165	150	165	180	203	240
	220	200	220	240	270	320
	330	300	330	360	405	480
	440	400	440	480	540	640
	550	500	550	600	668	668
	660	600	660	668	668	668
15000	75	50	55	60	68	80
	150	100	110	120	135	160
	225	150	165	180	203	240
	300	200	220	240	270	320
	450	300	330	360	405	480
	600	400	440	480	540	640
	750	500	550	600	668	668
22000	110	50	55	60	68	80
	220	100	110	120	135	160
	330	150	165	180	203	240
	440	200	220	240	270	320
	660	300	330	360	405	480
	880	400	440	480	540	640
33000	165	50	55	60	68	80
	330	100	110	120	135	160
	495	150	165	180	203	240
	333	231	254	277	312	370
	660	200	220	240	270	320

† 55/65 °C rise rating on VR-32 regulators gives an additional 12% increase in capacity if the tap-changer's maximum current rating has not been exceeded. For loading in excess of the above values, please refer to your Eaton representative.

* Regulators are capable of carrying current corresponding to rated kVA when operated at 7200 V.

Wiring diagrams and schematics

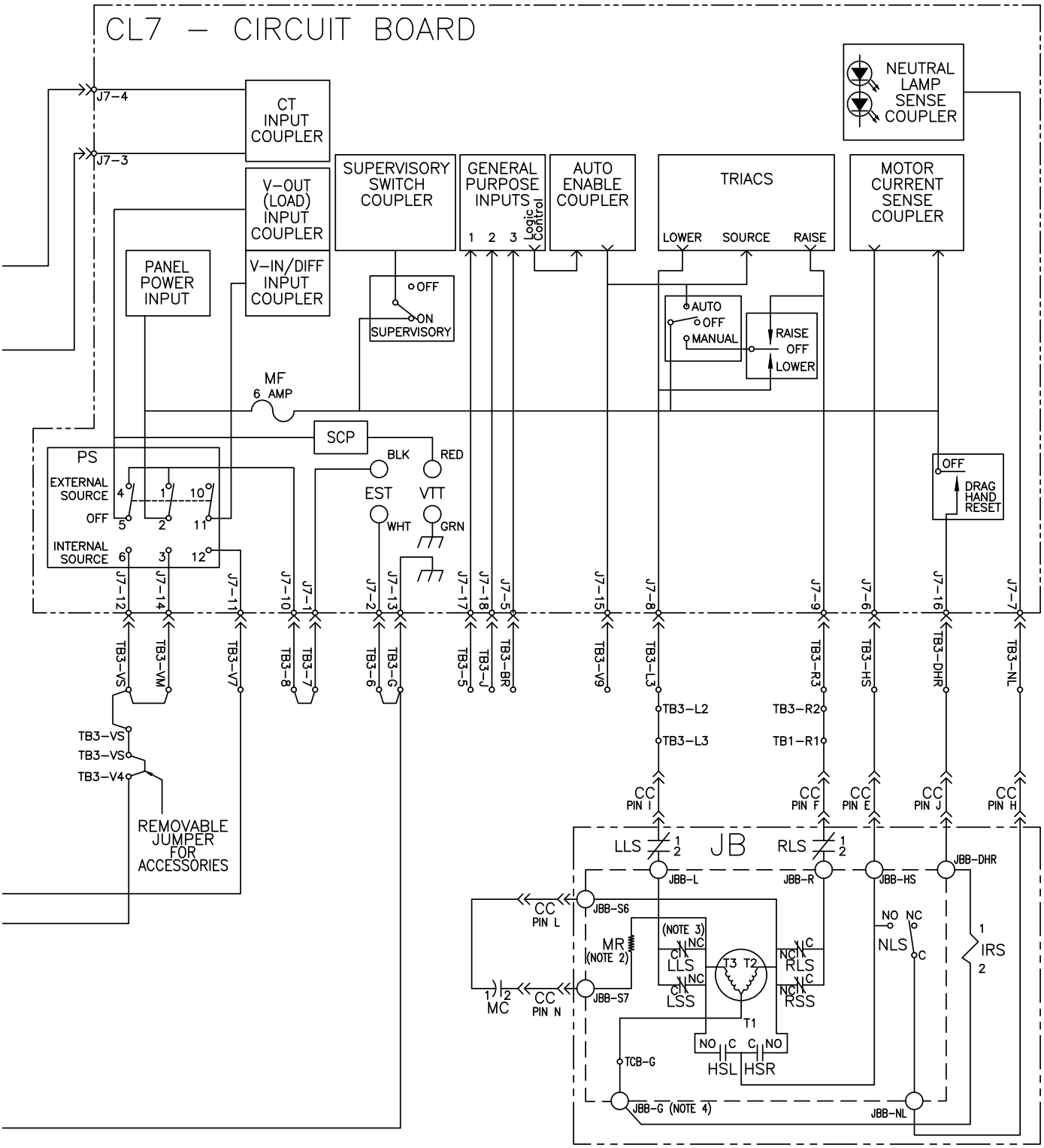
C	CT Shorting Switch
CC	Control Cable
CT	Current Transformer (Toroidal Coil)
DPT	Differential Potential Transformer
DHR	Drag Hand Reset
EST	External Source Terminals
GIB	Ground Integrated into Terminal Board
HSL	Holding Switch Lower
HSR	Holding Switch Raise
IRS	Indicator Reset Solenoid (Position Indicator)
JB	Junction Box on the Regulator Cover
JBB	Junction Box Terminal Board on the Cover
LLS	Lower Limit Switch (Position Indicator)
LLS	Lower Logic Switch (Tap-Changer)
LSS	Lower Safety Switch
MC	Motor Capacitor
MF	Motor Fuse
MR	Motor Resistor
NL	Neutral Light
NLS	Neutral Light Switch
PS	Power Switch
RCT	Ratio Correction Transformer
RLS	Raise Limit Switch (Position Indicator)
RLS	Raise Logic Switch (Tap-Changer)
RSS	Raise Safety Switch
SCP	Short Circuit Protection
TB	Control Terminal Board
TCB	Tap-Changer Terminal Board
V1	PT Voltage Interrupting Switch
V6	DPT Voltage Interrupting Switch
VM	Motor Voltage
VS	Sensing Voltage
VTT	Voltage Test Terminals



