Technical Note **11015** Effective October 2019

XLM Module with temperature output instruction manual

Introduction

The XLM-62 modules are self-contained energy storage devices comprised of twenty-three individual supercapacitor cells. The module includes bus bar connections, integrated cell voltage management circuitry and an overvoltage alarm. Units may be connected in series to obtain higher operating voltage (maximum 1,500 V), in parallel to provide higher current or longer run time, or a combination of series/parallel arrangements as needed. The module is intended for installation in a standard 19" equipment rack or a 23" UPS rack, but may be installed in custom racks as well. To fully meet Zone 4 earthquake standards, each module should be secured to a shelf.

The module is designed to provide backup power for graceful shutdown of systems, for ride through of power transients (sags, spikes, dropouts), and for transition to a permanent backup solution such as a fuel cell or diesel generator. The module is intended for occasional charge/discharge (typically less than once per hour) as it contains no cooling features. The module is not intended for installation on vehicles or in high vibration environments.

The cell voltage management provides the highest reliability for optimizing product lifetime. An alarm circuit is available which provides an open collector signal when the voltage exceeds 2.7 V on any cell in the module.

Safety

The XLM-62 modules contain stored energy of 69 watt-hours and can discharge up to 11,000 amps if short circuited. Only personnel trained in high power electrical systems should work on such systems. Modules are typically connected in series to increase the operating voltage and potential discharge current. Before working on a system with modules installed, the module(s) should be discharged and the voltage on each module verified prior to conducting any work.

WARNING

Danger - High Voltage Hazard!

Never touch the power terminals as the module may be charged and cause fatal electrical shocks. Always check that the module is fully discharged before manipulating the module.

For more information about the discharge procedure, please refer to page 6.

- Do not operate unit above 62.1 V voltage.
- Do not operate unit above specified temperature rating.
- Do not touch terminals with conductors while charged. Serious burns, shock, or material fusing may occur.
- Protect surrounding electrical components from incidental contact.
- Provide sufficient electrical isolation when working above 50 Vdc.
- Prior to installation on and removal from the equipment, it is mandatory to fully discharge the module.

Powering Business Worldwide

Theory of operation

Supercapacitors function on electrostatic principles with no chemical reactions and no moving parts. They avoid the lifetime issues associated with chemical storage of batteries or mechanical issues associated with fly wheels. The XLM modules are non-toxic and designed for years of maintenance-free operation.

Supercapacitors are intended as energy storage with a DC discharge. The module should not be used for AC charging or discharging. Discharges may be constant current or constant power. Example discharges are shown in Figure 1a and 1b. The voltage of the module drops linearly under a constant current discharge.

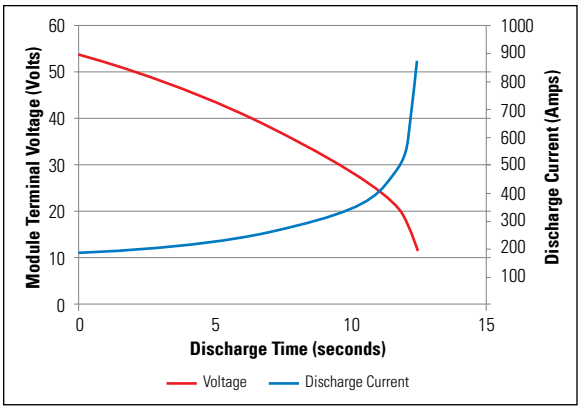

Figure 1a. Example voltage and current discharge curves for 10 kW discharge from one module with 56 V float voltage.

