



# CoolIX<sup>®</sup>1000 Modular Power Supply

## Designers Manual

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### **WARNING:**

Read this entire manual and all other publications pertaining to the work to be performed before you install, operate, or maintain this equipment. Practice all plant and product safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment might be impaired. All personnel who work with or who are exposed to this equipment must take precautions to protect themselves against serious or possibly fatal bodily injury.

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# Safety and Product Compliance Guidelines

## IMPORTANT SAFETY INFORMATION

To ensure safe installation and operation of the Advanced Energy CoolX unit, read and understand this manual before attempting to install and operate this unit. At a minimum, read and follow the safety guidelines, instructions, and practices.

## DANGER, WARNING, AND CAUTION BOXES



This symbol represents important notes concerning potential harm to people, this unit, or associated equipment. Advanced Energy includes this symbol in danger, warning, and caution boxes to identify specific levels of hazard seriousness.



### **DANGER:**

**DANGER** indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury. **DANGER** is limited to the most extreme situations.



### **WARNING:**

**WARNING** indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury, and/or property damage.



### **CAUTION:**

**CAUTION** indicates a potentially hazardous situation that, if not avoided, could result in minor or moderate injury, and/or property damage. **CAUTION** is also used for property-damage-only accidents.

## SAFETY GUIDELINES

Review the following information before attempting to install and operate the product.

## Rules for Safe Installation and Operation

Please note the following rules:

- Install the CoolX unit indoors. The CoolX unit is designed for indoor use.
- Install the CoolX unit so that it is only accessible to service engineers.
- Do not unplug CoolMod modules while input power is applied to the CoolPac chassis. The modules are not designed for hot-plug insertion.
- Ensure that input and output screw terminals are torqued to 0.74 Nm (6.5 in-lb) before applying power to the CoolX unit.
- Arrange positive and negative power cables as a twisted pair to minimize inductive loops.
- Wait 4 minutes after shutting off power before inserting or removing modules.
- Use properly sized wires to avoid overheating and excessive voltage drop.
- Take appropriate precautions when touching the CoolX unit after it has been operating for a period of time. Due to the conduction cooling methods to the chassis, the chassis will remain hot for some time after power has been removed. Exactly how long the chassis remains hot depends on the system incorporating the CoolX unit.
- Completely disconnect the installation from power before working on the unit. The unit uses double pole/neutral fusing. If the unit is not completely disconnected from power, parts might remain live even if one of the two mains fuses has blown.

## INTERPRETING PRODUCT LABELS

The following labels might appear on your unit:



or



CE label

Complies with applicable European directives.



Hazardous voltage

Voltage > 30 V<sub>RMS</sub>, 42.4 V peak, or 60 VDC



Hot surface



Refer to manual for more information

## PRODUCT COMPLIANCE

The following sections include information about unit compliance and certification, including the conditions of use required to be in compliance with the standards and directives.

### Product Certification

Certain options of this product may be certified according to the list below.

For more information, refer to the Certificate or Letter of Conformity (US) or Declaration of Conformity (EU) accompanying the product.

- NRTL – Safety certified by CSA International, a Nationally Recognized Testing Laboratory
- CE Marking – Self-declaration, assessed by AE Corporate Compliance
- EMC measurements – Verified by AE Corporate Compliance
- SEMI® guidelines – Verified by AE Corporate Compliance

### Safety Approvals

CoolX units are compliant with the latest safety approvals and with several future changes in safety standards for medical, industrial, and ITE equipment.

CX10S is certified to IEC60950-1 2nd Edition and is compliant with the upcoming EN62368-1 safety approvals.

CX10M is certified to IEC60601-1 3rd Edition for medical applications.