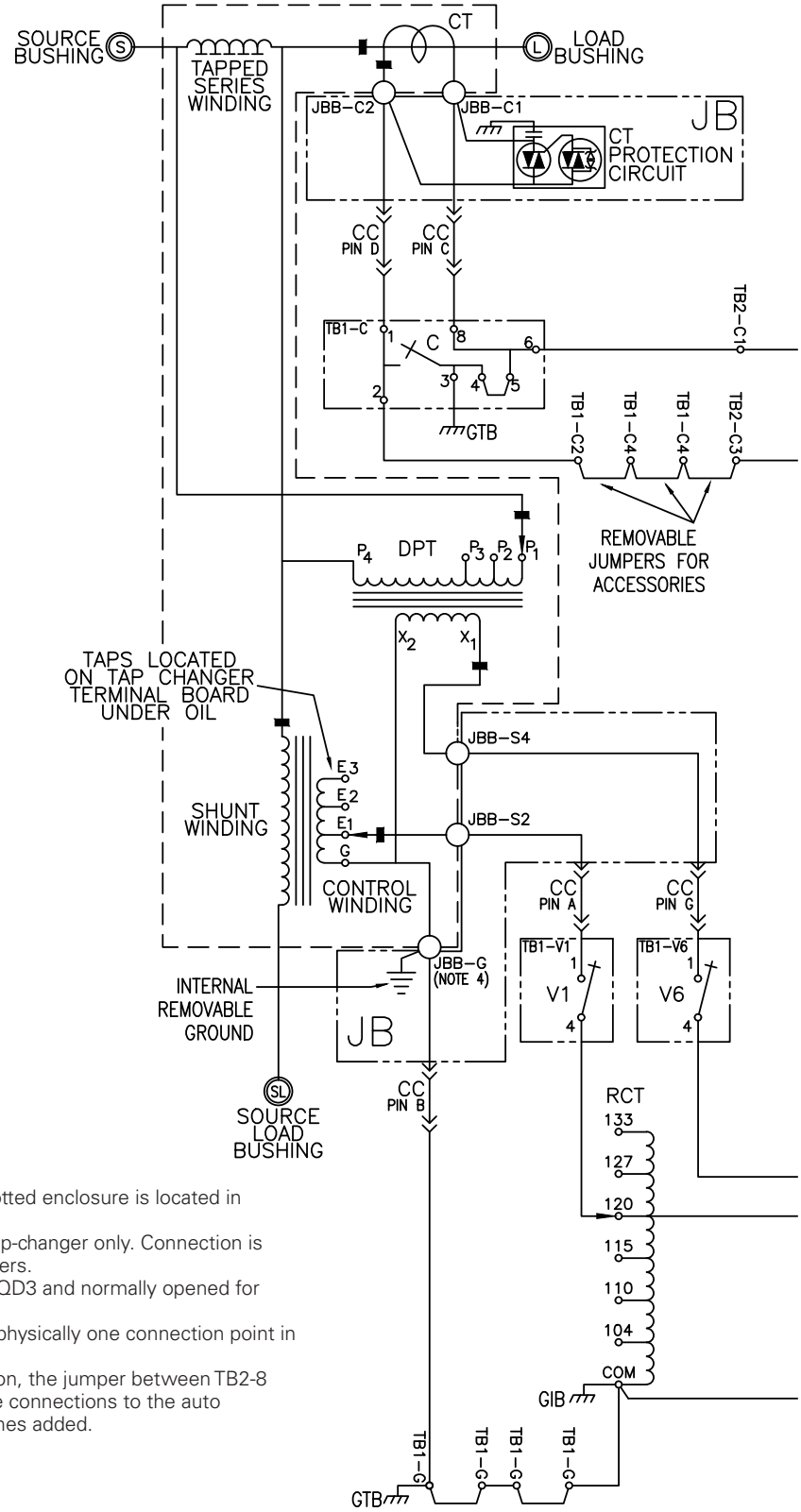
Notes:

1. Portions of schematic shown in dotted enclosure is located in regulator tank.
2. Motor resistor required for QD3 tap-changer only. Connection is direct for QD5 and QD8 tap-changers.
3. This switch is normally closed for QD3 and normally opened for QD5 and QD8 tap-changers.
4. The two JBB-G points shown are physically one connection point in the junction box.