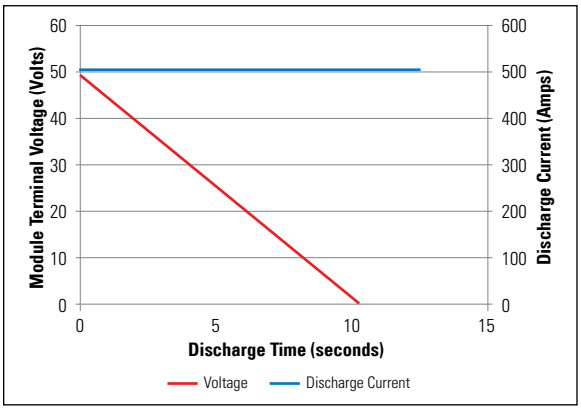

Figure 1b. Example voltage and current discharge curves for 500 A discharge from one module with 56 V float voltage.

Due to the very low equivalent series resistance (ESR) of the supercapacitors, minimal heat is generated during operation. However, as supercapacitors can handle very high currents, a significant heat rise can occur if the discharges and re-charging is frequent or above 50 A continuous current. See *Thermal performance* on page 5 for more information.

Most systems require multiple modules connected in series to reach higher operating voltages. The XLM-62 modules with temperature output can be series connected for operation up to 1450 V when using the overvoltage signal or up to 1500 V when the overvoltage signal is not used.

Due to manufacturing variations in capacitance and leakage current, cells in a module can differ in voltage. This voltage difference affects the capacitance and equivalent series resistance over time and results in a shortening of the life of the system.

The XLM-62R1137A-T has an integrated passive balancing system while the XLM-62R1137B-T has an integrated shunt balancing system.

The passive balance system uses voltage dividing resistors in parallel with each of the 23 XL60 cells that are assembled in series within the XLM-62. This allows current to flow naturally from higher voltage cells to adjacent lower voltage cells, providing natural balancing. This method also ensures that cell balancing is always occurring during all operation states.

The shunt balance circuit uses voltage sensing shunts that monitors the voltage of each cell. When the voltage on a cell exceeds a preset voltage limit, the balancing circuit activates to discharge the cell into resistors to under the specified voltage limit. The balancing resistors selected are of low enough value to ensure current flow during operation is higher than the cell leakage current.

Installation

Unpacking

Inspect the shipping carton for signs of damage prior to unpacking the module. Damage to the shipping carton or module should be reported to the carrier immediately.

Remove the module from the shipping carton and retain the shipping materials until the unit has been inspected and is determined to be operational.

NOTE: The original shipping materials are approved for both air and ground shipment. The module should be removed from the shipping carton by lifting it by the body of the module.

If the unit is found to be defective or any parts are missing, contact your local sales representative. A Return Material Authorization (RMA) number must be issued prior to returning the unit for repair or replacement.

Mechanical

Modules are intended for installation horizontally as shown in Figure 5. The module should be mounted on a shelf. The modules should further be secured to the rack using the front or side mounting holes. See the data sheet click here for available mounting locations.

The XLM module has eight M6 mounting holes. Four of these holes are shown in Figure 3. Refer to Figure 4 for the location of mounting holes.

