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<b>Models.....</b>	<b>1</b>
<b>Warnings.....</b>	<b>1</b>
<b>Warranty Limitation.....</b>	<b>1</b>
<b>Introduction.....</b>	<b>1</b>
<b>Module Part Numbering and It's Meaning.....</b>	<b>2</b>
<b>Handling</b>	
Unpacking.....	2
Handling.....	2-3
<b>Installation</b>	
Orientation and Application.....	3-4
Terminals and Torquing.....	5
Environment.....	5
Electrical.....	5-6
Monitoring.....	6-7
Balancing.....	8
<b>Safety.....</b>	<b>9</b>
<b>Discharge.....</b>	<b>9-10</b>
<b>Accessories.....</b>	<b>10</b>
<b>Operation.....</b>	<b>10</b>
<b>Maintenance.....</b>	<b>10-11</b>
<b>Reconditioning.....</b>	<b>11</b>
<b>Storage.....</b>	<b>11</b>
<b>Disposal.....</b>	<b>11</b>
<b>Appendix.....</b>	<b>12</b>

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## MODELS

- **Standard iMOD X-Series® Rev B Modules**

iMODXXXVYYA23-XXB

- **Special iMOD X-Series® Rev B Modules**

iMOD096V083CCX-XXB (96V, 83F module with passive balancing)

iMOD102V083ACX-XXB (102V, 83F module for high voltage operation)

## WARNING



**Never touch the power terminals on ultracapacitor modules as any residual voltage can cause fatal electrical shock. Always check with a calibrated meter that the ultracapacitor module is discharged prior to handling the module. Please see the step by step instructions in this manual for the discharge procedure.**

## WARRANTY LIMITATION

IOXUS® modules are unserviceable property of the customer and if opened or otherwise modified, are no longer covered by any warranty written or implied.

## INTRODUCTION

The X-Series® Modules represented in this document are designed for a wide variety of applications from stationary back up power to transportation usage. Each module is built with welded bus bars and internal balancing circuitry. The balancing circuitry can be one of several formats based on the options selected. The standard balancing circuitry for the large format modules is a 2-stage active balancing that will be described later in the document. The balancing circuitry is built in and protected by the aluminum housing allowing the entire structure to be rugged and also meet the water resistance requirements of IEC 60529 – IP67. The specifications and recommended configurations suggested in this manual are subject to change and should be verified by checking the most recent version of this document and the product datasheets on [ioxus.com](http://ioxus.com).

Please keep note of your model number when referencing this manual and note if each section refers to your specific model number.

If your model has an output connector, specifications for that connector and how to use each connection will be detailed in the appropriate sections below.

# MODULE PART NUMBER & IT'S MEANING

i	MOD	x	x	x	V	y	y	y	B	G	T	-	z	z	R
															REV
															Numeric for Proto
															Alpha for Production
															Option Codes
															Numeric for Standard
															Alpha for Customer Specials
															Separator(used for readability)
															Cell Terminal Type
															Cell Type
															P for Passive Balancing Without Clamping
															A for Semi-Active 2 Stage Balancing With Clamping
															B for Balancing With Single Stage Clamping
															X for No Balancing
															Others Possible
															Capacitance value rounded to the nearest Farad(3 digits)
															V for "voltage"(for multiples of 6 cells, round down to closest multiple of 16)
															Module Voltage Rating in Volts(3 digits)
															MOD for Module
															i for IOXUS®

## HANDLING

### Unpacking

Please inspect the shipping carton for signs of damage prior to unpacking the carton. Report any damage to the carton, or the contents, to the carrier immediately. Retain all shipping materials until the module is fully inspected and determined to be operational.

The module should be lifted by the module body. The terminals should not be used for hoisting. The terminal shorting wire should remain in place.

If any parts are determined to be missing or defective an RMA number must be issued prior to returning the unit for repair or replacement. Please contact your salesperson or distributor to request an RMA number.