Figure 62. Wiring diagram for Type B VR-32 regulator and CL-7 control with differential potential transformer


CL7 – CIRCUIT BOARD
J7–4
J7–3
CT INPUT COUPLER
V–OUT (LOAD) INPUT COUPLER
V–IN/DIFF INPUT COUPLER
PANEL POWER INPUT
SUPERVISORY SWITCH COUPLER
OFF
ON SUPERVISORY
GENERAL PURPOSE INPUTS
1 2 3
Logic Control
AUTO ENABLE COUPLER
TRIACS
LOWER SOURCE RAISE
AUTO
OFF
MANUAL
RAISE
OFF
LOWER
NEUTRAL LAMP SENSE COUPLER
MOTOR CURRENT SENSE COUPLER
OFF
DRAG HAND RESET
MF
6 AMP
SCP
BLK
RED
EST
VTT
WHT
GRN
PS
EXTERNAL SOURCE
OFF
INTERNAL SOURCE
4
1
10
5
2
11
6
3
12
J7–12
J7–14
J7–11
J7–10
J7–1
J7–2
J7–13
J7–17
J7–18
J7–5
J7–15
J7–8
J7–9
J7–6
J7–16
J7–7
TB3–VS
TB3–VM
TB3–V7
TB3–8
TB3–7
TB3–6
TB3–G
TB3–5
TB3–J
TB3–BR
TB3–V9
TB3–L3
TB3–R3
TB3–HS
TB3–DHR
TB3–NL
TB3–L2
TB3–L3
TB3–R2
TB1–R1
TB3–VS
TB3–VS
TB3–V4
REMOVABLE JUMPER FOR ACCESSORIES
CC PIN I
CC PIN F
CC PIN E
CC PIN J
CC PIN H
LLS
JB
RLS
JBB–L
JBB–R
JBB–HS
JBB–DHR
CC PIN L
JBB–S6
MR
(NOTE 2)
(NOTE 3)
NC
C
LLS
LSS
T3 T2
RLS
RSS
NO NC
NLS
C
1
IRS
2
1 2
MC
CC PIN N
JBB–S7
T1
NO C C NO
HSL HSR
TCB–G
JBB–G (NOTE 4)
JBB–NL

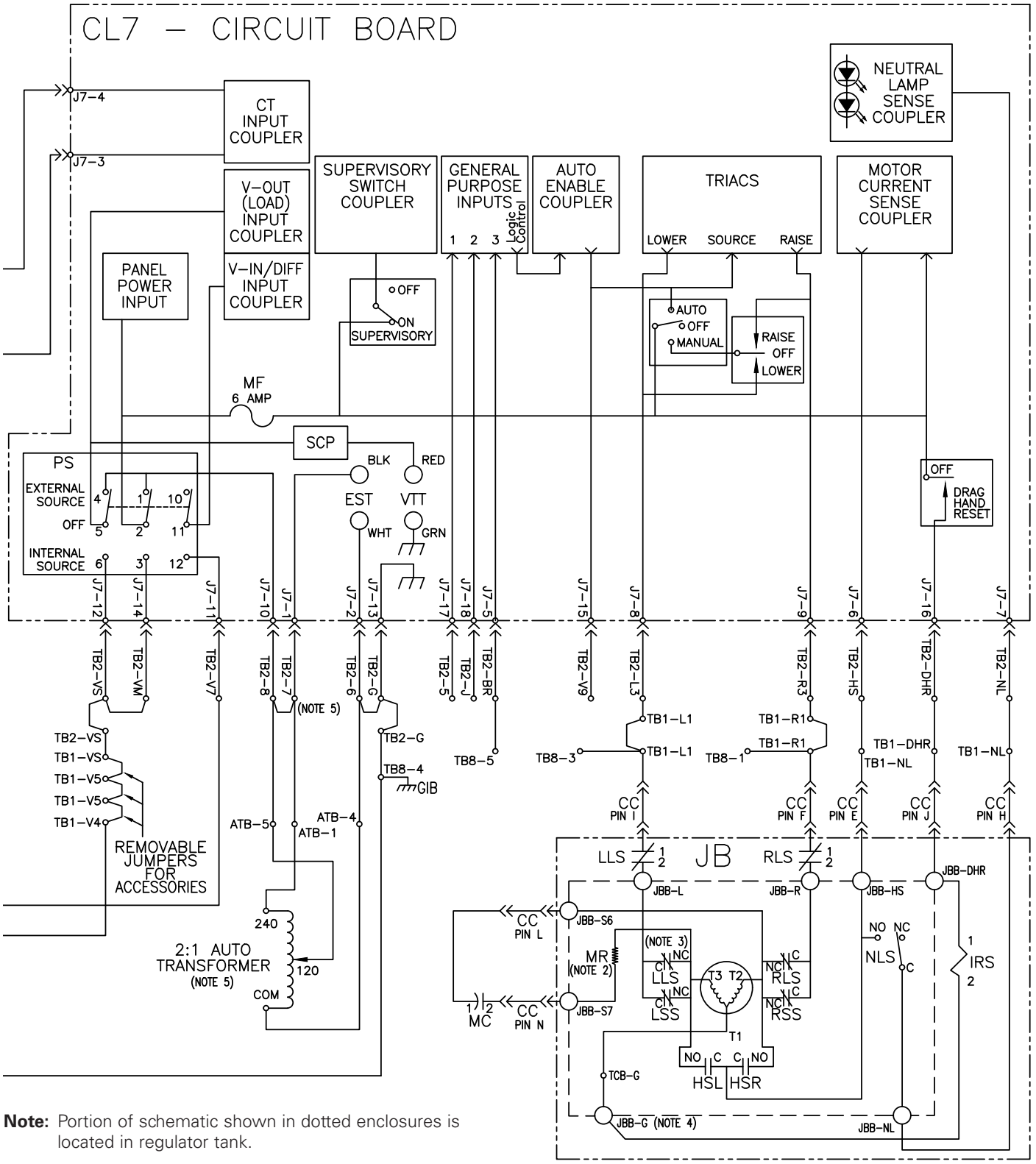
ATB	Auto-Transformer Terminal Board
C	CT Shorting Switch
CC	Control Cable
CT	Current Transformer (Toroidal Coil)
DPT	Differential Potential Transformer
DHR	Drag Hand Reset
EST	External Source Terminals
GIB	Ground Integrated into Terminal Board
GTB	Grounded to Back Panel
HSL	Holding Switch Lower
HSR	Holding Switch Raise
IRS	Indicator Reset Solenoid (Position Indicator)
JB	Junction Box on the Regulator Cover
JBB	Junction Box Terminal Board on the Cover
LLS	Lower Limit Switch (Position Indicator)
LLS	Lower Logic Switch (Tap-Changer)
LSS	Lower Safety Switch
MC	Motor Capacitor
MF	Motor Fuse
MR	Motor Resistor
NL	Neutral Light
NLS	Neutral Light Switch
PS	Power Switch
RCT	Ratio Correction Transformer
RLS	Raise Limit Switch (Position Indicator)
RLS	Raise Logic Switch (Tap-Changer)
RSS	Raise Safety Switch
SCP	Short Circuit Protection
TB	Control Terminal Board
TCB	Tap-Changer Terminal Board
V1	PT Voltage Interrupting Switch
V6	DPT Voltage Interrupting Switch
VM	Motor Voltage
VS	Sensing Voltage
VTT	Voltage Test Terminals