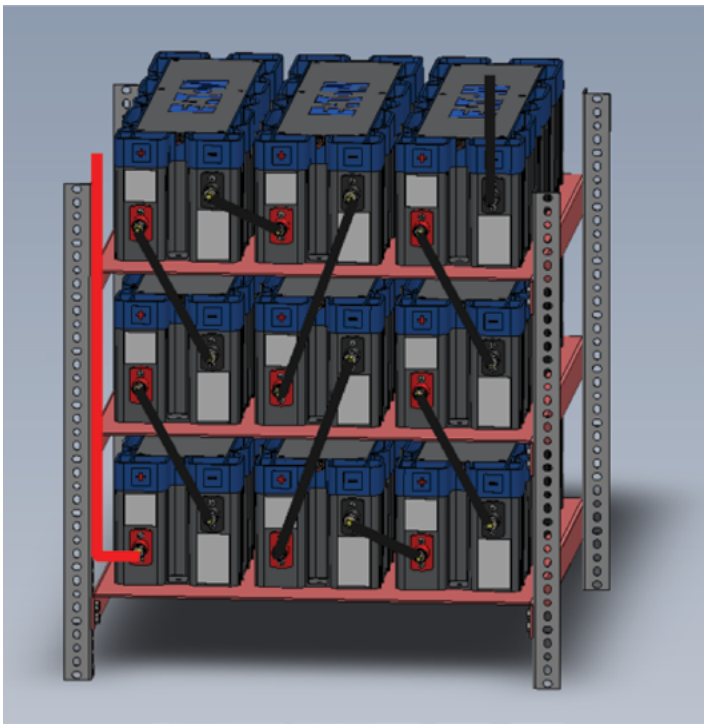

Figure 5. Nine series connected modules mounted in a 24" rack.

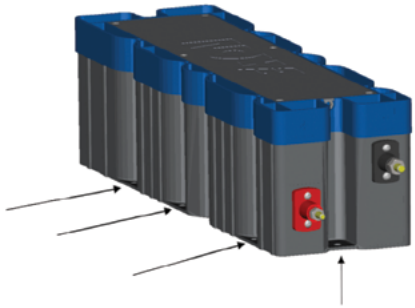

Figure 3. View of side and front mounting holes. Corresponding holes on the opposite sides of the module for a total of eight (8) mounting points

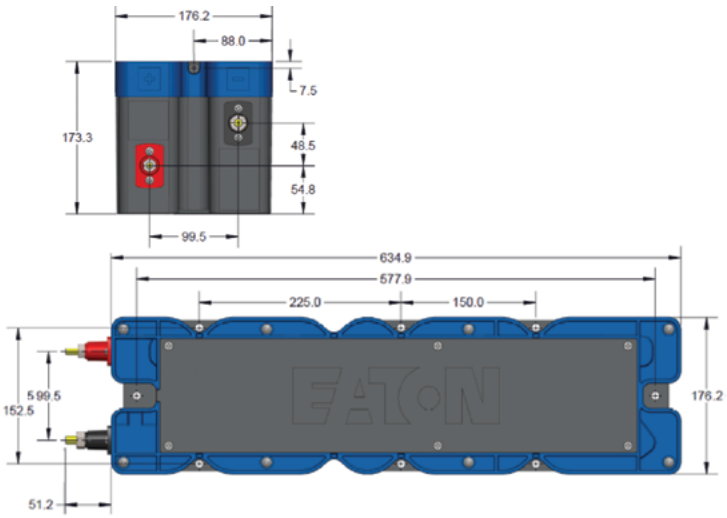

Figure 4. Dimensional drawing of module, all dimensions in mm.

Electrical

WARNING

Caution

To avoid arcing and sparking the energy storage module should be in a discharged state and the system power disconnected during installation. The module is shipped discharged and with a shorting wire. The shorting wire should be removed prior to electrical connection.

WARNING

Caution

To provide the lowest possible ESR the energy storage modules are not fused. Care should be taken within the application to prevent excessive current flow as required. Excessive current and/or duty cycle will result in overheating the module which will cause irreparable damage. Please consult the specific data sheet for each module for current and duty cycle capabilities.

Output terminal posts

The output terminals of the module consist of threaded, tin-plated brass posts. They are designed to connect directly to a ring lug or a bus bar. The positive terminal is a 5/16"-18 threaded stud and the negative terminal is a 3/8"-16 threaded stud. Securing nuts are included.

The maximum stack height of lugs/bus bars/lock washers is 0.6" / 15 mm. When applying torque to the terminals, it is recommended to use a maximum torque of 10 N-m / 7.3 ft-lbs with an absolute maximum torque of 15 N-m / 11.1 ft-lbs. Applying torque above 15 N-m / 11.1 ft-lbs may result in damage to the terminals.

Attachment to the output terminals should be made with ring lugs or bus bars of an appropriate size for the application current. The energy storage modules have low ESR. As a result, the resistance of the cable connecting the energy storage module to the load can easily exceed the ESR of the module.