Galvanic isolation levels follow:

**Table 1-1. CoolX galvanic isolation barriers**

Isolation Barrier	Type	Withstand Voltage
Input to output	Reinforced (2 x MOPP)	4000 VAC
Input to case (GND)	Basic (1 x MOPP)	1850 VAC
Output to case (GND)	Basic (1 x MOPP)	1850 VAC
Output to output (one module to another)	Basic (1 x MOPP)	1850 VAC

**Table 1-1. CoolX galvanic isolation barriers (Continued)**

Isolation Barrier	Type	Withstand Voltage
Output to output (within a dual module)	Functional	500 VDC

## LOW VOLTAGE DIRECTIVE (LVD) 2006/95/EC

The LVD applies to equipment with an AC input voltage from 50 V to 1000 V or a DC input voltage from 75 V to 1500 V. The CoolX series is CE marked to show compliance with the LVD.

The relevant European standard for the CX10S model is EN 60950-1 2nd Edition (information technology) and 62368-1 Edition 2. The relevant European standard for the CS10M model is EN60601-1 3rd Edition (Medical Devices Directive).

The full table of safety certifications follows.

**Table 1-2. CoolPac safety certifications**

CoolPac Chassis	Safety Standards	Additional Details
CX10S	IEC/EN 60950-1 Edition 2	UL 60950-1/CSA C22.2 No 60950-1 Edition 2  5000 m (16,404') altitude, 100 VAC to 240 VAC $\pm$ 10%
	IEC 62368-1 Edition 2	IEC 62368-1 (2014) Edition 2  5000 m (16,404') altitude, 100 VAC to 240 VAC $\pm$ 10%
CX10M	IEC/EN 60601-1 Edition 3	IEC 60601-1(2005), EN 60601-1(2006) ANSI/AAMI ES 60601-1(2005)  CAN/CSA C22.2 No. 60601-1 (2008)  5000 m (16,404') altitude, 100 VAC to 240 VAC $\pm$ 10%

## EMC Characteristics

### EMC DIRECTIVE 2004/108/EC

Component power supplies such as the CoolX series are not covered by the EMC directive. It is not possible for any power supply manufacturer to guarantee conformity of the final product to the EMC directive, because performance is critically dependent on the final system configuration. System compliance with the EMC directive is facilitated by this product complying with several of the requirements as shown in [Table 1-3](#). Although CoolX units meet these requirements, the CE mark does not cover this area.

A full EN60601-1-2 4<sup>th</sup> Edition test report is available on request. Contact AE Global Services for details.

**Table 1-3.** EMC characteristics of CoolX unit under load conditions

Parameter	Conditions/Descriptions	Criteria
Radiated emissions	EN55011, EN55022 and FCC, Class B	
Conducted emissions	EN55011, EN55022 and FCC, Class B	
Power line harmonics	EN61000-3-2, Class A	
Voltage flicker	EN61000-3-3	
ESD	EN61000-4-2, Level 4, 8 kV contact, 15 kV air	A
Radiated immunity	EN61000-4-3, Level 3, 10 V/m	A
Electrical fast transient	EN61000-4-4, Level 4, $\pm$ 4 kV	A
Surge immunity	EN61000-4-5, Level 4, 2 kV DM, 4 kV CM	A
Conducted RF immunity	EN61000-4-6, Level 2, 3 V <sub>RMS</sub>	A
Power frequency magnetic field	EN61000-4-8, Level 4, 30 A/m	A

Radiated EMI should be tested in a system environment. Radiated EMI performance in a system will vary significantly from a standalone power supply because the system enclosure provides additional shielding.

## EMC CRITERIA

There are four criteria levels, each referring to a specific performance level of the product during and after the EMC phenomenon is applied. These are specifically observed during immunity testing and are described in the following table:

**Table 1-4. EMC criteria**

Criteria Level	Description
A	The apparatus shall continue to operate as intended. No degradation of performance or loss of function is observed during or after the test.
B	The apparatus shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer when the apparatus is used as intended. During the test, temporary degradation of performance is allowed if it is self recoverable.
C	Temporary loss of function is allowed during and after the test that requires operator intervention to restore the product/apparatus to normal operation.
D	During the test, loss of function that is not recoverable occurs.