### Handling

Ultracapacitor modules are designed for years of maintenance free operation if handled, installed and used properly. These handling precautions should be observed.

## Handling

- The modules should not be stacked unless still in original packaging.
- The only tools to be used on the module should be properly sized wrenches for the terminal and mounting bolts (hammers, chisels, files or power tools in general should not be used).
- Do not drop modules. If a module is dropped during handling it should not be used. Invisible internal damage may occur.

# INSTALLATION

## Orientation & Application

X-SERIES® modules can be mounted in any orientation and are qualified for shock and vibration as is detailed on the applicable datasheet. Please review the datasheet and test specifications to determine the appropriateness of the module for your application.

The modules must be mounted in a manner that applies does not apply any stress torque or twisting to the module housing. Shims and spacers should be used if any of the mounting points are more than  $\pm 1\text{mm}$  out of plane. Hardware of a grade appropriate for the application should be used for standard X-SERIES® modules. Rack mount installations will use the hardware required for standard 19" EIA rack specifications. Rack mounting is primarily for stationary applications and considerations should be made if using rack mounts in mobile applications.

For high (continuous) duty cycle applications it is required that the modules are individually exposed to free or forced air convection in order to facilitate even cooling and to maximize the life of the module.

For high shock and vibration applications IOXUS® recommends additional mounting along the module's length. Spacing between mounting points should not exceed 10" (~25cm) for applications requiring ISO 16750-3 Table 12 or Table 14 level dynamics. The first and last mounting points in these applications should be placed within 5" (12.5cm) of the ends but at least 1" (2.5cm) from the end of the module.