Connection of modules in series or parallel or combination thereof should utilize the same gauge wire (or equivalent bus bar) as determined for final output connections. When connecting in series, connect the positive output terminal of one module to the negative output terminal of the next module (as shown in Figure 6 and Figure 8). For parallel connections, connect positive terminals together and negative terminals together (as shown in Figure 7 and Figure 8). The maximum operating voltage of a series connected system should not exceed 1450 V when using the overvoltage signal; each module can be series connected up to 1500 V when the overvoltage signal is not used.

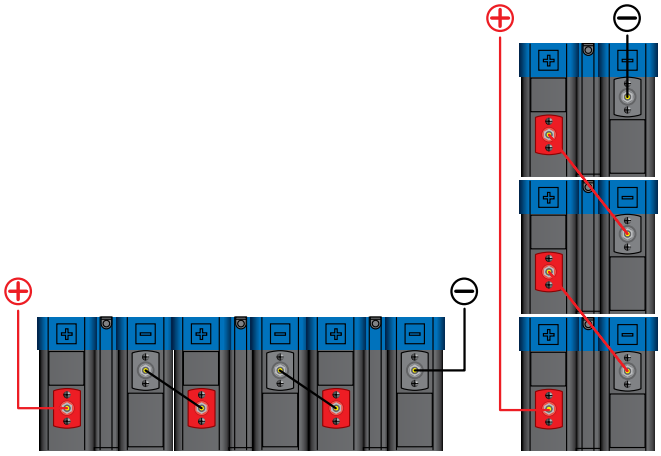

Figure 6. Series connected modules (horizontal or vertical). In this example, the system would provide 30 KW for 15 seconds at 168 V.

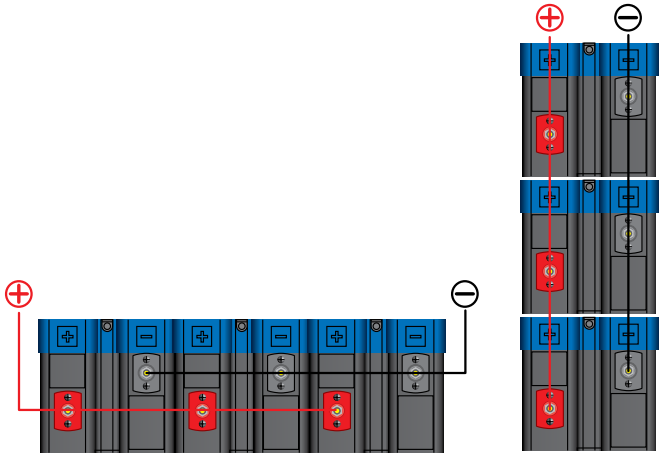

Figure 7. Parallel connected modules (horizontal or vertical). In this example, the system would provide 30 kW for 15 seconds at 56 V.

Figure 8. 3 Series x 2 Parallel connect modules. In this example, the system would provide 60 kW for 15 seconds at 168 V. Parallel cables (dashed lines) connecting modules in the middle are optional.

Voltage balancing

The modules are equipped with passive voltage management circuitry that balances the voltage between cells. The voltage management functions over hours to minimize the voltage differential between cells.

Thermal performance

Low internal resistance of the energy storage modules enables low heat generation within the modules during use. As with any electronic component, the cooler the part operates the longer the service life. In most applications natural air convection should provide adequate cooling. In severe applications requiring maximum service life, forced airflow may be required.

The thermal resistance, Rth, of the units has been experimentally determined assuming free convection at ambient (~ +25 °C). The Rth value provided on the data sheet is useful for determining the operating limits for the units. Using the Rth value a module temperature rise can be determined based upon any current and duty cycle. The temperature rise can be expressed by the following equation.

$$\Delta T = I^2 R_{esr} R_{th} d_f$$

where:

I = RMS current (A)

Resr = DC equivalent series resistance (Ω)

Rth = Thermal resistance (°C/W)

This ΔT plus ambient should remain below the specified maximum operating temperature for the module (Please refer to the data sheet click here)

Operation

General

The module should only be operated within specified voltage and temperature ratings. Determine whether current limiting is necessary on input/output based on current ratings of ancillary devices. Observe polarity indicated on module. Reverse polarity operation of the module(s) is not recommended.