## ADDITIONAL EMI CHARACTERIZATION

CoolX units are compliant with SEMI F47 for voltage dips and interruptions. Input voltage must be > 180 VAC.

Contact Advanced Energy Global Services for additional details.

## GUIDELINES FOR OPTIMUM EMC PERFORMANCE

All CoolX products are designed to comply with European Normative limits (EN) for conducted and radiated emissions and immunity when correctly installed in a system. For performance levels attained, refer to [Table 1-3](#). However, power supply compliance with these limits is not a guarantee of system compliance. System EMC performance can be impacted by various system characteristics. Design considerations, such as PCB layout and tracking, cabling arrangements, and orientation of the power supply, among others, all directly contribute to the EMC performance of a system.

Cabling arrangements and PCB tracking layouts are the greatest contributing factors to system EMC performance. It is important that PCB tracks and power cables are arranged to minimize current carrying loops that can radiate, and to minimize loops that could have noise currents induced into them. All cables and PCB tracks should



be treated as radiation sources and antenna, and every effort should be made to minimize their interaction.

Use the following guidelines to optimize CoolX EMC performance:

- Keep all cable lengths as short as possible.
- Use twisted pairs of power cables, with the maximum possible twist, to minimize the area of power carrying loops. This will minimize radiation.
- Run PCB power tracks back to back.
- Use twisted pairs for sense cables, with the maximum possible twist, to minimize noise current induced in signal carrying lines.
- Do not combine power and sense cables in the same harness.
- Ensure good system grounding. System earth should be a starpoint. The power supply earth should be directly connected to the starpoint. All other earths should be of minimum length and directly connected to the starpoint.

## Safety and EMC Directives and Standards

For information concerning compliance to applicable EU requirements, refer to the EU Declaration of Conformity for this unit. The Declaration of Conformity might also include a supplementary section covering compliance to non-EU regulatory requirements and/or industry standards or guidelines.

## Environmental Compliance

- **EU RoHS – European Union Directive 2011/65/EU (RoHS 2)**

Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment

This product is EU 2011/65/EU (RoHS 2) compliant, containing no more than the maximum concentration of hazardous substances listed in Annex II, but might utilize application exemptions in Annex III or IV.

**European Delegated Directive (EU) 2015/863 (RoHS 3) – Amendment to Annex II of Directive 2011/65/EU (RoHS 2) Regarding the List of Restricted Substances**

This product is also compliant to the 2015/863 amendment, containing no more than the maximum concentration of four additional hazardous substances (phthalates) listed in amended Annex II.

- **EU REACH – European Union Regulation (EC) No. 1907/2006**

Registration, Evaluation, Authorization and Restriction of Chemicals

Advanced Energy manufactures articles subject to Article 33 of REACH and, upon request, will provide information regarding Substances of Very High Concern (SVHC) currently identified by the European Chemical Agency

(ECHA) that are contained in this product, at concentrations greater than 0.1% by weight.

# Product Overview

## GENERAL DESCRIPTION

The CoolX1000 unit is a convection-cooled modular power supply that can provide 1000 W with no fan. With an optimum configuration, a CoolX unit can achieve an efficiency of up to 93.5%.

The series comprises two base models: the CX10S for industrial applications and the CX10M for medical applications. A complete power supply consists of a CoolPac chassis populated with up to six CoolMod modules. Each module provides one or two isolated DC outputs, and outputs can range from 1 V to 58 V. Each module output voltage can be individually trimmed to its required setpoint.

You can connect modules in parallel to increase output current, or in series to increase output voltage (subject to staying within isolation ratings and giving due consideration to any SELV requirements). You can connect CoolPac chassis in parallel for higher power and N+1 redundancy applications. For more information, contact AE Global Services.

