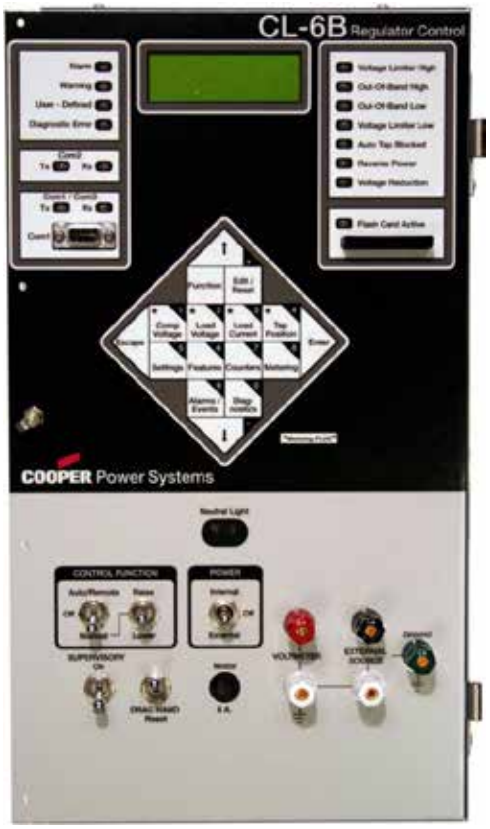
CL-6 series control installation, operation, and maintenance instructions



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, could result in minor or moderate injury.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, could 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. G122.3

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Product information

Introduction

This document describes the operation, and maintenance instructions for Eaton's Cooper Power™ series CL-6 series control for voltage regulators. Refer to *Service Information 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.

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 610255-5

Quality standards

ISO 9001 Certified Quality Management System.

Description

The reliable CL-6 control from Eaton 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-6 control is CE (Commonwealth Europe) compliant. The nameplate located on the control box defines the power circuit.

The CL-6 control allows keypad programming, Metering-PLUS™ status inquiries, flashcard uploading and downloading, and multiple communication ports with user-selectable DNP3 or 2179 protocol. LED indicators provide instant information on alarm, communications, and regulation condition status. A four-line display provides more detailed information and further simplifies programming. In addition, the CL-6 control is highly configurable and ready for use in applications where either digital or analog supervisory control and data acquisition (SCADA) is required.

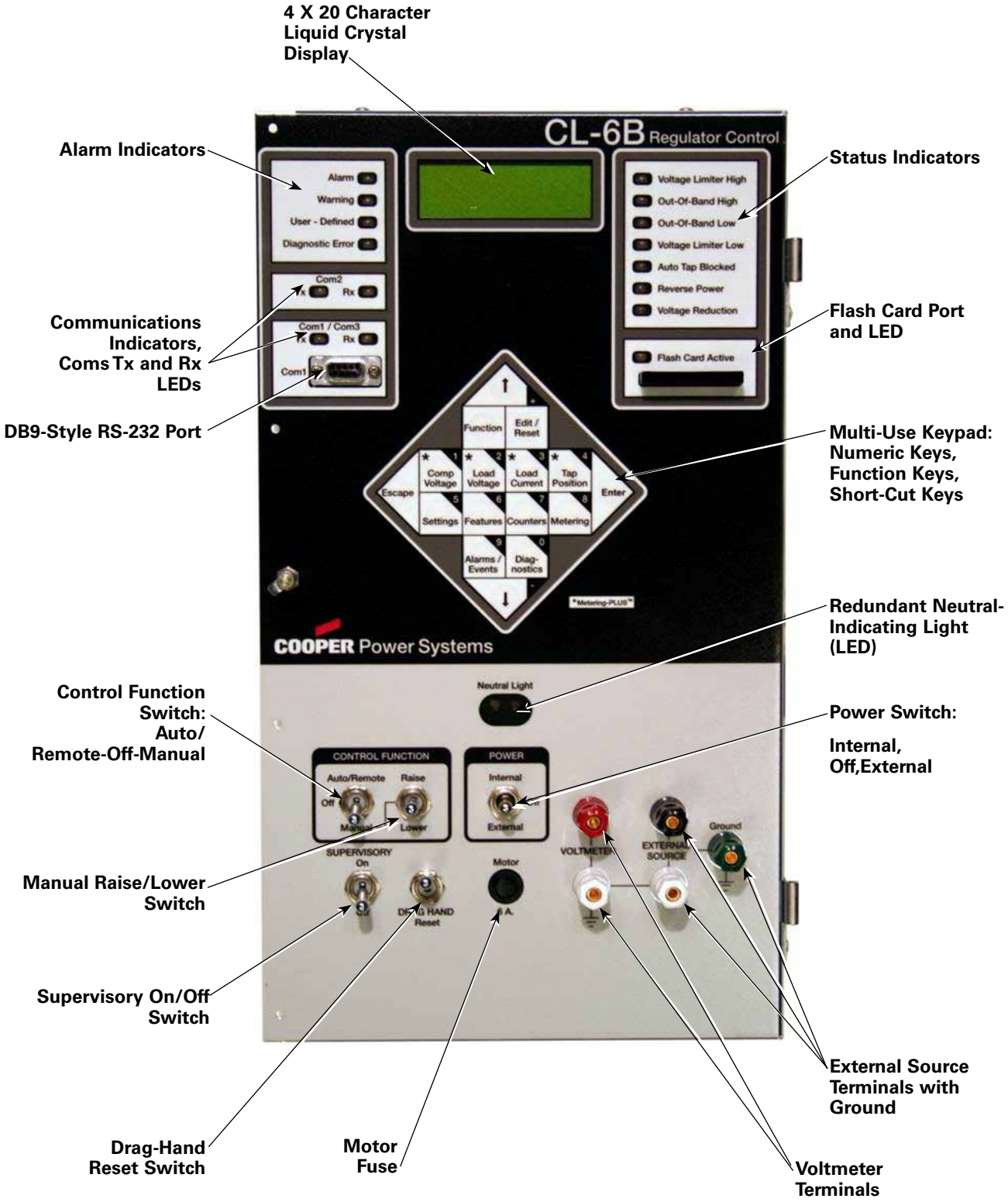


Figure 1-1. Control panel layout.

Section 1: Control panel

Lower panel (grey)

The lower section of the control contains components which are similar to other controls in Eaton's Cooper Power series CL line of controls. Refer to Figure 1-1.

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 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 Manual.

Supervisory switch

This switch is used for digital communications only. When set to **On**, SCADA has full capabilities. When set to **Off**, SCADA may only read the control database.

Drag-hand reset switch

This switch operates a solenoid in the position indicator to move the drag hands to the present tap position.

Neutral light

This is the primary indication that the tap-changer is in the neutral position. See the **Control Installation: Determining Neutral Position** section of this manual.

Voltmeter terminals

These 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 terminal and a white terminal.

Fuse

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

External source terminals

CAUTION

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

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 terminal(s). 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.

CAUTION

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.

The CL series control can be powered externally through the front 'external power' binding posts. The control panel itself utilizes 120 Vac to operate. However, there are optional configurations in which a 240 Vac control cabinet is supplied. Whichever the case, care must be taken when applying an external source to the control.

Connecting power to external source terminals

240 Vac applications to Eaton 240 V control

Option 1:

Control Box Assembly/Panel connected to earth ground to provide protection to operations personnel (typical field application where control is mounted on grounded Regulator tank or dropped down pole with control box grounded properly).

The 240 Vac Eaton control cabinet 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-6 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 1-2.

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 isolation transformer is through the control box connection to ground.

Option 2:

Control Box Assembly floating (typical shop or lab application where control is mounted on ungrounded regulator tank or sitting on workbench).

Eaton 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-6 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 1-3.

In this case, the ground of the isolation transformer is connected to the green terminal post on the CL-6 series 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.

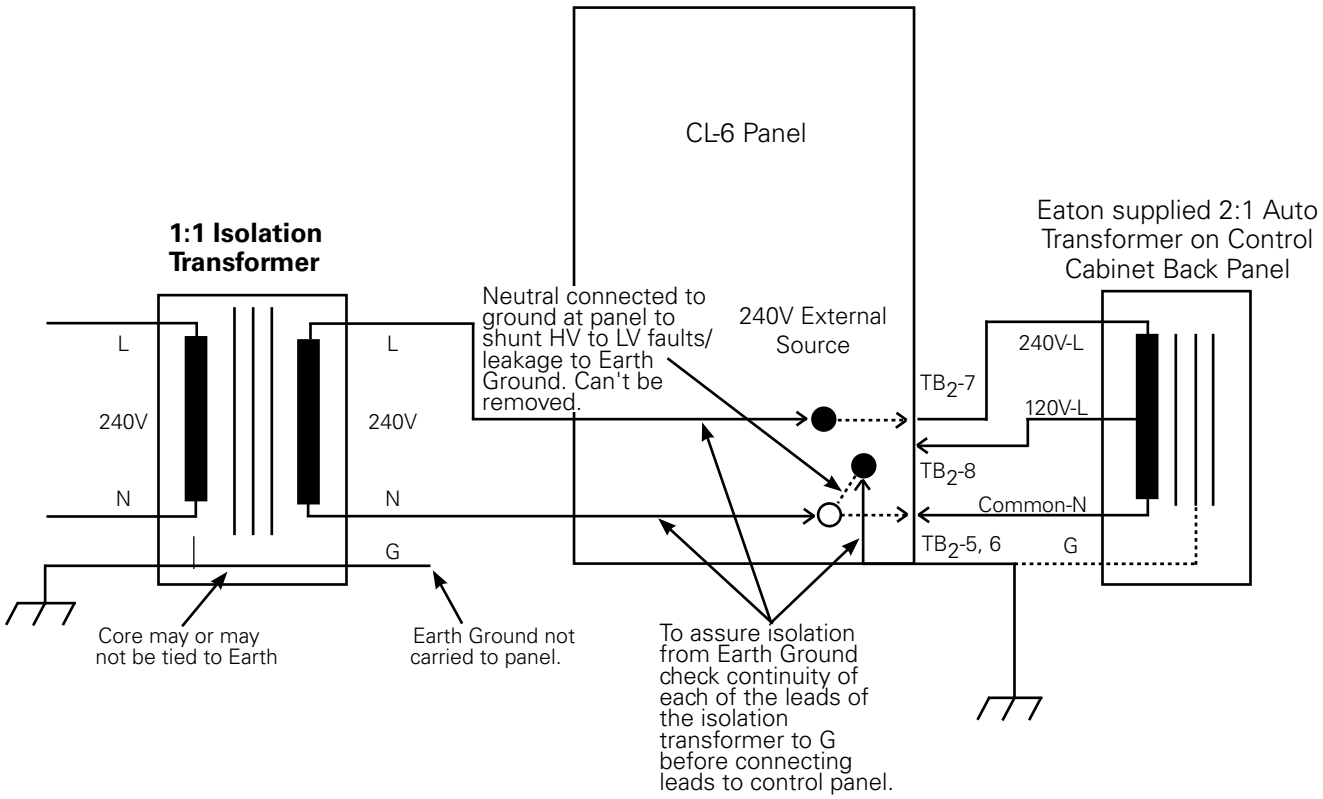


Figure 1-2. 240 Vac application with Eaton 240 V control - Option 1.

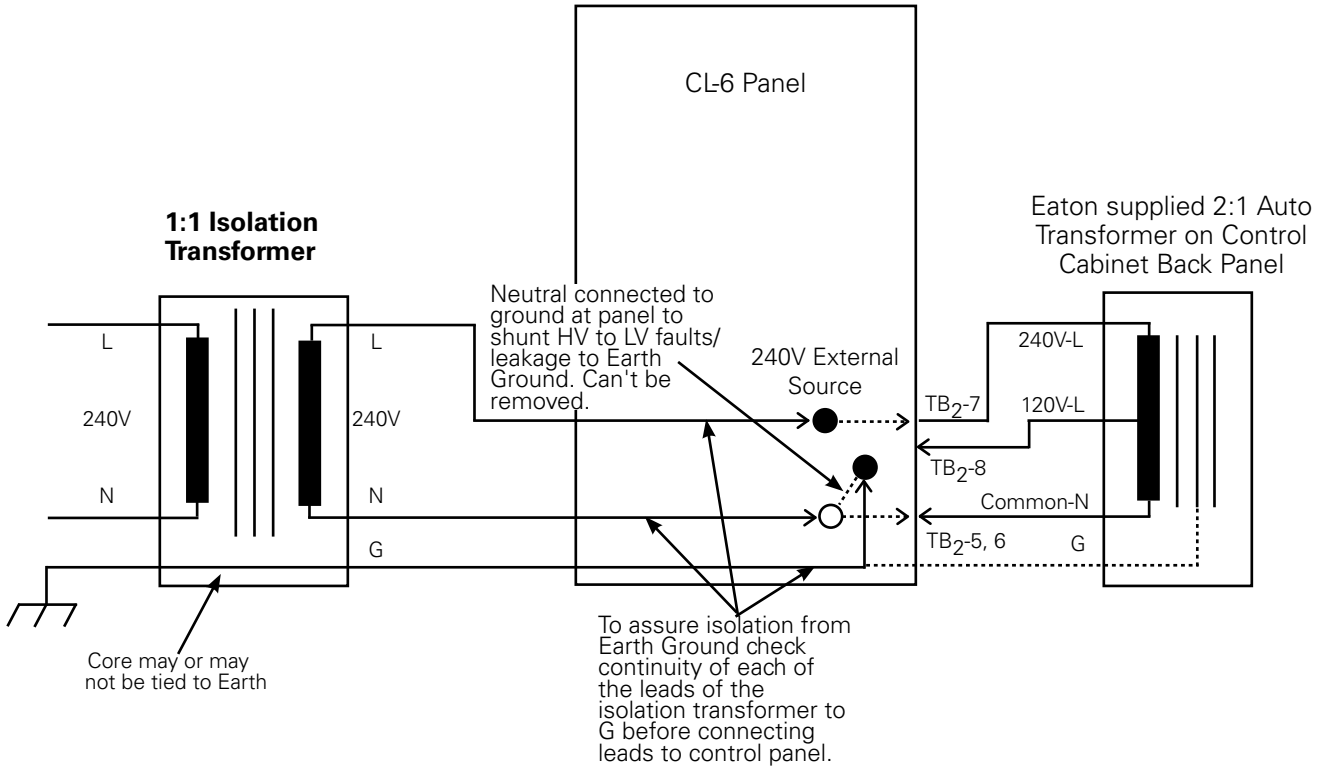


Figure 1-3. 240 Vac application with Eaton 240 V control - Option 2.

240 Vac applications to Eaton 120 V control

Option 1:

Control Box Assembly/Panel connected to earth ground to provided protection to operations personnel (typical field application where control is mounted on grounded Regulator tank or dropped down pole with 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 1-4.

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. Only source of earth ground reference on secondary of Isolation transformer is through Control Box connection to ground.

Option 2:

Control Box assembly floating (typical shop or lab application when control is mounted on ungrounded regulator tank or setting on 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 1-5.

In this case the ground of the isolation transformers is connected to the green terminal post on the CL-6 series 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.

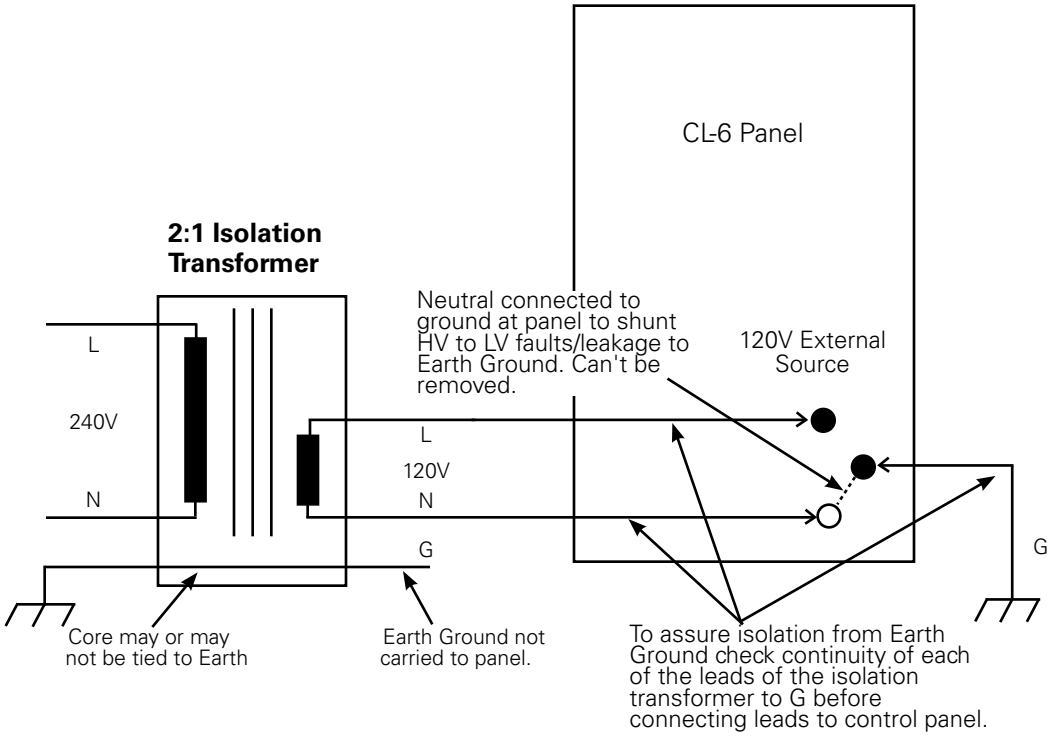


Figure 1-4. 240 Vac application with Eaton 120 V control - Option 1.

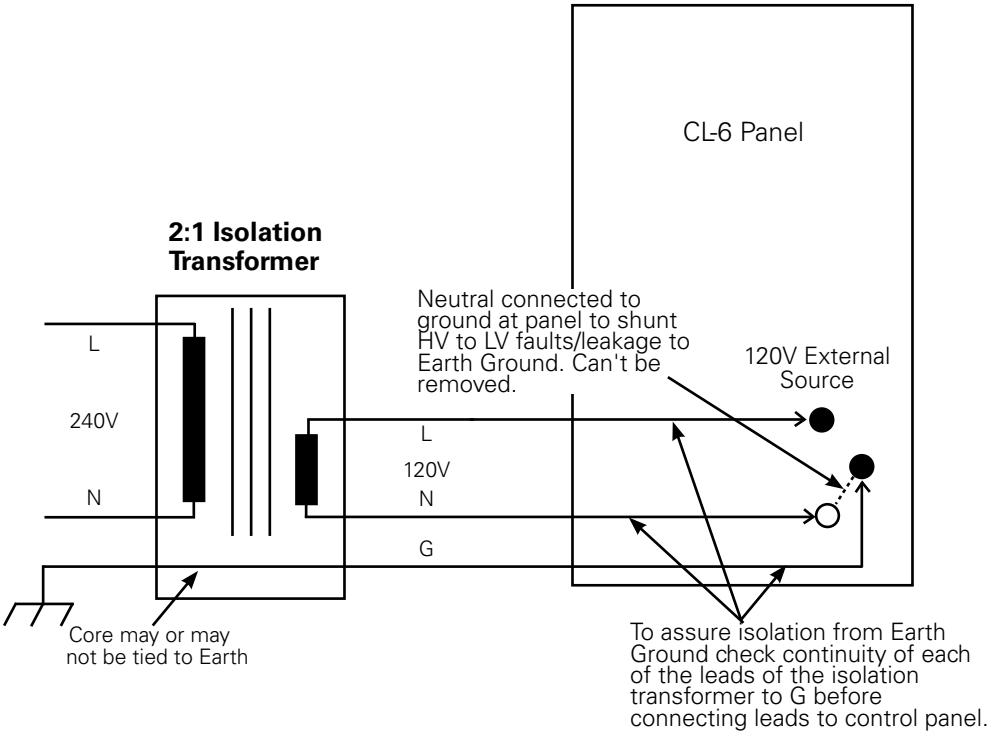


Figure 1-5. 240 Vac application with Eaton 120 V control - Option 2.

120 Vac applications to Eaton 120 V control

Option 1:

Control Box Assembly Panel connected to earth ground to provide protection to operations personnel (typical field application where control is mounted on grounded regulator tank or dropped down pole with 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 1-6.

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. Only source of earth ground reference on secondary of Isolation transformer is through control box connection to ground.

Option 2:

Control Box Assembly floating (typical shop or lab application where control is mounted on ungrounded regulator tank or sitting on 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 1-7.

In this case, the ground of the isolation transformer is connected to the green terminal post on the CL-6 series 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.

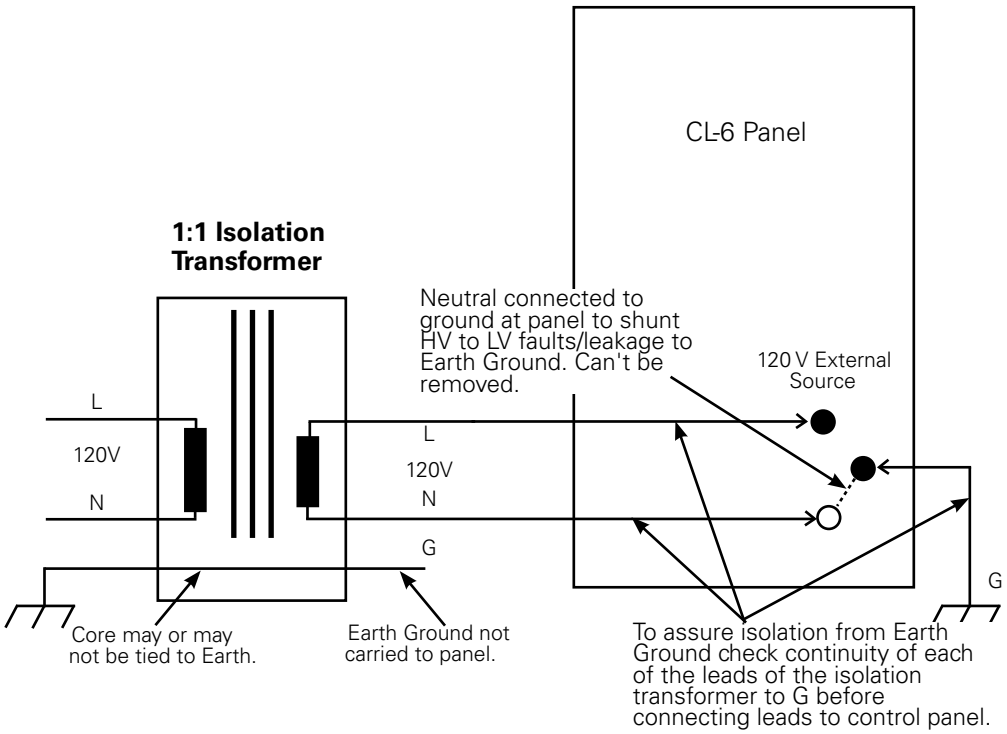


Figure 1-6. 120 Vac application with Eaton 120 V control - Option 1.

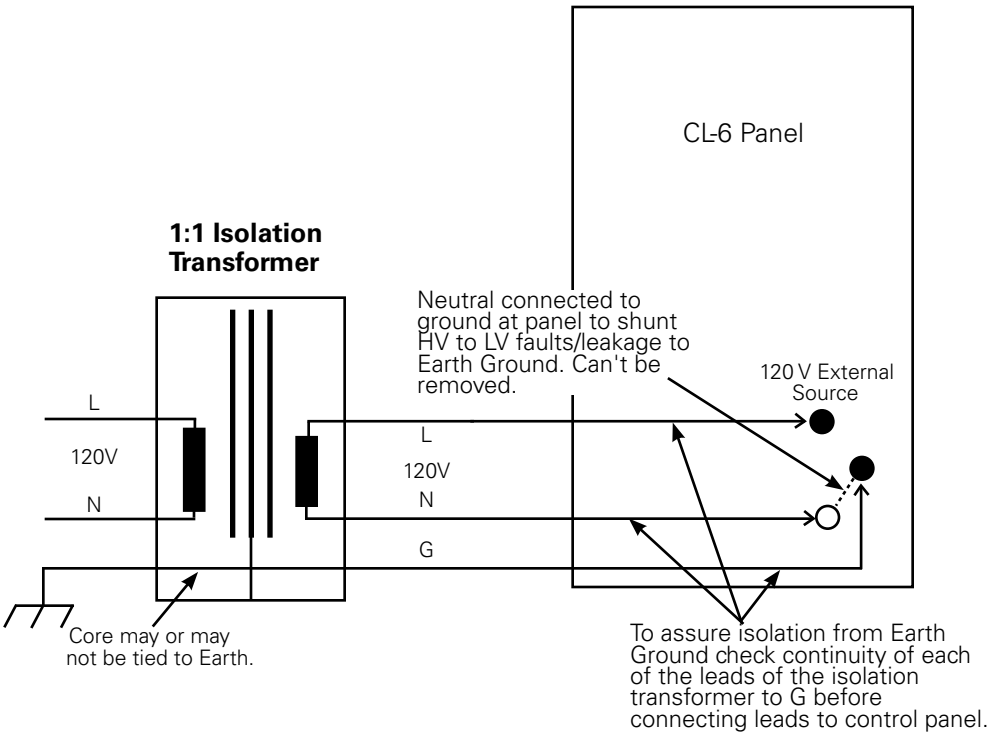


Figure 1-7. 120 Vac application with Eaton 120 V control - Option 2.

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 1-8.

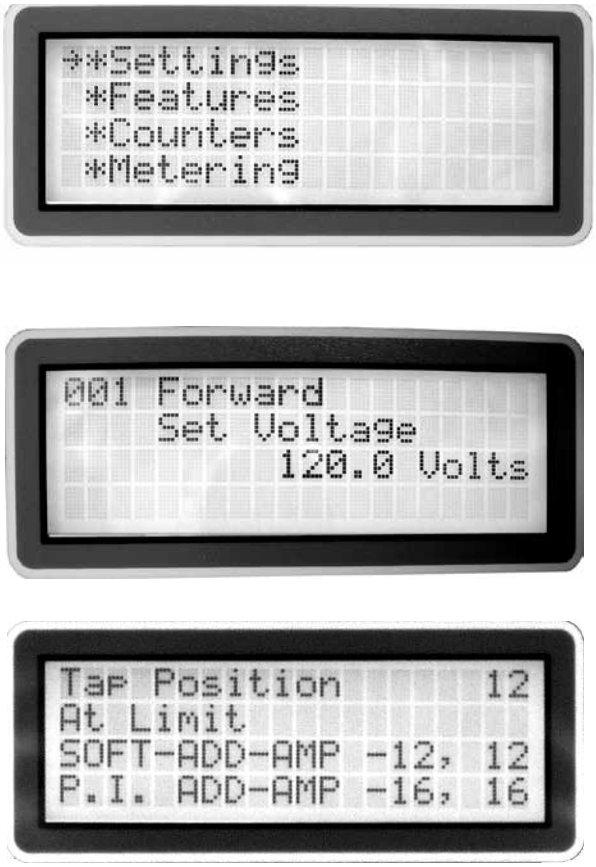


Figure 1-8. Main Menu, Forward Direction, and Metering-PLUS Tap Position screens.

Utilizing a 3-level, nested menu structure, items are structured in levels one and two and parameters are in level three. The main menu is the default display; refer to Table 5-2 for the complete nested menu. When a menu is displayed, the current menu item is indicated by a cursor 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.

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

Keypad

The front panel interface for the CL-6 control uses a 16-key touchpad laid out in a diamond pattern. Refer to Figure 1-9. The keypad allows for three modes of interface with the three levels of nested menu structure: numeric keys, short-cut keys, and scroll keys.

Numeric keys

To use the keypad as a numeric keypad to enter function codes (FC) or parameter values, press the **Function** or **Edit/Reset** keys. When the numeric keying is complete, press **Enter**.

Use function codes to quickly program and read Level 3 parameters. To display a parameter on the LCD via a function code (FC), press **Function**, key in the function code (FC) number, then press **Enter**. For security, certain parameters, as noted in Table 4-1, can only be accessed via the function code method. Also, certain parameters and data, such as alarms, custom logic, histograms, and profiler data, can only be accessed using ProView™ NXG interface software.

See Table 5-2 for a list of the functions grouped by menu level and Table 5-3 for a numerical listing of function codes.

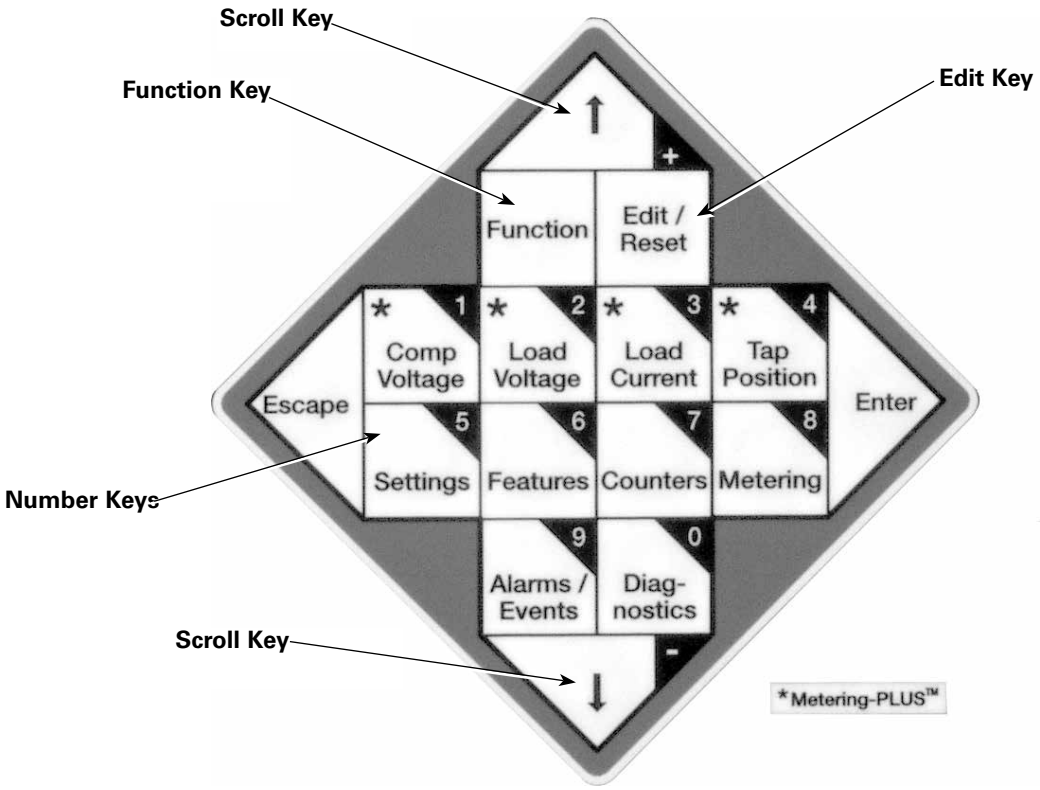


Figure 1-9. Fully numeric, scrollable keypad with Metering-PLUS.

Short-cut keys

There are two types of short-cut keys which access specific locations within the nested menu structure. Keys ***1–*4** support the Metering-PLUS feature which provides, with one touch, commonly requested diagnostic data; see Figures 1–8 and 1–9. Keys **5–9** and **0** support Level 1 menu items; press keys **5–9** and **0** and the associated Level 2 menu items will display in the LCD.

The Metering-PLUS data includes Compensated Voltage, Load Voltage, Load Current, and Tap Position; refer to the **Advanced Features: Metering-PLUS** section of this manual for more information.

The Level 1 menu items include Settings, Features, Counters, Metering, Alarms/Events (occurrences), and Diagnostics.