Electric isolation of the module is tested to 3500 Vdc for maximum operating voltage of 1500 V when the overvoltage signal is not used.

When several modules are connected in series for operating at higher voltage, care must be taken to ensure proper creepage and clearance distances in compliance with national safety standards for electrical equipment.

Overvoltage signal

An electrically isolated open collector logic output is made available for alarm interface. If a supercapacitor cell is charged above 2.95 V, a signal will be triggered at alarm connector J1 present on module. Connector J1 is Molex® part number 50-57-9404.

When several modules are connected in series, parallel or series-parallel combination, alarm logic output signal can be monitored individually or wired to form a single fault signal.

Table 1 shows pin out indication of connector J1, and maximum current allowed. 5.0 Vdc can be the maximum open circuit voltage across connector provided.

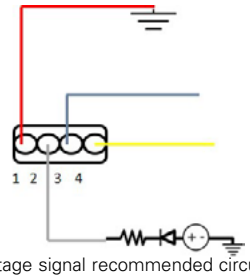

Figure 9. Overvoltage signal recommended circuit.

Table A. Overvoltage signal pin out

Pin #	Signal name	Output	Maximum current	Color
1	GND	N/A		Red
2	Overvoltage	H – Not active L – Active	20 mA	Black
3	Temperature	See table		Green
4	Temperature			White

NOTE:

1. Overvoltage pin i.e. Pin 2 goes active (closes the circuit to ground) if any cell inside module exceeds overvoltage limit of 2.7 V.
2. Since Pin 2 (overvoltage signal) is an open collector transistor output, pull-up resistor (~1K) connected to a 5 V supply should be connected to Pin 2. Typical connections are shown below.
3. When a simple pull up circuit is built around Pin 2, Pin 2 will remain ~5 V when there is no overvoltage which indicates normal operating condition. When the cell goes into over-voltage condition, Pin 2 goes low. This alarming signal can be used to signal system electronics to abort charging of module and to permit overcharged cells to appropriately discharge down to set limits, through a built-in passive balancer.
4. Internal overvoltage circuit can sink up to 20 mA with an output signal low voltage of no more than 0.7 V. When there is no over voltage signal, maximum leakage current through pull up resistor is 100 nA. Based on the overall electronic system, proper value of the pull-up resistor should be selected.

Temperature monitoring

A thermistor is attached to a cell inside the module. This allows monitoring of the internal module temperature. The temperature can be monitored with a constant current circuit and measuring the resistance.