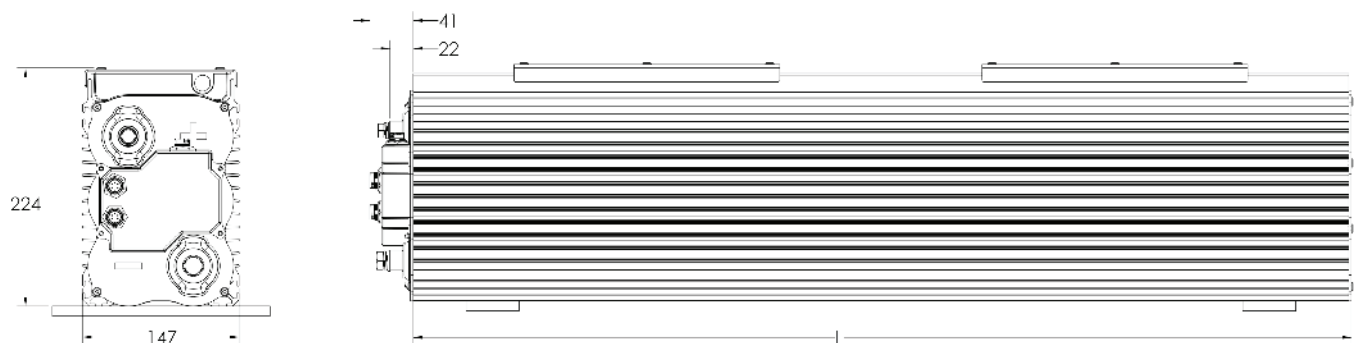


Figure 1 - Generalized Dimensions

## Orientation & Application

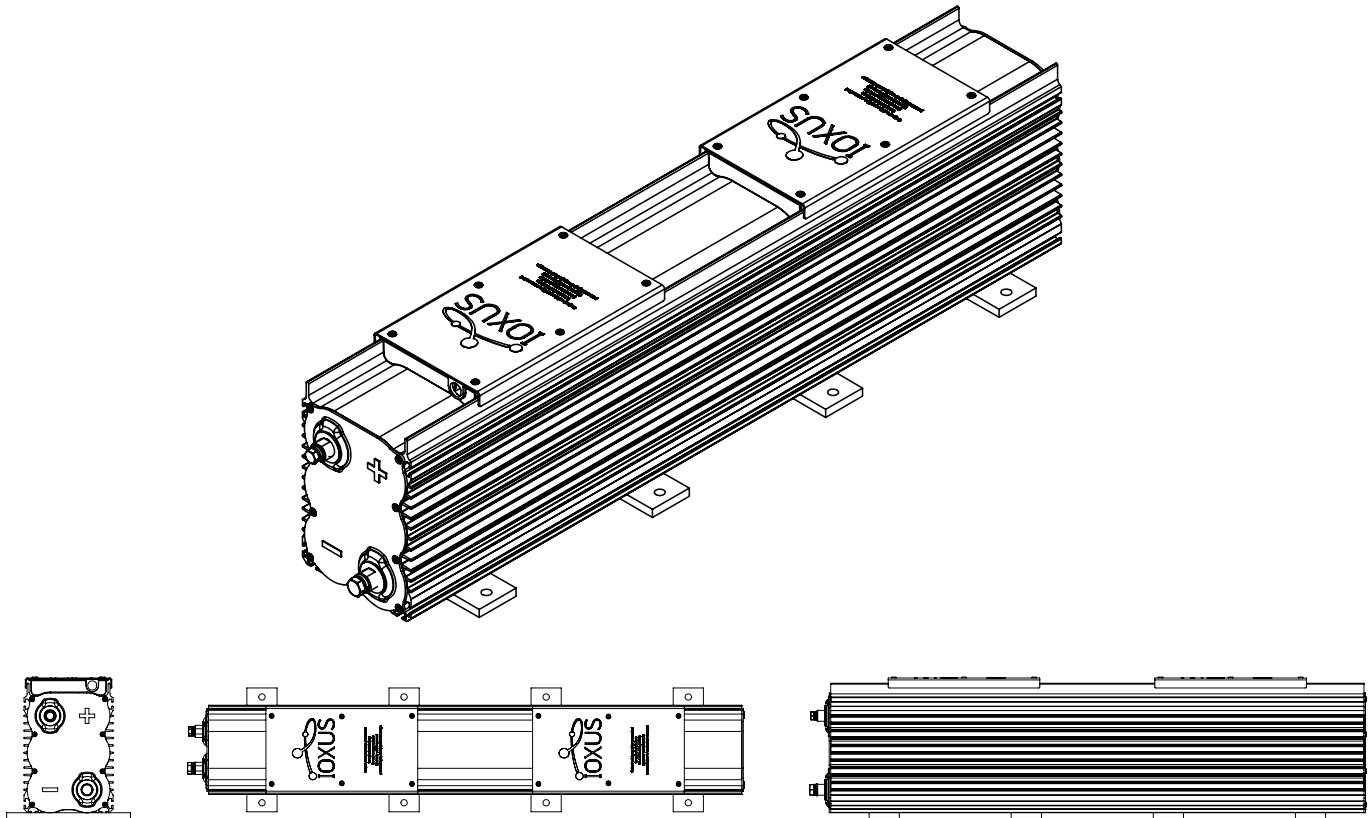


Figure 2 - Multi-Foot Mounting for High Mechanically Dynamic Applications

For rack mounting, the modules should be secured in at least 4 locations (using 4 T-nuts). Final mounting requirements are the responsibility of the customer and should be evaluated relative to the expected application.

Mounting feet or other mounting hardware may be attached using a double T-Nut. Mounting location can be adjusted by loosening the bolts and sliding the double T-nut to the desired location.



Figure 3 - Double T-nut

## Terminal and Torquing

There are 2 power terminals on each module, 1 that accepts M8 Bolts and 1 that accepts M10 bolts. Each terminal should be held with an appropriately sized wrench to prevent twisting while loosening and tightening the terminal bolts. Each terminal should be torqued within 5% of the specified values in the table below.

Terminal Size	Torque Spec
M8	20 Nm $\pm$ 5%
M10	30Nm $\pm$ 5%

## Environment

For best results modules should not be exposed directly to the environment, particularly the avoidance of direct water splashes or exposure to conditions that could lead to freeze/thaw cycles should be considered. In systems with voltages greater than 60V, protection of the terminals to avoid shock and corrosion should be instituted.