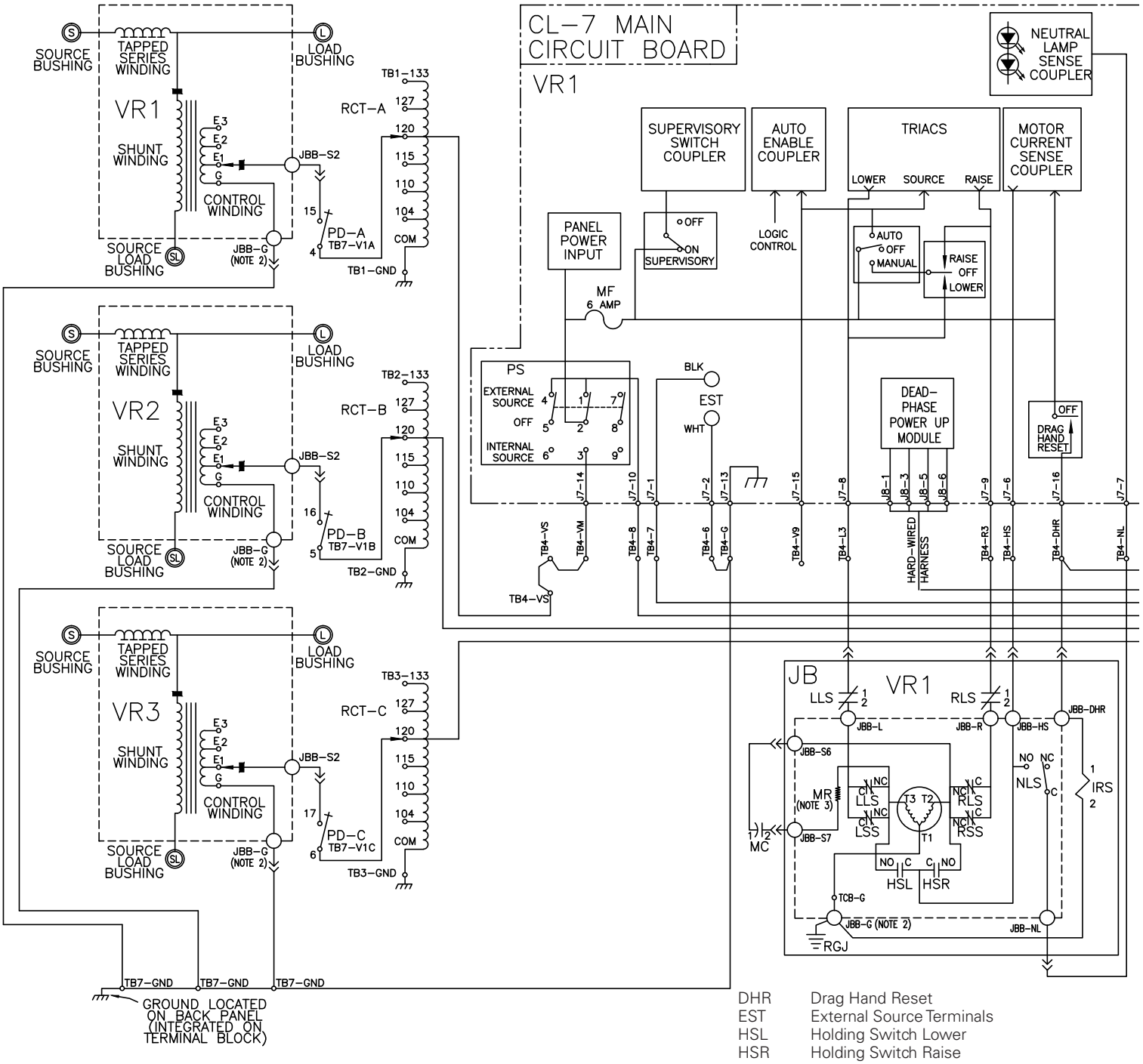
Notes:

1. Portions of schematic shown in dotted enclosure is located in regulator tank.
2. Motor resistor required for QD3 tap-changer only. Connection is direct for QD5 and QD8 tap-changers.
3. This switch is normally closed for QD3 and normally opened for QD5 and QD8 tap-changers.
4. The two JBB-G points shown are physically one connection point in the junction box.
5. For the 240 V external source option, the jumper between TB2-8 and TB2-7 will be removed and the connections to the auto transformer shown with dashed lines added.