Table B. Temperature monitoring- resistance values at intermediate values

Temperature (°C)	RT (Ω) [°F= x°C*1.8+32]	RT/R25 [°F= x°C*1.8+32]	R-Tol. (± %)	α (%/K)	T-Tol. (± °C)	R min. (Ω) [°F= x°C*1.8+32]	R max (Ω) [°F= x°C*1.8+32]
-40.0	190,953	19.095	4.24	-5.46	0.78	182,848	199,057
-35.0	145,953	14.595	3.93	-5.30	0.74	140,213	151,693
-30.0	112,440	11.244	3.63	-5.14	0.71	108,354	116,526
-25.0	87,285	8.7285	3.35	-4.99	0.67	84,364	90,206
-20.0	68,260	6.8260	3.07	-4.85	0.63	66,164	70,355
-15.0	53,762	5.3762	2.80	-4.71	0.60	52,254	55,270
-10.0	42,636	4.2636	2.55	-4.57	0.56	41,549	43,723
-5.0	34,038	3.4038	2.30	-4.44	0.52	33,254	34,822
0.0	27,348	2.7348	2.07	-4.31	0.48	26,783	27,913
5.0	22,108	2.2108	1.84	-4.19	0.44	21,702	22,515
10.0	17,979	1.7979	1.62	-4.08	0.40	17,689	18,270
15.0	14,706	1.4706	1.40	-3.96	0.35	14,499	14,912
20.0	12,094	1.2094	1.20	-3.86	0.31	11,949	12,239
25.0	10,000	1.0000	1.00	-3.75	0.27	9900.0	10,100
30.0	8310.8	0.83108	1.19	-3.65	0.33	8211.7	8409.8
35.0	6941.1	0.69411	1.38	-3.55	0.39	6845.5	7036.7
40.0	5824.9	0.58249	1.56	-3.46	0.45	5734.1	5915.6
45.0	4910.6	0.49106	1.73	-3.37	0.51	4825.6	4995.7
50.0	4158.3	0.41583	1.90	-3.28	0.58	4079.2	4237.3
55.0	3536.2	0.35362	2.06	-3.20	0.65	3463.2	3609.2
60.0	3019.7	0.30197	2.22	-3.12	0.71	2952.5	3086.8
65.0	2588.8	0.25888	2.38	-3.04	0.78	2527.3	2650.4
70.0	2228.0	0.22280	2.53	-2.96	0.85	2171.7	2284.3
75.0	1924.6	0.19246	2.67	-2.89	0.92	1873.1	1976.0
80.0	1668.4	0.16684	2.81	-2.82	1.00	1621.5	1715.3
85.0	1451.3	0.14513	2.95	-2.75	1.07	1408.5	1494.2
90.0	1266.7	0.12667	3.08	-2.69	1.15	1227.7	1305.8
95.0	1109.2	0.11092	3.21	-2.62	1.22	1073.6	1144.8
100.0	974.26	0.097426	3.34	-2.56	1.30	941.74	1006.8
105.0	858.33	0.085833	3.46	-2.50	1.38	828.62	888.04

Maintenance

Prior to removal from the system, cable removal, or any other handling ensure that the energy storage module is completely discharged in a safe manner. The stored energy and the voltage levels may be lethal if mishandling occurs. Maintenance should only be conducted by trained personnel on discharged modules.

Discharge Procedure

Proceed as follow to discharge the module:

1. Using a voltmeter, measure the voltage between the 2 terminals.

2. If the module voltage is above 1 V, a resistor pack (not supplied) will need to be connected between the terminals. Proper care needs to be taken in the design and construction of such a dissipative pack. e.g. at 56 V, for a 2 Ohm pack, the module will be discharged with a peak current of 28 A and will take about 15 minutes to discharge. However, in this case, the heat/power dissipated in the resistor pack will be ~ 3.9 kW. The resistor pack will need to be sized and provided with suitable cooling to handle this power dissipation. Additionally, proper enclosure or other packaging is necessary to ensure safety. In all cases, proper design of the dissipative resistor pack is necessary.

3. If the voltage is under 1 V, connect the shorting wire (minimum 18 AWG) to the + and – connectors. Due to the extremely low module ESR, there may be a spark and warming of the wire when first connecting the shorting wire.

4. The module is now safe for handling. However, leave the shorting wire connected at all times until the module is installed in the system and the power cables are connected.

Routine Maintenance

- If any dirt or grime, use a cleaning cloth dampened with a water/ soap solution. Do not use high-pressure sprays or immersion
  - Frequency - Annually
- Check mounting fasteners for proper torque
  - Frequency – Annually
- Inspect housing for signs of damage
  - Frequency - Annually
- Check signal/ground connections
  - Frequency – Annually

Storage

The discharged module can be stored in the original package in a dry place. Discharge a used module prior to stock or shipment. A wire across the terminals should be used to maintain short circuit after having discharged the module.

Disposal

Do not dispose of module in the trash. Dispose of according to local regulations for general electronics waste. The disposal method should be compatible with aceontrile

Specifications

Please refer to the data sheet click here.

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