Scroll keys

Use the scrolling arrows to move the cursor between items within a menu level location. For example, within the Level 2 submenu for Metering, the arrows will scroll the cursor through Instantaneous, Forward Demand, Reverse Demand, and Master Reset, and then return to Instantaneous.

The **Enter** and **Escape** keys are used to enter the menu structure or move between menu levels. **Enter** is used to access submenus. **Escape** is used to step back or exit submenus. Repeated pressing of the **Escape** key will return the display screen to the level one main menu. (A deeply nested level location necessitates a greater number of depressions.)

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.

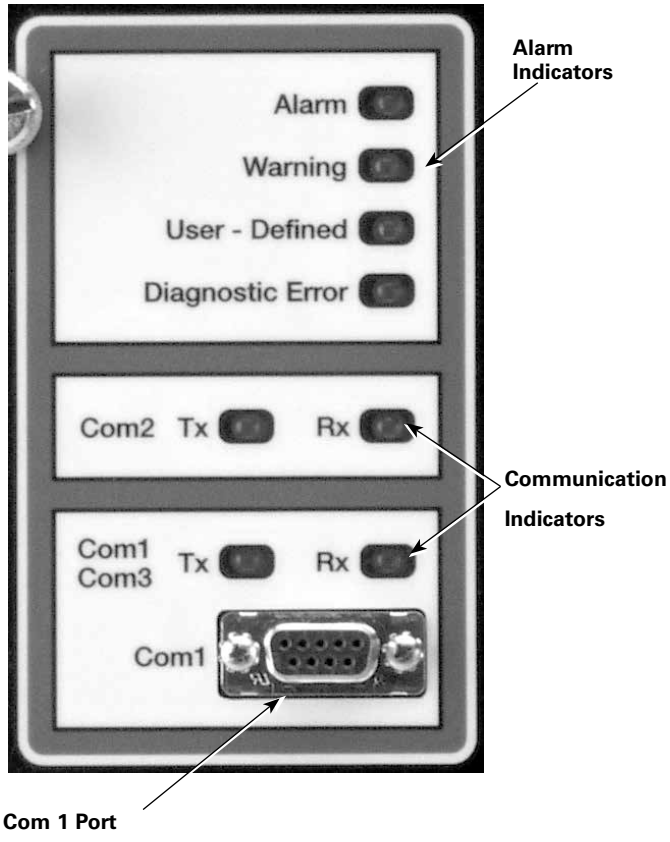


Figure 1-10. Alarm and communication indicators and Com 1 Port.

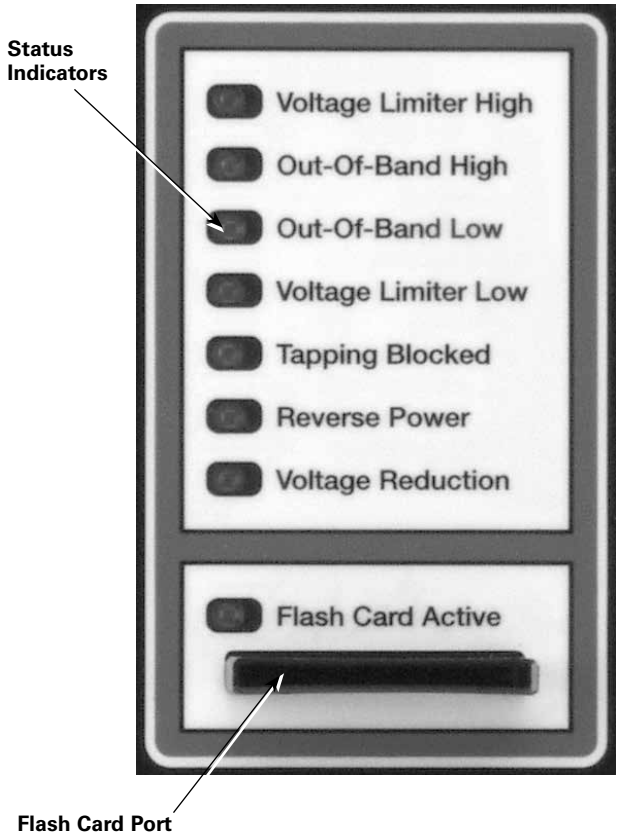


Figure 1-11. Status indicators and flash card port.

Alarm indicators

These LEDs indicate an Alarm or Warning, a user-defined condition, or a diagnostic error. See Figure 1-10.

Communications

Communication indicators

These LEDs give the ability to see that transmit and receive messages are active when the transfer of information is taking place. See Figure 1-10.

Communication Port 1

Com 1 Port is an RS-232 (DCE) port that interfaces local communication between the control and a PC using a standard DB9-style RS-232 cable. A null modem is not required. See Figure 1-10.

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 1-11.

Refer to the **Control Operation, Control Features,** and **Advanced Features** sections of this manual for more information.

Flash card port

The flash card port accepts a Type 1 compact flash card. It is used to write existing data logs and to load and save standard and custom configurations. See Figure 1-11. FC 350 through FC 368 are flash card functions; refer to the appropriate listing in Table 5-3. See the **Advanced Features: Compact Flash Card** section of this manual for more information.

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.

⚠ WARNING

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

CAUTION

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.

CAUTION

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

Mounting the control

The CL-6 regulator control from Eaton can be mounted on the regulator tank or at a point remote from the unit. Rubber-covered cable is available for interconnection between the control and the regulator. Refer to the **Accessories** section of this manual.

Placing the control into service

Refer to the appropriate regulator manual, as indicated on the regulator nameplate, for specific information on the regulator installation (see Figure 3-3). Refer to Tables 2-1 and 2-2 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	417 mm (16.4")
Width	234 mm (9.2")
Depth	81 mm (3.2")
Weight	3.8 kg (8.4 lbs.)
Burden @ 120 V	4 VA
Operating Temperature Range	-40°C to +85°C
Control System Accuracy	±1%

Table 2. Metering Accuracy

Load Voltage and Differential/Source Voltage	
	80–137 Vac, 45–65 Hz with error not to exceed 0.5%*† of the reading under all conditions. The control will withstand up to 137 V without damage or loss of calibration.
Current Input	
	0-0.400 A AC 45–65 Hz with error not to exceed 0.6% (0.0012 A)* of the nominal full load current (0.200 A), 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	
	0–9999, with error not to exceed 1% * under all conditions.
Harmonic Analysis, Current and Voltage Harmonics	
	2nd–15th harmonic frequencies and THD, with error not to exceed 5% under all conditions

* Basic accuracy of the device, excluding PT and CT errors.
† 0.5% on 120 V base: (0.5%) (120) = 0.6 V

Setting the control for service

The control must be properly programmed for service. Refer to the **Initial Control Programming** section of this manual.

The control must be energized to be programmed. Apply 120 Vac, or other voltage as indicated by decal, to the external source terminals; ensure the ground wire is connected to the ground terminal; and place 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-diagnostic 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 the **FAILURE** or **Diagnostic Error** message is displayed, refer to the **Troubleshooting** section of this manual.

Operational check

Pre-installation check

The CL-6 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 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 **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 ***Tap Position** key.
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 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, control will issue a lower-tap-change signal. Verify tap position indication (TPI) is registering properly by pressing ***Tap Position** key and comparing the reading to the tap position indicator on the regulator junction box.
9. Decrease 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, control will issue a raise-tap-change signal. Verify tap position indication (TPI) is registering properly by pressing ***Tap Position** key and comparing the reading to the tap position indicator on the regulator junction box.
10. Place CONTROL FUNCTION switch in **Manual** position and manually return 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. Press down on DRAG HAND Reset momentary toggle 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 ***Comp Voltage** key to display compensated voltage and both band edges in the LCD.
2. Place CONTROL FUNCTION switch in **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 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 in the LCD.

   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 CONTROL FUNCTION switch to the 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 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 in the LCD.

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

Control bench testing

When applying external voltage to a CL-6 control, disconnected from the control enclosure, 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 jumper between positions **5** and **6** of the disconnect plug on the wiring harness of the control.
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. See the detailed instructions for applying power to the external source terminals in Section 1 of this manual.

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 the **Troubleshooting** section of this manual.

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

   FUNCTION, *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-correcting 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 3-3 gives a general indication of these voltages.

When mounting the CL-6 control into an existing enclosure, the existing enclosure may not have RCTs 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.

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. If the regulator is not in the neutral 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.

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.

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 more than one method to determine the neutral condition.

Return the regulator to neutral

WARNING

Explosion Hazard. To insure a complete tapping operation when returning the tap changer to the neutral position, the CONTROL FUNCTION switch must be placed in the OFF position before the POWER switch is placed in the OFF position. Failure to comply can result in the tap changer stepping off of neutral immediately upon being energized which can result in death or severe personal injury and equipment damage.

1. Use the **Raise/Lower** switch to bring the regulator to the neutral position.
2. When in neutral, the **Neutral Light** will be continuously 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 illuminated.
   B. Verify the tap position of the control indicates neutral (numeric key pad number 4).
   C. Verify that the position indicator on the regulator is in the neutral position.
   D. Using an acceptable method, 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.

4. When the regulator has been placed in the neutral position, but prior to bypassing, additional safety action must be taken to 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.

Removing the 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 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.

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, 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 **TB2**.
3. Disconnect the control from the back panel at **TB2**, 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.

WARNING

Flashover Hazard. Do not pull open the current shorting switch C until the TB2 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.

Replacing the control

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 **TB2**, located at the bottom of back panel.
4. Push closed disconnect switch **V1** (and **V6** if present).
5. Pull open current shorting switch **C**.
6. Close control and tighten locking screws.

Section 3: Initial control programming

This section explains each step for properly completing initial control programming settings on a CL-6 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,** in this section of this manual, when installing/replacing the CL-6 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 EXTERNAL SOURCE binding posts: hot lead to black, top binding posts; neutral lead to white, bottom binding posts; ground to green ground binding posts. See detailed instructions for applying power to the external source terminals in Section 1 of this manual.

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

Basic programming

Complete the steps in Table 3-1 (on the next page) to program the control for basic operation. Continue with the steps in Table 3-2 to then program the control for additional features or control replacement. For each item, check each value and verify or change as appropriate.

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

Step-by-step instructions are included in Tables 3-1 and 3-2. 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 141 to change the language setting.

Table 3-1. Programming for Basic Operations

Function Code	Description	Instructions
99	Security Function	Function, 99, Enter Password 32123 (default), Enter
1	Forward Set Voltage	Function, 1, Enter, Edit, Value, Enter
2	Forward Bandwidth	Function, 2, Enter, Edit, Value, Enter
3	Forward Time Delay	Function, 3, Enter, Edit, Value, Enter
4	Forward Line Drop Comp. Resistance	Function, 4, Enter, Edit, Value, Enter
5	Forward Line Drop Comp. Reactance	Function, 5, Enter, Edit, Value, Enter
40	Regulator Identification	Function, 40, Enter, Edit, I. D. number, Enter
41	Regulator Configuration	Function, 41, Enter, Edit, Scroll - Wye; Delta Lagging; Delta Leading, Enter
42	Control Operating Mode	Function, 42, Enter, Edit, Scroll - Sequential; Time Integrating; Voltage Averaging, Enter
43	System Line Voltage	Function, 43, Enter, Edit, Value, Enter
44	Overall P.T. Ratio	Function, 44, Enter, Edit, Value, Enter
45	C.T. Primary Rating	Function, 45, Enter, Edit, Value, Enter
46	Demand Time Interval	Function, 46, Enter, Edit, Value, Enter
49	Tap Changer Type	Function, 49, Enter, Edit, Scroll - Cooper QD8; Cooper QD5; Cooper QD3; Cooper Spring Drive; Cooper Direct Drive; Siemens; General Electric; Howard; LTC-Reinhausen, Enter
50	Calendar/Clock	Function, 50, Enter, Edit, Month, Day, Year, Hour, Minute, Enter
140	Regulator Type	Function, 140, Enter, Edit, Scroll - Type A; Type B; Type C; Type D, Enter
144	P.I. ADD-AMP™ High Limit	Function, 144, Enter, Edit, Value, Enter
145	P.I. ADD-AMP Low Limit	Function, 145, Enter, Edit, Value, Enter
146	Vin P.T. Configuration	Function, 146, Enter, Edit, Scroll - Vdiff Mode; Vin Mode, Enter
69	Auto Operation Blocking Status	Function, 69, Enter, Edit, Scroll - Normal; Blocked, Enter
Requirements for Reverse Sensing Mode without IDPTs		
039	Source Voltage Calculation	Function, 39, Enter, Edit Scroll - On; Off, Enter
Required for Reverse Sensing Modes		
051	Reverse Set Voltage	Function, 51, Enter, Edit, *Value*, Enter
052	Reverse Bandwidth	Function, 52, Enter, Edit, *Value*, Enter
053	Reverse Time Delay	Function, 53, Enter, Edit, *Value*, Enter
054	Reverse Line Drop Comp. Resistance	Function, 54, Enter, Edit, *Value*, Enter
055	Reverse Line Drop Comp. Reactance	Function, 55, Enter, Edit, *Value*, Enter
056	Reverse Sensing Mode	Function, 56, Enter, Edit, Scroll - *Locked Forward*; *Locked Reverse*; *Reverse Idle*; *Bi-directional*; *Neutral Idle*; *Co-generation*; *React Bi-directional*, Enter
Required for Voltage Reduction Mode		
070	Voltage Reduction Mode	Function, 70, Enter, Edit, Scroll - *Off*; *Local/Digital Remote*; *Remote/Latch*; *Remote/Pulse*, Enter
072	Local/Digital Reduction Value	Function, 72, Enter, Edit, *Value*, Enter
073	Remote #1 Value	Function, 73, Enter, Edit, *Value*, Enter
074	Remote #2 Value	Function, 74, Enter, Edit, *Value*, Enter
075	Remote #3 Value	Function, 75, Enter, Edit, *Value*, Enter
076	# of Pulse Reduction Steps	Function, 76, Enter, Edit, *Value*, Enter
077	% of Voltage Red Per Pulse Step	Function, 77, Enter, Edit, *Value*, Enter
Required for Voltage Limit Mode		
080	Voltage Limit Mode	Function, 80, Enter, Edit, Scroll - *Off*; *High Limit Only*; *High/Low Limits*, Enter
081	High Voltage Limit	Function, 81 Enter, Edit, *Value*, Enter
082	Low Voltage Limit	Function, 82, Enter, Edit, *Value*, Enter

Programming and reconfiguring for different voltage systems

Reconfiguring regulators requires more than just reprogramming the control. In reconfiguring, refer to the nameplate and, if necessary, change the connection of the ratio-correcting transformers (RCTs) on the back panel (see Figure 3-1). In some cases, it may be necessary to reconnect the tap windings in the regulator via the hand-hole cover.

Refer to the nameplate for information on programming and reconfiguring a regulator: confirm Regulator Configuration (FC 41), System Line Voltage (FC 43), and Overall PT Ratio (FC 44). Refer to **Allowable System Voltages and Calculation of Overall PT Ratio** and **Determination of Leading or Lagging in Delta-Connected Regulators,** in this section of the manual.

⚠ WARNING

Explosion Hazard. Bypass a regulator with the line energized only if both the position indicator and the neutral light indicate neutral. If both do not indicate neutral, 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.

1. Start with all switches on the control front panel turned **Off**.
2. Refer to the nameplate. If the Control Winding Taps are required to be changed to reconfigure, de-energize the regulator. Open up the hand hole and reconnect the **E** tap lead on the tap-changer terminal board on top of the tap-changer. (Example: If the regulator is being changed from a 7200 to 14400 load voltage, the Control Winding tap needs to be changed from $\mathbf{E_2}$ to $\mathbf{E_1}$.) See Figure 3-3 for nameplate information.
3. Open **V1** switch and, if present, **V6**. Refer to Figure 3-2.
4. Connect the RCT per the information supplied by the nameplate. The RCT is to be connected to the value listed on the nameplate for the load voltage to be regulated. The adjustable lead is tagged and has a loop in it.
5. Close **V1** switch and, if present, **V6**.
6. There are two options for powering the control panel: internal power or external power. Select one method and follow the appropriate step.

   A. Internal Power

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

   B. External Power

   Apply external source to EXTERNAL SOURCE binding post: hot lead to black, top binding post; neutral lead to white bottom binding post; ground to green ground binding post. Turn POWER switch to **External** power from the **Off** position. See the detailed instructions for applying power to the external source terminals in Section 1 of this manual.

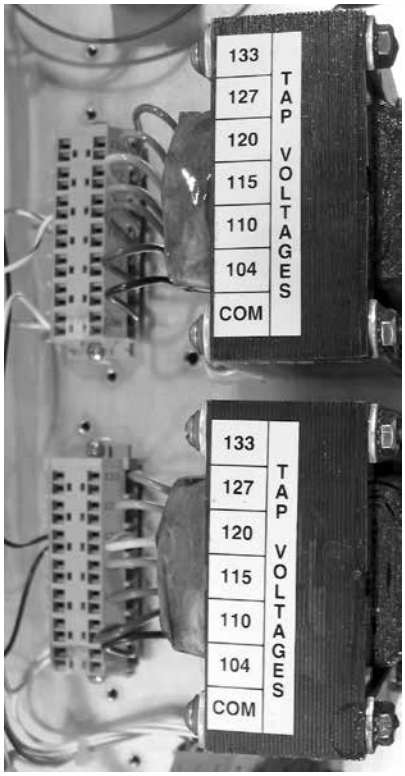


Figure 3-1. Ratio-correcting transformers' connections.

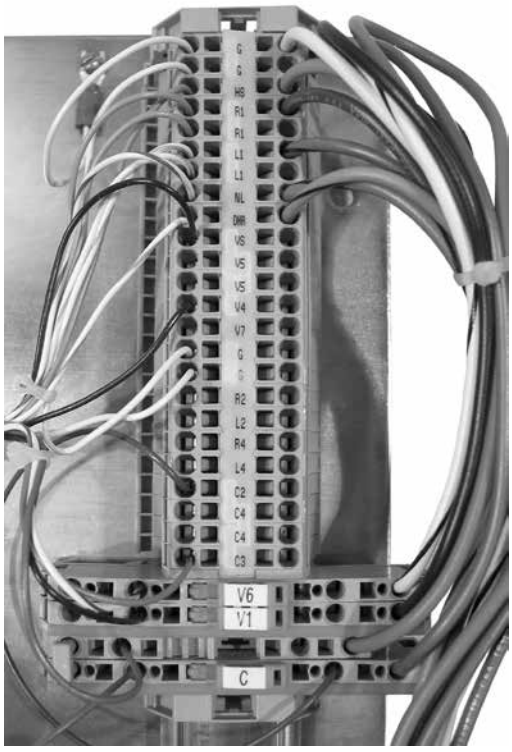


Figure 3-2. V1, V6, and C connections.

Refer to Table 3-1 for the steps to program the control panel for operation. Refer to the **Appendix** for the Wiring Diagram.

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-6 Series 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 ratios.

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 3-2 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 3-2. RCT Ratios

RCT Input Tap	RCT Ratio
133	1.108
127	1.058
120	1.000
115	.0958
110	.0917
104	.0867

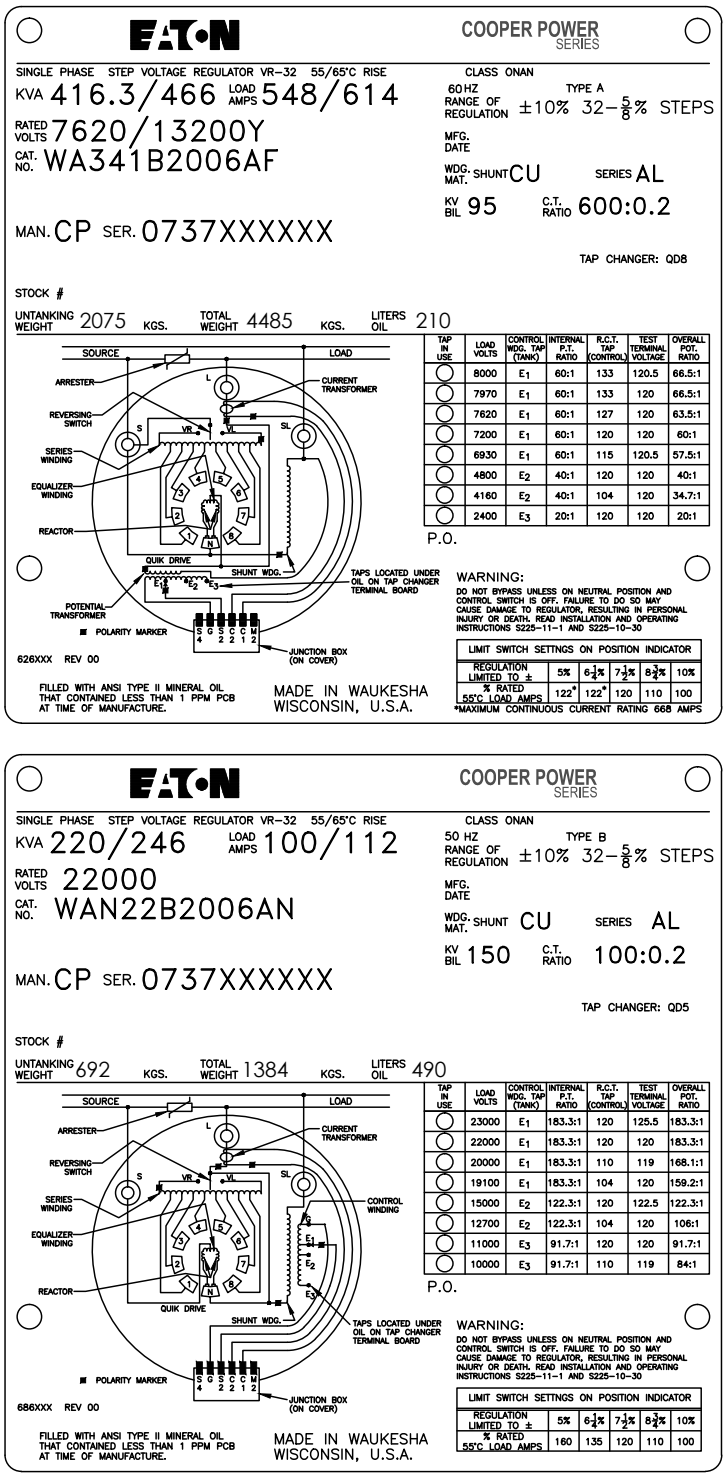


Figure 3-3. Nameplates, 60 Hz regulator and 50 Hz regulator shown.

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.
3. Knife switch **C** must be open. Current must be flowing.
4. CONTROL FUNCTION switch may be in any position **(Auto/Remote-Off-Manual).**
5. For regulator #1, set FC 41 to Delta Lagging and record the Power Factor, FC 13.
6. For the same regulator, set FC 41 to Delta Leading and record the Power Factor.
7. Repeat steps 6 and 7 for each regulator in the bank.
8. For each regulator, one of the two power factor values will be reasonable and the other will be unreasonable.

   Set the Regulator Configuration (FC 41) to the value which produced the reasonable power factor. See Table 3-3.

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 3-3. 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 3-3. 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**. The regulator is assumed energized from the primary circuit. If the sequential mode of operation (the standard mode) 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 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. This 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 is 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 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-diagnostics

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

Security system

The security (password) system implemented on the 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 level 0, the base (unsecured) level. The security level required to change or reset each parameter is listed in Table 4-1. 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 4-1. 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 standard security mode (no override), override level 1, override levels 2 and 1, and override levels 3, 2, and 1.

The values of the three security codes, FC 96, FC 97, and FC 98, may be read only at level 3. If the level 3 code has been changed and forgotten, it may be retrieved with a compact flash card or a personal computer using ProView NXG software.

Table 4-1. Security Codes

Security Level	Accessible at Function Code	Factory-Programmed Code	User-Definable Range	Functions Available at the Active Code
0	No Code Required	No Code Required	No Code Required	Read all parameters except security (FC 96, FC 97, & FC 98).
1	96	1234	1-9999	Read all parameters as described above,and reset all demand metering and tap position maximum and minimum values and date/times
2	97	12121	10000-19999	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.
3	98	32123	20000-32766	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 base. Since the control performs ratio correction in the firmware, this value will normally be set for 120.0 V, 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 by the regulator nameplate.

Bandwidth

The bandwidth is defined as that total voltage range, around the voltage setting, which the control will consider as a satisfied condition. As an example, a 2 V bandwidth on a 120 V setting means the operational 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 proper 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 limiting feature. Refer to the **Voltage Limiting** section of this manual.

Line 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 source (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.

Control operating modes

The CL-6 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-out, 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.

Potential transformer ratio

Since the control performs ratio correction in the firmware, the PT ratio for the voltage-sensing supply must be entered for the control to perform this calculation. The ratio to be programmed in the control is the OVERALL PT RATIO, as shown on the regulator nameplate for every applicable system voltage for the particular regulator. The 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 PT ratio must also be entered for proper operation. This value includes the correction performed by the ratio-correcting transformer (RCT) on the back panel of the control enclosure. 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 base and 120 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.

Current transformer primary rating

The control is designed for 200 mA (full scale) as the rated CT current and will meter to 400 mA (200% load) 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. Setting the Regulator Configuration, FC 41, correctly, 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. 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 set correctly.
- 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 $\sqrt{3}$ (1.732) before adding the three together.

Section 5: Control programming

Use the front keypad to program the control. A Quik-Start™ setup is given for programming for basic regulation. Refer to the **Control Front Panel** section of this manual for information on using the front panel.

Note: After turning on the control and the LCD displays **PASS**, press **Escape** 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 (Level 1), a sub-menu (Level 2), and parameters (Level 3). These parameters and other text information are displayed on the LCD screen.

Refer to Table 5-2 for the three-level, nested menu of functions and parameters.

Refer to Table 5-3 for a numerical listing of Function Codes 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 5-1 for a quick start up for basic regulation. Please note the following Function Code information when using the Quik-Start settings.

99 Security Function Code and password needs to be applied before changes can be made to parameters.

39 Source-Side Voltage must be on for Reverse Power Flow operation if source-side calculations are to be used instead of an internal differential potential transformer to determine source-side voltage.

140 Regulator Type A, B, C, or D needs to 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 Section 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 24 hours.

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

Table 5-1. Quik-Start Set-Up for Basic Regulation

Function Code	Description	Instructions
Security		
099	Security	Function, 99, Enter, *Password (32123)*, Enter
Forward Settings		
001	Forward Set Voltage	Function, 1, Enter, Edit, *Value,* Enter
002	Forward Bandwidth	Function, 2, Enter, Edit, *Value,* Enter
003	Forward Time Delay	Function, 3, Enter, Edit, *Value,* Enter
004	Forward Line Drip Comp. Resistance	Function, 4, Enter, Edit, *Value,* Enter
005	Forward Line Drip Comp. Reactance	Function, 5, Enter, Edit, *Value,* Enter
Reverse Settings		
056	Reverse Sensing Mode	Function, 56, Enter, Scroll - Locked Forward; Locked Reverse; Reverse Idle; Bi-Directional; Neutral Idle; Co-generation; React Bi-directional, Enter
039	Source Voltage Calculation	Function, 39, Enter, Edit, Scroll - *On or Off,* Enter
140	Regulator Type	Function, 140, Enter, Edit, Scroll - *Type A; Type B; Type C; Type D,* Enter
051	Reverse Set Voltage	Function, 51, Enter, Edit, *Value,* Enter
052	Reverse Bandwidth	Function, 52, Enter, Edit, *Value,* Enter
053	Reverse Time Delay	Function, 53, Enter, Edit, *Value,* Enter
054	Reverse Line Drip Comp. Resistance	Function, 54, Enter, Edit, *Value,* Enter
055	Reverse Line Drip Comp. Reactance	Function, 55, Enter, Edit, *Value,* Enter
Configurations		
041	Regulator Configuration	Function, 41, Enter, Edit, Scroll - *Wye; Delta Lag; Delta Lead,* Enter
042	Control Operation Mode	Function, 42, Enter, Edit, Scroll - *Sequential; Time-Integrating; Voltage-Averaging,* Enter
043	System Line Voltage	Function, 43, Enter, Edit, *Value,* Enter
044	Overall P.T. Ratio	Function, 44, Enter, Edit, *Value,* Enter
045	C.T. Primary Rating	Function, 45, Enter, Edit, *Value,* Enter
049	Tap-Changer Type	Function, 49, Enter, Edit, Scroll - *Cooper QD8; Cooper QD5; Cooper QD3; Cooper Spring Drive; Cooper Direct Drive; Siemens; General Electric; Howard; LTC-Reinhausen,* Enter
050	System Calendar and Clock	Function, 50, Enter, Edit, *Month, Day, Year, Hour, Minute,* Enter
069	Auto Operation Blocking Status	Function, 69, Enter, Edit, Scroll - Normal; Blocked, Enter
Voltage Reduction		
070	Voltage Reduction Mode	Function, 70, Enter, Edit, *Scroll - Off; Local/Digital Remote; Remote/Latch, Remote/Pulse,* Enter
072	Local/Digital Reduction Value	Function, 72, Enter, Edit, *Value,* Enter
073	Remote #1 Value	Function, 73, Enter, Edit, *Value,* Enter
074	Remote #2 Value	Function, 74, Enter, Edit, *Value,* Enter
075	Remote #3 Value	Function, 75, Enter, Edit, *Value,* Enter
076	# of Pulse Reduction Steps	Function, 76, Enter, Edit, *Value,* Enter
077	% of Voltage Red Per Pulse Step	Function, 77, Enter, Edit, *Value,* Enter
Voltage Limiter		
080	Voltage Limiter Mode	Function, 80, Enter, Edit, Scroll - Off; *High Limit Only; High/Low Limit*, Enter
081	High Voltage Limit	Function, 81, Enter, Edit, *Value,* Enter
082	Low Voltage Limit	Function, 82, Enter, Edit, *Value,* Enter

Function menu

Refer to Table 5-2 for the three levels of the nested menu structure: Main Menu, Sub-Menu, and Parameter.

Table 5-2. Function Menu

Level 1 Main Menu	Level 2 Sub-Menu	Parameter	Code
*Settings	*Forward Direction	Forward Set Voltage	001
		Forward Bandwidth	002
		Forward Time Delay	003
		Forward Line Drop Comp. Resistance	004
		Forward Line Drop Comp. Reactance	005
	*Reverse Direction	Reverse Set Voltage	051
		Reverse Bandwidth	052
		Reverse Time Delay	053
		Reverse Line Drop Comp. Resistance	054
		Reverse Line Drop Comp. Reactance	055
	*Configuration	Regulator 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
		C.T. Primary Rating	045
		Demand Time Interval	046
		P.I. ADD-AMP, High Limit	144
		P.I. ADD-AMP, Low Limit	145
		V_{in} P.T., Configuration	146
	*Calendar/Clock	System Calendar and Clock	050
	_Menu System	Language Selection	141
		Date Format	142
		Time Format	143
*Features	*Auto-Block Status	Auto Operation, Blocking Status	069
	*Reverse Power Mode	Reverse Sensing Mode	056
		Reverse Current, Sense Threshold	057
	*Source Side, Voltage Calculation	Source Voltage Calculation	039
	*Voltage Limiter	Voltage Limiter Mode	080
		High Voltage Limit	081
		Low Voltage Limit	082
	*Voltage Reduction	Voltage Reduction Mode	070
		Reduction in Effect	071
		Local/Digital Reduction Value	072
		Remote #1 Value	073

TABLE 5-2. Function Menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Parameter	Code
*Features, cont.	*Voltage Reduction, cont.	Remote #2 Value	074
		Remote #3 Value	075
		# of Pulse Reduction Steps	076
		% of Voltage Red Per Pulse Step	077
	*Tap to Neutral	Tap to Neutral	170
	* Soft ADD-AMP™	Soft ADD-AMP Limits	079
		Soft ADD-AMP High Limits Soft ADD-AMP Low Limits	176
	*Alternate Config	Alternate Configuration	450
		Alternate Configuration	451
	*Leader/Follower	LoopShare Communications	400
		LoopShare Comms State	401
		LoopShare Comms Port	402
		LoopShare Comms Table Assignment	403
		LoopShare Comms Tx Delay	404
		LoopShare Comms Timeout	405
		Leader/Follower	410
		Leader/Follower State	411
		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
	*Communications	Com Port #1 Protocol	060[a]
		Com Port #1 Speed	061[a]
		Com Port #1 Sync Time	062[a]
		Com Port #1 DNP Master Adrs	063[a]
		Com Port #1 DNP Remote Adrs1	064[a]
		Com Port #1 DNP Remote Adrs2	064[a]
		Com Port #1 2179 Remote Adrs	064[a]
		Com Port #1 Handshake Mode	065[a]
		Com Port #1 Tx Enable Delay	066[a]
		Com Port #1 Tx Disable Delay	067[a]
		Com Port #1 2179 Ordinal Map	266
		Com Port #1 DNP Data Dict	267
		Com Port #2 Protocol	160
		Com Port #2 Speed	161
		Com Port #2 Sync Time	162
		Com Port #2 DNP Master Adrs	163
		Com Port #2 DNP Remote Adrs1	164

[a] Settings for Com Port #1 also apply to Com Port #3.