Figure 63. Wiring diagram for Type B VR-32 regulator and CL-7 control configures for 240 Vac external power source



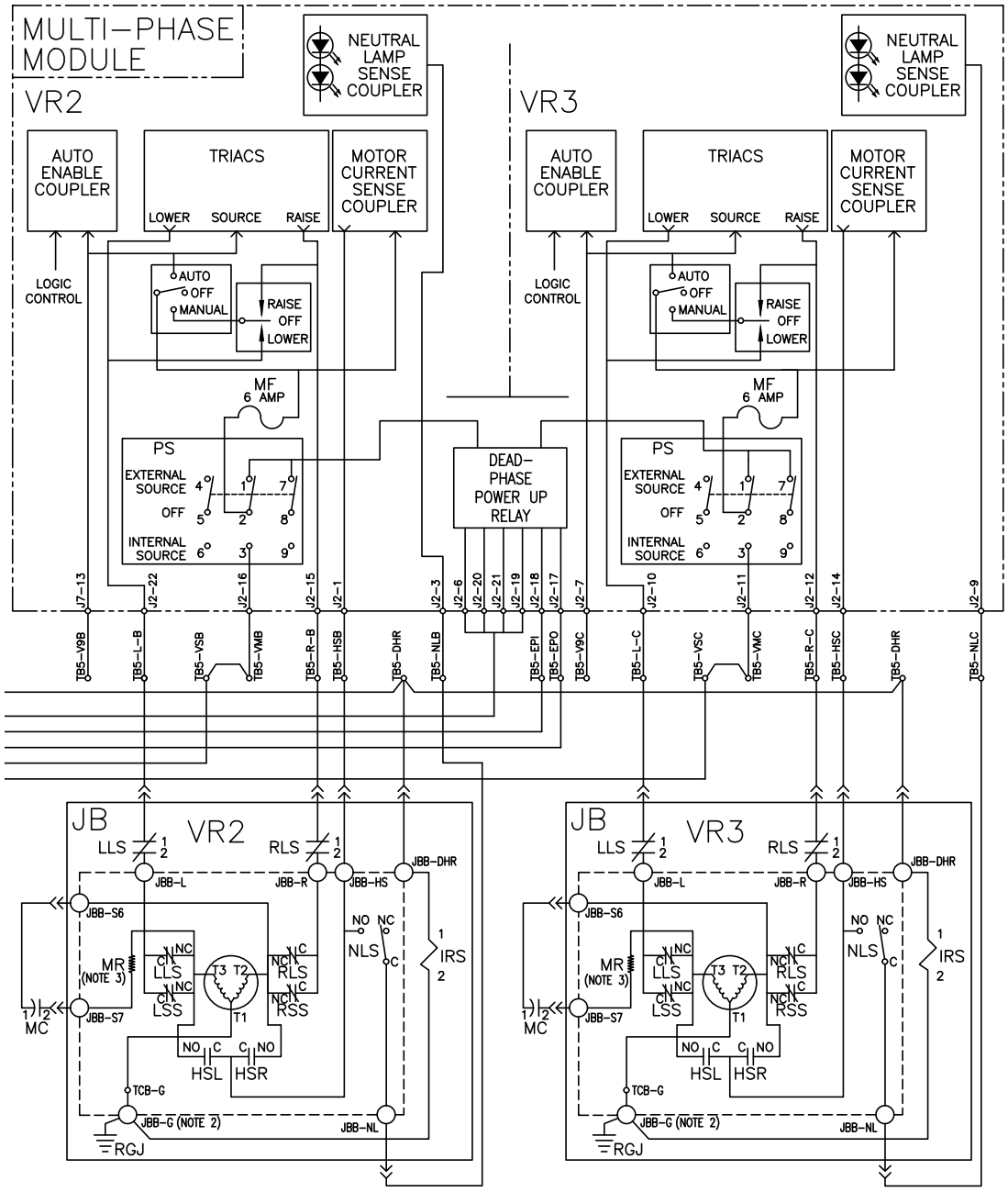
Note: Portion of schematic shown in dotted enclosures is located in regulator tank.



DHR	Drag Hand Reset
EST	External Source Terminals
HSL	Holding Switch Lower
HSR	Holding Switch Raise
IRS	Indicator Reset Solenoid (Position Indicator)
JB	Junction Box on the Regulator Cover
JBB	Junction Box Terminal Board on the Cover

Note: Portion of schematic shown in dotted enclosures is located in regulator tank.

Figure 64. Multi-phase motor schematic



LLS	Lower Limit Switch (Position Indicator)
LLS	Lower Logic Switch (Tap-Changer)
LSS	Lower Safety Switch
MC	Motor Capacitor
MF	Motor Fuse
MR	Motor Resistor
NL	Neutral Light
NLC	Neutral Light Capacitor
NLS	Neutral Light Switch
PD	Potential Opening Device
PS	Power Switch
RCT	Ratio Correction Transformer
RGJ	Removable Ground in Junction Box
RLS	Raise Limit Switch (Position Indicator)
RLS	Raise Logic Switch (Tap-Changer)
RSS	Raise Safety Switch
SCP	Short Circuit Protection
TB	Control Terminal Board
TCB	Tap-Changer Terminal Board
VM	Motor Voltage
VR	Voltage Regulator
VS	Sensing Voltage