Modules that are expected to see significant cycling should be mounted in free air or in forced ventilation housing. Care should be taken to protect modules in potentially corrosive environments and direct water splash or spray should be avoided.

In all environments the best possible performance is aided by using an anti-oxidation agent on the aluminum terminals. No-Alox or other similar products are appropriate and highly recommended for all terminal connections.

Careful design consideration should be given to the application to prevent the overheating of the modules. Temperature monitoring is optionally available and discussed later in this document. Please refer to the operational temperature range on the data sheet and be sure to allow for internal heating of the modules. If you require help with the design considerations and sizing, please contact your IOXUS® representative for assistance.

## Electrical

Modules can be mounted in series and parallel with each other. Care should be taken to ensure that modules with similar capacitance and ESR are used for series chains. Your design should account for differences in ESR and capacitance if modules of different type or age are used in series and parallel configurations.

Appropriate size bus bars or cables and terminals should be used for the application. Please note that to minimize system losses capacitor modules do not have fusing or internal circuit breakers; careful consideration in system design should be taken to prevent damage from over current. With the low ESR of the capacitors they can deliver very large amounts of current.

For series string operations above 400 V, care should be taken to maintain physical separation between power terminals or busbars and any signal lines. The degree of separation between signal lines and power conductors shall be maintained at minimum distance of 5 mm/kV of maximum string voltage.

Module housings are made of anodized or coated aluminum and are insulated from power conductors. However, a small amount of charge can accumulate on the housings which can make them a source of electrostatic discharge (ESD). If ESD suppression is desired and the mounting solution does not provide a discharge path to ground, a grounding strap may be installed on each module. It is recommended to remove the anodizing or coating (if applied) on the housing at one of the bolting points to allow for the ground strap to be properly installed. Since grounding capacitor

## Electrical

modules increases risk of hazards during a ground fault, it is recommended to limit ground current by use of high voltage resistors. For example, connect a 250k $\Omega$  50W resistor between mounting chassis common and earth ground to limit ground fault current to <8 mA at 2000V.

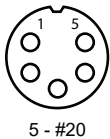
Thread locking should be done with star lock washers, or split ring plus flat washer combinations, or an appropriate chemical thread locker used on the threaded portion of the terminal/bolt only; in no case should flat washers be used with star lock washers.

Care should be taken in cable routing to not impose undue forces (torques or tensions) on the module terminals. Appropriately sized ring terminals or bus bars for the expected currents are all that should be used.

## Monitoring

There are two types of available monitoring configurations noted by the suffix on the part number for your module(s).

1. -01X - Digital Overvoltage Caution, Analog Temperature Monitoring
  2. -03X - CAN Network Communication
- 01X Digital Overvoltage (OV), Analog Temperature Operating Voltage 3-30V Max 80V
    - Module Connector: Conxall 7280-5PG-300, Contacts=4
    - MFG part number for mating connector: Conxall 6280-5SG-522
    - Pin Out Diagram



- Pin out as follows:
  - Pin1: Optical Collector (VC)
  - Pin2: Optical Emitter (SG)
  - Pin3: **Not Used**
  - Pin4: NTC (TH1)
  - Pin5: NTC (TH2)
- OV Output: Digital - Open Collector
  - Trigger if any group of cells exceeds 2.84V/cell.
  - Max Operating Current: 5mA
  - Digital OV are continuously parallel-able, they can be paralleled across parallel and series module connections.
  - Recommended pull-up resistor for 24V: 10k $\Omega$ ,  $\pm 1\%$ , 1/4W
  - Recommended pull-up resistor for 5V: 2k $\Omega$ ,  $\pm 1\%$ , 1/4W
- Temperature Output: Digital - Analog Thermistor
  - Thermistor Type: Cantherm MF52A1103G3380