TABLE 5-2. Function Menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Parameter	Code
*Features, cont.	*Communications, cont	Com Port #2 DNP Remote Adrs2	164
		Com Port #2 2179 Remote Adrs	164
		Com Port #2 Handshake Mode	165
		Com Port #2 Tx Enable Delay	166
		Com Port #2 Tx Disable Delay	167
		Com Port #2 2179 Ordinal Map	268
		Com Port #2 DNP Data Dict	269
	*Calibration	Voltage Calibration	047
		Current Calibration	048
		Reset Calibration	150
	*Compact Flash	CompactFlash Data Writer	350
		CompactFlash Load Custom	351
		CompactFlash Load Std Config	352
		CompactFlash Save Custom Cfg	353
		CompactFlash Save Std Config	354
		CompactFlash Format CF Card	355
		CF Load Custom Basic Config	357
		CF Load Standard Basic Config	358
		CF Save Custom Basic Config	359
		CF Save Standard Basic Config	360
		CF Load Custom AdvFeat Config	361
		CF Load standard AdvFeat Config	362
		CF Save Custom AdvFeat Config	363
		CF Save Standard AdvFeat Config	364
		CF Load Custom Comms Config	365
		CF Load Standard Comms Config	366
		CF Save Custom Comms Config	367
		CF Save Standard Comms Config	368

TABLE 5-2. Function Menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Parameter	Code
*Features, cont.	_Security Access	Security Override	092
		Security Code Level 1	096
		Security Code Level 2	097
		Security Code Level 3	098
*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
		Comp. Voltage Secondary	008
		Load Current Primary	009
		Load Voltage Primary	010
		Source Voltage Primary	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-hour Forward	125
		Energy kW-hour Reverse	125
		Energy kvar-hour Forward	126
		Energy kvar-hour Reverse	126
	*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

TABLE 5-2. Function Menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Parameter	Code
*Metering, cont.	*Forward Demand, cont.	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
		Maximum Tap Position	027
		Maximum % Boost	127
		Minimum Tap Position	028
		Maximum % Buck	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
		Reverse Source Voltage, High	037
		Reverse Source Voltage, Low	037
		Reverse Source Voltage, Present	037
	_Master Reset	Master Reset	038

TABLE 5-2. Function Menu (continued)

Level 1 Main Menu	Level 2 Sub-Menu	Parameter	Code
*Alarms/Events	*Alarms Active		
	Unacknowledged	(Unacknowledged Active Alarms List)	–
	*Alarms Active		
	Acknowledged	(Acknowledged Active Alarms List)	–
	_Events	(Events Log)	–
*Diagnostics	*Control	Firmware Version	089
		Database Version	189
		PLD Version	190
		2179 Version	191
		DNP Version	192
		DNP Checksum	193
		Self-Test	091
	*Communications	Com Port #1 Tx Messages	260
		Com Port #1 Rx Messages	261
		Com Port #1 Rx Errors	262
		Com Port #2 Tx Messages	263
		Com Port #2 Rx Messages	264
		Com 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 Designation	326
		PMT Mode B Current Limit	327
		PMT Mode B Issue Test	328
	_Metering PLUS	Comp. Voltage	–
		Load Voltage	–
		Load Current	–
		Tap Position	–
		LF TPI TRG STATUS	–
		Reg TPI CompV BandE	–
		sV Src Load Comp	–
*Test LEDs	No Items		–
*Turn Display Off	No Items		–

Function codes

Refer to Table 5-3 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 scrollable choices, examples, and related functions and features for each function code.

TABLE 5-3 Function Codes

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
0	Counters	Operations Counter	000 Total Operations XXXXX	0	3	NA	NA	0	999999
• The total operations counter is activated by detecting tap-changer motor operation, which is determined by sensing current flow in the holding switch circuit. • The total operations counter is written into non-volatile memory after every count. • Access other operations counters at FC 100–FC 107.									
1	Settings	Forward Direction	001 Forward Set Voltage 120.0 Volts	0	2	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 base, during forward power flow.									
2	Settings	Forward Direction	002 Forward Bandwidth 2.0 Volts	0	2	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.									
3	Settings	Forward Direction	003 Forward Time Delay 45 Sec	0	2	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. • See FC 42, Control Operating Mode.									
4	Settings	Forward Direction	001 Fwd Line Drop Comp. Resistance 0.0 Volts	0	2	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.									

TABLE 5-3 Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
5	Settings	Forward Direction	005 Fwd Line Drop Comp. Reactance 0.0 Volts	0	2	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.									
6	Metering	Instantaneous	006 Load Voltage Secondary XXX.X Volts	0	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.									
7	Metering	Instantaneous	007 Source Voltage Secondary XXX.X Volts	0	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 (Overall 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.									
8	Metering	Instantaneous	008 Compensated Volt. Secondary XXX.X Volts	0	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.									
9	Metering	Instantaneous	009 Load Current Primary XXX.X A	0	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.									

TABLE 5-3 Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
10	Metering	Instantaneous	010 Load Voltage Primary kV XX.XX kV	0	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.									
11	Metering	Instantaneous	011 Source Voltage Primary kV XX.XX kV	0	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 (Overall 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.									
12	Metering	Instantaneous	012 Present Tap Position XX	0	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 the **Control Features: Tap Position** section of this manual. • See Percent Regulation, FC 112.									
13	Metering	Instantaneous	013 Power Factor X.XXX	0	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.									

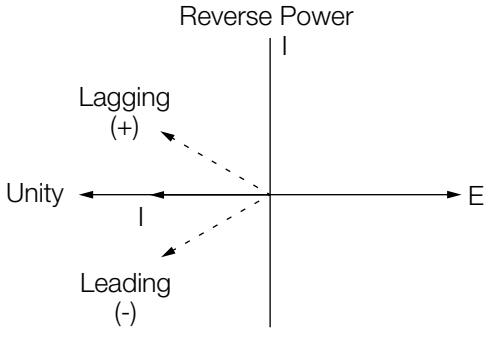


Figure 5-1. Reverse power vector diagram

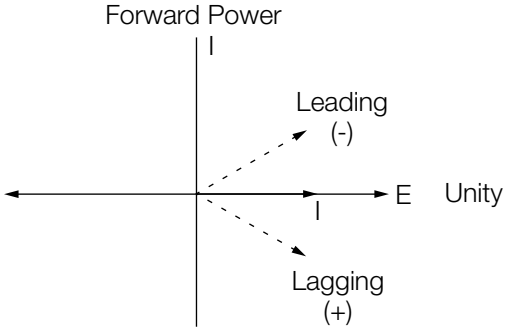
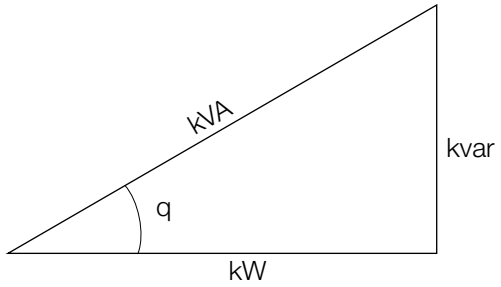


Figure 5-2. Forward power vector diagram.

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
14	Metering	Instantaneous	014 kVA Load XXXX.X kVA	0	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 5-3.									
15	Metering	Instantaneous	015 kW Load XXXX.X kW	0	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 5-3. • 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.									
16	Metering	Instantaneous	016 kvar Load XXXX.X kvar	0	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 5-3. • 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.									
17	Metering	Instantaneous	017 Line Frequency XX.XX Hz	0	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.									
18	Metering	Instantaneous	018 Voltage THD XX.X %	0	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.									



Power Facter = $\frac{kW}{kVA}$

kW=kVA cos q

kvar=kVA sin q

Figure 5-3. Power Triangle

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
18↓	Metering	Instantaneous	018 Voltage 2nd–15th Harmonic XX.X %	0	NA	NA	NA	NA	NA
• The values of the 2nd through 15th harmonic are displayable. • Use the arrow keys to scroll through the 2nd through 15th harmonic.									
19	Metering	Instantaneous	019 Current THD XXX.X %	0	NA	NA	NA	NA	NA
• The total harmonic distortion (THD) is displayed after entering FC 19. • 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.									
19↓	Metering	Instantaneous	019 Current 2nd–15th Harmonic XX.X %	0	NA	NA	NA	NA	NA
• The values of the 2nd through 15th harmonic are displayable. • Use the arrow keys to scroll through the 2nd through 15th harmonic.									
20	Metering	Forward Demand	020 Forward Load Voltage High XXX.X Volts (Date / Time shown)	0	NA	1	NA	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.									
20↓	Metering	Forward Demand	020 Forward Load Voltage Low XXX.X Volts (Date / Time shown)	0	NA	1	NA	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 load voltage is displayed.									
20↓	Metering	Forward Demand	020 Forward Load Voltage Present XXX.X Volts	0	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									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
21	Metering	Forward Demand	021 Fwd Compensated Voltage High XXX.X Volts (Date / Time shown)	0	NA	1	NA	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 this calculation. • Date and time of the occurrence of the highest compensated voltage is displayed.									
21↓	Metering	Forward Demand	021 Fwd Compensated Voltage Low XXX.X Volts	0	NA	1	NA	NA	NA
• This is the lowest value of the calculated secondary voltage at the load center (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 this calculation. • Date and time of the occurrence of the lowest compensated voltage is displayed.									
21↓	Metering	Forward Demand	021 Fwd Compensated Voltage Present XXX.X Volts	0	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 this calculation.									
22	Metering	Forward Demand	022 Forward Load Current High XXX.X A (Date / Time shown)	0	NA	1	NA	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.									
22↓	Metering	Forward Demand	022 Forward Load Current Low XXX.X A (Date / Time shown)	0	NA	1	NA	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.									
22↓	Metering	Forward Demand	022 Forward Load Current Present XXX.X A	0	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 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
23	Metering	Forward Demand	023 Power Factor at Max Forward kVA X.XX (Date / Time shown)	0	NA	NA	NA	NA	NA
• This is the instantaneous power factor of the load at the first time when the maximum kVA demand occurred, since last reset. • Date and time of the occurrence of the highest maximum kVA demand is displayed. • **Note:** This parameter is associated with the maximum kVA demand; therefore, it cannot be reset independent of that parameter.									
23↓	Metering	Forward Demand	023 Power Factor at Min Forward kVA X.XX (Date / Time shown)	0	NA	NA	NA	NA	NA
• This is the instantaneous power factor of the load at the first time when the minimum kVA demand occurred (since last reset). • Date and time of the occurrence of the lowest minimum kVA demand is displayed. • **Note:** This parameter is associated with the minimum kVA demand; therefore, it cannot be reset independent of that parameter									
024	Metering	Forward Demand	024 Forward kVA Load High XXXX.X kVA (Date / Time shown)	0	NA	1	NA	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.									
24↓	Metering	Forward Demand	024 Forward kVA Load Low XXXX.X kVA (Date / Time shown)	0	NA	1	NA	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 kVA load is displayed.									
24↓	Metering	Forward Demand	024 Forward kVA Load Present XXXX.X kVA	0	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.									
25	Metering	Forward Demand	025 Forward	0	NA	1	NA	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.									
25↓	Metering	Forward Demand	025 Forward kW Load High XXXX.X kW (Date / Time shown)	0	NA	1	NA	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 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
25↓	Metering	Forward Demand	025 Forward kW Load Present XXXX.X kW	0	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.									
26	Metering	Forward Demand	026 Forward kvar Load High XXXX.X kvar (Date / Time shown)	0	NA	1	NA	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 lowest value occurred is displayed.									
26↓	Metering	Forward Demand	026 Forward kvar Load Low XXXX.X kvar (Date / Time shown)	0	NA	1	NA	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 the occurrence of the lowest kvar load displayed.									
26↓	Metering	Forward Demand	026 Forward kvar Load Present XXX.X kvar	0	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.									
27	Metering	Forward Demand	027 Maximum Tap Position XX (Date / Time shown)	0	NA	1	NA	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 via the reset 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.									
28	Metering	Forward Demand	028 Minimum Tap Position XX (Date / Time shown)	0	NA	1	NA	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 via the reset 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.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
029	Metering	Forward Demand	029 Forward Source Voltage High XXX.X Volts (Date / Time shown)	0	NA	1	NA	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.									
29↓	Metering	Forward Demand	029 Forward Source Voltage Low XXX.X Volts (Date / Time shown)	0	NA	1	NA	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.									
29↓	Metering	Forward Demand	029 Forward Source Voltage Present XXX.X Volts	0	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.									
30	Metering	Reverse Demand	030 Reverse Load Voltage High XXX.X Volts (Date / Time shown)	0	NA	1	NA	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.									
30↓	Metering	Reverse Demand	030 Reverse Load Voltage Low XXX.X Volts (Date /Time shown)	0	NA	1	NA	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.									
30↓	Metering	Reverse Demand	030 Reverse Load Voltage Present XXX.X Volts	0	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 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
31	Metering	Reverse Demand	031 Rev Compensated Voltage High XXX.X Volts (Date / Time shown)	0	NA	1	NA	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 this calculation. • Date and time of the occurrence of the highest compensated 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.									
31↓	Metering	Reverse Demand	031 Rev Compensated Voltage Low XXX.X Volts (Date / Time shown)	0	NA	1	NA	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 this calculation. • 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.									
31↓	Metering	Reverse Demand	031 Rev Compensated Voltage Present XXX.X Volts	0	NA	NA	NA	NA	NA
• This is the present value of the calculated secondary 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 this calculation. • 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.									
32	Metering	Reverse Demand	032 Reverse Load Current High XXX.X A (Date / Time shown)	0	NA	1	NA	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.									
32↓	Metering	Reverse Demand	032 Reverse Load Current Low XXX.X A (Date / Time shown)	0	NA	1	NA	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.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
32↓	Metering	Reverse Demand	032 Reverse Load Current Present XXX.X A	0	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.									
33	Metering	Reverse Demand	033 Power Factor at Max Reverse kVA X.XX (Date / Time shown)	0	NA	NA	NA	NA	NA
• This is the instantaneous power factor of the load at the first time the maximum kVA demand occurred (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.									
33↓	Metering	Reverse Demand	033 Power Factor at Min Reverse kVA X.XX (Date / Time shown)	0	NA	NA	NA	NA	NA
• This is the instantaneous power factor of the load at the first time the minimum kVA demand occurred 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.									
34	Metering	Reverse Demand	034 Reverse kVA Load High XXXX.X kVA (Date / Time shown)	0	NA	1	NA	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.									
34↓	Metering	Reverse Demand	034 Reverse kVA Load Low XXXX.X kVA (Date / Time shown)	0	NA	1	NA	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.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
34↓	Metering	Reverse Demand	034 Reverse kVA Load Present XXXX.X kVA	0	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.									
35	Metering	Reverse Demand	035 Reverse kW Load High XXXX.X kW (Date / Time shown)	0	NA	1	NA	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.									
35↓	Metering	Reverse Demand	035 Reverse kW Load Low XXXX.X kW (Date / Time shown)	0	NA	1	NA	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.									
35↓	Metering	Reverse Demand	035 Reverse kW Load Present XXXX.X kW	0	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.									
36	Metering	Reverse Demand	036 Reverse kvar Load High XXXX.X kvar (Date / Time shown)	0	NA	1	NA	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.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
36↓	Metering	Reverse Demand	036 Reverse kvar Load Low XXXX.X kvar (Date / Time shown)	0	NA	1	NA	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.									
36↓	Metering	Reverse Demand	036 Reverse kvar Load Present XXXX.X kvar	NA	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.									
37	Metering	Reverse Demand	037 Reverse Source Voltage High XXX.X Volts (Date / Time shown)	0	NA	1	NA	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.									
37↓	Metering	Reverse Demand	037 Reverse Source Voltage Low XXX.X Volts (Date / Time shown)	0	NA	1	NA	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.									
37↓	Metering	Reverse Demand	037 Reverse Source Voltage Present XXX.X Volts	0	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 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
38	Metering	Master Reset	038 Master Reset (PRESS RESET)	0	NA	1	NA	NA	NA
• Only demand metering, forward and reverse, and maximum and minimum buck, boost, and tap position values (and associated time/date) are reset to their corresponding present demand values at FC 38: press **Edit/Reset,** then press **Enter.** • 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, and FC 128) may be reset to the present demand value: access the appropriate function code on display, press **Edit/Reset,** then press **Enter**. • Successful master reset is indicated by the word **(Done)** appearing on the display. • See the **Control Programming: Special Functions** section of this manual.										
39	Features	Source Side Voltage Calculation	039 Source Voltage Calculation On	0	2	NA	On	NA	NA
• The source side voltage is calculated based on tap position and the regulator type (see FC 140). • Options include: • source voltage calculator off • source voltage calculator on • The source voltage calculation provides accuracy to ±1.5% maximum error. • When the calculated values are used, the LCD will display **(Calculated).** • If source voltage is sensed, it will take precedence over the calculated voltage.									
40	Settings	Configuration	040 Regulator Identification 12345	0	2	NA	12345	1	32766
• 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) was entered at FC 40 at the factory. However, any other number within the limits defined above may be chosen instead. • When using flashcards for file transfers, the regulator identification is included in the transferred files Refer to the **Advanced Features: Compact Flash Card** section of this manual.									
41	Settings	Configuration	041 Regulator Configuration Wye	0	2	NA	See Note	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 the **Initial Control Programming** section of this manual to determine whether the regulator is leading or lagging. • **Note:** See Reference Bulletin R225-10-1 for a discussion of delta connections. • The LCD will display dashes if this is not set correctly									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
42	Settings	Configuration	042 Control Operating Mode Sequential	0	2	NA	Sequential	NA	NA
• The manner in which the control responds to out-of-band conditions is selectable by the user. The appropriate mode is selected by entering one of the corresponding choices: • Sequential (Standard) • Time Integrating • Voltage Averaging • For detailed information, see the **Control Operation: Control Operating Modes** section of this manual.									
43	Settings	Configuration	043 System Line Voltage 7200 Volts	0	2	NA	See Note	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 at FC 43. • Example: A regulator installed open or closed delta on an 11000 V system (line-to-line) would have 11000 entered at FC 43. • **Note:** Ratio correction is performed by the firmware, and, consequently the system line voltage rating must be entered. The line voltage rating is available on the regulator nameplate and is summarized in Tables 10-1 and 10-2 for most regulator ratings.									
44	Settings	Configuration	044 Overall P.T. Ratio 20.0	0	2	NA	See Note	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 Tables 10-1 and 10-2 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.									
45	Settings	Configuration	045 C.T. Primary Rating 100 Amps	0	2	NA	100	25	2000
• The control is designed for a 200 mA as the rated current transformer (C.T.) output current, and will meter to 400 mA (200% load) with no loss of accuracy. • Ratio correction is performed by the firmware and consequently the C.T. primary rating must be entered. The C.T. primary rating is available on the regulator nameplate. EXAMPLE: A 7620 V, 328A regulator (250 kVA) would have a C.T. rating of 400:0.2 and therefore, 400 is entered at FC 45.									
46	Settings	Configuration	046 Demand Time Interval 15.0 Minutes	0	2	NA	15.0	0.5	60.0
• This is the time period during which the demand integral is performed for all demand readings (FC 20–FC 36). • Demand readings are useful because they represent the values which produce actual heating effects in electrical equipment and they do not respond to the continuous fluctuations which occur on the line.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
47	Features	Calibration	047 Voltage Calibration 110.0 Volts	0	3	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 and should not be necessary in the field. • See the **Troubleshooting: Control Calibration** section of this manual.									
48	Features	Calibration	048 Current Calibration 100.0 mA	0	3	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 400 mA (200% load) 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 and should not be necessary in field. • See the **Troubleshooting: Control Calibration** section of this manual.									
49	Settings	Configuration	049 Tap Changer Type Cooper QD8	0	2	NA	See Note	NA	NA
• This function code identifies the tap-changer type. See Service Information S225-10-10. Changing this function code changes the control's sampling rate to accommodate varying tap-changer types. • Options include: • Cooper QD8 • Cooper QD5 • Cooper QD3 • Cooper Spring Drive • LTC Reinhausen • Cooper Direct Drive • Siemens • General Electric • Howard • None **Note:** The LCD will display "_ _ _ _" **(Invalid)** if this is set to "None".									
50	Settings	Calendar/Clock	050 System Calendar and Clock (Date / Time shown)	0	3	NA	NA	NA	NA
• The system date and time utilizes the MM/DD/YYYY and 24-hour format. • The default is Jan. 1, 1970. • Refer to the **Control Features: Calendar/Clock** section of this manual for more information.									
51	Settings	Reverse Direction	051 Reverse Set Voltage 120.0 Volts	0	2	NA	120.0	100.0	135.0
• The set voltage is the voltage level to which the control will regulate, on the 120 V base, during reverse power flow. • See FC 1 and the **Control Features: Reverse Power Operation** section of this manual.									
52	Settings	Reverse Direction	052 Reverse Bandwidth 2.0 Volts	0	2	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–FC 5 and the **Control Features: Reverse Power Operation** section of this manual.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
53	Settings	Reverse Direction	053 Reverse Time Delay 45 Seconds	0	2	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 2–FC 5 and the **Control Features: Reverse Power Operation** section of this manual.									
54	Settings	Reverse Direction	054 Rev Line Drop Comp. Resistance 0.0 Volts	0	2	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 2–FC 5 and the **Control Features: Reverse Power Operation** section of this manual.									
55	Settings	Reverse Direction	055 Rev Line Drop Comp. Reactance 0.0 Volts	0	2	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 2– FC 5 and the **Control Features: Reverse Power Operation** section of this manual.									
56	Features	Reverse Power Mode	056 Reverse Sensing Mode Locked Forward	0	2	NA	Locked	NA	NA
• The control offers seven different response characteristics for reverse power flow operation, selectable by the user. • Options include: • Locked Forward • Locked Reverse • Reverse Idle • Bi-directional • Neutral Idle • Co-generation • Reactive Bi-directional • The current threshold set at FC 57 must be exceeded for the reverse sensing mode to function. • See the **Control Features: Reverse Power Operation** section of this manual.									
57	Features	Reverse Power Mode	057 Reverse Current Sense Threshold 1%	0	2	NA	1	1	5
• This is the current threshold at which the control switches operate, either from forward to reverse, or reverse to forward. • This threshold is programmable as a percentage of the rated CT primary rating. • Example: A 328 A regulator utilizing a CT with a 400 A primary rating and with a 3% threshold value would have a threshold of 12 A. • The metering of the control switches on a fixed 1% threshold, completely independent from FC 57. • See the **Control Features: Reverse Power Operation** section of this manual.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
60	Features	Communications	060 Com Port #1 Protocol DNP	0	2	NA	DNP	NA	NA
• This function defines which resident protocol of the control will be used on Com1/Com3. • Options include: • DNP • 2179 • See the **Control Features: Digital SCADA** section of this manual.									
61	Features	Communications	061 Com Port #1 Speed 9600	0	2	NA	9600	NA	NA
• The control microprocessor has two communications channels, each with selectable baud rates. • Options for Com1/Com3 include: • 300 • 600 • 1200 • 2400 • 4800 • 9600 • 19200 • 38400									
62	Features	Communications	062 Com Port #1 Sync Time 0 mSec	0	2	NA	0	0	65535
• This defines the period of time, for Com1/Com3, the received data line must idle to assume the start of a request message. • See the **Control Features: Digital SCADA** section of this manual.									
63	Features	Communications	063 Com Port #1 DNP Master Adrs 1234	0	2	NA	1234	0	65535
• The control will send unsolicited responses to this master address for Com1/Com3.									
64	Features	Communications	064 Com Port #1 DNP Remote Adrs1 1	0	2	NA	1	0	65535
• This is the primary DNP remote address used by user. • The DNP Remote Address 1 for Com1/Com3 is entered at FC 64.									
64↓	Features	Communications	064 Com Port #1 DNP Remote Adrs2 65519	0	2	NA	65519	0	65535
• This is the DNP remote address available for remote configuration. For more information, contact your Eaton representative. • The DNP Remote Address 2 for Com1/Com3 is entered at FC 64.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
64↓	Features	Communications	064 Com Port #1 2179 Remote Adrs 1	0	2	NA	1	0	2046

- This is the control SCADA 2179 Remote Address for Com1/Com3.
- Each control on the system can be uniquely addressed by the SCADA RTU or other communications device. For 2179, the options include:
  - 0–2046 = Unique device address range. Controls with addresses in this range uniquely respond when the particular address is sent.
- All controls on the system listen and change as commanded, with no response, if a message is sent to address 2047.
- The control SCADA address for Com Port #1 is entered at FC 64.
- For 2179, the High Entry Limit is 2046.

65	Features	Communications	065 Com Port #1 Handshake Mode RTR without CTS	0	2	NA	RTR without CTS	NA	NA

- FC 65 allows the user to select the appropriate method for control-to-SCADA message interaction (handshake mode) on Com1/Com3.
- The transmit/receive handshaking mode allows adaptability to different types of communication system interfaces with the control. Options include:
  - RTS without CTS - Request to Send (RTS) without Clear to Send (CTS) support
  - RTS with CTS - Request to Send (RTS) with Clear to Send (CTS) support
  - RTR without CTS- Ready to Receive (RTR) without Clear to Send (CTS) support
  - RTR with CTS - Ready to Receive (RTR) with Clear to Send (CTS) support
- See FC 66 and FC 67 for programming of the Transmit Enable Delay and Transmit Disable Delay settings.

66	Features	Communications	066 Com Port #1 Tx Enable Delay 0 mSec	0	2	NA	0	0	1000

- When the control is set for transmit control handshaking, the user may require a delay (in milliseconds) on Com1/Com3 between the time when the transmit enable 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.
- For more information, refer to the **Advanced Control Features: Communications** section of this manual.

67	Features	Communications	067 Com Port #1 Tx Disable Delay 0 mSec	0	2	NA	0	0	1000

- When the control is set for transmit control handshaking, the user may require a delay (in milliseconds) on Com1/Com3 between the time when the data transmission is terminated and the transmit enable signal is disabled.
- See Figure 5-4.

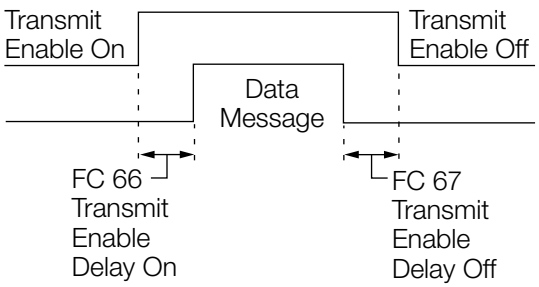


Figure 5.4. Data transmission from the CL-6 control to the communication system for handshaking applications.