A signal interface on each module provides control and output sequencing capability and status indicators. Alternatively, digital control and monitoring is accessible through the PMBus® interface.

## CoolPac Options

A CoolX unit has two CoolPac chassis options. The following table describes the two options:

**Table 2-1. CoolPac chassis options**

Chassis	Number of Slots	Power (W)	Approval Type
CX10S	6	1000	Industrial Approval IEC 60950-1 2nd Edition and IEC 62368-1 2nd Edition
CX10M	6	1000	Medical Approval IEC 60601-1 3rd Edition and IEC 60601-1-2 4th Edition (EMC)

The standard CoolPac chassis has the following features:

- AC mains connector or 3-screw terminal block
- Earth leakage current of < 300 µA

The following table describes alternate CoolPac options:

**Table 2-2. CoolPac options**

Option	Description
Option 1: Input connector	The AC mains connector is an IEC320 inlet.
Option 4: Low leakage current 150 $\mu$ A	The leakage current is < 150 $\mu$ A, meant for medical applications using two or more power supplies or containing additional parts that contribute to the system earth leakage current. This ensures that system earth leakage current does not exceed levels defined in IEC60601 3rd Edition.
Option A: 12 V auxiliary voltage	The chassis includes a 12 V/1.97 A isolated bias supply voltage.
Option B: 5 V auxiliary voltage	The chassis includes a 5 V/4.7 A isolated bias supply voltage.
Option L: Enclosed frame	This chassis has an enclosed frame with a lid.

## CoolPac Operation

The CoolPac chassis provides the front end input power to each module. The CoolPac chassis operates off 85 VAC to 264 VAC, 47 Hz to 63 Hz and can withstand 300 VAC input voltage for up to 5 sec. The chassis can operate off up to 440 Hz, but operating off > 63 Hz puts the unit outside the unit safety ratings and approvals. Contact AE Global Services before operating the unit off > 63 Hz.

The chassis can also operate off DC inputs of 125 VDC to 300 VDC. However, operation with DC inputs is not within unit safety ratings and approvals. Contact AE Global Services before operating the unit with DC inputs.

[Table 2-1](#) details each CoolPac version.

## AUXILIARY VOLTAGE (BIAS)

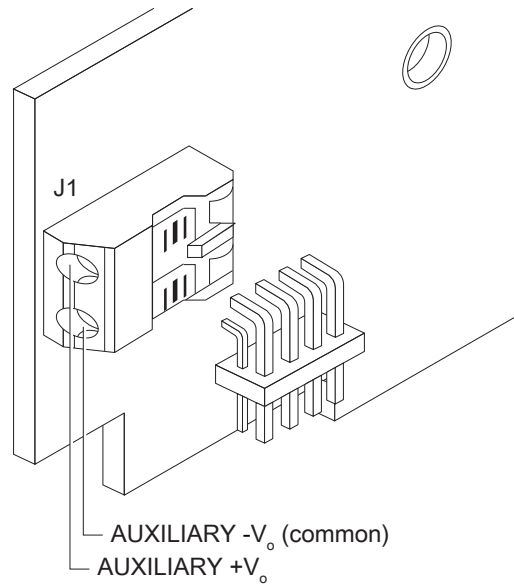
Each CoolPac has an isolated, SELV 24 W auxiliary (always on) voltage of 12 V/ 1.97 A or 5 V/4.7 A (optional). This bias supply is available through the J1 connector and can be used as follows:

- For powering displays
- For system housekeeping
- In control circuits
- As an additional output voltage



## Important

The negative of the auxiliary ( $-V_o$ ) is connected to the common of the system signal connector.