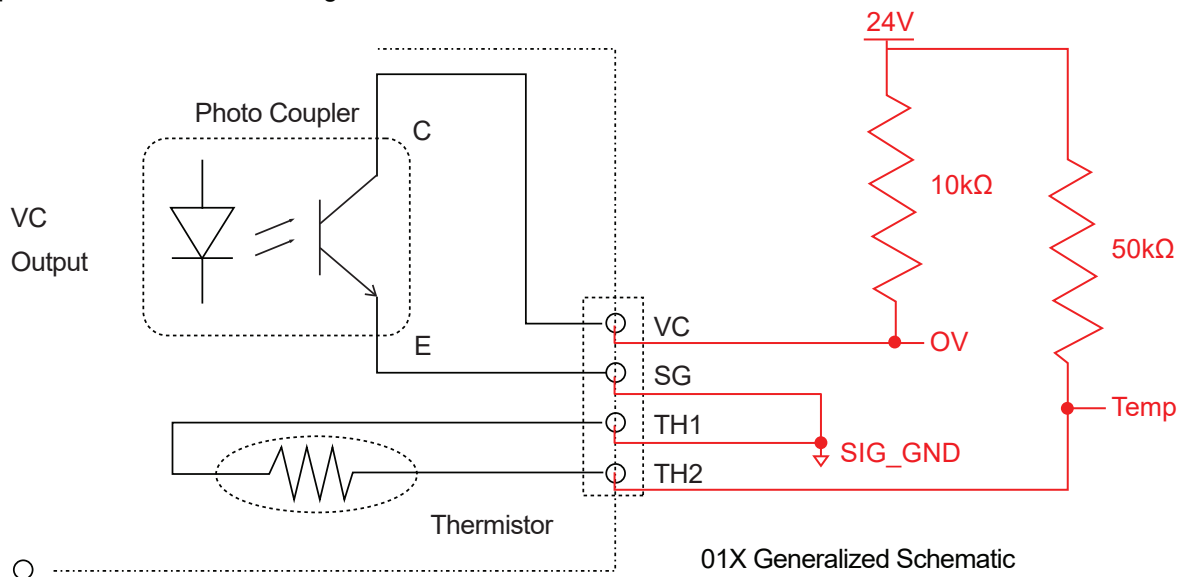


## Monitoring

- Base Resistance 10kΩ @ 25°C
- Lookup Table in Appendix
- Recommended pull-up resistor for 24V: 10kΩ, ±1%, 1/4W
- Recommended pull-up resistor for 5V: 2kΩ, ±1%, 1/4W

- Generalized Schematic:

- Typical customer interface configured in RED.



- Safety Recommendation for Installation:

- Use two series resistors with half total value for pull-up, so if one becomes shorted, the other limits fault current to a safe level.
- Place fuses between voltage supply and pull up resistors so that a short circuit in signal wiring does not cause damage. Fuse rating shall be ≤0.5A. Limit number of signals per fuse such that maximum current for all signals is ≤80% of the fuse rating.
- Fusing Example: A 0.05A fuse protects up to 13 ultracapacitor modules with signals from each module drawing a maximum of 0.003A using recommended pull-up resistor values.