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
69	Features	Auto Block Status	069 Auto Operation Blocking Status Normal	0	2	NA	Normal	NA	NA
• The control with communications options allows the user to completely control the regulator through the SCADA system. The SCADA system may place the regulator in a blocked state, thus inhibiting any further tap-changer operation initiated by the control. 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 disabling of the tap-changer (inhibit additional operations) for an indefinite time period. • The operator may change the state of this code by entering the level 2 security at the control and pressing the Edit/Reset key. If SCADA has the control blocked, the operator may override the SCADA system by changing FC 69 from blocked to normal, or, if the operator chooses to block automatic operation, FC 69 can be changed from normal to blocked. • Refer to the **Control Features: SCADA** section of this manual for additional information concerning the SCADA interaction with the control.										
70	Features	Voltage Reduction	070 Voltage Reduction Mode Off	0	2	NA	Off	NA	NA
• The control has three voltage reduction modes available for user selection. Options include: • Off • Local/Digital Remote • Remote - Latch • Remote - Pulse • Refer to the **Control Features: Voltage Reduction** section of this manual.									
71	Voltage Limiter	Voltage Reduction	071 Reduction in Effect 10.0 %	0	NA	NA	NA	NA	NA
• This is the actual percentage of voltage reduction presently active. • See the **Control Features: Voltage Reduction** section of this manual.									
72	Features	Voltage Reduction	072 Local/Digital Reduction Value 0.0 %	0	2	NA	0.0	0.0	10.0
• Three levels of remotely activated latching voltage reduction are available. • The percentage of voltage reduction to be performed is programmed at FC 72. Remote activation is then accomplished through SCADA communications.									
73	Features	Voltage Reduction	073 Remote #1 Value 0.0 %	0	2	NA	0.0	0.0	10.0
• Three levels of remotely activated latching voltage reduction are available. • The percentage of voltage reduction to be performed at Remote Level #1 is programmed at FC 73. Remote activation is then accomplished by applying a signal to the appropriate input terminal when FC 70 is set to remote latch. • See the **Control Features: Analog SCADA** section of this manual.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
74	Features	Voltage Reduction	074 Remote #2 Value 0.0 %	0	2	NA	0.0	0.0	10.0
• Three levels of remotely activated latching voltage reduction are available. • The percentage of voltage reduction to be performed at Remote Level #2 is programmed at FC 74. Remote activation is then accomplished by applying a signal to the appropriate input terminal when FC 70 is set to remote latch. • See the **Control Features: Analog SCADA** section of this manual.									
75	Features	Voltage Reduction	075 Remote #3 Value 0.0 %	0	2	NA	0.0	0.0	10.0
• Three levels of remotely activated latching voltage reduction are available. • The percentage of voltage reduction to be performed at Remote Level #3 is programmed at FC 75. Remote activation is then accomplished by applying a signal to two appropriate input terminals when FC 70 is set to remote latch. • See the **Control Features: Analog SCADA** section of this manual.									
76	Features	Voltage Reduction	076 # of Pulse Reduction Steps 0	0	2	NA	0	0	10
• Up to ten steps of voltage reduction are available when pulsed voltage reduction mode is selected. (FC 70 set to remote/pulse.) • FC 76 defines the number of steps selected for pulsed reduction operation. The percentage of voltage reduction of each step is defined at FC 77. • See the **Control Features: Analog SCADA** section of this manual.									
77	Features	Voltage Reduction	077 % of Voltage Red Per Pulse Step 0.0 %	0	2	NA	0.0	0.0	10.0
• FC 77 defines the percentage of voltage reduction which will be applied for each step of pulsed voltage reduction selected at FC 76. • See the **Control Features: Analog SCADA** section of this manual.									
79	Features	SOFT-ADD-AMP	079 Soft ADD-AMP Limits Off	0	2	NA	Off	NA	NA
• The control has Soft ADD-AMP capabilities. Options include: • Off • On • PIO Activate • Default is Off; On with Remote Override • See the **Control Features: Soft ADD-AMP** section of this manual.									
80	Features	Voltage Limiter	080 Voltage Limiter Mode Off	0	2	NA	Off	NA	NA
• The control has voltage-limiting capabilities for both high-voltage and low-voltage conditions. • Additional voltage-limiting capabilities are included which are to be used when Integrate Volt/VAR Control (IVVC) software is controlling regulation. • Options include: • Off • High limit only • High/low limits • IVVC High limit only • IVVC High/low limits • See the **Control Features: Voltage Limiting** section of this manual.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
81	Features	Voltage Limiter	081 High Voltage Limit 130.0 Volts	0	2	NA	130.0	120.0	135.0
• The high voltage limit is programmed here. • 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 exceeding this value. • See the **Control Features: Voltage Limiting** section of this manual.									
82	Features	Voltage Limiter	082 Low Voltage Limit 105.0 Volts	0	2	NA	105.0	105.0	120.0
• The low voltage limit is programmed here. • 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 the **Control Features: Voltage Limiting** section of this manual.									
89	Diagnostics	Control	089 Firmware Version XX.YY.ZZ	0	NA	NA	NA	NA	NA
• XX=Version number. Used for major changes that involve database enhancements. • YY=Revision number. Used for changes that do not involve database enhancements. • ZZ=Used for new firmware release.									
91	Diagnostics	Control	091 Self Test	NA	NA	NA	NA	NA	NA
• Access this screen to initiate the self test. • With FC 91 accessed, the LCD will display **(Enter):** press the **Enter** key to select and press **Enter** again to confirm; the system will reboot, then display the startup screen. (Press **Escape** for further keypad use.) • Refer to **Power-Up/Reset Conditions** in this section of this manual.									
92	Features	Security Access	092 Security Override 0	0	3	NA	0	0	3
• FC 92 is the control security override parameter. • Entering the level 3 security code at FC 99 will permit the security parameters to be modified. • See the **Control Operation: Security System** section of this manual.									
96	Features	Security Access	096 Security Code Level 1 1234	3	3	NA	1234	1	9999
• The number to be used as the level 1 security code is entered here. • Entry of this number at FC 99 permits the user to change/reset only the parameters marked as level 1 security (demand and tap position readings). • See the **Control Operation: Security System** section of this manual.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
97	Features	Security Access	097 Security Code Level 2 12121	3	3	NA	12121	10000	19999
• The number to be used as the level 2 security code is entered here. • Entry of this number at FC 99 permits the user to change/reset only the parameters marked as level 2 security (control settings, configuration, and clock) and level 1 security (demand and tap positions readings). • See the **Control Operation: Security System** section of this manual.									
98	Features	Security Access	098 Security Code Level 3 32123	3	3	NA	32123	20000	32766
• The number to be used as the level 3 security code is entered here. • Entry of this number at FC 99 permits the user to change/reset any parameter. • **Note:** If the level 3 code is changed by the user, the new value should be recorded and kept in a safe place. If lost, the security codes can be retrieved with a flash card and CCI software, with the CCI software via a PC directly connected to the control, or with the remote communications system. • See the **Control Operation: Security System** section of this manual.									
99	Features	Security Access	Security Code _____	3	3	NA	32123	20000	32766
• 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 the **Control Operation: Security System** section of this manual.									
100	Counters	Operations Counter	100 Last Counter Change XXXXX (Date / Time shown)	0	NA	NA	NA	NA	NA
• FC 100 displays the time and date since the last total-operations counter change, as well as the quantity of operations since the last change. • The function code may be set to a specific value.									
101	Counters	Operations Counter	101 Last 24 Hours Operations XXXXX (Date / Time shown)	0	NA	3	See Note	NA	NA
• Operations in last 24 hours (updated hourly and on every tap change). • **Note**: This is reset to zero by pressing **Edit/Reset**, then **Enter.**									
102	Counters	Operations Counter	102 Last 30 Days Operations XXXXX (Date / Time shown)	0	NA	3	See Note	NA	NA
• Operations in last 30 days (updated daily and on every tap change). • **Note:** This is reset to zero by pressing **Edit/Reset**, then **Enter**.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
103	Counters	Operations Counter	103 Current Month Operations XXXXX (Date / Time shown)	0	NA	3	See Note	NA	NA
• Operations since the beginning of current month (updated on every tap change and reset when the clock's month changes). • **Note:** This is reset to zero by pressing **Edit/Reset**, then **Enter.**									
104	Counters	Operations Counter	104 Last Month Operations XXXXX (Date / Time shown)	0	NA	3	See Note	NA	NA
• Operations in last calendar month (if reset, this field will remain zero until the month changes). • **Note**: This is reset to zero by pressing **Edit/Reset**, then **Enter.**									
105	Counters	Operations Counter	105 Current Year Operations XXXXX (Date / Time shown)	0	NA	3	See Note	NA	NA
• Operations since January 1st of current year (updated on every tap change and reset when the clock's year changes). • **Note:** This is reset to zero by pressing **Edit/Rese**t, then **Enter.**									
106	Counters	Operations Counter	106 Last Year Operations XXXXX (Date / Time shown)	0	NA	3	See Note	NA	NA
• Operations in last calendar year (if reset, this field will remain zero until the year changes). • **Note:** This is reset to zero by pressing **Edit/Reset**, then **Enter.**									
107	Counters Counter	Operations	107 Enable Interval Counters Enabled	0	3	NA	Enabled	NA	NA
• FC 107 is used for enabling FC 101 to FC 106. Options include: • Enabled • Disabled									
112	Metering	Instantaneous	112 Percent Regulation XX.X %	0	NA	NA	NA	NA	NA
• 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 (-). • This is the actual percentage that the regulator is actively boosting (raising) or bucking (lowering) the input (source) voltage. • 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	Metering	Instantaneous	125 Energy kW-hour Forward XXXX.X kW-h	0	NA	1	See Note	NA	NA
• This is the total forward energy, measured in kilowatt hours. • **Note:** This is reset to zero by pressing **Edit/Reset,** then **Enter**, and when the Date/Time is changed.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
125↓	Metering	Instantaneous	125 Energy kW-hour Reverse XXXX.X kW-h	0	NA	1	See Note	NA	NA
• This is the total reverse energy, measured in kilowatt hours. • **Note:** This is reset to zero by pressing **Edit/Reset**, then **Enter**, and when the Date/Time is changed.									
126	Metering	Instantaneous	126 Energy kvar-hour Forward XXXX.X kvar-h	0	NA	1	NA	NA	NA
• This is the total forward energy, measured in kvar.									
126↓	Metering	Instantaneous	126 Energy kvar-hour Reverse XXXX.X kvar-h	0	NA	1	NA	NA	NA
• This is the total reverse energy, measured in kvar.									
127	Metering	Forward Demand	127 Maximum % Boost XX.X % (Date / Time shown)	0	NA	1	NA	NA	NA
• This is the highest percentage that the regulator has raised the input voltage (since last reset). • This parameter is the upper drag-hand value for the present percent regulation, FC 12. • 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.									
128	Metering	Forward Demand	128 Maximum % Buck XX.X % (Date / Time shown)	0	NA	1	NA	NA	NA
• This is the highest percentage that the regulator has lowered the input voltage (since last reset). • This parameter is the lower drag-hand value for the present percent regulation, FC 12. • 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.									
140	Settings	Configuration	140 Regulator Type Type B	0	2	NA	See Note	NA	NA

• Regulator type defines the regulator type based on ANSI standards. Options include:
  • Type A (series design)
  • Type B (inverted design)
  • Type C (series transformer design) Series TX is listed on nameplate. Used on Eaton voltage regulators with voltage rating of 2.5 kV and current ratings above 875 A.
  • Type D (series auto transformer design) Series AX is listed on nameplate. Used on Eaton 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 nameplates.									

141	Settings	Menu System	141 Language Selection English	0	2	NA	English	NA	NA
• This setting allows the user to select the language to display. Options include: • English • Spanish • French • Portuguese									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
142	Counters	Menu System	142 Date Format MM/DD/YYYY	0	2	NA	MM/DD/	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									
143	Counters	Menu System	143 Time Format 12 Hour AM/PM	0	2	NA	12 Hour	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									
144	Settings	Configuration	144 P.I. ADD-AMP High Limit 16	0	2	NA	16	NA	NA
• The physical location of the high P.I. limit of the position indicator, as set by the user, is entered by the user-operator here. • The allowable values are 16, 14, 12, 10, or 8.									
145	Settings	Configuration	145 P.I. ADD-AMP Low Limit -16	0	2	NA	-16	NA	NA
• The physical location of the low P.I. limit of the position indicator, as set by the user, is entered by the user-operator here. • The allowable values are -16, -14, -12, -10, or -8.									
146	Settings	Configuration	146 Vin P.T. Configuration Vdiff Mode	0	2	NA	Vdiff Mode	NA	NA
• This defines the configuration of the PT for the source-side voltage. Options include: • V_{diff} Mode • V_{in} Mode. • The V_{diff} Mode is used when the regulator is provided with an internal differential PT or if the Source Voltage Calculator (FC 39) is turned on. The V_{in} Mode is selected when an external source PT is supplied by the user to provide the source voltage for the CL-6 control. • See the **Control Features: Source-Side Voltage** section of this manual.									
150	Features	Calibration	150 Reset Calibration	0	3	NA	NA	NA	NA
• This is a command. When **Enter** key is pressed, a **(CONFIRM)** message is displayed on the fourth line of LCD. When **Enter** key is pressed again, voltage and current calibration factors are reset.									
151	Settings	Calendar Clock	151 Daylight Savings Time Enable Off	0	3	NA	Off	NA	NA
• This function enables daylight savings time to function. Options include: • Off • On									
152	Settings	Calendar Clock	152 Daylight Savings Time Active No	0	NA	NA	NA	NA	NA
• This function displays if daylight savings time is currently active (Yes or No).									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
160	Features	Communications Protocol	160 Com Port #2 DNP	0	2	NA	DNP	NA	NA
• This function defines which resident protocol of the control will be used on Communications Port #2; options include: • DNP •2179 • See the **Control Features: Digital SCADA** section of this manual.									
161	Features	Communications	161 Com Port #2 Speed 9600 BPS	0	2	NA	9600	NA	NA
• The control microprocessor has two communications channels, each with selectable baud rates. • Options for Communications Port #2 include: • 300 • 600 • 1200 • 2400 • 4800 • 9600 • 19200 • 38400									
162	Features	Communications	162 Com Port #2 Sync Time 0 msec	0	2	NA	0	0	65535
• This defines the period of time, for Com Port #2, the received data line must idle to assume the start of a request message. • See the **Control Features: Digital SCADA** section of this manual.									
163	Features	Communications	163 Com Port #2 DNP Master Adrs 1234	0	2	NA	1234	0	65535
• The control will send unsolicited responses to this master address.									
164	Features	Communications	164 Com Port #2 DNP Remote Adrs1 2	0	2	NA	2	0	65535
• This is the primary DNP remote address for Com Port #2. • The DNP Remote Address 1 for Com Port #2 is entered at FC 64 with a factory preset address of 2.									
164↓	Features	Communications	164 Com Port #2 DNP Remote Adrs2 65519	0	2	NA	65519	0	65535
• This is the DNP remote address available for remote configuration. For more information, contact your Eaton representative. • The DNP Remote Address 2 for Com Port #2 is entered at FC 64 with a factory preset address of 65519.									
164↓	Features	Communications	164 Com Port #2 2179 Remote Adrs 6	0	2	NA	6	0	2046
• This is the control SCADA 2179 Remote Address for Com Port #2. • Each control on the system can be uniquely addressed by the SCADA RTU or other communications device. For 2179, the options include: • 0-2046 = Unique device address range. Controls with addresses in this range uniquely respond when the particular address is sent. • All controls on the system listen and change as commanded, with no response, if a message is sent to address 2047. • The control SCADA address for Com Port #1 is entered at FC 64 with a factory preset address of 6. • For 2179, the High Entry Limit is 2046.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
165	Features	Communications	165 Com Port #2 Handshake Mode RTR without CTS	0	2	NA	RTR without CTS	NA	NA
• FC 165 allows the user to select the appropriate method for control-to-SCADA message interaction (handshake mode) on Com Port #2. • The transmit/receive handshaking mode allows adaptability to different types of communication system interfaces with the control. Options include: • RTS without CTS - Request to Send (RTS) without Clear to Send (CTS) support • RTS with CTS - Request to Send (RTS) with Clear to Send (CTS) support • RTR without CTS- Ready to Receive (RTR) without Clear to Send (CTS) support • RTR with CTS - Ready to Receive (RTR) with Clear to Send (CTS) support • See FC 166 and FC 167 for programming of the Transmit Enable Delay and Transmit Disable Delay settings.									
166	Features	Communications	166 Com Port #2 Tx Enable Delay 0 mSec	0	2	NA	0	0	1000
• When the control is set for transmit control handshaking, the user may require a delay (in milliseconds) on Com Port #2 between the time when the transmit enable 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. • For more information, refer to the **Advanced Control Features: Communications** section of this manual.									
167	Features	Communications	167 Com Port #2 Tx Disable Delay 0 mSec	0	2	NA	0	0	1000
• When the control is set for transmit control handshaking, the user may require a delay (in milliseconds) on Com Port #2 between the time when the data transmission is terminated and the transmit enable signal is disabled.									
170	Features	Tap to Neutral	170 Tap to Neutral Off	0	2	NA	Off	NA	NA
• The Tap-to-Neutral feature is enabled here. The options include: • Off • On • For more information, refer to the **Control Features: Tap-to-Neutral** section of this manual.									
175	Features	Soft ADD-AMP	175 SOFT-ADD-AMP High Limit 16	0	2	NA	16	NA	NA
• Soft ADD-AMP restricts the range of regulation 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.									
176	Features	Soft ADD-AMP	176 SOFT-ADD-AMP Low Limit -16	0	2	NA	-16	NA	NA
• The low limit of the Soft ADD-AMP restriction on the range of regulation are set here. • The allowable values are -16, -14, -12, -10, or -8.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
189	Diagnostics	Control	189 Database Version XX	0	NA	NA	NA	NA	NA
• This is the Database Version Number of the firmware. • XX = Version Number									
190	Diagnostics	Control	190 PLD Version XX	0	NA	NA	NA	NA	NA
• This is the Programmable Logic Device (PLD) Version Number • XX = Programmable Logic Device (PLD) Version Number									
191	Diagnostics	Control	191 2179 Version XX	0	NA	NA	NA	NA	NA
• This is the 2179 Protocol Version Number • XX = 2179 Protocol Version Number									
192	Diagnostics	Control	192 DNP Version XX	0	NA	NA	NA	NA	NA
• This is the DNP Protocol Version Number • XX = DNP Protocol Version Number									
193	Diagnostics	Control	193 DNP Checksum XXXX	0	NA	NA	NA	NA	NA
• This is the DNP Protocol Checksum									
260	Diagnostics	Communications	260 Com Port #1 Tx Messages XXXXX	0	NA	1	NA	NA	NA
• This is a count of Transmitted Messages from Com1/Com3.									
261	Diagnostics	Communications	261 Com Port #1 Rx Messages XXXXX	0	NA	1	NA	NA	NA
• This is a count of Received Messages from Com1/Com3.									
262	Diagnostics	Communications	262 Com Port #1 Rx Errors XXXXX	0	NA	1	NA	NA	NA
• This is a count of Receive Errors from Com1/Com3.									
263	Diagnostics	Communications	263 Com Port #2 Tx Messages XXXXX	0	NA	1	NA	NA	NA
• This is a count of Transmitted Messages from Com Port #2									
264	Diagnostics	Communications	264 Com Port #2 Rx Messages XXXXX	0	NA	1	NA	NA	NA
• This is a count of Received Messages from Com Port #2									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
265	Diagnostics	Communications	265 Com Port #2 Rx Errors XXXXX	0	NA	1	NA	NA	NA
• This is a count of Received Errors from Com Port #2									
266	Features	Communications	266 Com Port #1 2179 Ordinal Map CL-6	0	2	NA	CL-6	NA	NA
• This allows the user to set the control to emulate different maps for different CL-series regulator controls for Com1/Com3 when using the 2179 communications protocol. • The options include: • USER • CL-5D • CL-5E • CL-6A • CL-6 (default)									
267	Features	Communications	267 Com Port #1 DNP Data Dict CL-6	0	2	NA	CL-6	NA	NA
• This allows the user to set the control to emulate different data dictionaries for different CL-series regulator controls for Com Ports #1/#3 when using the DNP communications protocol. • The options include: • USER • CL-5D • CL-5E • CL-6A • CL-6A w/Events • CL-6 (default)									
268	Features	Communications	268 Com Port #2 2179 Ordinal Map CL-6	0	2	NA	CL-6	NA	NA
• This allows the user to set the control to emulate different maps for different CL-series regulator controls for Com Port #2 when using the 2179 communications protocol. • The options include: • USER • CL-5D • CL-5E • CL-6A • CL-6 (default)									
269	Features	Communications	269 Com Port #2 DNP Data Dict CL-6	0	2	NA	CL-6	NA	NA
• This allows the user to set the control to emulate different data dictionaries for different CL-series regulator controls for Com Port #2 when using the DNP communications protocol. • The options include: • USER • CL-5D • CL-5E • CL-6A • CL-6A w/Events • CL-6 (default)									
300	Diagnostics	Maintenance	300 PMT Mode A State Off	0	2	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 PMT feature Mode A is turned off or on here. The options include: • Off • On									
301	Diagnostics	Maintenance	301 PMT Mode A Countdown Delay 20 Days	0	NA	NA	NA	NA	NA
• This is the time remaining until the next PMT Mode A operation.									
302	Diagnostics	Maintenance	302 PMT Mode A Time Delay 7 Days	0	2	NA	7	1	99
• This is the user-defined period of time between PMT Mode A operations.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
303	Diagnostics	Maintenance	303 PMT Mode A Issue Test	NA	2	NA	NA	NA	NA
• The user can force the PMT Mode A operation independent of the time-delay setting. • This is a command. When the **Enter** key is pressed, the **(CONFIRM)** message is displayed on the fourth line of the LCD. When the **Enter** key is pressed again, the test sequence begins.									
320	Diagnostics	Maintenance	320 PMT Mode B State Off	NA	2	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	Diagnostics	Maintenance	321 PMT Mode B Countdown Delay XX Days	0	NA	NA	NA	NA	NA
• This is the time remaining until the next PMT Mode B operation.									
322	Diagnostics	Maintenance	322 PMT Mode B Time Delay 7 Days	0	2	NA	7	1	99
• This is the user-defined period of time between PMT Mode B operations.									
323	Diagnostics	Maintenance	323 PMT Mode B Start Time 22:00	0	2	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	Diagnostics	Maintenance	324 PMT Mode B Stop Time 02:00	0	2	NA	02:00	00:00	23:59
• The PMT Mode B operation is disabled after the stopping time set here.									
325	Diagnostics	Maintenance	325 PMT Mode B Max Deviation 8	0	2	NA	8	1	16
• This is the maximum number of tap positions beyond neutral for which PMT Mode B is enabled.									
326	Diagnostics	Maintenance	326 PMT Mode B Designation Off	0	2	NA	Off	NA	NA
• This allows the performance of PMT Mode B maintenance operations to be coordinated among multiple regulators. Options include: • Off • Master • Slave									
327	Diagnostics	Maintenance	327 PMT Mode B Current Limit 50 %	0	2	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.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
328	Diagnostics	Maintenance	328 PMT Mode B Issue Test	NA	2	NA	NA	NA	NA
• This is a command. When the **Enter** key is pressed, the **(CONFIRM)** message is displayed on the fourth line of the LCD. When the **Enter** key is pressed again, the test sequence begins.									
333	Diagnostics	Maintenance	333 Contact Duty Cycle Monitor XX.XXX%	0	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 CCI software.									
350	Features	Compact Flash	350 CompactFlash Data Writer	NA	NA	NA	NA	NA	NA
• This is a command to write information to the compact flash card. Refer to the **Advanced Features: Compact Flash Card** section of this manual.									
351	Features	Compact Flash	351 CompactFlash Load Custom Cfg	NA	2	NA	NA	NA	NA
• This is a command to load a custom configuration to the CL-6 control. Refer to the **Advanced Features: Compact Flash Card** section of this manual.									
352	Features	Compact Flash	352 CompactFlash Load Std Config	NA	2	NA	NA	NA	NA
• This is a command to load a standard configuration to the CL-6 control. Refer to the **Advanced Features: Compact Flash Card** section of this manual.									
353	Features	Compact Flash	353 CompactFlash Save Custom Cfg	NA	NA	NA	NA	NA	NA
• This is a command to save a custom configuration from the CL-6 control. Refer to the **Advanced Features: Compact Flash Card** section of this manual.									
354	Features	Compact Flash	354 CompactFlash Save Std Config	NA	NA	NA	NA	NA	NA
• This is a command to save a standard configuration from the CL-6 control. Refer to the **Advanced Features: Compact Flash Card** section of this manual.									
355	Features	Compact Flash	355 CompactFlash Format CF Card	NA	NA	NA	NA	NA	NA
• This is a command to format the compact flash card. Refer to the **Advanced Features: Compact Flash Card** section of this manual.									
357	Features	Compact Flash	357 CF Load Custom Basic Config	NA	2	NA	NA	NA	NA
• This is a command to load a custom Basic Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									
358	Features	Compact Flash	358 CF Load Standard Basic Config	NA	2	NA	NA	NA	NA
• This is a command to load a Standard Basic Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
359	Features	Compact Flash	359 CF Save Custom Basic Config	NA	2	NA	NA	NA	NA
• This is a command to save a Custom Basic Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									
360	Features	Compact Flash	360 CF Save Standard Basic Config	NA	2	NA	NA	NA	NA
• This is a command to save a Standard Basic Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									
361	Features	Compact Flash	361 CF Load Custom AdvFeat Config	NA	2	NA	NA	NA	NA
• This is a command to load a Custom Advanced Feature Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									
362	Features	Compact Flash	362 CF Load Standard AdvFeat Config	NA	2	NA	NA	NA	NA
• This is a command to load a Standard Advanced Feature Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									
363	Features	Compact Flash	363 CF Save Custom AdvFeat Config	NA	2	NA	NA	NA	NA
• This is a command to save a Custom Advanced Feature Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									
364	Features	Compact Flash	364 CF Save Standard AdvFeat Config	NA	2	NA	NA	NA	NA
• This is a command to save a Standard Advanced Feature Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									
365	Features	Compact Flash	365 CF Load Custom Comms Config	NA	2	NA	NA	NA	NA
• This is a command to load a Custom Comms Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									
366	Features	Compact Flash	366 CF Load Standard Comms Config	NA	2	NA	NA	NA	NA
• This is a command to load a Standard Comms Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									
367	Features	Compact Flash	367 CF Save Custom Comms Config	NA	2	NA	NA	NA	NA
• This is a command to save a Custom Comms Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									
368	Features	Compact Flash	368 CF Save Standard Comms Config	NA	2	NA	NA	NA	NA
• This is a command to load a Custom Basic Configuration. • See Flash Card Functions in the Advanced Control Features section of this manual for more information.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
400	Features	Leader/ Follower	400 LoopShare Communication	0	2	NA	Off	NA	NA
• This will turn On or Off LoopShare Communications. The options include: • On • Off									
401	Features	Leader/ Follower	401 LoopShare Comms State	NA	2	NA	NA	NA	NA
• This is the state of LoopShare Communications. It will display either Active or Inactive.									
402	Features	Leader/ Follower	402 LoopShare Comms Port	0	2	NA	COM3	NA	NA
• This is the Port LoopShare is using. The options are: • COM2 • COM3									
403	Features	Leader/ Follower	403 LoopShare Comms Table Assignment	0	2	NA	Passive	NA	NA
• This is the device in the LoopShare Table. The options include: • Device 1 • Device 2 • Device 3 • Passive									
404	Features	Leader/ Follower	404 LoopShare Comms Tx Delay XXXXX mSec	0	2	NA	0	0	10000
• This is the delay between the time a device receives an updated LFDT and when the device passes it along.									
405	Features	Leader/ Follower	405 LoopShare Comms Timeout XX seconds	0	2	NA	3	1	60
• LoopShare timeout time.									
410	Features	Leader/ Follower	410 Leader/Follower Off	0	2	NA	Off	NA	NA
• This will turn On or Off Leader/Follower. The options include: • On • Off									
411	Features	Leader/ Follower	411 Leader/Follower State Active	NA	2	NA	NA	NA	NA
• This is the state of the Leader/Follower function. It will display either Active, Inactive/Ready, or Not Ready.									
413	Features	Leader/ Follower	413 Leader/Follower Designation Follower 1	0	2	NA	Follower 1	NA	NA
• This is the Leader/Follower table designation. The options include: • Leader • Follower 1 • Follower 2									
414	Features	Leader/ Follower	414 Follower Devices Configured One	0	2	NA	One	1	2
• The number of Follower devices.									
415	Features	Leader/ Follower	415 Leader/Follower Tap Wait Timer XXXXX mSec	0	2	NA	0	0	10000
• The length of time in milliseconds the device waits between receiving a signal to tap and actually tapping.									

TABLE 5-3. Function Codes (continued)

Func. Code	Level 1 Main Menu	Level 2 Sub-Menu	Level 3 Parameter	Security Level			Factory Setting	Key Entry Limit	
				Read	Edit	Reset		Low	High
416	Features	Leader/ Follower	416 Leader/Follower Timeout XX Seconds	0	2	NA	10	1	60
• The length of time in seconds before the Leader returns to starting tap position if a Follower device does not tap.									
417	Features	Leader/ Follower	417 Leader/Follower Retry Delay XX Seconds	0	2	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	Features	Leader/ Follower	418 Leader/Follower Retries XX	0	2	NA	3	1	10
• The number of tap retries before the Leader stops retrying taps. Enter the number of times to retry tapping.									
420	Features	Leader/ Follower	420 Leader/Follower Monitor Disabled	NA	NA	NA	NA	NA	NA
• This is the state of the leader Follower Monitor. It will display either enabled or disabled.									
450	Features	Alternate Config	450 Alternate Configuration Off	0	2	NA	OFF	NA	NA
• This will turn on Alternate Configurations. The options are: • Off • On • ARLH • ARLC • P.I.O. • Selecting "On" will enable the basic Alternate Configuration settings. • Selecting ARLH will enable the Auto-Restore Local Heartbeat function. This function will revert control settings modified through SCADA communications back to original settings when a heartbeat signal is lost or discontinued. • Selecting ARLC will enable the Auto-Restore Local Comms function. This function will revert control settings modified through SCADA communications back to original settings when a communications signal is lost. • Selecting P.I.O. will enable Alternate Configuration settings to be enabled or disabled using P.I.O. logic equations.									
451	Features	Alternate Config	451 Alternate Configuration Inactive	0	NA	NA	NA	NA	NA
• This is the state of Alternate Configuration. It will display either Active or Inactive.									

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

   (PRESS RESET)
```

While the (PRESS RESET) message is displayed, pressing the **Escape** key causes the LCD to exit the viewing of this command and to display the previous sub-menu items. Or, pressing the **Edit/Reset** button will request a "Confirm" before resetting all demand metering and tap position maximum and minimum values.

Confirm message

While the **(CONFIRM)** message is displayed:

```
038 Master Reset

     (CONFIRM)
```

pressing the **Escape** key causes the LCD to display the initial **(PRESS RESET)** message; pressing the **Enter** key causes the execution of the command and the LCD will display **(DONE)**.

Done message

While the **(DONE)** message is displayed:

```
038 Master Reset

      (DONE)
```

pressing the **Escape** or **Enter** key will cause the LCD to exit the viewing of this command and to display the previous sub-menu items.

Enter security code - FC 99

Entering FC 99 as follows:

```
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 menu system.

Self-test - FC 91

Using the Self-Test, FC 91, will reboot the system. After pressing **Function, 9-1-Enter** and accessing the FC 91 display, press **Enter** again to select the option and again to confirm. When the reboot is complete, the LCD displays the startup screen. Press **Escape** for further keypad use.

Test LEDs

Access this from the Main Menu (Level 1). With the cursor selecting "Test LEDs" in the main menu, press the **Enter** key and the front panel LEDs will blink three times. The Com port and Neutral Light LEDs do not blink.

Turn display off

Access this from the Main Menu (Level 1). With the cursor selecting "Turn Display Off" in the main menu, 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/Events > Alarms Active Unacknowledged

  This displays a list of active, unacknowledged system alarms.

- Alarms/Events > Alarms Active Acknowledged

  This displays a list of active, acknowledged system alarms.

This section covers Alarm displays; for more information, see the **Advanced Features: Alarms** section of this manual.

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 follows:

```
System Alarm #1 is
Active
01/14/2004 11:35:58a
      (MORE...□)
```

Status alarms

The status alarms include the following:

- Supervisory Active
- Reverse Power Flow
- No Input Voltage Detected
- No Output Voltage Detected
- Tap At Neutral
- PMT Mode A in Progress
- PMT Mode B in Progress
- Volt Limit On
- Reg Blocked Annunciator
- Voltage Reduct On Annunciator
- Alternate Profile Active
- Default Time
- Power Up Self Test Error
- Met Indeterminate Pwr Dir
- Met Rev Pwr Flow
- LF Ldr Unable to Operate
- LF Ldr Inactive
- LF Follower Not Ready
- LS Loss of Comms
- Motor Trouble

Data alarms

Instantaneous metering 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.

- Secondary Load Voltage High
- Secondary Load Voltage Low
- Secondary Source Voltage High
- Secondary Source Voltage Low
- Compensated Voltage High
- Compensated Voltage Low
- Primary Load Voltage High
- Primary Load Voltage Low
- Primary Source Voltage High
- Primary Source Voltage Low
- Load Current High
- Load Current Low
- Power Factor Low (only LOW threshold is available)
- kVA High
- kVA Low
- kW High
- kW Low
- KVAR High
- KVAR Low
- Forward kWHr High
- Forward kWHr Low
- Reverse kWHr High
- Reverse kWHr Low
- Forward KVARHr High
- Forward KVARHr Low
- Reverse KVARHr High
- Reverse KVARHr Low
- Frequency High
- Frequency Low
- Load Voltage Total Harmonic Dist. High (only HIGH threshold is available)
- Load Current Total Harmonic Dist. Low (only LOW threshold is available)

Counter quantities

For most Counter quantities, there will be only one data alarm that can be triggered for a HIGH threshold value.

- Tap Position High
- Tap Position Low
- Total Operations Counter High
- Last 24 Hours Operations Counter High
- Last 30 Days Operations Counter High
- Current Month Operations Counter High
- Last Month Operations Counter High
- Current Year Operations Counter High
- Last Year Operations Counter High

Maintenance quantities

See the **Advanced Features: Duty Cycle Monitor** section of this manual for more information on these alarms.

- DCM (Duty Cycle Monitor) Level 1 High
- DCM (Duty Cycle Monitor) Level 2 High

Events

Use the nested menu to access the lists of events. No security code is needed to display an event; a security code is needed to acknowledge an event.

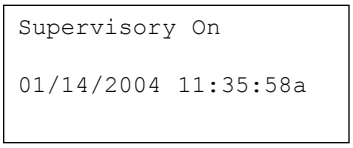
- Alarms/Events > Events

This displays a list of system events.