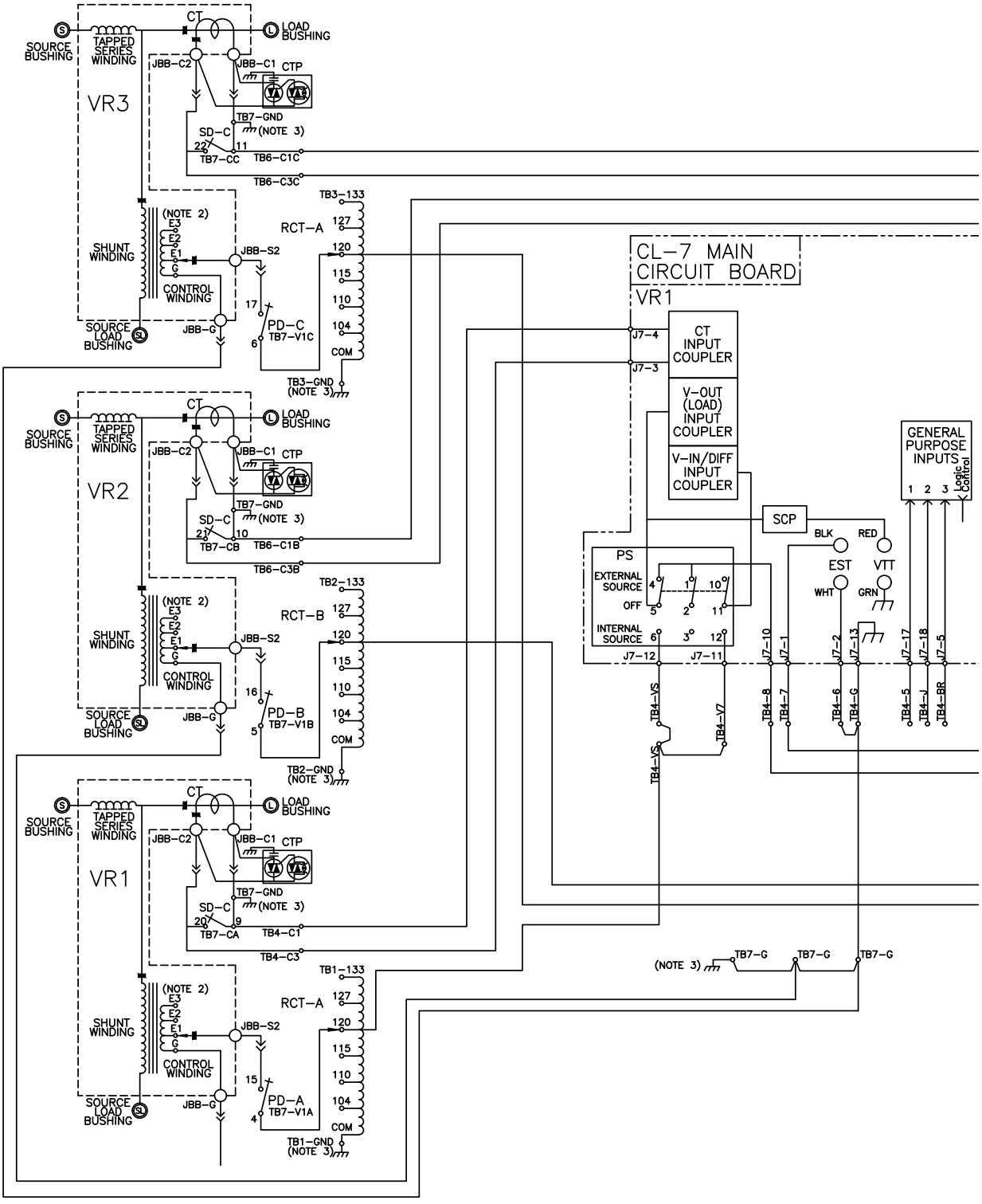
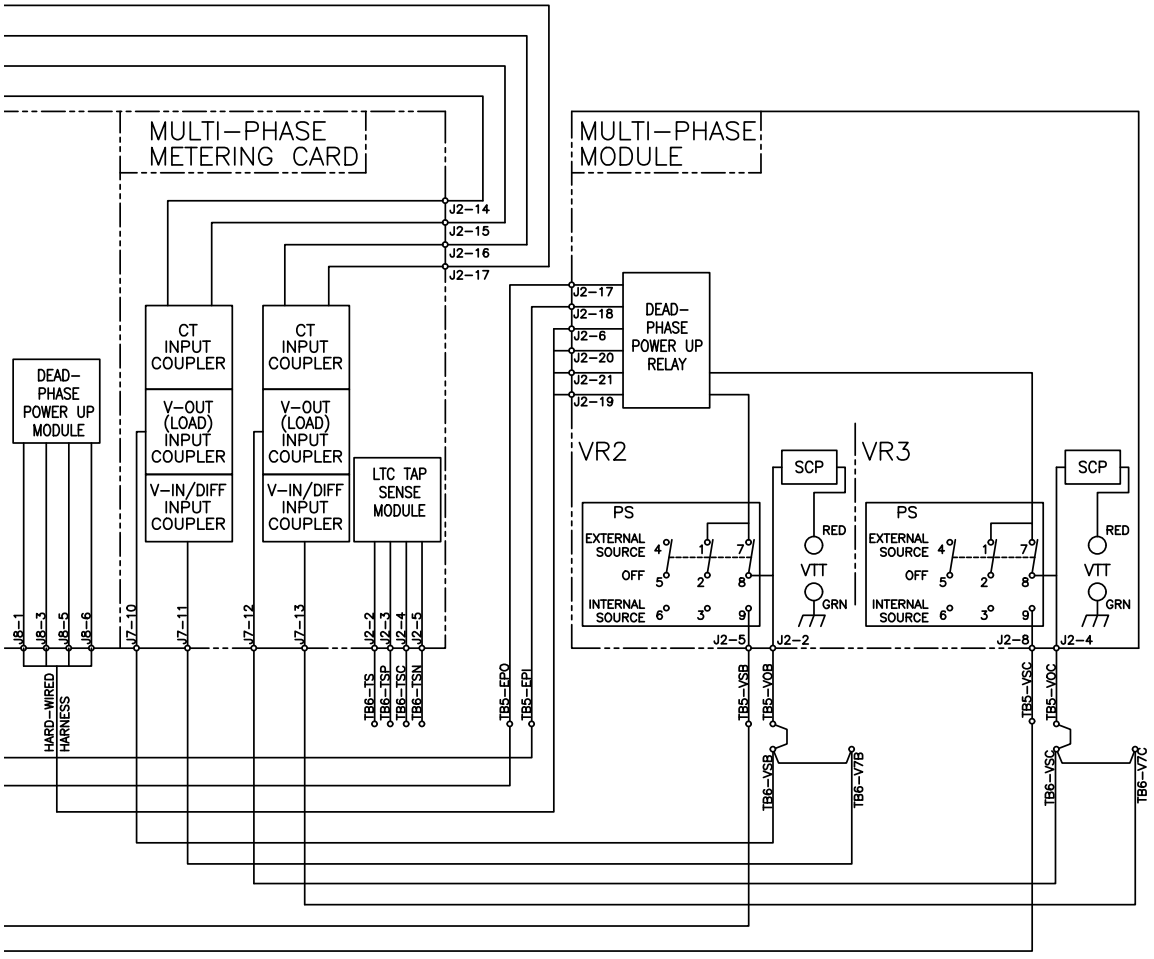