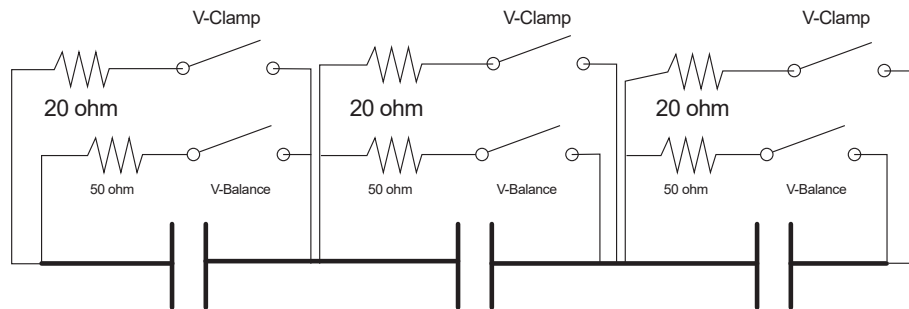
- -03X CAN Monitor

- The CAN Bus communications protocols and data formats and commands are provided in a separate document. Please see document 1-0005 CAN Extension User Manual for additional CAN details.
- Note: CAN connections can be daisy chained(parallel networking), they do not require a switch or any special devices, IOXUS® CAN Extensionmodules will have two connectors for easier integration.
- Additional considerations may be required for the primary connection to the network.
- There are maximum number of nodes on a CAN network, there also may be limits to the addresses a customer can use. IOXUS® can help configure the address range to your needs.
- Please see CAN manual for additional CAN details including pin-out and messaging/address protocols.

## Balancing

### • Two Stage Balancing Modules

- Includes PN's:
  - Standard X-Series Modules: iMODXXXVYYA23-XXB
  - High Voltage X-Series Module: iMOD102V083ACX-XXB
- The two-stage balancing employs a low-level equalization resistor that operates when any cell is individually above the balance voltage threshold (V-Balance). There is also a second stage voltage clamp that is much more aggressive and triggers if any cell exceeds the clamping threshold (V-Clamp).
- Any cells exceeding the damping threshold will activate the OV(over voltage) signal output.
- Simple Schematic

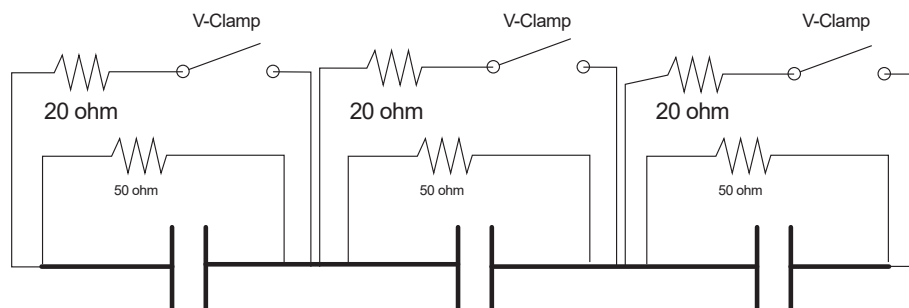


### - Two Stage Balancing Set Point

Module P/N:	Balance Threshold		Voltage Clamp Threshold	
	Activation(Rising)	De-Activation(Falling)	Activation(Rising)	De-Activation(Falling)
iMODXXXVYYA23-XXB	2.1	2.0	2.84	2.7
iMOD102V083ACX-XXB	2.1	2.0	3.15	3.0

### • Passive Balancing Modules

- Includes PN: iMOD96V083CCX-XXB
- Passive balancing employs the same equalization resistors as 2 stage balancing, however the equalization resistor is always connected, so equalization occurs until cells reach 0V.
- The voltage clamp circuit operates the same thresholds as standard X-SERIES® modules.
- Any exceeding the clamping threshold will activate the OV(over charge) signal output.
- Simplified Schematic



## SAFETY



Never touch the power terminals as any residual voltage can cause fatal electrical shocks. Always check with a calibrated meter that the module is discharged prior to handling the module, please see the step by step instructions in this manual for the discharge procedure.

- Prior to installation or removal, the module and/or system of modules must be discharged fully and shorting wires installed(discharging procedure below).
- Provide sufficient electrical isolation for operation above 50VDC.
- Protect surrounding electrical and conductive components from incidental contact.
- Do not operate above specified voltage or temperature range.
- Do not touch terminals while charged, serious burns, shock or material fusing may occur.

## DISCHARGING



A fully discharged module may “bounce back” if it is stored without a shorting wire connected to the + and – terminals. This bounce back can be as much as 12V for the 96V module, and is enough to cause dangerous electrical shocks and other undesirable consequences.