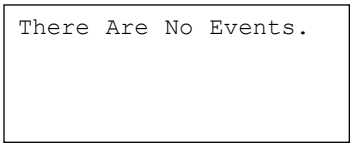
This section covers Event displays; for more information, see the **Advanced Features: Events** section of this manual.

The event labels can use 2 LCD lines for a total of up to 40 characters. An actual event display example follows:

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



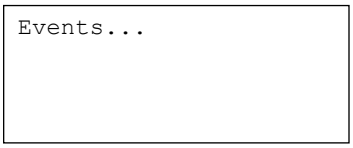
The events list may include the following:



- User Reset
- Clock Has Been Set
- Factory Calibration Required
- No Data Acquisition
- Tap Raise
- Tap Lower
- Tap at Neutral Position
- Neutral Sync
- Max Tap Position Sync
- Min Tap Position Sync
- Voltage Limit Activated
- Voltage Limiter High
- Voltage Limiter Low
- Voltage Reduction Activated
- Soft ADD-AMP High
- Soft ADD-AMP Low
- PMT Mode A Auto Wipe Complete
- PMT Mode B Auto Wipe Complete
- Input Voltage Missing
- Input Voltage Restored
- Output Voltage Missing
- Output Voltage Restored

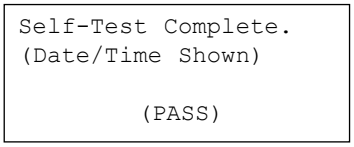
Note: When an alarm is configured to generate an event, the alarm label will be displayed as the event label.

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 event:



Power-up/reset conditions

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



If error conditions are detected, the LCD may display the following messages:

```
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 Programming**. Perform basic programming steps and then initiate a self-test.

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

 (ATTENTION...MORE  ↓)
```

```
Self-Test Complete.
Input Voltage
Missing!

(ATTENTION...MORE  ↓)
```

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

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

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 Power-Up/Reset Mode:

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

Displayed when an invalid function code is entered:

- (INVALID FUNCTION)

Displayed when an 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 edit/reset mode is active:

- (EDIT)
- (CONFIRM) (also displayed to prompt the user when issuing a command from the menu system, i.e., PMT Mode A Issue Test)

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

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

Displayed when listing alarms or events:

- (MORE...)
- (LAST...)

Displayed when the user access Master Reset:

- (PRESS RESET)
- (DONE)

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

- (ACKNOWLEDGE)
- (UNACKNOWLEDGED)

Displayed when the user accesses Compact Flash operations:

- (WRITING)
- (WRITING COMPLETE)
- (WRITING FAILED)
- (WRITING ABORTED)
- (LOADING...)
- (LOADING COMPLETE)
- (LOADING FAILED)
- (LOADING ABORTED)
- (SAVING...)
- (SAVING COMPLETE)
- (SAVING FAILED)
- (SAVING ABORTED)
- (FORMATTING...)
- (FORMATTING COMPLETE)
- (FORMATTING FAILED)
- (FORMATTING ABORTED)

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

- (CALCULATED)

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

- (TAP AT NEUTRAL)
- (TAP NOT AT NEUTRAL)

Metering-PLUS formats

This section covers Metering-PLUS displays; for more information, see the **Advanced Features: Metering** PLUS section of this manual.

Compensated voltage

When the ***Comp Voltage** key is pressed while the control is operating under Forward Power Flow conditions, the LCD displays:

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

If the control is operating under Reverse Power Flow conditions, the LCD displays:

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

When operating in the Cogeneration Mode, metering always operates in the *forward* direction **except** that load center voltage is calculated based upon the *reverse* line-drop compensation settings when the fixed 1% reverse metering threshold is exceeded. So, the LCD displays:

```
Comp Voltage    123.0
Band      119.0-121.0
Using Func  1-3,54,55
```

Load voltage

When the ***Load Voltage** key is pressed while the Voltage Limiting Mode = High and Low Limits Active, the LCD displays:

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

If Voltage Limiting Mode = Only High Limit, the LCD displays:

```
Load Voltage    115.0
Limiter         121.0
```

If Voltage Limiting Mode = Off, the LCD displays:

```
Load Voltage    115.0
Limiter           Off
```

Load current

When the ***Load Current** key is pressed while the control is operating under Forward Power Flow conditions and automatic tapping is inhibited, the LCD displays:

```
Load Current  600 Fwd
Current Threshold  12
Mode   Locked Forward
Blocked:    TB8 - 4&5
```

On the first line, "Fwd" corresponds to Forward Power Flow direction. The third line is used to display one of the following operating modes:

- Mode Locked Forward
- Mode Locked Reverse
- Mode Reverse Idle
- Mode Bi-directional
- Mode Neutral Idle
- Mode Cogeneration
- Mode Reactive Bi-directional

If automatic operation is blocked, the fourth line displays one of the following blocking conditions:

- Blocked: Cntrl Switch
- Blocked: Tap-to-Neutral
- Blocked: TB8-4&5
- Blocked: Func Code 069
- Blocked: Rev Pwr Mode

If the control is operating under Reverse Power Flow conditions and automatic tapping is not inhibited, the LCD displays the following:

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

Tap position

When the ***Tap Position** key is pressed while the Soft ADD-AMP feature = On, the LCD displays the following:

```
Tap Position         8

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

If the Soft ADD-AMP feature = On and the present tap position indicates that tap-changer is at a limit, the LCD displays the following:

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

If the Soft ADD-AMP feature = Off and the present tap position indicates that tap-changer is at neutral, the LCD displays the following:

```
Tap Position         0


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

If the Soft ADD-AMP feature = Off and if the tap-changer is at or beyond user-configured P.I. ADD-AMP limits, the LCD displays the following:

```
Tap Position        16
At Limit

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

Section 6: Control features

Calendar/clock

Integral to several functions of the control is an internal calendar/clock. The digital clock maintains the year, month, day, hour, minute and seconds, within 1 second. The display format is user-selectable (see FC 142 and FC 143). The control time is synchronized to the system frequency when powered by ac. When ac power is lost, the clock maintains time, for a minimum of 72 hours, 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 either arrow scroll key.

Daylight Savings Time is available starting with the CL-6B control. The factory default is for daylight savings time to be off. Daylight savings time can be turned on using FC 151.

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. They may be accessed directly at FC 6 through FC 19, FC 125, and FC 126. See Table 5-3 in the **Control Programming** section of this manual for more information on these function codes.

Demand metering

The control provides demand metering values for these parameters: load voltage, and, for forward and reverse, source voltage, compensated voltage, load current, kVA load, kW load, and kvar load. For each of these parameters the present value, the high value since last reset, and the low value since last reset are recorded, as well as the earliest time and date that the high and low values occurred.

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

See Table 5-3 in the **Control Programming** section of this manual for information on the function codes associated with demand metering (FC 20 through FC 38, FC 127, and FC 128).

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 6.1.

The task works like this:

1. For 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 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 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 15 minutes. This prevents loss of data during a power interruption or outage.

Notice that the provisions are made to reset any demand value by itself via the change/reset 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.

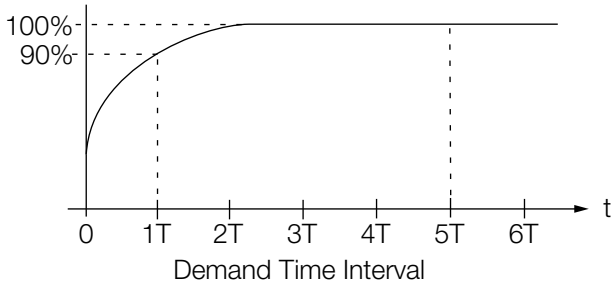


Figure 6-1. Demand time interval response.

Tap position indication

The control has the ability to track the position of the tap-changer. The tap position indication (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 security level 3; 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-6 control: a differential potential transformer (PT), an external source-side PT, or source-side voltage calculation.

Differential voltage

The regulator may be designed and ordered with an internal differential potential transformer (IDPT). This is noted by the schematic on the voltage regulator nameplate. A differential PT 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 voltage regulator, the source voltage accuracy is within ± 1%.

External source voltage

An external source-side PT may be connected to the voltage regulator to supply a directly measured source voltage. To use an external source-side PT, the user must change Vin PT Configuration, FC 146, from the default Vdiff Mode to Vin Mode. 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 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.

Source-side voltage calculation

The CL-6 control has the ability to calculate the source-side voltage without a series-winding PT or an external PT. When this feature is turned on, 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 within ±1.5% of actual. Only the regulator type needs to be programmed into the control. The other values are already available to the control.

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 **Source-Side Voltage** in this section of the manual.

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

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 senses the real component of the current (except in reactive bi-directional mode), then determines the current direction and magnitude in that direction. When the conditions indicate the 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[a]:

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

[a]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

When FC 56 is set for Locked Forward, no source voltage is required. This mode is not intended to be used in applications where reverse power flow is possible.

METERING: Always operates 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.

OPERATION: (Figure 6-2) Always operates in the forward direction using the forward settings at FC 1, FC 2, FC 3, FC 4, and FC 5. This allows operation down to zero current conditions since there is no forward threshold involved. A safeguard has been built into the control to prevent misoperation in the event reverse power flow does occur. If more than 2% (.004 A CT secondary) reverse current occurs, the control idles on the last tap position held and the band edge indicators will turn off. As the current flow returns to a level above this reverse threshold, normal forward operation resumes.

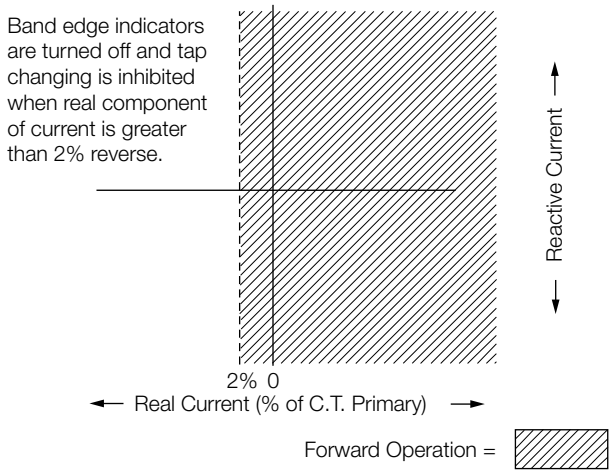


Figure 6-2. Locked forward mode operation.

Locked reverse mode

When FC 56 is set for Locked Reverse, source voltage is required. This mode is not intended to be used in applications where forward power flow is possible.

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

OPERATION: (Figure 6-3) Always operates in the reverse direction using the reverse settings at FC 51, FC 52, FC 53, FC 54, and FC 55. This allows operation down to zero current conditions since there is no reverse threshold involved. A safeguard has been built into the control to prevent misoperation in the event forward power flow does occur. If more than 2% (.004 A CT secondary) forward current occurs, the control idles on the last tap position held and the band edge indicators will turn off. As the current flow returns to a level above this forward threshold, normal reverse operation resumes.

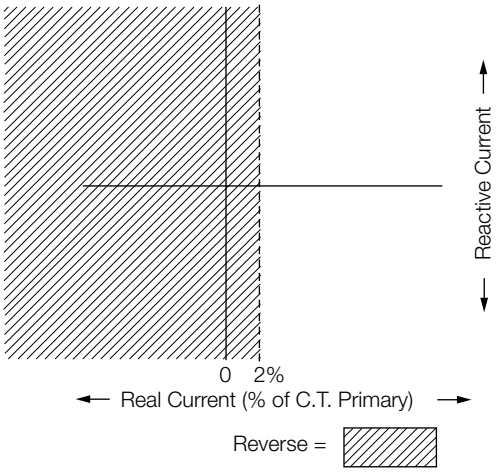


Figure 6-3. Locked reverse mode operation.

Reverse idle mode

When FC 56 is set for Reverse Idle, a source voltage is required for metering only. This mode is recommended for installation where reverse power flow may occur, but a source voltage is not available.

METERING: (Figure 6-4.) A threshold level of 1% (.002 A) of the full load CT secondary current (.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.

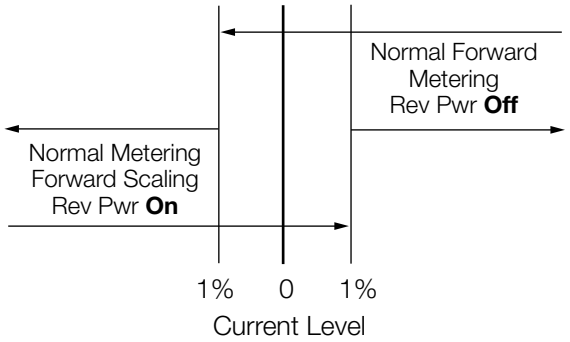


Figure 6-4. Reverse idle metering.

OPERATION: (Figure 6-5.) The threshold for which the control switches operation is programmable at FC 57 over the range 1 to 5% of the rated CT current. When the real component of the current is above this threshold, the control operates in the normal forward direction. When current falls below this threshold, all tap changing is inhibited.

The control idles on the last tap position held before the threshold was crossed. The operational timer (time delay) is reset on any excursion below this threshold, and the band edge indicators turn off.

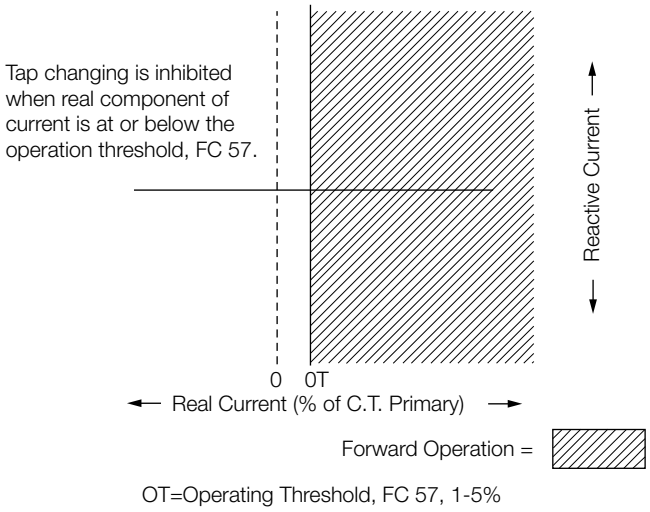


Figure 6-5. Reverse idle mode* operation.

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

Bi-directional mode

When FC 56 is set for Bi-directional, source voltage is required. This mode is recommended for all installations where reverse power flow may occur except where the source of reverse power is a cogeneration facility or independent power producer.

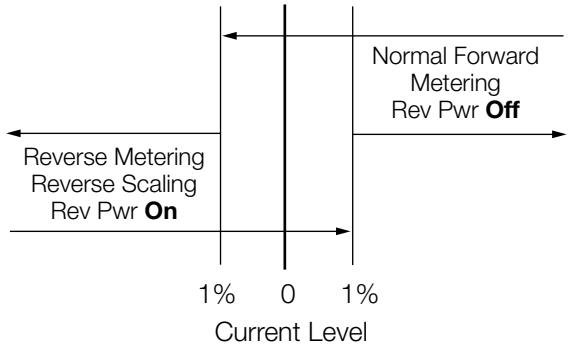


Figure 6-6. Bi-directional, neutral idle and reactive bi-directional metering.

METERING: (Figure 6-6.) A threshold level of 1% (.002 A) of the full load CT secondary current (.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.

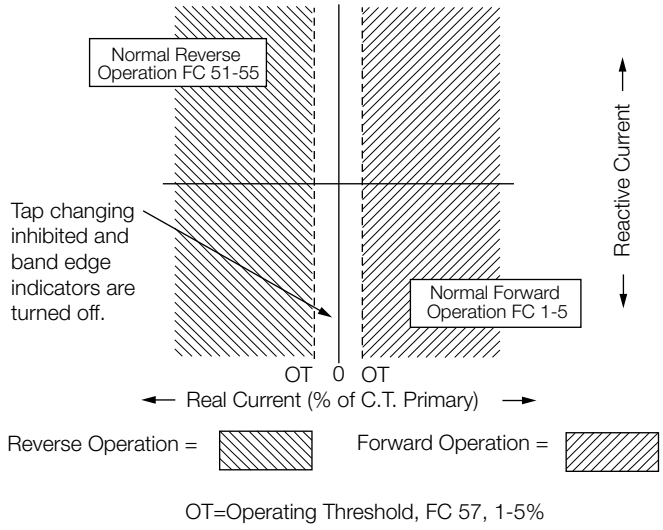


Figure 6-7. Bi-directional mode operation.

OPERATION: (Figure 6-7.)The control operates in the forward direction whenever the real component of the current is above the operator defined forward threshold (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 current is above the operator defined reverse threshold (FC 57). When the current is in the region between the two thresholds, the control idles on the last tap position held before the current fell below the threshold. The operational timer (time delay) is reset on any excursion below the threshold in either direction, and the band edge indicators turn off.

Neutral Idle mode

When FC 56 is set to Neutral Idle, a source voltage is required.

METERING: (Figure 6-6) A threshold level of 1% (.002 A) of the full load CT secondary current (.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: (Figure 6-8) The control operates in the forward direction whenever the real component of the current is above the operation-defined forward threshold (FC 57). When the current exceeds the operator-defined reverse threshold (FC 57) and is held for 10 continuous seconds, the control will tap to neutral. Neutral position is determined using Tap Position. If the tap position is not valid, neutral is determined using percent regulation (buck and boost). When the current is in the region between the two thresholds, the control idles on the last 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. The operational timer (time delay) is reset on any excursion below the forward threshold, and the band edge indicators turn off.

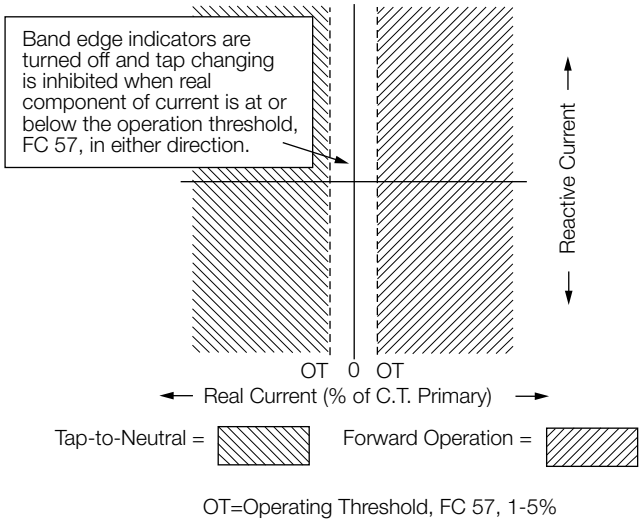


Figure 6-8. Neutral idle mode* operation.

*Band edge indicators turned off.

Cogeneration mode

When FC 56 is set for cogeneration, a source voltage is required.

In recent years, there have been a growing number of voltage regulator applications involving cogeneration by utility customers. The cogeneration mode was developed for the Cooper regulator control to satisfy the specialized needs of these applications. Normally, the desired operation of a regulator installed on a feeder involving cogeneration is to regulate the voltage at the customer substation during times of power flow into the customer site and to regulate the voltage at the regulator (on the same output side) during power flow into the utility grid. This is accomplished by simply not reversing the control sensing input voltage when reverse power is detected and by altering the line-drop compensation settings to account for this change in power flow direction. (See Figure 6-9.)

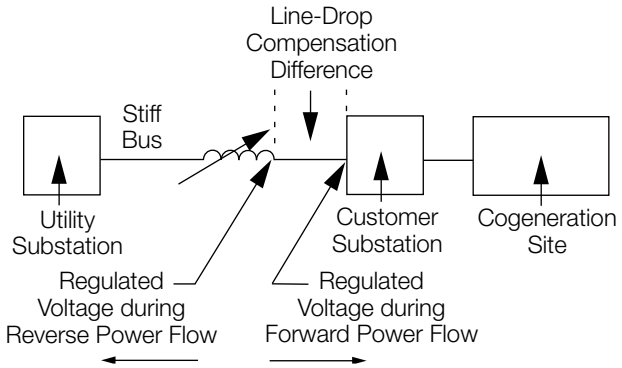


Figure 6-9. Cogeneration regulation points.

METERING: (Figure 6-10.) 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.

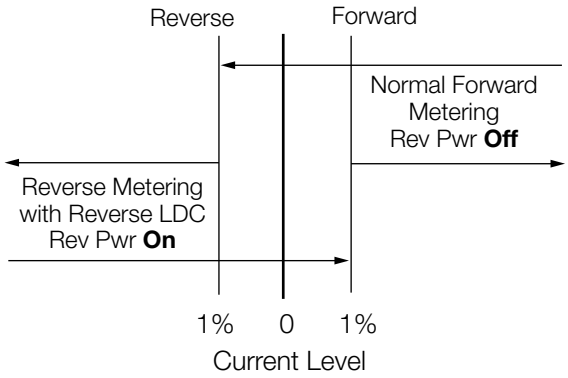


Figure 6-10. Cogeneration metering.

OPERATION: (Figure 6-11.) The control always operates in the forward direction. The control will operate in the forward direction, but will use the reverse settings for line-drop compensation when the real component of the current is above the fixed 1% reverse metering threshold. The control will continue to use the reverse line-drop compensation settings until the real component of the current is above the fixed 1% forward metering threshold. The operational timer (time delay) is not reset on any transitions between the application of forward and reverse line drop compensation settings.

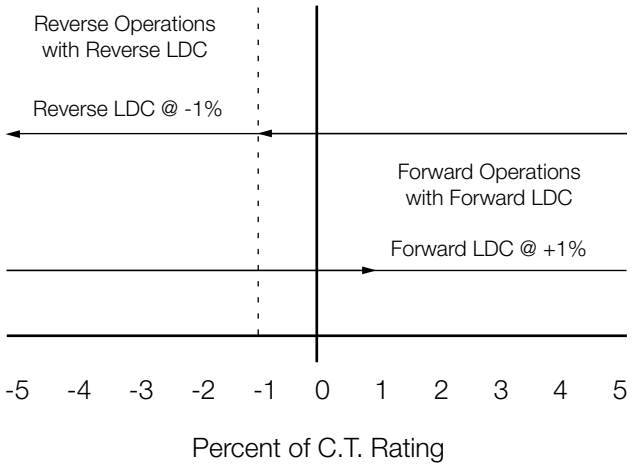


Figure 6-11. Cogeneration mode operation.

Reactive bi-directional mode

When FC 56 is set for Reactive Bi-directional, source voltage is required.

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 cogeneration facility or independent power producer.

METERING: (Figure 6-12.) A threshold level of 1% (0.002 A) of the full load CT secondary current (0.200 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: (Figure 6-12.) 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).

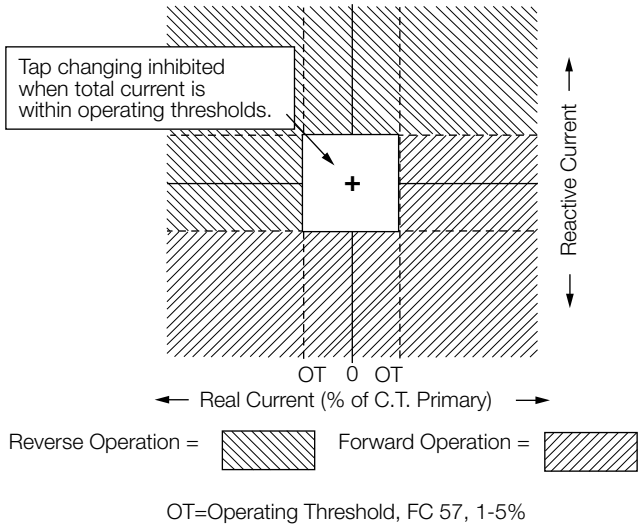


Figure 6-12. Reactive bi-directional mode operation.

Voltage limiter

The voltage-limiter feature is used to place high and low limits on the output voltage of the regulator. Voltage Limiter is equipped with both standard and Integrated Volt/Var Control (IVVC) modes of operation; the IVVC options are used when voltage is being regulated through SCADA. Voltage Limiter operates in either the forward or reverse directions.

When the standard modes are enabled, Voltage Limiter has one of the highest priorities of all operating functions and is overridden only when the control switch is set to Off or Manual, 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 IVVC modes are used, Voltage Limiter will take an even higher priority by operating to limit voltage at the set limits, even when FC 69 is set to Blocked. In addition, it will limit SCADA tapping commands if the control voltage is either at a set limit or when the next tap change will take it over a limit.

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; and IVVC High/Low Limits. If low-voltage limiting only is desired, FC 80 should be set to both high and low limiting to enable this limit and the value programmed into FC 81 for the high limit can be set to some extreme number (such as 135) to prevent the high limit from activating.

The control has two response sensitivities. If the output voltage exceeds either the high or low limit by 3 V or more, the control samples the voltage for two seconds 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 10 seconds then taps to bring the voltage to the limit value. The 10-second delay is used to prevent false responses to transient conditions. The control uses the sequential method of tapping, a two-second pause between taps for voltage sampling, when bringing the voltage back to the limit value. Voltage Limiter High and Voltage Limiter Low indicators in the display 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 limits. When the output voltage is within this "grey zone", the control will not perform any tap changes that would take the output voltage closer to 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. Analog Remote/Latch and Remote/Pulse are discussed in the Analog SCADA section starting later in this section of this manual.

All voltage reduction modes of the control 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.

When any mode of voltage reduction is in effect, the Voltage Reduction indicator is turned on. Voltage reduction occurs after 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%.

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, Adaptive 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. Adaptive ADD-AMP is controlled by the Programmable Input and Output (PIO) capabilities of the CL-6 control which are described in more detail in the **Advanced Control Features** section of this manual.

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-6 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-6 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 Upload**.

Data retrieval and settings uploading

The Com 1 port of the CL-6 control is a DB9-style RS-232 port located on the front of the control. 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)

The Channel #1 baud rate is selectable at 300, 600, 1200, 2400, 4800, 9600, 19200, and 38400 Baud. It is factory set to 9600 Baud.

Digital SCADA

Refer to the **Advanced Control Features** section for information on communications and physical interface.

Local operator security

Through the communications channel, the SCADA master may read the CL-6 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-6 control is equipped with a Supervisory On/Off switch. When this switch is in the on position, SCADA may perform the normal read, write, and reset activity. When the switch is in the off position, 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 switch (Auto/Remote-Off-Manual) to either Off or 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 level 1 or above, or security override is set to override 1 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, as compared to the CL-4C control which required that the power be turned off, then on, to reset those parameters on the separate protocol communications board.

Analog SCADA

The CL-6 control can be used with Analog SCADA systems. Discrete inputs 1 through 3 have been programmed by default for use as inputs for voltage reduction and Tap-to-Neutral. The back panel has provisions for remote motor control, auto-inhibiting, and transducer connections.

Discrete voltage reduction

During voltage reduction, the control remains in the Automatic mode. See Figures 6-13 and 6-14 for the location of the physical connections. For either of the two modes, Remote Latching and Pulse, a nominal 120 Vac needs to be supplied to either or both discrete inputs 1 and 2 (pins 10 and 11, respectively). Discrete inputs 1 and 2 have been configured as voltage reduction inputs 1 and 2 by default. The user may modify this configuration; see the **Advanced Control Features: Programmable Input and Output** section of this manual.

If the user supplies dry contacts, the voltage should be obtained from Pin 14 of the discrete I/O port. This whetting voltage is only available when the control switch is in the **Auto/Remote** position. If the user supplies whet contacts, the connections should be as shown in Figure 6-13.

Analog remote/latching mode

This feature is set at FC 70. Up to three independent values of voltage reduction (VR) are possible. Levels 1, 2, and 3 are programmed at FC 73, FC 74, and FC 75, respectively. VR 1 activates the VR programmed at FC 73; VR input 2 activates the VR programmed at FC 74; and latching both contacts activates the VR programmed at FC 75. Each of these function codes may be set from 0.1 to 10.0%.

Analog remote/pulse mode

This feature is set at FC 70. The same contacts are used for this mode as shown in Figures 6-13 and 6-14, but the contacts are pulsed (momentarily closed) rather than latched closed. 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. Starting at zero percent reduction, every time the contact 1 is pulsed, one step of reduction is added to the accumulated total.

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. Pulsing to one step higher than the programmed number returns the reduction to zero. Also, any time VR input 2 is pulsed, the reduction returns to zero.

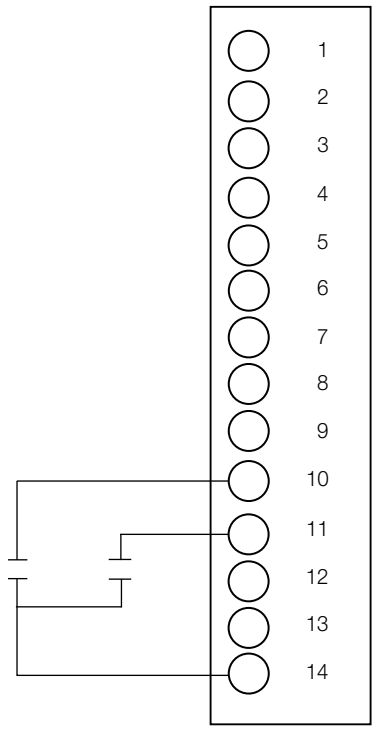


Figure 6-13. Dry contact connections for remote latching and pulse mode.

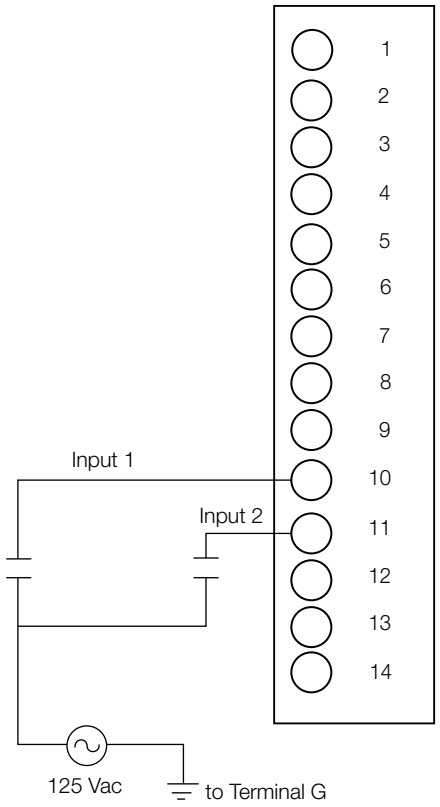


Figure 6-14. Whet contact connections for remote latching and pulse modes.

Tap-to-neutral

When activated, the tap-to-neutral feature will automatically take the voltage regulator to the neutral position and then block automatic operation, until the feature is disengaged. By default, to activate the tap-to-neutral feature, FC 170 is set to "On" and 120 Vac is applied to discrete input 3. The setting at FC 170 enables or disables the tap-to-neutral function. The Programmable Input/Output (PIO) tap-to-neutral turns on or off the feature. By default, a PIO equation has been written so that discrete input 3 activates the PIO tap-to-neutral feature. For additional information on PIO, see **Programmable Input and Output** in the **Advanced Control Features** section of this manual.

Remote motor control and auto inhibit

Note: Terminal board TB_8, located below RCT_1 on the control back panel, is supplied for user-connections for Auto Inhibit (blocking) and Motor Control. See Figure 6-15. When the motor is controlled remotely, it is necessary to inhibit automatic operation. To control Auto Inhibit remotely, remove the jumper between terminals 4 and 5 and supply a nominal 120 Vac to terminal 5. This will inhibit automatic operation.

To remotely raise or lower the tap-changer, the appropriate set of contacts is momentarily closed. If user-provided interposing relays are used, such that raise and lower contact closure cannot occur simultaneously, the operator should make a permanent connection from TB_2-V_9 to TB_8-2.

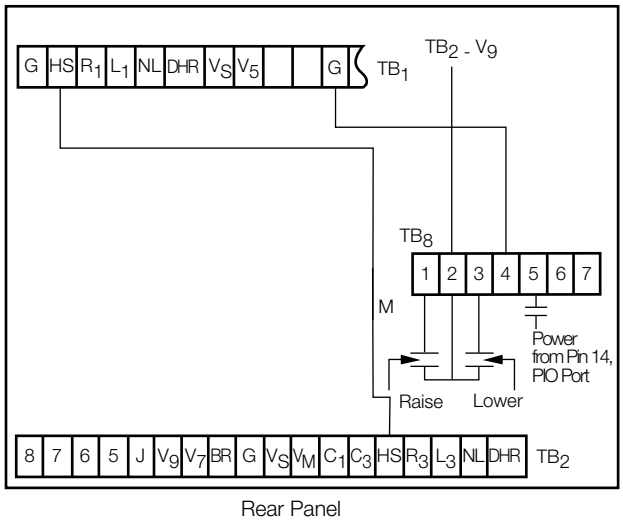


Figure 6-15. Auto inhibit and remote motor control connections.

For units supplied with TB_3 back panel (after October, 2010)

When the motor is controlled remotely, it is necessary to inhibit automatic operation. To control Auto Inhibit remotely, supply a nominal 120 Vac to terminal BR (Blocking Relay) on TB_3. This will inhibit automatic operation.

To remotely raise or lower the tap-changer, the appropriate set of contacts is momentarily closed. A user provided interposing relay is recommended, such that the raise and lower contact closure cannot occur simultaneously. A 120 Vac voltage is required at R1 for raise or L1 for lower. Whetting voltage can be obtained from terminal TB_3-V9.

Alternate configuration

The CL-6 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 (see Communications in the Control Accessories section of this manual for more information on ProView NXG software). The Alternate Configuration mode allows for the CL-6 control to be programmed with an additional set of configuration settings that can then be activated at FC 450. The Alternate Configuration status can be monitored at FC 451 and will display either Active or Inactive.

When the Alternate Configuration mode is activated using FC 450, the 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 are: Forward Direction (FC 1 through FC 5), Reverse Direction (FC 51 through FC 55), Auto-Block Status (FC 69), Reverse Power Mode (FC 56), Voltage Limiter (FC 80 through FC 82), Voltage Reduction (FC 70 and FC 72 through FC 75), Tap-To-Neutral (FC 170) and Soft ADD-AMP (FC 79 and FC 175 through FC 176).

Alternate Configuration settings can be entered using two methods: 1) Activate the Alternate Configuration mode by turning it on at FC 450 and then set the individual settings using each function code. 2) Using ProView NXG software, enter the Alternate Configuration settings in the Alternate Configuration Setting screen 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 "(AltConfig)" at the bottom. 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
    (AltConfig)
```

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

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

Auto-restore local (ARL)

Two additional functions that can be enabled at FC 450 are Auto-Restore Local Heartbeat (ARLH) and Auto-Restore Local Comms (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. When either ARL function is active, FC 451 will display Active.