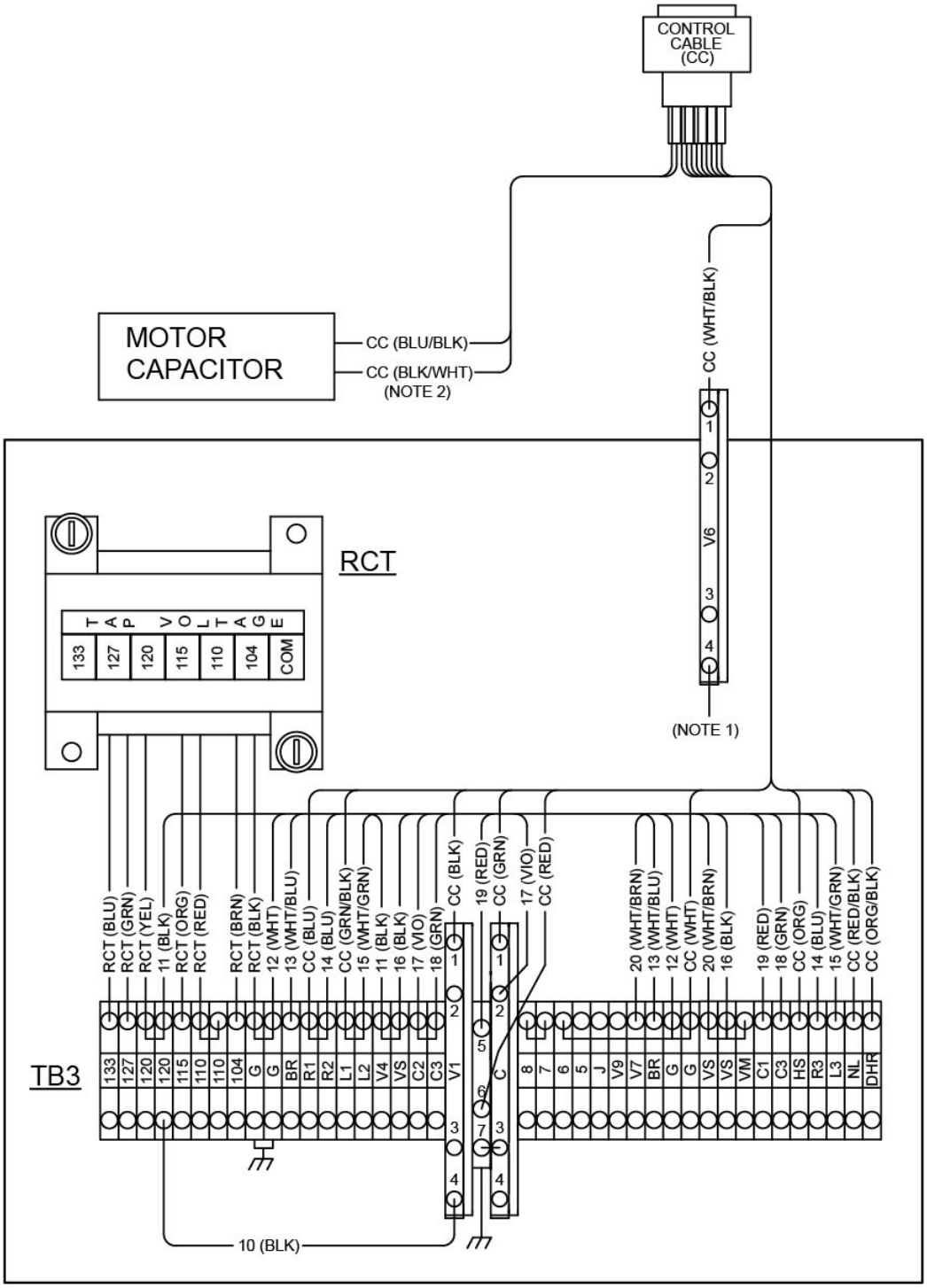