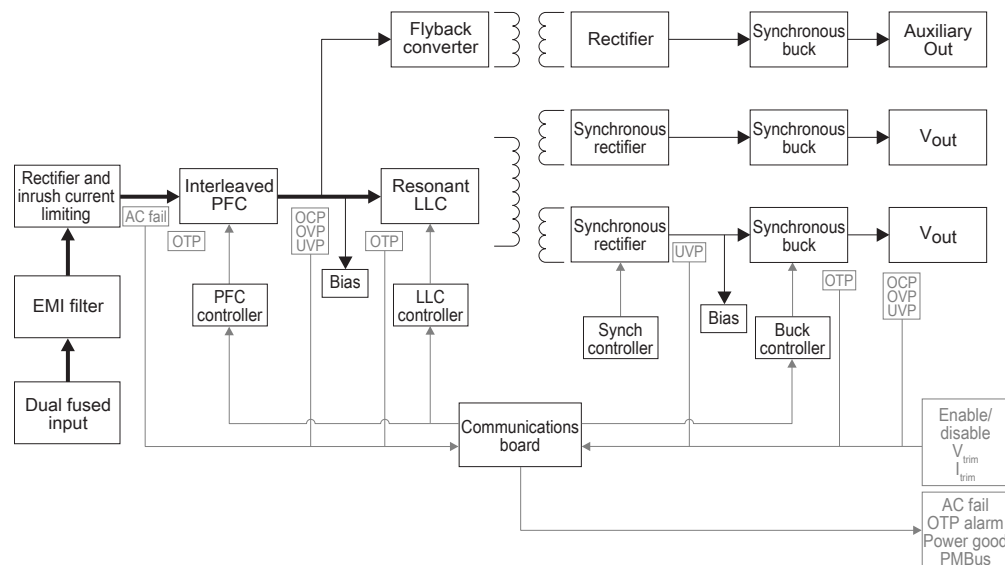


**Figure 2-1.** J1 auxiliary output connector

Refer to “Communication Controls” on page 5-1 for more details.

## THEORY OF OPERATION

The CoolX platform comprises a CoolPac chassis and CoolMod DC output modules, all selected to deliver the volts and amps required by the system designer. An operational block diagram follows:



**Figure 2-2.** Operational block diagram

The chassis is an open-frame chassis containing circuitry for an offline, single-phase, AC front end; an EMI filter; and a customer interface and associated housekeeping circuits. Input AC mains voltage (L, N, and GND) is applied to either a screw terminal input block or an IEC type input connector (optional), and then through an EMI filter designed to meet EN55022 Class B. Some applications might require an external ferrite on cabling to meet Class B radiated EMI. Contact AE Global Services for recommendations.

For medical applications, the EMI filter also ensures that the power supply meets the low earth leakage current requirements of EN60601-1 3rd Edition. All modules provide medical isolation of 4000 VAC (2 x MOPP) from input to output and extended isolation of 1850 VAC from output to earth.

**Important**

1 x MOPP requirement is 1500 VAC.

A 24 W auxiliary, always-on, isolated bias supply of 12 VDC or 5 VDC (optional) is provided for peripheral use. This bias supply also has medical isolation of 4000 VAC (2 x MOPP).

Modules provide isolated DC outputs. These can be set to the required voltage setpoints by the user or factory as required. Each module has its own discrete controls. Refer to [“Communication Controls”](#) on page 5-1 for more details.

To see the galvanic isolation barriers for a configured CoolX unit, refer to [Table 1-1](#).