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

Programmable input/output (P.I.O.)

Alternate Configurations settings can be enabled using P.I.O. In order to enable Alternate configuration settings using P.I.O., the Alternate Configuration setting (FC 450) must be set to P.I.O. Equations must then be created using CCI software which program the conditions under which Alternate Configuration settings will become active. When Alternate Configuration settings are active due to P.I.O. logic, the status at FC 451 will display Active.

For more information on enabling Alternate Configuration settings using P.I.O., contact your Eaton representative.

Transducer connections

Refer to Figure 10-4. 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 V_4 on TB_1 and its ground lead to G on TB_1. A current transducer, 200 mA input, may be connected as follows: Close knife switch C; remove the jumper between C_2 and C_4 on TB_1; connect the transducer hot lead to C_2 and its ground lead to C_4; and open knife switch C.

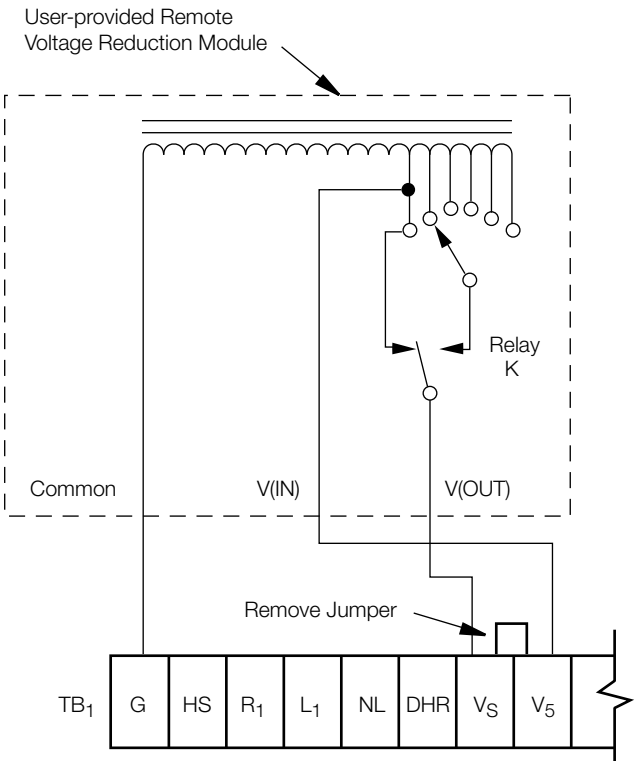


Figure 6-16. Typical user provided "Fooler Voltage" module.

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-6 Series controls. A VR module, as shown in Figure 6-16, 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.

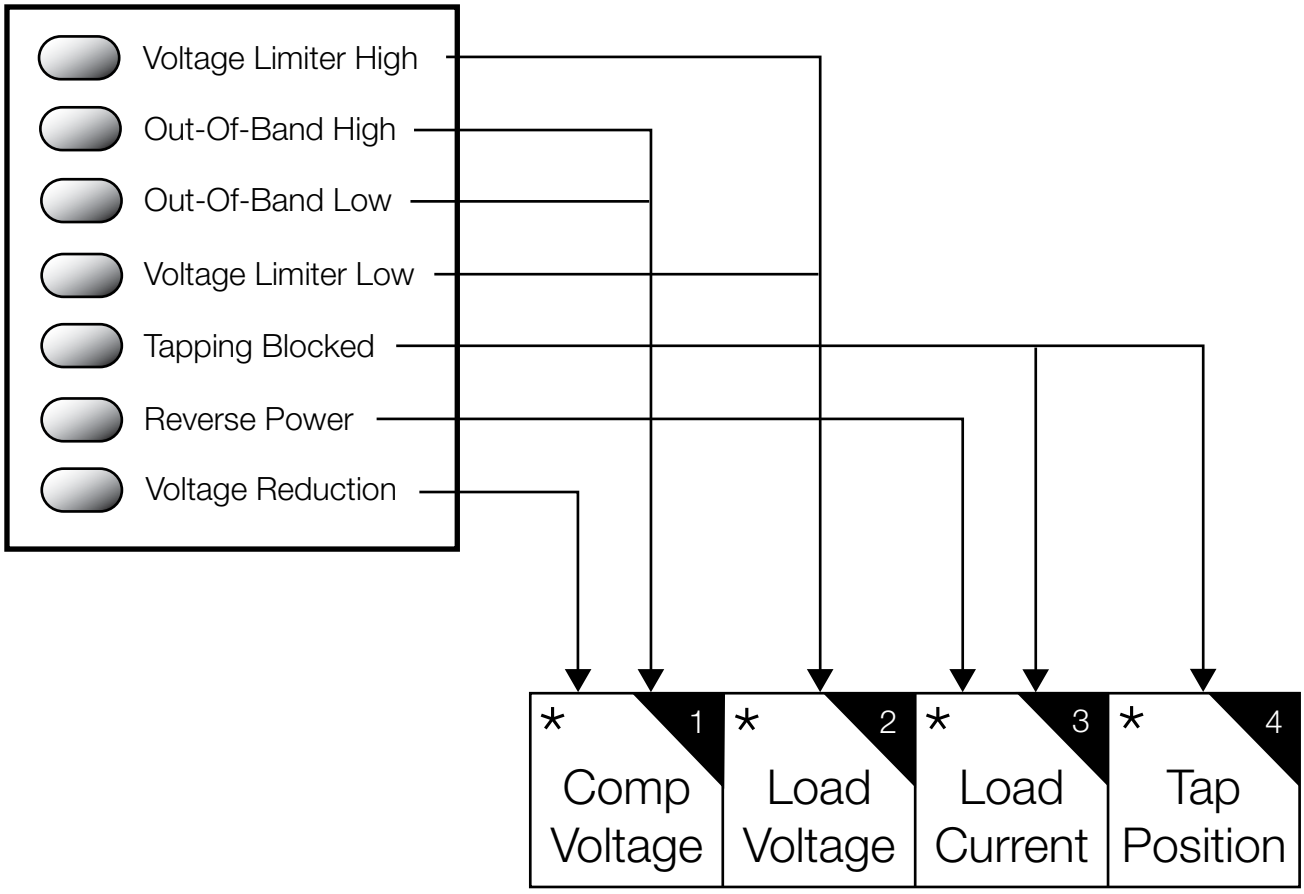


Figure 7-1. Operation analysis using Metering-PLUS feature.

Metering-PLUS feature

The Metering-PLUS feature was designed to allow immediate access to basic control information. On the control keypad, four keys display an asterisk (*), identifying them as Metering-PLUS* keys. These keys access information on compensated voltage, load voltage, load current, and tap position.

Compensated voltage

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

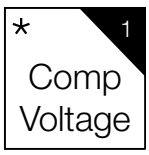
The first line displays a live representation of the compensated voltage. The compensated voltage is available at FC 8.

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.

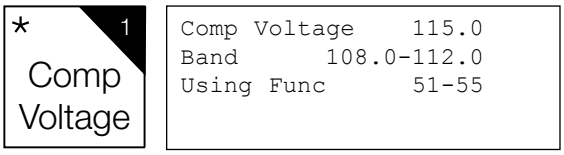
EXAMPLE 1:




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

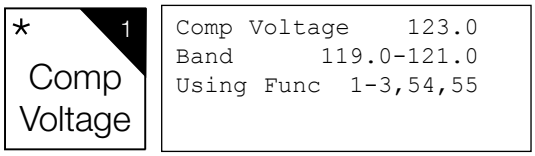
- Compensated Voltage = 125.0 V
- Fwd. Set Voltage = 120.0 V
- Fwd. Bandwidth = 2.0 V
- Control experiencing: Forward Power Flow

EXAMPLE 2:



- Compensated Voltage = 115.0
- Rev. Set Voltage = 110.0 V
- Rev. Bandwidth = 4.0 V
- Control experiencing: Reverse Power Flow

EXAMPLE 3:



- Compensated Voltage = 123.0 V
- Cogeneration Mode
- Fwd. Set Voltage = 120.0 V
- Fwd. Bandwidth = 2.0 V
- Control experiencing: Reverse Power Flow

Note: When operating in the Cogeneration Mode, metering always operates in the *forward* direction **except** that load center voltage is calculated based upon the line-drop compensation settings when the fixed 1% reverse metering threshold is exceeded.

Load voltage

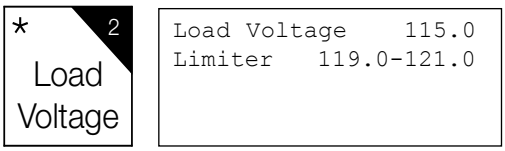
When the ***Load Voltage** key is pressed, the LCD will display the following information:

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

The second line displays the voltage limits to be applied by the Voltage-Limiting feature (see FC 80). If a voltage range is displayed, a high and low limit is enabled. A single value implies that only the high limit is active.

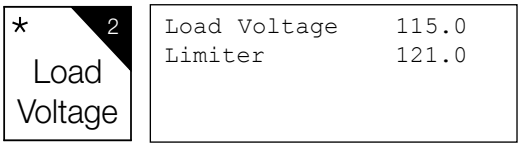
The Voltage Limiter High and Voltage Limiter Low LEDs are used to indicate the voltage limiter is active.

EXAMPLE 1:



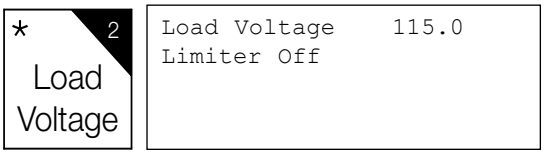
- Load Voltage = 115.0 V
- Voltage-Limiting Mode = High and Low Limits Active
- High Voltage Limit = 121.0 V
- Low Voltage Limit = 119.0 V

EXAMPLE 2:



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

EXAMPLE 3:



- 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 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 point at which the control switches operation, either from forward-to-reverse or reverse-to-forward. The current threshold is the product of the CT Primary Rating, and the Reverse Threshold percentage.

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, Cogeneration, or Reactive Bi-directional

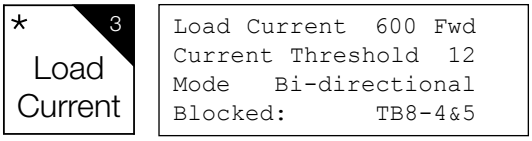
If automatic operation is blocked, the fourth line displays the blocking condition. If multiple blocking conditions exist, the blocking condition with the highest precedence will be displayed. Refer to Table 7-1 for the blocking condition priority levels.

The condition illustrated in Example 1 indicates that automatic operation is inhibited due to an open condition that exists between terminals 4 and 5 of terminal block 8.

TABLE 7-1 Blocking Condition Priority Levels

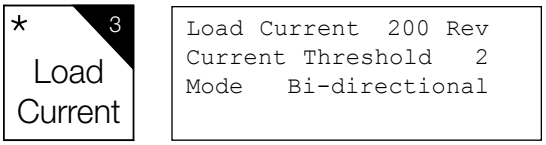
Level (1 = Highest)	Automatic Blocking Condition	LCD display text (line 4)
1	Control Function Switch is in **Off** or **Manual** position.	Blocked:Cntrl Switch
2	Tap-to-Neutral enabled.	Blocked:Tap-To-Neutr
3	Voltage applied to terminal 5, TB 8.	Blocked: TB8-4&5
4	Blocked due to configuration setting found at FC 69.	Blocked:Func Code 69
5	Blocked due to reverse power flow mode.	Blocked:Rev Pwr Mode

EXAMPLE 1:



- Load Current = 600 A
- Forward Power Flow
- Reverse Threshold Current = 12 A
- Bi-directional operating mode
- Voltage applied to Terminal 5, Terminal Block #8. (See Remote Motor Control & Auto Inhibit.)

EXAMPLE 2:



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

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.

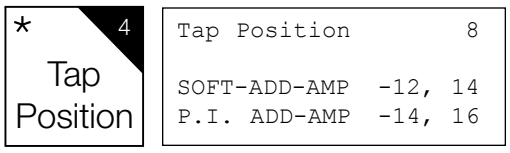
The second line is used to indicate when the tap changer has reached a Soft ADD-AMP limit or a user-configured Position Indicator (P.I.) ADD-AMP limit. In Example 1, the second line is blank because the tap changer is not at an ADD-AMP limit.

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.

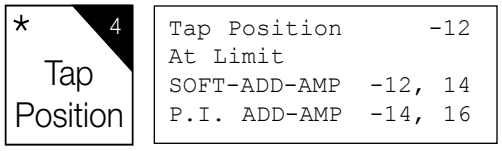
Note: Physical ADD-AMP always takes precedence over soft.

EXAMPLE 1:



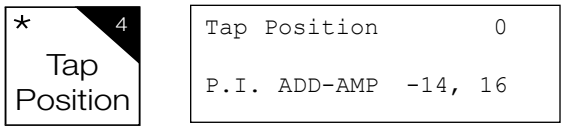
- Present tap position = 8 Raise
- Soft ADD-AMP feature = On
- Soft ADD-AMP feature lower tap limit = -12
- Soft ADD-AMP feature upper tap limit = 14
- User-configured P. I. ADD-AMP lower tap limit = -14
- User-configured P. I. ADD-AMP upper tap limit = 16

EXAMPLE 2:



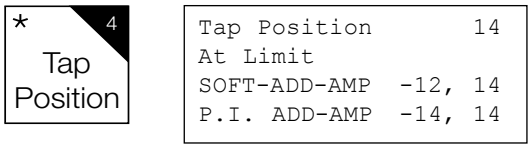
- Present tap position = 12 Lower
- Tap Changer at ADD-AMP Limit
- Soft ADD-AMP feature = On
- Soft ADD-AMP feature lower tap limit = -12
- Soft ADD-AMP feature upper tap limit = 14
- User-configured external lower tap limit = -14
- User-configured external upper tap limit = 16

EXAMPLE 3:



- Present tap position = Neutral
- Soft ADD-AMP feature = Off
- User-configured external lower tap limit = -14
- User-configured external upper tap limit = 16

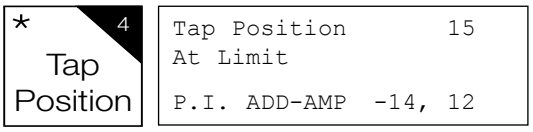
EXAMPLE 4:



- 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
- User-configured external lower tap limit = -14
- User-configured external 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:



- Present tap position = 15
- Tap Changer above ADD-AMP Limit
- Soft ADD-AMP feature = Off
- User-configured external lower tap limit = -14
- User-configured external 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 must be at position 16.

This condition may occur if the user-configured P.I. ADD-AMP limits do not match the physical P.I. ADD-AMP tap position settings. 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.

Compact flash card

The CL-6 series control has a compact flash (CF) card 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 are loaded with a flash card. (Firmware is the software resident in the control that provides processing algorithms and functionality to the hardware. Firmware upgrades are supplied by the factory when revisions are necessary.)

CF cards, readily available at most major electronics retailers, are widely accepted memory devices. The CF card port was designed and tested with a SanDisk® Type I CompactFlash® card. Other manufacturers cards may work, but performance was not evaluated. When the controls save data to the CF card, the files range in size from 20 to 90 KB, depending on what is being saved. While any size CF card may be used, a standard 32 MB CF card is capable of storing hundreds of such files.

The compact flash card replaces the Data Reader. An external flash card reader/writer is necessary to allow for the data to be imported into a computer. Determine the appropriate type of reader/writer, available at most major electronics retailers, for your computer's configuration.

Figure 7-2. Inserting compact flash card into port.

By inserting a CF card into the port, the operator has the ability to easily transfer information to and from the control. Use care when inserting the CF card into the card port; do not attempt to force the card into position. Align the card in the guide, with the connector toward the control; refer to Figure 7-2. When the CF card is properly seated, the **Flash Card Active** LED will blink.

If a CF card is not inserted and one of the CF functions is accessed, an error message will appear on the display.

Flash card functions

Data Writer, FC 350

The Data Writer saves all of the data within the control (metering data, settings, configuration, etc.) in a file with the format "regulator ID-reading #.DAT.

EXAMPLE : 12345-001.DAT

After inserting a CF card, access FC 350. Press **Enter**. The control LCD will display (CONFIRM). Press **Enter** again to confirm. The **Flash Card Active** LED will illuminate, the LCD will display (WRITING...), and the control will write the data to a file on the CF card. Upon completion, the control will display (WRITING COMPLETE). The CF card may be removed after this message is displayed.

If the command is completed with errors, a (WRITING 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 (WRITING ABORTED) message is displayed on the fourth line of the LCD.

Save Standard Configuration, FC 354

The Save Standard Configuration function saves all of the settings and configuration data to a file labeled "STANDARD.CFG".

EXAMPLE: STANDARD.CFG

After inserting a CF card, access FC 354. Press **Enter**. The control LCD will display (CONFIRM). Press **Enter** again to confirm. The **Flash Card Active** LED will illuminate, the LCD will display (SAVING...), and the control will save the configuration data to the CF card. Upon completion, the control will display (SAVING COMPLETE). The CF card may be removed after this message is displayed.

If the command is completed with errors, a (SAVING 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 (SAVING ABORTED) message is displayed on the fourth line of the LCD.

Save Custom Configuration, FC 353

The Save Custom Configuration function saves all of the settings and configuration data to a file with the format "regulator ID-reading #.CFG".

EXAMPLE : 12345-001.CFG

After inserting a CF card, access FC 353. Press **Enter**. The control LCD will display (CONFIRM). Press **Enter** again to confirm. The **Flash Card Active** LED will illuminate, the LCD will display (SAVING...), and the control will save the configuration data to the CF card. Upon completion, the control will display (SAVING COMPLETE). The CF card may be removed after this message is displayed.

If the command is completed with errors, a (SAVING 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 (SAVING ABORTED) message is displayed on the fourth line of the LCD.

Load Standard Configuration, FC 352

The Load Standard Configuration function loads all of the settings and configuration data from the file labeled with the file titled "STANDARD.CFG".

EXAMPLE : STANDARD.CFG

After inserting a CF card, access FC 352. Press **Enter**. The control LCD will display (CONFIRM). Press **Enter** again to confirm. The **Flash Card Active** LED will illuminate, the LCD will display (LOADING...), and the control will load the configuration data from the CF card. Upon completion, the control will display (LOADING COMPLETE). The CF card may be removed after this message is displayed.

If the command is completed with errors, a (LOADING 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 (LOADING ABORTED) message is displayed on the fourth line of the LCD.

Load Custom Configuration, FC 351

The Load Custom Configuration function loads all of the settings and configuration data from the file labeled with the file format "regulator ID-reading #.CFG".

EXAMPLE : 12345-001.CFG

After inserting a CF card, access FC 351. Press **Enter**. The control LCD will display (CONFIRM). Press **Enter** again to confirm. The **Flash Card Active** LED will illuminate, the LCD will display (LOADING...), and the control will load the configuration data from the CF card. Upon completion, the control will display (LOADING COMPLETE). The CF card may be removed after this message is displayed.

If the command is completed with errors, a (LOADING 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 (LOADING ABORTED) message is displayed on the fourth line of the LCD.

Format Compact Flash Card, FC 355

The Format Compact Flash Card function effectively erases all data on a CF card and prepares the card for use in the CL-6 series control. A card that has not been formatted for use on the CL-6 control may not work on the control (i.e., cards used to store digital photos, etc.)

After inserting a CF card, access FC 355. Press **Enter**. The control LCD will display (CONFIRM). Press **Enter** again to confirm. The **Flash Card Active** LED will illuminate, the LCD will display (FORMATTING...), and the control will format the CF card. Upon completion, the control will display (FORMATTING COMPLETE). The CF card may be removed after this message is displayed.

If the command is completed with errors, a (FORMATTING 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 (FORMATTING ABORTED) message is displayed on the fourth line of the LCD.

Other compact flash card functions

There are several other Compact Flash Card Functions available using FC 357 through FC 368. Each of the functions allows for saving or loading subsets of control and communications settings either as standard or custom operations. The load and save functions along with the standard and custom configurations have the same meaning as described for FC 351 through 354.

FC 357 through FC 360 apply to the loading and saving of standard and custom Basic Configuration settings. Basic Configuration settings include all basic voltage regulation settings entered using the control key pad except for communications settings.

FC 361 through FC 364 apply to the loading and saving of standard and custom Advanced Feature Configuration settings. Advanced Feature Configuration settings include settings for Histograms, Alarm and Event Recorders, Profile Data, Programmable I/O and Leader/Follower.

FC 365 through FC 368 apply to loading and saving of standard and custom Communication Configuration settings. Communication configuration settings include all settings involving communications. A list of these settings can be found in Table 5-2 under *Features/ *Communications.

See the list of functions in Table 5-3.

Communications

Communicate with the CL-6 control using ProView NXG software or protocols such as DNP3 or 2179. The ProView NXG software, used with a PC, can provide temporary local connection to the control.

Communication ports

There are three physical communications ports on the CL-6 control.

The communication port Com1 is for use as a temporary local communication connection to the control. Connection is made to Com1 by using a standard 9-pin RS-232 cable to the RS-232 DCE, female, 9-pin connector, located on the front of the control. The port settings are configured at FC 60 through FC 67, FC 266 and FC 267. When using ProView NXG software, modifications are not normally needed to these settings.

The communication port Com2 is for use as a permanent communication connection to the control. Connection is made by using an optional communication accessory card mounted on the back panel within the control enclosure such as the Fiber Optic/RS-232 accessory. The port settings are configured at FC 160 through FC 169, FC 268 and FC 269.

The communication port Com3 is for use as a secondary permanent communication connection to the control. The port shares its data source with the Com1 port and will be inactive if a local connection is made to the Com1 port. Com2 and Com3 may be active simultaneously and can be communicating to two separate master stations. The settings for this port are configured at FC 60 through 67.

There are two logical DNP3 addresses for each port. Normally the port's remote address 2 is used only by the ProView NXG software for configuration. The port's remote address 1 is designed for interfacing with master stations. It is possible to have two separate masters communicating to the device through a single communication port.

Depending upon the communication system into which the control is being implemented, communication timing may need to be modified. The sync time parameter defines a period of time that the control must idle before recognizing the start of a message. The amount of sync time may need to be increased when the control is placed in a loop (ring) configuration with more than three controls; refer to Figures 7-3 and 7-4.

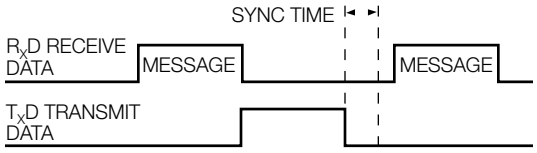


Figure 7-3. Message received at CL-6A control; message is for the CL-6A control.

Protocols

There are two protocols resident in the CL-6 control: 2179 and DNP3. 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.

The 2179 ordinal points map is selected at FC 266 and the DNP3 data dictionary is selected at FC 267. By changing from the default CL-6 control to either the CL-5E or CL-5D control, the control will look just like a CL-5E or CL-5D control to a master station. Therefore, the master does not need to be upgraded unless some of the new functions, not available in the older controls, need to be accessed through remote communications.

A "USER" 2179 ordinal points map setting and a "USER" DNP3 data dictionary setting are also available. These can be configured via remote communications, including ProView NXG software. This allows the user to create a map to match other existing equipment or optimize for their system as needed. DNP3-related parameters, including Class configuration and deadbands, may also be configured through communications.

Programmable input and output

Programmable Input and Output (Programmable I/O or PIO) 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. PIO can be configured via digital communications software, including ProView NXG software. PIO configuration is available via 2179 or DNP3 digital communications protocols.

To configure PIO, the user first selects the output to be performed. Then the logical form of the equation is chosen. Standard AND, OR logical operators may be used in the equation. A more advanced user may also choose to add If-Then, If-Else, If-Else-If, and Timer-based conditional forms within the programmable I/O feature. Lastly, the inputs to the equation are chosen. A total of eighteen different logical inputs may be included in one expression. The inputs or outputs of the expression may be logically inverted.

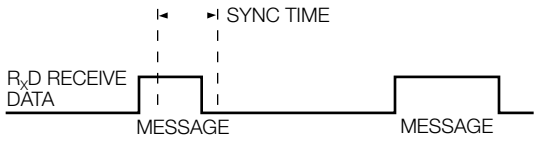


Figure 7-4. Message received at CL-6 control; message is not for the CL-6 control.

Inputs and outputs

Outputs

PORT CONTROL

Discrete Outputs (General Purpose Output 1-4)

User-Defined LED

Tap-changer control (Raise, Lower, Tap-to-Neutral)

Voltage Reduction Input 1 and 2

PMT Mode B Slave Input

Enable Histograms, Profiler, Events, or Alarms

User Forms 1-20

User Intermediate Equations 1-4

LoopShare Enabled

Leader/Follower Enabled

Soft ADD-AMP

AltConfig

Inputs

MODULE STATUS (CONTROL-PROCESSOR PERCEIVED STATES)

Active Alarms

Status Indicators (Tapping Blocked, Reverse Power, etc.)

Control Function Status

Tap At Neutral

No Input Volt Detected

No Output Volt Detected

PMT Status

System Errors

MODULE CONTROL (STATES DECIDED UPON BY THE CONTROL CPU)

Features Enabled (Events, Alarms, Histograms, Profiler)

Supervisory Active

Tap-To-Neutral Input Active

Analog Voltage Reduction 1 Input Active

Analog Voltage Reduction 2 Input Active

PMT Mode B Slave Input Active

Loop Share Enable

Leader Follower Enable

Loop Share Active

Port 1 Tagged

Port 2 Tagged

Port 3 Tagged

PORT STATUS

Port 1 (Physical Input states)

- Drag Hand Reset On
- Neutral Position
- Blocking Relay
- Discrete Inputs (General Purpose Inputs 1-4)
- Tap Raise Switch Active
- Tap Lower Switch Active
- Supervisory Switch On
- Power Switch is Internal
- Power Switch is External
- Control Function Switch Status (Auto, Manual, Off)
- Port 1 PMT Mode B Master Output

Port 2 (Command from communications port 2)

- Tap Raise
- Tap Lower
- Tap-To-Neutral
- Features Enabled (Events, Alarms, Histograms, Profiler, Loop Share, Leader Follower)
- Digital Communications User Inputs (00 to 32)

Port 3 (Command from communications port 1 or 3)

- Tap Raise
- Tap Lower

STATUS ALARMS

All available Status Alarms

DATA ALARMS

All available Data Alarms

PORT CONTROL

Discrete Outputs (General Purpose Output 1-4)

User-Defined LED

Tap-changer control (Raise, Lower, Tap-to-Neutral)

Voltage Reduction Input 1 and 2

PMT Mode B Slave Input

Features Enabled (Histograms, Profiler, Events, Alarms, Loop Share, Leader Follower, Soft ADD-AMP, AltConfig)

User Forms 1-20

User Intermediate Equations 1-4

Discrete inputs and outputs (auxiliary I/O)

The CL-6 control provides the user with four discrete inputs and four discrete outputs (Form C contacts); see Figures 7-6 and 7-7. The user can program the CL-6 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-6 control to toggle the discrete output states based on internal control logic.

Note: If the CL-6 control is being applied in a CRA application, the user may configure discrete inputs #1 through #3. The fourth discrete input must be reserved for use by the control.

EXAMPLE :

A utility noticed that the control function switch and supervisory switch were being left in the incorrect positions for their normal operation. The utility chose the User-Defined LED to be the output of a PIO equation. They used a standard equation with the logical OR operator. Lastly, they chose inputs as the Supervisory Switch On (Inverted) and the Control Status Switch Auto/Remote (Inverted). Refer to Figure 7-5.

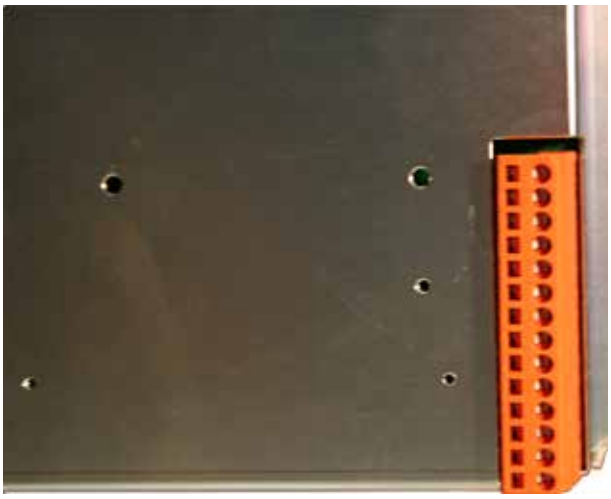


Figure 7-6. Discrete input and output connector.