Figure 65. Multi-phase metering schematic



CT	Current Transformer (Toroidal Coil)
CTP	CT Protection Device
DHR	Drag Hand Reset
EST	External Source Terminals
JB	Junction Box on the Regulator Cover
JBB	Junction Box Terminal Board on the Cover
NL	Neutral Light
PD	Potential Opening Device
PS	Power Switch
RCT	Ratio Correction Transformer
SCP	Short Circuit Protection
TB	Control Terminal Board
VS	Sensing Voltage
VTT	Voltage Test Terminals



NOTES
1. LEAD 20 (WHT/BRN) CONNECTS V6-4 TO V7 INSTEAD OF VS TO V7 WHEN A DIFFERENTIAL PT IS UTILIZED.
2. CONTROL CABLES CONTAINING 14 CONDUCTORS WILL HAVE CAPACITOR WIRE COLORS OF RED/WHITE AND GREEN/WHITE.

Figure 66. Standard back panel signal circuit

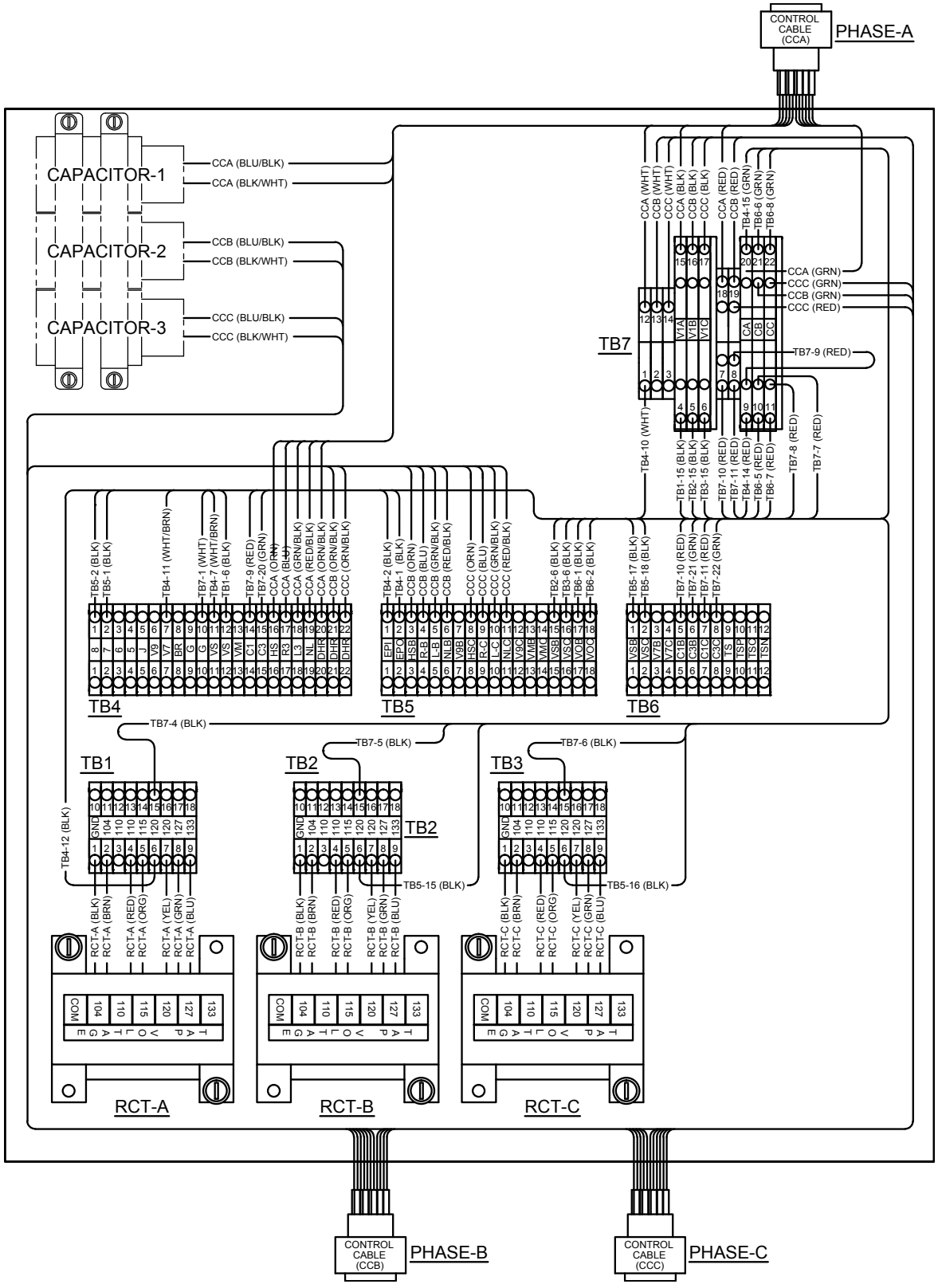


Figure 67. Multi-phase back panel signal circuit

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Printed in USA
Publication No. MN225003EN
April 2018

For Eaton's Cooper Power series product information, call 1-877-277-4636 or visit: www.eaton.com/cooperpowerseries.