# Specifications

## PHYSICAL SPECIFICATIONS

**Table 3-1. Physical specifications**

Description	Specification
<b>General</b>	
Size	41 mm (H) x 164 mm (W) x 260 mm (L) 1.6" (H) x 6.5" (W) x 10.2" (L)
Weight	1.6 kg (3.5 lb) – chassis + 6 x modules
<b>Mounting</b>	
Mechanical	Four mounting holes on base for M4 screws  Two mounting holes on each side for M3 screws  The CoolX unit can be mounted on its base or on its side. It can also be mounted on the Excelsys DIN rail accessory.
<b>Connectors</b>	
AC/DC input terminal block	TE 2-1437667-S, DINKLE DT-31-B01W-03
AC/DC IEC input (option)	IEC 320 inlet
Main DC output terminal block	M4 screws
System signal connector J1007	8-way Molex® 87833-0831  Mating connectors: <ul style="list-style-type: none"> <li>• Locking Molex 51110-0860</li> <li>• Non-locking Molex 51110-0850</li> <li>• Locking and polarizing Molex 51110-0856</li> <li>• Crimp terminal – Molex p/n 50394</li> </ul>
Output signal connectors J1001 – J1006	6-way Molex 87833-0631  Mating connectors: <ul style="list-style-type: none"> <li>• Locking Molex 51110-0660</li> <li>• Non-locking Molex 51110-0650</li> <li>• Locking and polarizing Molex 51110-0656</li> </ul>

**Table 3-1. Physical specifications (Continued)**

Description	Specification
	<ul style="list-style-type: none"> <li>• Crimp terminal – Molex p/n 50394</li> </ul>
Output sense connectors J3	JST-S2BPH-K(LF)(SN) Mating connectors: <ul style="list-style-type: none"> <li>• JST PHR2</li> <li>• Crimp terminal – JST BPH-002T-P.0.5S or SPH-002T-P.05S</li> </ul>
Auxiliary output connector J1	Molex 1041880210 2-pin

## ELECTRICAL SPECIFICATIONS

The nominal values of the following specifications apply when the unit operates at 25°C (77°F) with nominal output voltage.

**Table 3-2. Electrical specifications**

Description	Specification
<b>Electrical Requirements</b>	
AC operating input range	85 VAC to 264 VAC
Frequency range	Universal input 47 Hz to 440 Hz <sup>[1]</sup>
DC input voltage range	120 VDC to 300 VDC <sup>[2]</sup>
Input current	8.5 A at 90 VAC, 620 W
Inrush current	Maximum 25 A at 230 VAC, 1000 W
Input fuses rating	10 A, 500 VAC dual-fused (line and neutral)
Power rating	1000 W Refer to the derating curves in <a href="#">“Power Ratings”</a> .
<b>Module Output</b>	
Module outputs vary between modules. For specific module outputs, see the following sections:	
<ul style="list-style-type: none"> <li>• <a href="#">“Standard Module Specifications”</a> on page 3-4</li> <li>• <a href="#">“Bulk Module Specifications”</a> on page 3-9</li> <li>• <a href="#">“Dual Module Specifications”</a> on page 3-12</li> <li>• <a href="#">“Wide-trim Module Specifications”</a> on page 3-15</li> </ul>	



**Table 3-2. Electrical specifications (Continued)**

Description	Specification	
Auxiliary Output		
Nominal output voltage	Aux Voltage Option A	Aux Voltage Option B
	Nominal 12 V	Nominal 5 V
	Minimum 11.6 V	Minimum 4.8 V
	Maximum 12.4 V	Maximum 5.2 V
Load regulation	± 2%	
Line regulation	± 0.5% (for ± 10% change from nominal line)	
Output current (maximum)	Aux Voltage Option A	Aux Voltage Option B
	1.96 A	4.7 A
Output capacitive load (maximum)	1,000 µF	
Output overcurrent protection	105% to 145% (hiccup condition)	
Short circuit protection	Yes, autorecovery	
Leakage Currents (at mains voltage 264 VAC/60 Hz)		
Type	AC leakage current (input to earth ground)	Touch current
Normal condition	<300 µA	<100 µA
Single fault condition	<500 µA	<500 µA
Operational Limits		
Extended AC operating range	300 VAC for a maximum of 5 secs	
Electrical efficiency	> 93.5% at 230 VAC, 1000 W with a CmB, CmC, CmD, and CmF module	
Power factor	> 0.99 at full rated power, nominal line conditions	
Undervoltage lockout	68 VAC to 78 VAC, shutdown	
<sup>1</sup> Operating off > 63 Hz puts the unit outside the unit safety ratings and approvals. Contact AE Global Services before operating the unit off > 63 Hz.		
<sup>2</sup> Operation with DC inputs is not within unit safety ratings and approvals. Contact AE Global Services before operating the unit with DC inputs.		