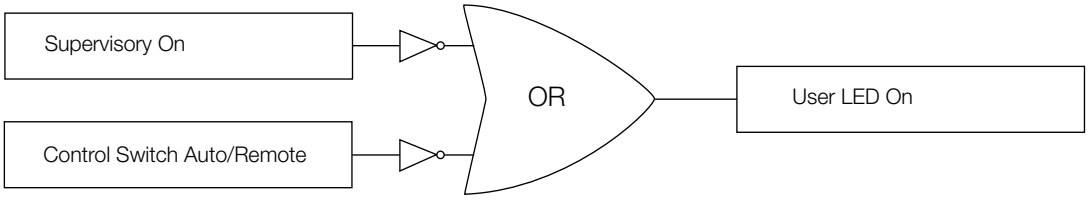


Figure 7-5. Logic diagram for the I/O example.

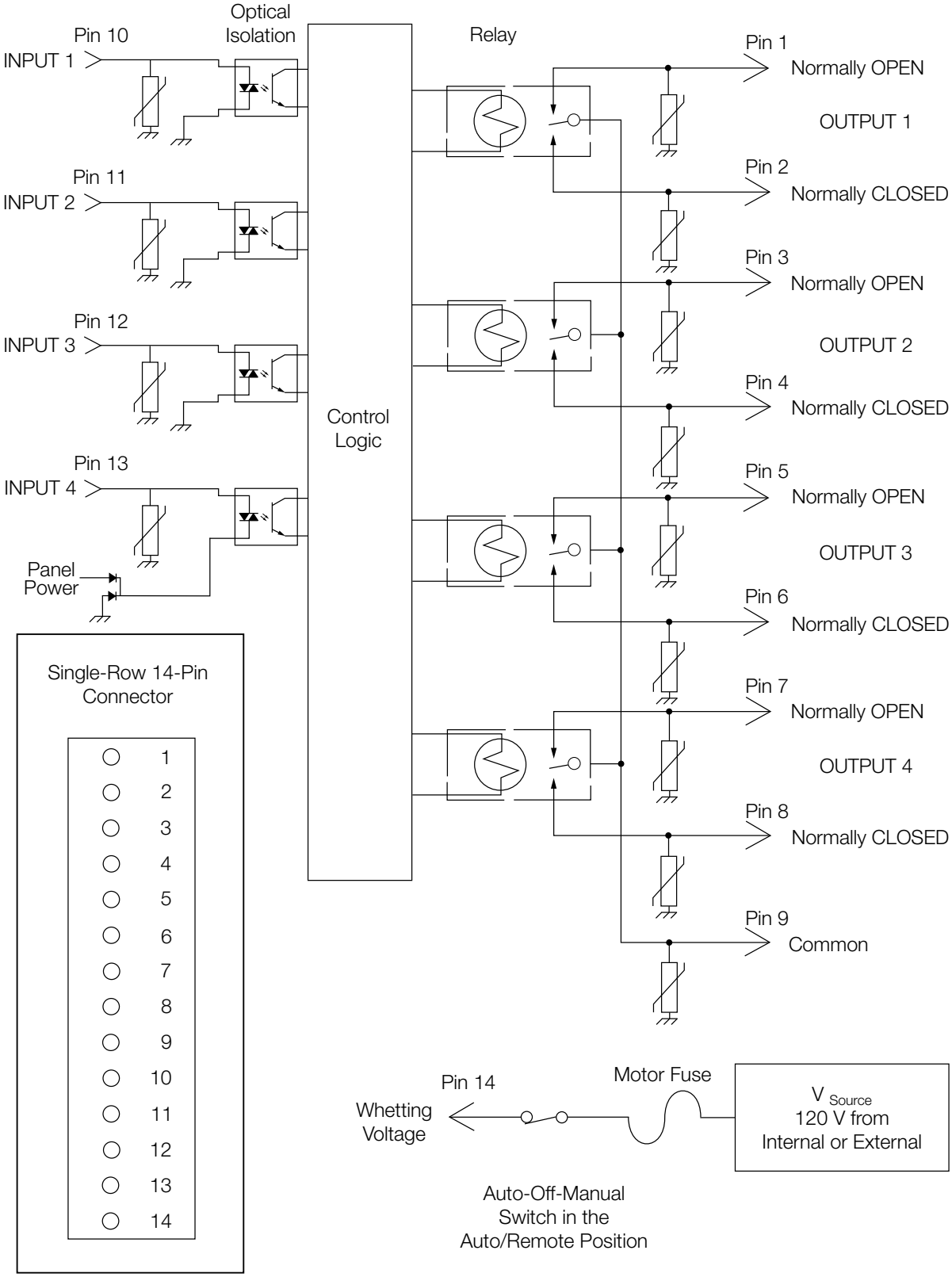


Figure 7-7. Discrete I/O connections.

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 display or through communications, including the ProView NXG software. Alarms can only be configured via communications.

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 display or through communications when 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 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 user enters Alarms > Alarms Active Unacknowledged via the menu, displays the alarm, and presses the **Enter** key twice. If the alarm is configured to illuminate an LED and has been acknowledged, the light will be on continuously. The alarm will turn off whenever the alarm configuration 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. The following is a list of some of the available parameters for the Status Alarms:

Supervisory Active

Reverse Power Flow

No Input Voltage Detected

No Output Voltage Detected

Tap at Neutral

Voltage Limit On

Reg Blocked Annunciator

Voltage Reduc On Annunciator

Power Up Self Test Error

LF Ldr Unable to Operate

Motor Trouble

Alternate Configuration Active

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. The following is a list of some of the available Data Alarms:

Secondary Load Voltage High

Secondary Load Voltage Low

Secondary Source Voltage High

Secondary Source Voltage Low

Compensated Voltage High

Compensated Voltage Low

Primary Load Voltage High

Primary Load Voltage Low

Primary Source Voltage High

Primary Source Voltage Low

Buck / Boost Voltage High

Buck / Boost Voltage Low

Load Current High

Load Current Low

Power Factor Low

Tap Position High

Tap Position Low

Total Operations Counter High

Last 24 Hours Operations Count High

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.

Events

An Event is a time-stamped record of an Alarm condition. The last fifty Events can be viewed via the display using the nested menu item _Events under *Alarms/Events. The last 300+ Events can be viewed via communications. Events are stored in non-volatile memory.

Profiling

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 and configured via communications. The user can choose to profile as many of the instantaneous and demand (present) parameters as desired. The user can set the sampling interval from 1 minute to 1 day. The greater the number of parameters chosen and the faster the sampling interval, the less overall time will pass before the record begins to be overwritten.

EXAMPLE:

Choosing 10 parameters sampling every 10 minutes will provide over 4,460 samples or over 30 days before data begins to be overwritten. While choosing 40 parameters sampling every 5 minutes, the Data Profiler will only provide over 1550 samples or over 5 days before data begins to be overwritten.

Another consideration when configuring the profiler is that sampling unneeded parameters or unnecessarily often may lessen the life of the non-volatile memory in the control. The non-volatile memory life when sampling 10 parameters every 10 minutes, under normal conditions, the would be more than100 years.

Histograms

Histograms offer the user a quick visual method to understand the operation of the voltage regulator. The histogram data and configuration can only be accessed via communications. The histogram data is intended to be viewed in bar graph form. Data is available for Percent Regulation and the following Forward and Reverse demand parameters:

- Primary Load Current
- Secondary Load Voltage
- Secondary Source Voltage
- Secondary Compensated Voltage
- Load kVA
- Load kW
- Load kvar

The histogram is also configured via communications. The user sets a low and high limit for each parameter, creating a range of acceptable values. The control divides this range into 10 equal bins plus one Over and one Under bin for a total of twelve bins; see Figure 7-8.

EXAMPLE:

The user chooses a low limit of 118 V and a high limit of 122 V for the Compensated Voltage parameter. The control creates bins as shown in Figure 7-8.

The control then samples each of these parameters once per minute and increments the appropriate bin. The maximum and minimum value of the sampled parameter is also stored with the histogram data (note that these values may not be the same as the high and low value in the demand metering section due to the sampling used).

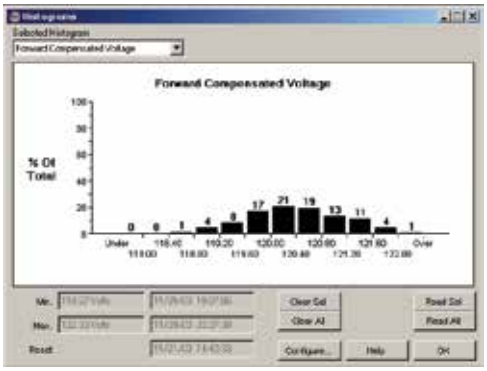


Figure 7-9. Sample histogram.

After a period of time has passed, the histogram for this example displays, using ProView NXG software to view, as shown in Figure 7-9. The sample Histogram suggests that the compensated voltage is varying greatly. The source of this variation should be investigated. Possible causes include an unstable system supply voltage, improper control settings, or a greatly varying load.

TIME-ON-TAP feature

The TIME-ON-TAP™ feature logs the amount of time spent on each tap-changer position. The TIME-ON-TAP data is accessed via the ProView NXG software and is viewed in bar graph format; see Figure 7-10.

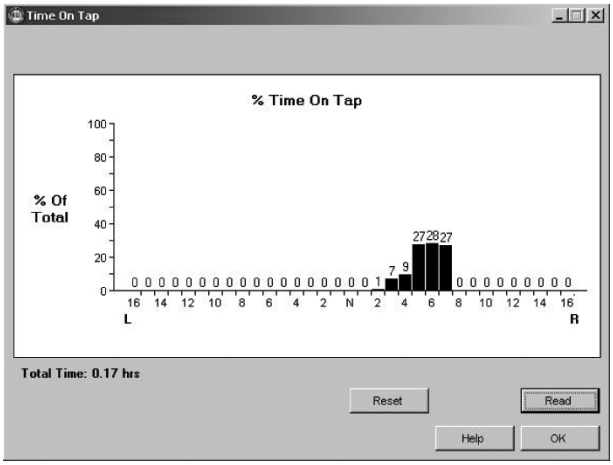


Figure 7-10. Sample TIME-ON-TAP bar graph.

Under	118.0 to	118.4 to	118.8 to	119.2 to	119.6 to	120.0 to	120.4 to	120.8 to	121.2 to	121.6 to	Over
118.0	118.4	118.8	119.2	119.6	120.0	120.4	121.8	121.2	121.6	122.2	122.0

Figure 7-8. Histogram sampling-bins example.

Preventive maintenance tapping

Preventive Maintenance Tapping (PMT™) will automatically operate the tap-changer based upon user-configured parameters. Under certain operating conditions and 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 stays 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, 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 to that maintenance may be scheduled. The suggested setting is 75%. The second Data Alarm is intended to be set at a higher level, suggested setting of 90%, to notify the user that a service outage due to contact failure may be imminent. For more information on Alarms, see **Alarms** in this section of the manual.

A detailed percentage of life-used for each arcing contact is available 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 regulators from Eaton with Quik-Drive tap-changes.

Leader/follower scheme

The Leader/Follower scheme is an electronic scheme designed to keep two or three individual single-phase step voltage regulators on the same mechanical tap position. This is primarily used by utilities and others needing three-phase voltage regulation at the expense of a balanced load voltage center with unbalanced loading. A fiber optic intelligent loop scheme is used between controls providing the communications necessary between phases to initialize a tap change and provide positive feedback in maintaining those equal tap positions. 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 as well as with ProView NXG software.

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, see *Service Information MN225023EN Leader/Follower scheme Installation and Operation Guide*.

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.

When using the CL-6 control with an Eaton regulator, refer to *Service Information 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 source bushing and that the source-load lead is connected to the source-load 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 Appendix, Figures 10-1 through 10-4, 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*.

Control panel troubleshooting

No power

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.

If the fuse has blown, the tap-changer motor will not run. If the 6 A fuse is okay, set the front panel POWER switch to **Internal Power** and check the following :

1. With a voltmeter, check **TB_2-V_S** to **G**. The voltage should approximate the set voltage. If the voltage is present at **TB_2-V_S**, then the problem is in the control. Replace the control.
2. Check the voltage-disconnect knife switch **V_1**, **V_6** (if present), and the current shorting knife switch **C** of the back panel in the control enclosure. Close the **V_1** and **V_6** voltage switches if open. Open the CT shorting switch if closed.
3. Check the voltage at **V_1** to **G**. If the voltage is present at **V_1** to **G**, 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 **RCT_1** 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-diagnostics

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

The duration of this test sequence is approximately three 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 **PASS** message will remain in the display until the operator makes an entry through the keypad or, after 20 minutes, the display will automatically be turned off.

The clock will maintain time-keeping for at least 24 hours after loss of ac power to control. The backup power source requires 65 hours operation on ac power to become fully charged.

Note: After the self-diagnostic and the LCD displays **PASS**, press **Escape** for further keypad use.

Note: The word **ERROR** on the LCD indicates a key entry error, not a diagnostic failure. See **Indication Messages** in the **Control Programming** section of this manual.

Diagnostic error messages

If the control indicates a failure on power up, the LCD displays an error message. This message will give information about the problem detected. Also, as long as there is a diagnostic error message, the Diagnostic Error LED indicator will be lit. Messages may include **No Neutral Sync Signal**, **Input Voltage Missing**, and **Configuration Value Required.** For more information, refer to **Power-Up/Reset Conditions** in the **Control Programming** section of this manual.

No neutral sync signal

CONTROL NOT INSTALLED ON REGULATOR

This most often occurs when powering up a control on a workbench. The **No Neutral Sync Signal** means the control did not have a neutral signal during the self-test during power 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. **Escape**.
2. **Function**, *99*, **Enter**, *32123* (default), **Enter**.
3. **Function**, *12*, **Enter**.
4. **Edit/Reset**, (*some number from one to 16*), **Enter**.
5. Initiate a self-test.

   Function, *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 at **TB_1-NL** to **G**. If the regulator is in neutral, there should be 120 V at the input. When there is not 120 V at **TB_1-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 **TB_1-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:

- **TB_2-NL**, located on the bottom terminal board on the control assembly back panel:

  If there in no voltage and there is voltage at **TB_1-NL**, the problem is in the connections in the wiring harness on the back panel. If there is voltage on **TB_2-NL** and no neutral light, the problem is in the control panel.

- **TB_1-NL**, 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.

No input voltage

The **(No Input Voltage)** 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 or a calculated value. The voltage calculation is enabled when FC 39, Source Voltage Calculation, is set to **On**, the regulator type is properly set at FC 140, and the tap position is know.

When this message is indicated and the regulator has a differential transformer, check for a voltage at **V_6** to **G**, if **V_6** 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 transformer.

If there is not a differential transformer on the regulator, turn FC 39 to **On** to verify this indicator. This will supply the calculated voltage signal, causing the input voltage diagnostic error message to turn off.

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, Security Code:

  Function, *99*, **Enter**, *Security Code*, **Enter**.

  Proceed with function code value and setting changes.

- **(Value Too Low)** means the function value entered is below the acceptable limit.
- **(Value Too High)** means the function value entered is above the acceptable limit.

For more information, refer to **Indication Messages** in the **Control Programming** section of this manual.

Tap-changer operation troubleshooting

The regulator will not operate manually or automatically

1. Connect a voltmeter between **TB_1-R_1** and **TB_1-G**. Set the CONTROL FUNCTION switch on **Manual.**
2. Toggle the **Raise** switch and measure the voltage between terminals **R_1** and **G** on terminal board **TB_1**. The voltage reading should approximate the set voltage setting.
3. Place the voltmeter hot lead on **TB_1-L_1**, then toggle the **Lower** switch.
4. Measure the voltage between terminals **L_1** and **G** on terminal board **TB_1**. 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 of *Service Information 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 (**R_3** to **G** and **L_3** to **G**) on lower terminal board **TB_2**.
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 between **TB_1** and **TB_2**.
8. If Steps 2, 4, and 6 do not provide voltage readings, measure the voltage between **VM** and **G** on terminal board **TB_2**. The reading should approximate the set voltage value.
9. If Step 8 does not yield a voltage measurement, check the voltage between **PD_1-1** (V1) and ground (G) at the voltage disconnect knife switch.
10. If Step 8 does not yield a voltage measurement, check the voltage between **PD_1-1** (V1) and ground (G) at the voltage disconnect knife switch.

    A. If the set voltage value is approximately obtained, the **V_1** disconnect or the ratio-correcting transformer (**RCT_1**) 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 *Service Information 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 *Service Information S225-12-1 QD3 Quik-Drive Voltage Regulator Tap-Changer Manual* and *Service Information S225-10-19 Voltage Regulator Quik-Drive T875 Tap-Changer Switch; Operating, Maintenance, Troubleshooting and Parts Replacement Instructions* for troubleshooting methods.

Motor capacitor problem

A problem in the motor capacitor can prevent a regulator from operating manually or automatically. To check the motor capacitor, use the following steps:

1. Connect a voltmeter from **TB_1-R_1** to **G**.
2. With the control powered up, place the **Auto/ Remote/Manual** switch on **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 to **TB_1-R_1** to **G**, give a lower signal.
6. The voltmeter should read a capacitive voltage. This voltage could be somewhere between 60 and 90 Vac.
7. A voltage reading on **TB_1-R_1** to **G** of 0 V or a mV reading is a sign of a bad capacitor.
8. To double check, place the voltmeter lead on **TB_1-L_1** to **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 **TB_1-L_1** to **G**, give a **Raise** signal.
12. The voltmeter should read a capacitive voltage. This voltage could be somewhere between 60 and 90 Vac.
13. A voltage reading on **TB_1-L_1** to **G** of 0 V, or a mV reading, 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.

Operation counter does not indicate tap change

If the operation counter does not indicate tap changes, check the following:

1. The voltage signal at **TB_2-R_3** and **L_3** 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 **TB_2-R_3** or **L_3** 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 **TB_2-R_3** or **L_3**, the problem could be in the back panel wiring harness connections at **TB_1-R_1** or **L_1**, the control cable, junction box connections, or the holding switch on the tap changer.
4. Check the voltage signal at **TB_1-R_1** or **L_1**. If the signal is not present at these points; 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 FC 49, Tap-Changer Type against the nameplate on the regulator. The nameplate indicates what type of tap-changer is on the regulator. FC 49 must be set for the type of tap-changer (Spring Drive, Direct Drive, QD8, QD5, QD3).

If the control is on a competitors regulator, FC 49 should be set for the manufacturers name.

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.

The regulator operates manually but operates incorrectly when set on automatic

Run the regulator to the neutral position with the control switch. Check for voltage between **V_4** and **G** on **TB_1**. This is the sensing circuit supplying voltage from the output of **RCT_1** 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** indicators 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 **Norma**l. Retry the automatic mode of operation.
3. Measure the voltage from **V_S** to **G** on lower terminal board **TB_2**.
   A. A measurement of approximately the set voltage value at **V_S** to **G** indicates that the problem is in the control.
   B. If there is no voltage present at **V_S** to **G**, the trouble is in the **V_1** disconnect or the ratio-correcting transformer of the back-panel circuit. Replace them.
4. Check the hold switch circuit.
   A. Verify that the tap changer will complete a tap change by placing the CONTROL FUNCTION switch to **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 hold 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 **TB_2-HS** and **G** and **TB_1-HS** and **G**. If voltage is present at **TB_1-HS** and not on **TB_2-HS**, the problem is in the back panel wiring harness. Replace the orange **HS** lead from **TB_1-HS** to **TB_2-HS**. If no voltage is present at **TB_1-HS**, the problem is in the control cable, junction box cover, or the hold switch (located inside the regulator) itself. Check cable continuity up to the junction box. If it appears normal, the problem is the hold switch. Adjust or replace it (see *Service Information S225-12-1 QD3 Quik-Drive Voltage Regulator Tap-Changer Manual* and *Service Information S225-10-19 Voltage Regulator Quik-Drive T875 Tap-Changer Switch; Operating, Maintenance, Troubleshooting, and Parts Replacement 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 Auto/Remote/Manual switch. The switch should be on **Auto/Remote**.
2. Verify that FC 69 is set to **Normal**. To check the FC 69 setting:

   Function, *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. **Function**, *99*, **Enter** *32123* (default), **Enter.**
   B. **Function**,*69*, **Enter.**
   C. **Edit/Reset**, 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:

   Function, *170*, **Enter.**
2. 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. **Function**, *99*, **Enter** *12121* (default), **Enter.**
   B. **Function**,*170*, **Enter.**
   C. **Edit/Reset**, Scroll to **Off**, **Enter**.

Testing with the voltage limiter ON and a limit value set

CAUTION

Equipment Damage. Be mindful of polarity when using an external source. Polarity reversal will result in control damage.

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.

Regulator will not tap beyond a certain tap position

If the regulator will not tap beyond a certain tap position and the position indicator limit switches setting are at 16 raise and 16 lower, check the Soft ADD-AMP settings: FC 175, Soft ADD-AMP High Limit, and FC 176, Soft ADD-AMP Low Limit.

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.

CAUTION

Equipment Damage. Be mindful of polarity when using an external source. Polarity reversal will result in control damage.

All controls are factory-calibrated and should not need to be recalibrated by user. However, calibration can be performed for both the voltage and current circuits as follows:

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.

   Function, *99*, **Enter**; *32123* (default), **Enter**.
6. Access FC 47, Voltage Calibration.

   Function, *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, 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.

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 C_1 and C_3 on fanning strip TB_2 (C_1 is identified by a red wire, and C_3 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**.
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.

   Function, 99, **Enter**, 32123 (default), **Enter**

   The proper level is now activated.
7. Access FC 48, Current Calibration.

   Function, *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: Control accessories

The CL-6 voltage regulator control has several accessory features available. Accessories available include communications software and hardware, a heater assembly, and a PC-to-dataport cable.

Communications

Software

ProView NXG software

Eaton's Cooper Power series ProView NXG software was developed as an advanced package to configure, program, and acquire data from CL-6 series voltage regulator controls. ProView NXG allows the user to:

- Create control settings
- Upload control settings
- Download control settings
- Provide output of settings and readings
- Manage settings and readings effectively

ProView NXG software is fully compatible with the Microsoft® Windows® 95 or later operating system, with Microsoft® Windows NT® Workstation Version 4.0 or later operating system, and the Microsoft® Windows® XP operating system. Both readings and settings are stored as convenient Microsoft® Excel (.XLS) format files to allow use of the data by other applications without awkward conversions.

ProView NXG software is a user-friendly, graphically oriented program that is easy to use and understand. On-line help and a complete user manual help make the program one of the most comprehensive in the industry. The software is designed for configuration of the regulator control using Data 2179 and DNP3 protocols.

Hardware

Fiber-optic with RS-232 interface board

In this configuration, a pair of standard ST type fiber-optic connectors and an RS-232 port are mounted on the interface board to provide the customer connection to digital SCADA via multi-mode fiber-optic cables or a standard 9-pin DB-9 RS-232 cable. Communication settings are easily changed with the use of DIP switches or through the ProView NXG software package. The fiber-optic connections are used for fiber looping (fiber loop or fiber star) with other controllers. The RS-232 interface provides for primary external communication with the control. In the event where multiple controls are being interconnected, only one device requires connection to the RS-232 port, while the remaining devices communicate through the fiber-optic connections. See Figure 9-1 for sample connection diagrams.

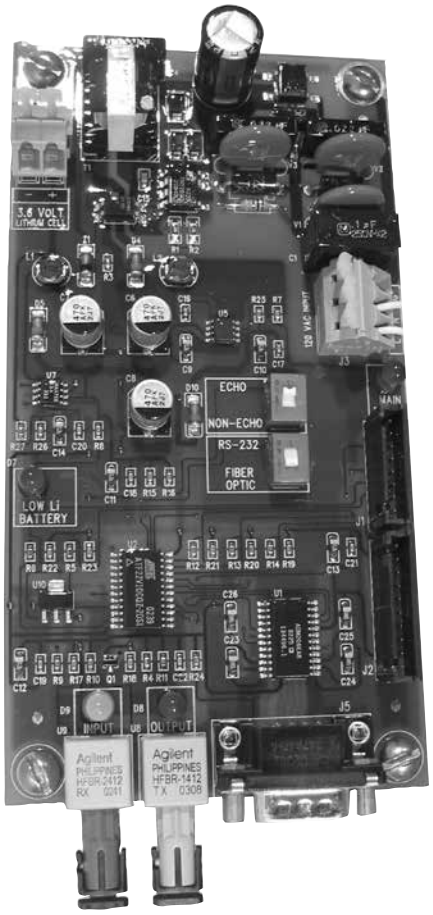


Figure 9-1. Fiber-optic with RS-232 Interface Board.

Ethernet interface board

In this configuration, an RJ-45 and ST fiber connectors are mounted to the interface board. These provide the customer with digital SCADA via standard cat 5 cable or multimode fiber.

RS-485 Interface Board

In this configuration, RS-485 twisted pair terminals are mounted on the interface board to provide the customer connection to digital SCADA via a twisted pair RS-485 connection.

Heater assembly

A thermostatically controlled heater assembly is available for use in high-humidity areas. The thermostat in the heater assembly will turn the heater on when the temperature falls below 85 °F (29 °C) and off when the temperature exceeds 100 °F (38 °C). For full details refer to *Service Information S225-10-12 VR-32 Regulator Control Heater Part No. 9000: Installation and Parts Replacement Instructions*.

Section 10: Appendix

TABLE 10-1

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

TABLE 10-2

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 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 10-3. 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
	517	150	165	180	203	240
	690	200	220	240	270	320

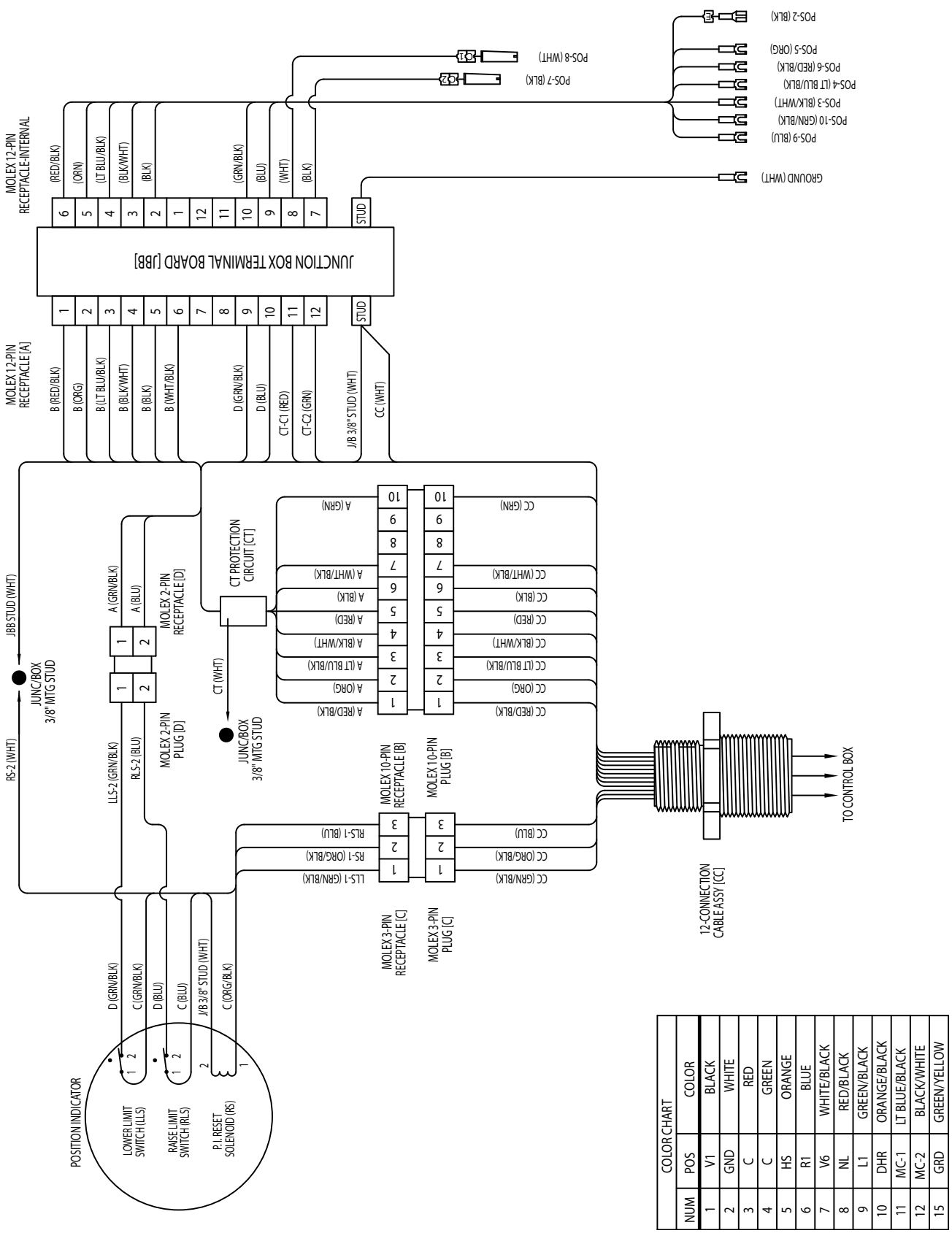
†55/65 °C rise rating on VR-32 regulators gives an additional 12% increase in capacity if the tap-changer's maximum current rating has not been exceeded. For loading in excess of the above values, please refer to your Eaton representative.

** Regulators are capable of carrying current corresponding to rated kVA when operated at 7200 V.*

TABLE 10-4. 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.



COLOR CHART		
NUM	POS	COLOR
1	V1	BLACK
2	GND	WHITE
3	C	RED
4	C	GREEN
5	HS	ORANGE
6	R1	BLUE
7	V6	WHITE/BLACK
8	NL	RED/BLACK
9	L1	GREEN/BLACK
10	DHR	ORANGE/BLACK
11	MC-1	LT BLUE/BLACK
12	MC-2	BLACK/WHITE
15	GRD	GREEN/YELLOW

Figure 10-1. Junction box wiring diagram.