## Discharging

Prior to any maintenance or replacement each module should be individually discharged and shorted with a resistor or wire. Even a fully discharged module can rebound naturally to an unsafe condition. Be sure to discharge with an appropriately sized resistor or resistor bank (not provided) and either keep that resistor attached or replace it with a shorting wire or bus bar when the module is depleted. Be sure to check the voltage with a calibrated meter prior to attaching the shorting device. The voltage should be  $0\pm0.5V$ .

1. Using a voltmeter, measure the voltage between the 2 terminals.
2. If the voltage is above 0.05V, a resistor pack (not supplied with the module) 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 96V, for a 4 Ohm pack, the module will be initially discharged with a current of 31.25A and will take about 20 minutes to fully discharge. However, in this case, the heat/power dissipated in the resistor pack will be  $\sim 2.3kW$ . 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 0.05V, connect a shorting wire to the + and – connectors.
4. The module is now safe for handling. Leave the shorting wire connected at all times when not in use.

## ACCESSORIES

Module accessories such as connectors, cables and CAN monitoring modules are available. Custom cables, bus bars and mounting hardware are available on request but may require an NRE charge and will require all relevant mounting considerations.

## OPERATIONS

All modules should only be operated within their prescribed voltage, constant current and temperature, operating window. These should be monitored to ensure the safe operation and long life of your module.

NOTE: Operation of module above 65C will void the warranty.

## MAINTENANCE

The modules should be kept free of dust and debris and cleaned at a regular interval. In inside locations, that should be no more than annually however, this may vary with your particular circumstances. Outside location will be as needed. Once the modules are discharged, proceed with cleaning with a cloth and a simple water/soap solution. Avoid the use of hoses or pressurized sprays. Once the assembly is clean, check for properly torqued fasteners and note any damage to any of the housings or signs of internal damage and replace as necessary.

## Maintenance

In high vibration applications fasteners used for mounting as well as electrical connections should be checked for torque every 6 months.

# RECONDITIONING

Reconditioning is not typically required due to individual cell balancing. If there is concern that the cells have become imbalanced then the module should be charged to a voltage above the minimum balancing voltage, but below the rated voltage, and allowed to self-discharge for at least 8 hours for equalization. This procedure only applies for 2 stage balance circuits and is not required for passive balancing.

Module Rated Voltage	Minimum Balancing Voltage
16V	12V
32V	24V
48V	36V
64V	48V
80V	60V
96V	72V
102V	72V
112V	84V
128V	96V

# STORAGE

The module can be stored in the original package discharged in a dry place. Observe the maximum storage temperature as stated in the specifications. Discharge used modules prior to storage or shipment using a resistor bank or load rated for the application. The shorting wire shipped with the unit should be retained for use during storage to prevent charge from accumulating in the module.

# DISPOSAL

This product should not be disposed of in the trash. Please dispose according to local codes and regulations. IOXUS® ultracapacitor modules consist of aluminum, carbon, polyurethane, plastics, printed circuit board materials, paper and electrolyte containing acetonitrile. No heavy metals are used in their construction.

The most common waste disposal method is incineration, but local codes and regulations must be observed.

Refer to the Safety Data Sheets on the IOXUS® website for additional information.

## APPENDIX

NTC look up able for analog monitoring.

Cantherm MF52A1103G3380		
Temperature		Resistance
°C	K	Ω
-40	233	172,059
-35	238	135,716
-30	243	111,300
-25	248	86,390
-20	253	67,740
-15	258	53,390
-10	263	42,450
-5	268	33,890
0	273	27,280
5	278	22,050
10	283	17,960
15	288	14,680
20	293	12,090
25	298	10,000
30	303	8,313
35	308	6,941
40	313	5,828
45	318	4,912
50	323	4,161
55	328	3,537
60	333	3,021
65	338	2,589
70	343	2,229
75	348	1,924
80	353	1,669
85	358	1,451
90	363	1,266
95	368	1,108
100	373	974
105	378	857
110	383	758