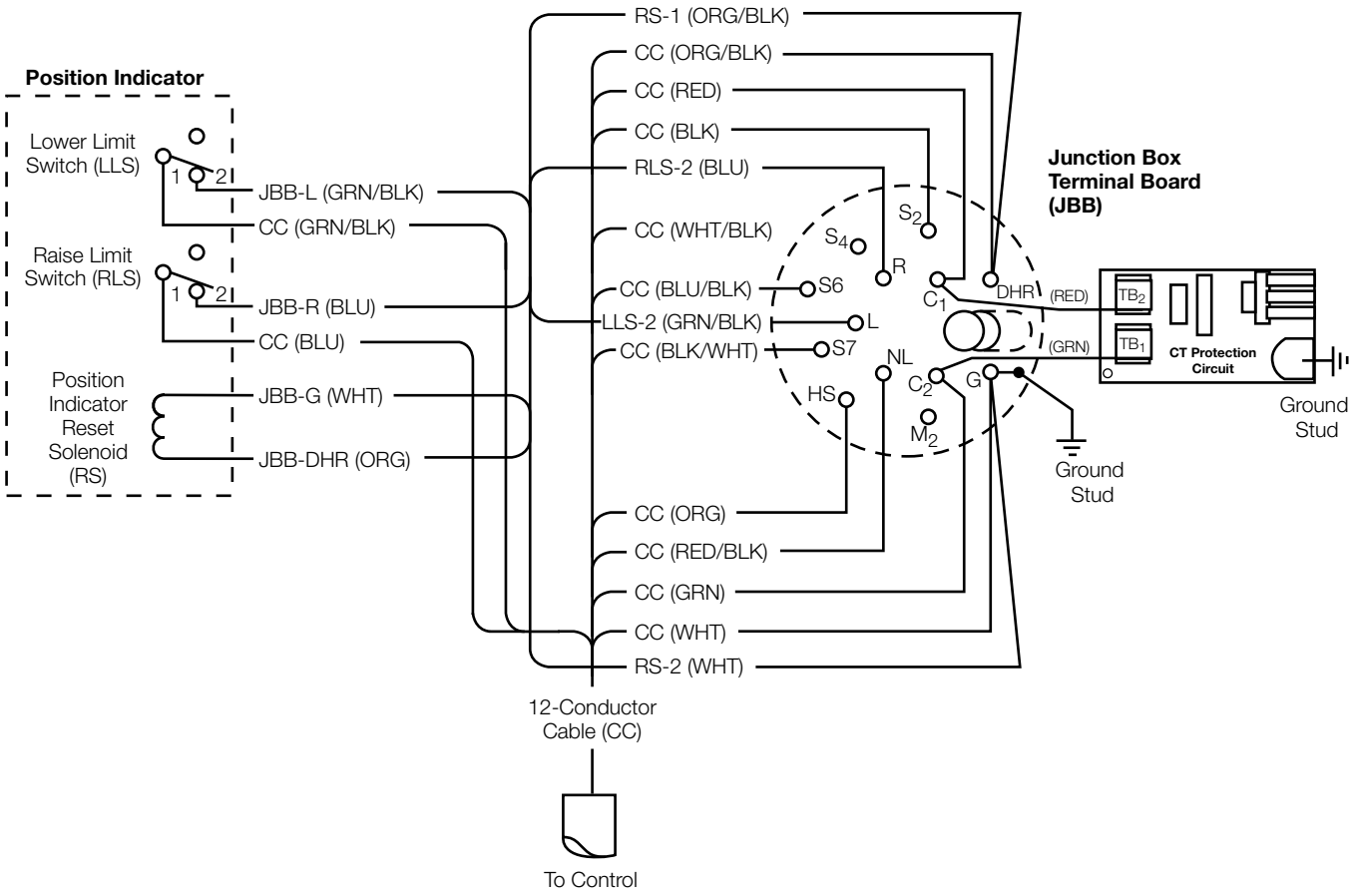


Figure 10-2. Legacy junction box wiring diagram.

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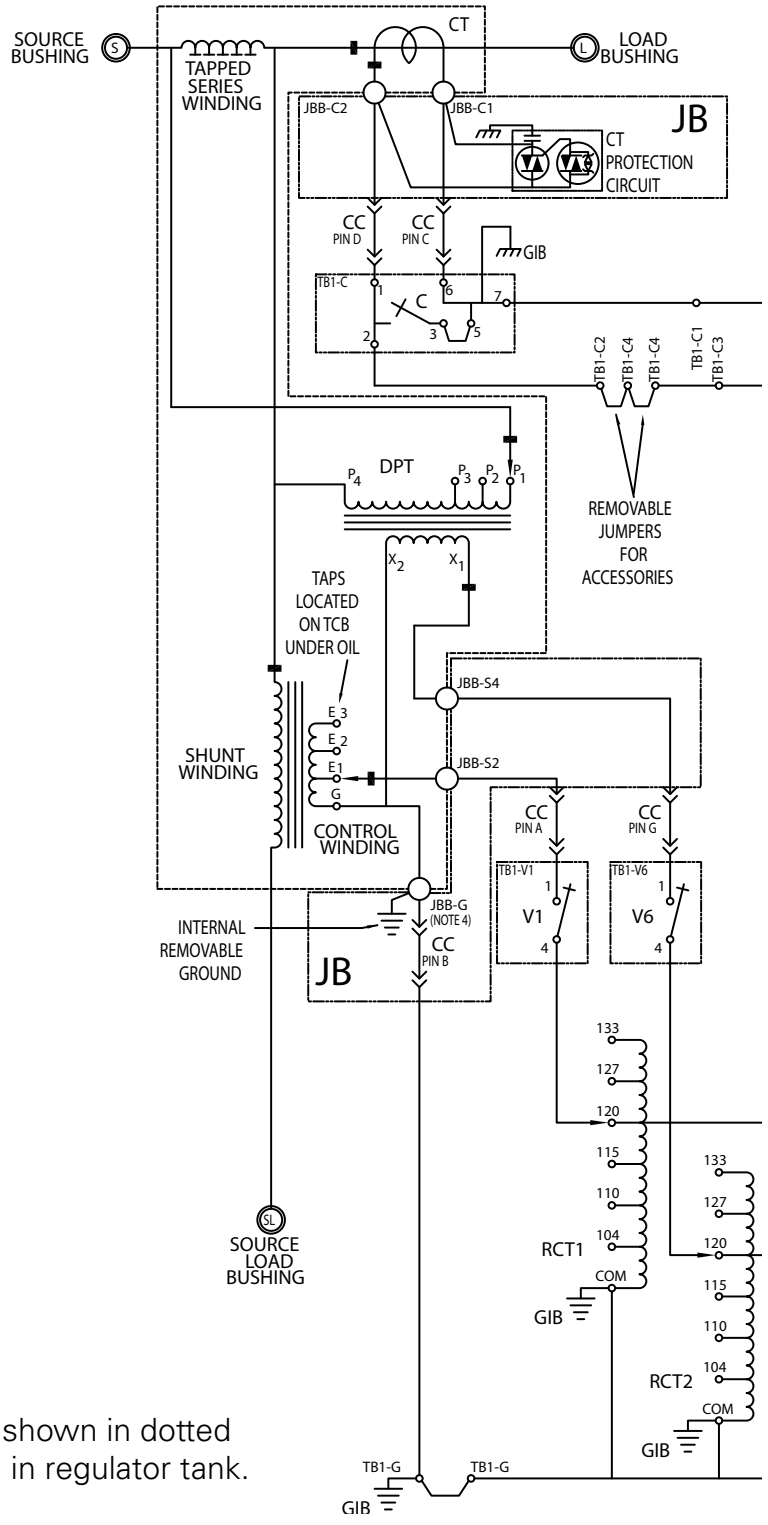
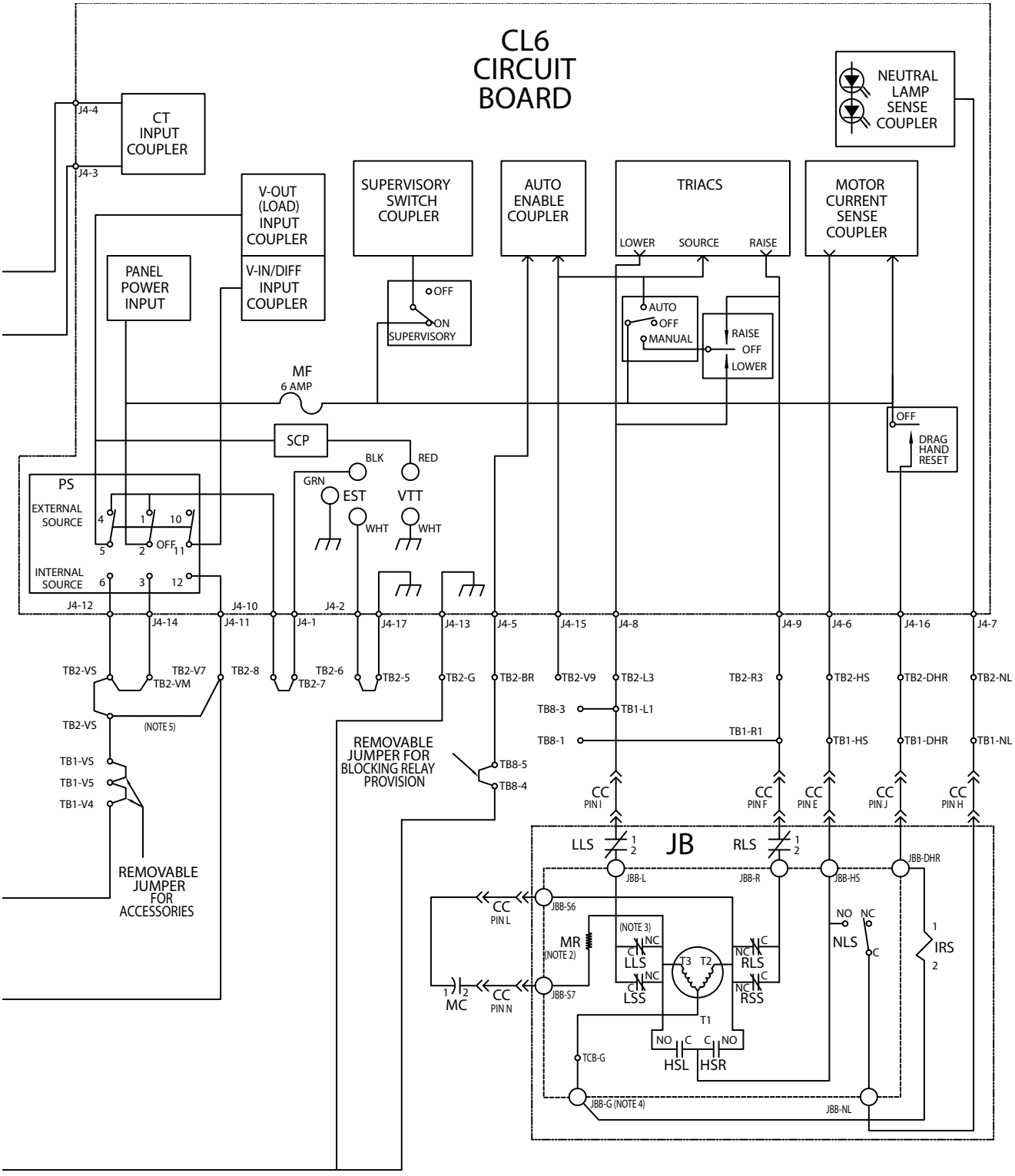
C	CT Shorting Switch
CC	Control Cable
CT	Current transformer (Toroidal Coil)
DPT	Differential Potential Transformer
DHR	Drag-Hand Reset
EST	External Source Terminals
GIB	Ground Integrated into Terminal Board
HSL	Holding Switch Lower
IRS	Indicator Reset Solenoid (Position Indicator)
JB	Junction Box on 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 Interrupt Switch
V6	DPT Voltage Interrupt Switch
VM	Motor Voltage
VS	Sensing Voltage
VTT	Voltage Test Terminals



NOTE: Portion of schematic shown in dotted enclosures is located in regulator tank.

Figure 10-3. Wiring diagram for Type B VR-32 Regulator and CL-6 control with differential potential transformer.


CL6
CIRCUIT
BOARD
NEUTRAL
LAMP
SENSE
COUPLER
CT
INPUT
COUPLER
J4-4
J4-3
V-OUT
(LOAD)
INPUT
COUPLER
V-IN/DIFF
INPUT
COUPLER
SUPERVISORY
SWITCH
COUPLER
AUTO
ENABLE
COUPLER
TRIACS
LOWER
SOURCE
RAISE
MOTOR
CURRENT
SENSE
COUPLER
PANEL
POWER
INPUT
OFF
ON
SUPERVISORY
AUTO
OFF
MANUAL
RAISE
OFF
LOWER
MF
6 AMP
SCP
BLK
RED
GRN
EST
VTT
WHT
WHT
OFF
DRAG
HAND
RESET
PS
EXTERNAL
SOURCE
INTERNAL
SOURCE
4
1
10
5
2
OFF
11
6
3
12
J4-12
J4-14
J4-10
J4-11
J4-2
J4-1
J4-17
J4-13
J4-5
J4-15
J4-8
J4-9
J4-6
J4-16
J4-7
TB2-VS
TB2-V7
TB2-VM
TB2-8
TB2-6
TB2-7
TB2-5
TB2-G
TB2-BR
TB2-V9
TB2-L3
TB2-R3
TB2-HS
TB2-DHR
TB2-NL
TB2-VS
(NOTE 5)
TB8-3
TB1-L1
TB8-1
TB1-R1
TB1-HS
TB1-DHR
TB1-NL
TB1-VS
TB1-V5
TB1-V4
REMOVABLE
JUMPER FOR
BLOCKING RELAY
PROVISION
TB8-5
TB8-4
CC
PIN I
CC
PIN F
CC
PIN E
CC
PIN J
CC
PIN H
REMOVABLE
JUMPER
FOR
ACCESSORIES
LLS
JB
RLS
JBB-L
JBB-R
JBB-HS
JBB-DHR
CC
PIN L
JBB-S6
MR
(NOTE 2)
(NOTE 3)
NC
C
LLS
NC
LSS
T3
T2
NC
C
RLS
NC
RSS
NO
NC
C
NLS
1
IRS
2
MC
CC
PIN N
JBB-S7
T1
NO
C
C
NO
HSL
HSR
TCB-G
JBB-G (NOTE 4)
JBB-NL

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
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 Interrupt Switch
V6	DPT Voltage Interrupt Switch
VM	Motor Voltage
VS	Sensing Voltage
VTT	Voltage Test Terminals

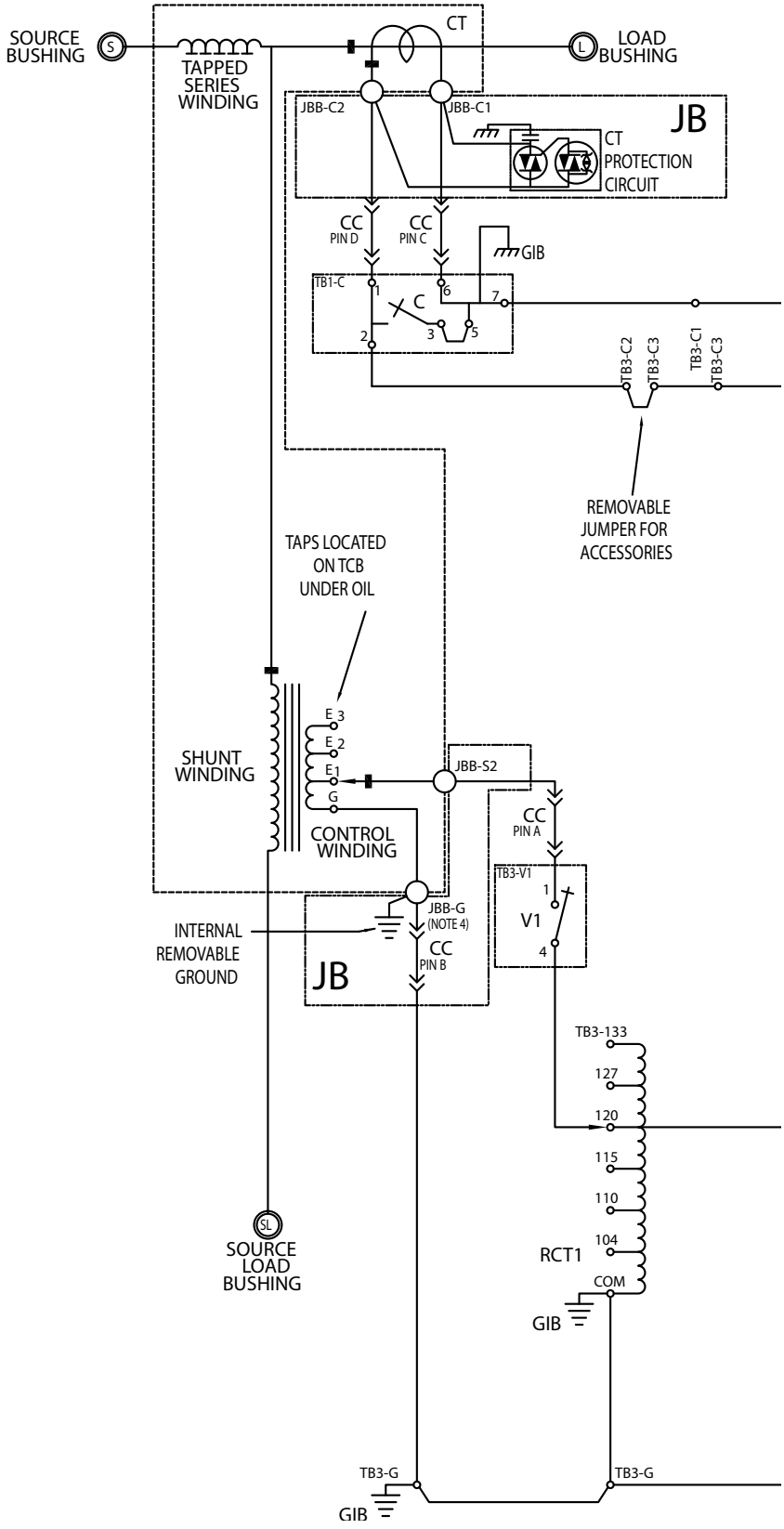
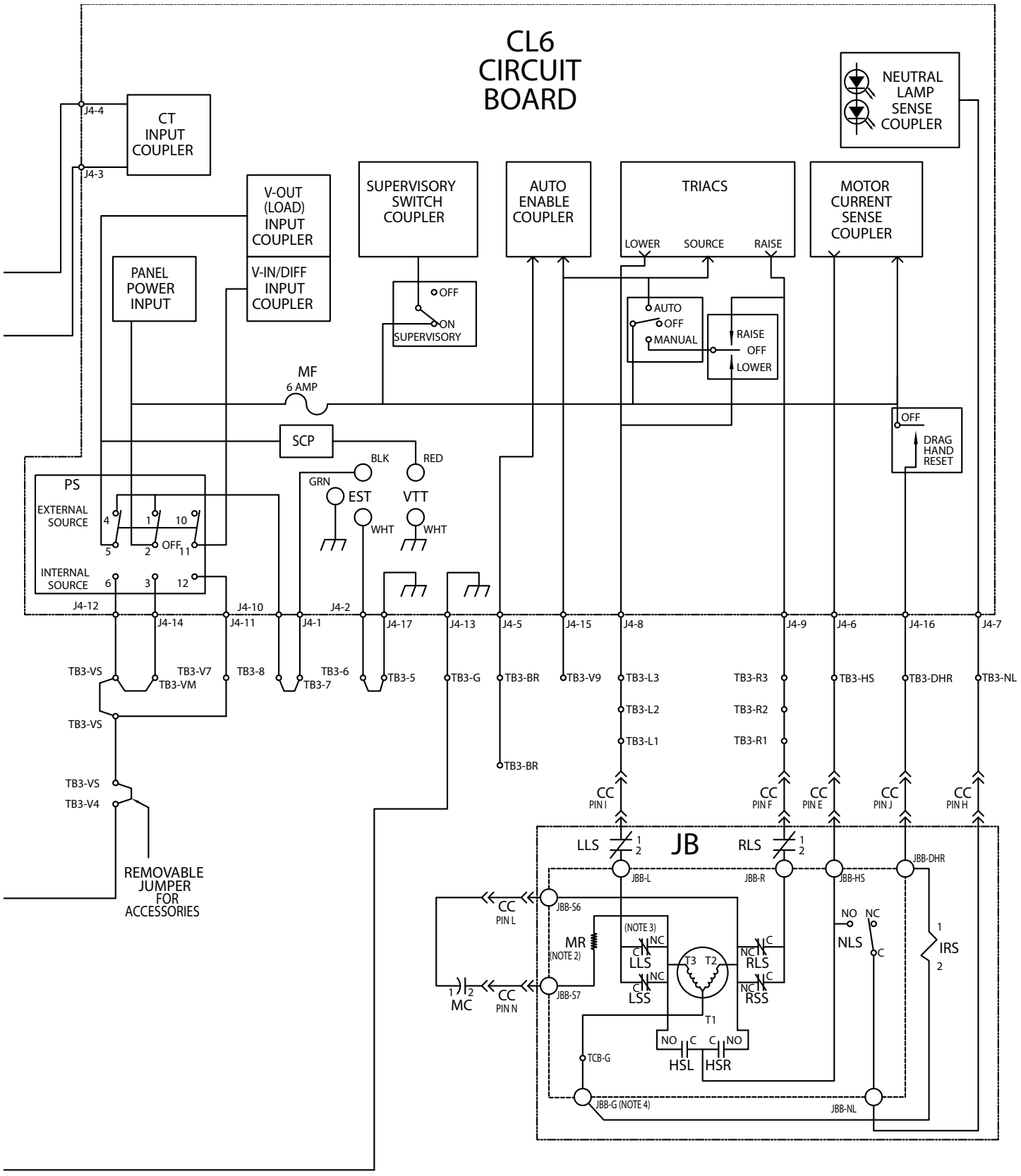


Figure 10-4. Wiring diagram for Type B VR-32 Regulator and CL-6 control with differential potential transformer and alternate back panel design.


CL6
CIRCUIT
BOARD
NEUTRAL
LAMP
SENSE
COUPLER
CT
INPUT
COUPLER
J4-4
J4-3
V-OUT
(LOAD)
INPUT
COUPLER
V-IN/DIFF
INPUT
COUPLER
SUPERVISORY
SWITCH
COUPLER
AUTO
ENABLE
COUPLER
TRIACS
LOWER
SOURCE
RAISE
MOTOR
CURRENT
SENSE
COUPLER
PANEL
POWER
INPUT
OFF
ON
SUPERVISORY
AUTO
OFF
MANUAL
RAISE
OFF
LOWER
MF
6 AMP
OFF
DRAG
HAND
RESET
SCP
BLK
RED
GRN
EST
VTT
WHT
WHT
PS
EXTERNAL
SOURCE
INTERNAL
SOURCE
J4-12
J4-14
J4-10
J4-11
J4-2
J4-1
J4-17
J4-13
J4-5
J4-15
J4-8
J4-9
J4-6
J4-16
J4-7
TB3-VS
TB3-V7
TB3-VM
TB3-8
TB3-6
TB3-7
TB3-5
TB3-G
TB3-BR
TB3-V9
TB3-L3
TB3-L2
TB3-L1
TB3-R3
TB3-R2
TB3-R1
TB3-HS
TB3-DHR
TB3-NL
TB3-V4
REMOVABLE
JUMPER
FOR
ACCESSORIES
CC
PIN I
CC
PIN F
CC
PIN E
CC
PIN J
CC
PIN H
JB
LLS
RLS
JBB-L
JBB-R
JBB-HS
JBB-DHR
JBB-S6
JBB-S7
CC
PIN L
CC
PIN N
MR
(NOTE 2)
MC
(NOTE 3)
LLS
LSS
RLS
RSS
T1
T2
T3
NLS
IRS
HSL
HSR
TCB-G
JBB-G (NOTE 4)
JBB-NL

JBB-G – White
JBB-HS – Orange
RLS-1 – Blue
LLS-1 – Green/Black
JBB-NL – Red/Black
JBB-DHR – Orange/Black
$JBB\text{-}S_6$ – Blue/Black
$JBB\text{-}S_7$ – Black/ White
$JBB\text{-}S_4$ – White /Black
$JBB\text{-}S_2$ – Black
$JBB\text{-}C_1$ – Red
$JBB\text{-}C_2$ – Green

TB_1-G – White
TB_2-HS – Orange
TB_2-R_3 – Blue
TB_8-1 – Blue
TB_2-L_3 – White /Green
TB_8-3 – White /Green
TB_2-NL – White /Red
TB_2-DHR – White /Orange
TB_2-VS – Black
RCT_1-120 – Black
TB_1-G – White
RCT_2-G – White
SD_1-2 – Violet
TB_2-C_3 – Green
RCT_2 – White /Brown
RCT_1 – Black
TB_2-C_1 – Red

PD_2-2 – White /Brown
TB_2-V_7 – White /Brown
RCT_1-G – White
TB_1-G – White
PD_1-2 – Black
TB_1-V_4 – Black
RCT_2-G – White
TB_8-4 – White
TB_1-R_1 – Blue
TB_1-L_1 – White /Green
TB_2-G – White
RCT_1-G – White
TB_2-BR – White /Blue

TB_2-G – White
RCT_2-120 – White /Brown
TB_8-5 – White /Blue
TB_8-4 – White
TB_2-J – White
TB_1-VS – Black
SD_1-3 – Red
TB_1-C_3 – Green
TB_1-HS – Orange
TB_1-R_1 – Blue
TB_1-L_1 – White /Green
TB_1-NL – White /Red
TB_1-DHR – White /Orange

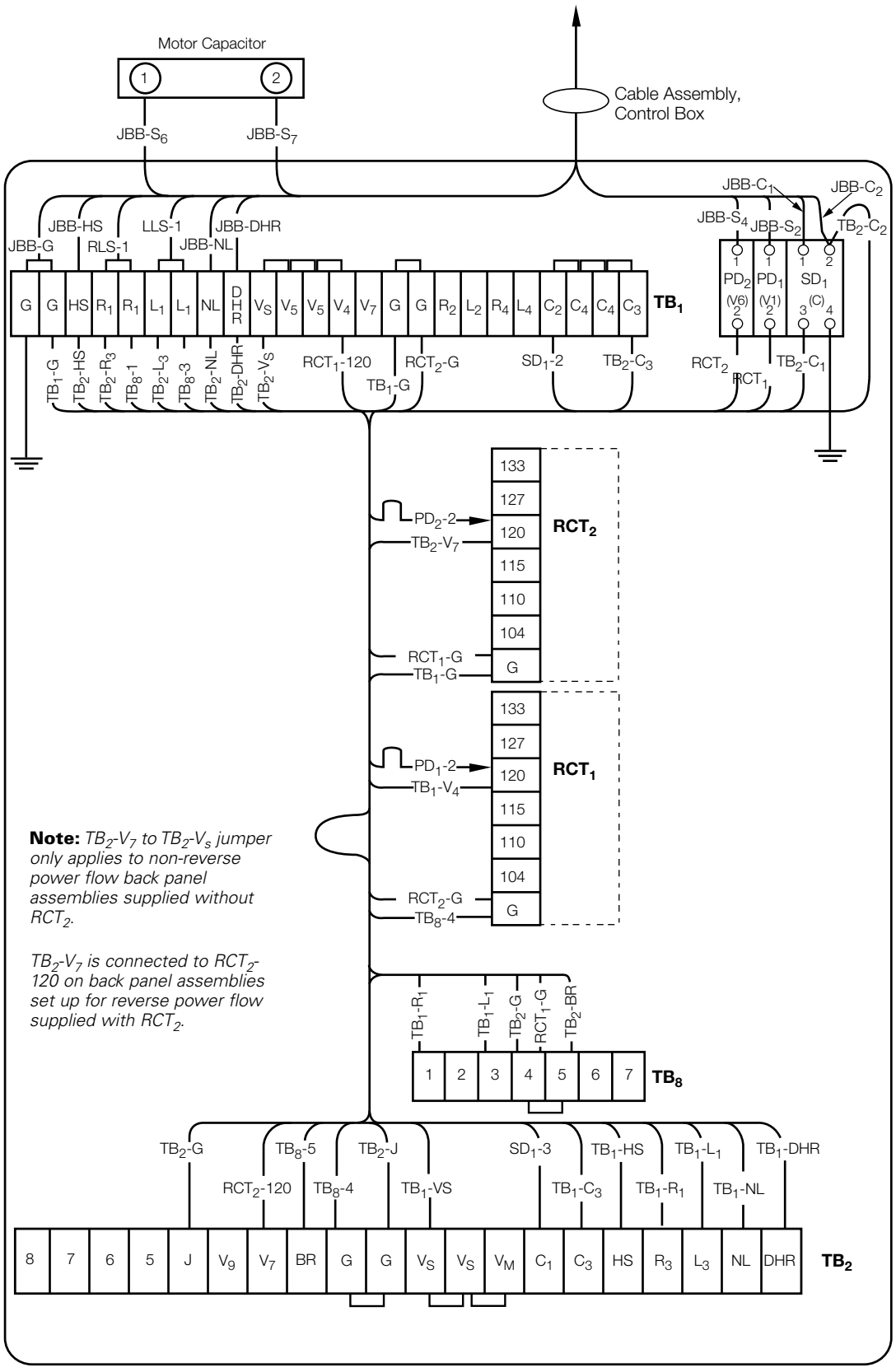


Figure 10-5. Back panel signal circuit.

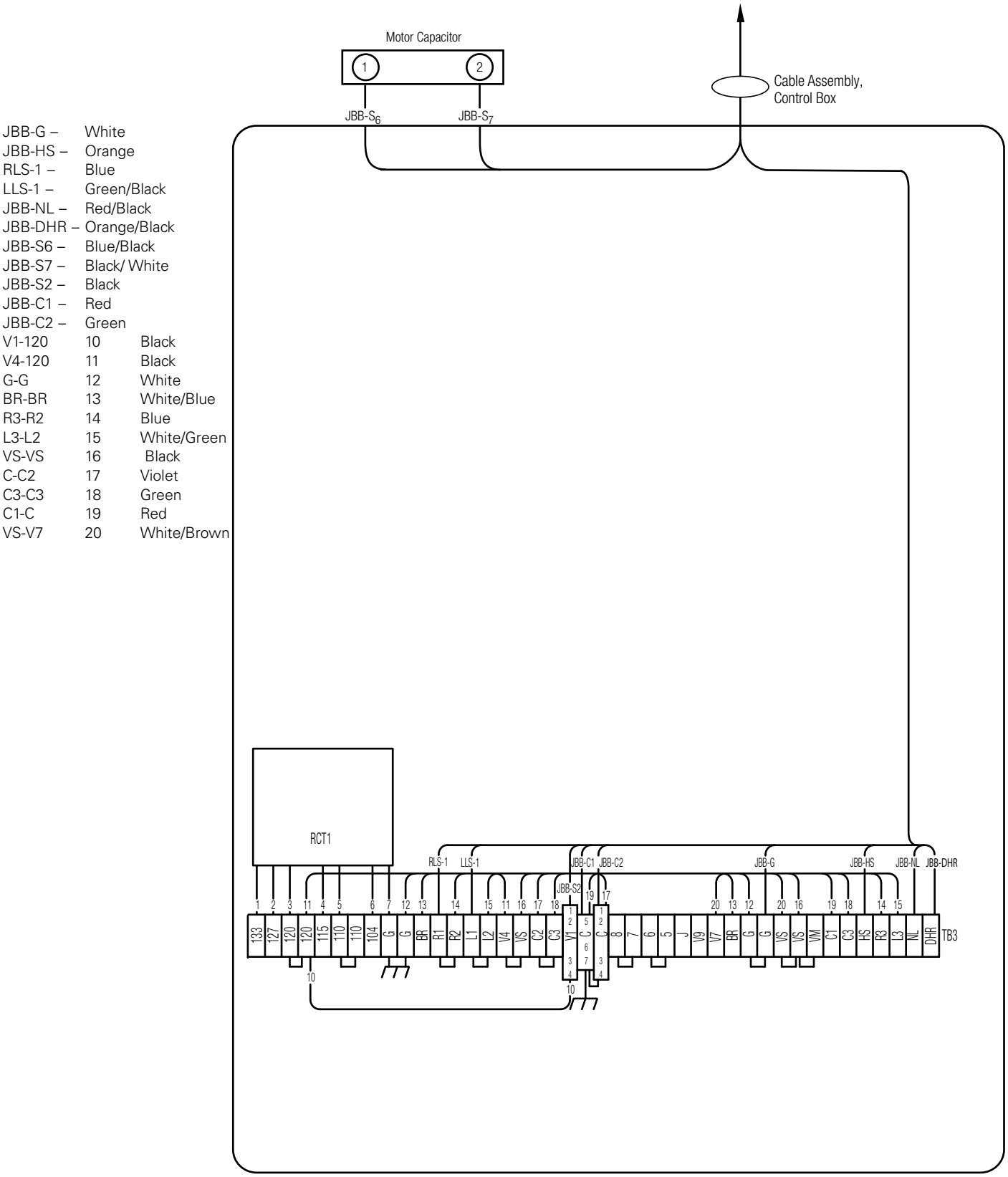


Figure 10-6. Alternate back panel signal circuit.

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