## Standard Module Specifications

Standard modules include CmA, CmB, CmC, and CmD modules. The following tables provide specifications for standard modules.

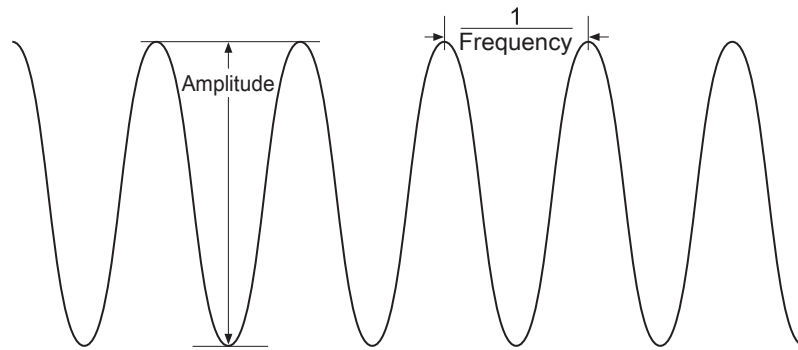
**Table 3-3. General standard module outputs**

Model	Nominal Voltage, $V_{nom}$ (V)	Setpoint Voltage Adjust, $V_{set}$ (V)	OVP Tracking (% of $V_{set}$ )	OVP All Module Hiccup (% of $V_{max}$ )	Maximum Current, $I_{max}$ (A)	Current Limit, $I_{lim}$ (%)	Maximum Power, $P_{max}$ (W)
CmA	5	2.5 – 6	103 – 125	125 – 160	21	105 – 130	105
CmB	12	6 – 15	103 – 125	113.3 – 140	15	105 – 130	180
CmC	24	15 – 28	103 – 125	114 – 132	8.33	105 – 130	200
CmD	48	28 – 58	103 – 125	107 – 120	4.16	105 – 130	200

Each type of CoolMod module has unique specifications. The following figures and tables detail specifications for each type of module:

**Table 3-4. Standard module ratings specifications**

Parameter	Value Type	CmA	CmB	CmC	CmD
Output voltage (rated voltage range)	Minimum	2.5 V	6 V	15 V	28 V
	Nominal/Typical	5 V	12 V	24 V	48 V
	Maximum	6 V	15 V <sup>[1]</sup>	28 V	58 V
Initial setting accuracy, deviation (factory set)	Maximum	10 mV	10 mV	20 mV	50 mV
Maximum output current <sup>[2]</sup>	Maximum	21 A	15 A	8.33 A	4.16 A
Maximum output power <sup>[3]</sup>	Maximum	105 W	180 W	200 W	200 W
Capacitive loading (monotonic startup)	Maximum	20 mF	10 mF	8 mF	4.7 mF
<sup>1</sup> Transient requirements might not be met if module is trimmed above 13 V <sup>2</sup> Maximum output current is derated by 10% when a module is used in parallel <sup>3</sup> Maximum output power is derated by 10% when a module is used in parallel					



**Figure 3-1.** Module ripple and noise

**Table 3-5.** Standard module ripple and noise specifications

Parameter	Value Type	CmA	CmB	CmC	CmD
Output ripple and noise (20 MHz bandwidth)	Nominal/ Typical	75 mV	80 mV	90 mV	105 mV
	Maximum	100 mV	150 mV	240 mV	480 mV
Output ripple frequency	Minimum	220 kHz	220 kHz	220 kHz	220 kHz
	Nominal/ Typical	240 kHz	240 kHz	240 kHz	240 kHz
	Maximum	260 kHz	260 kHz	260 kHz	260 kHz

**Table 3-6.** Standard module regulation specifications

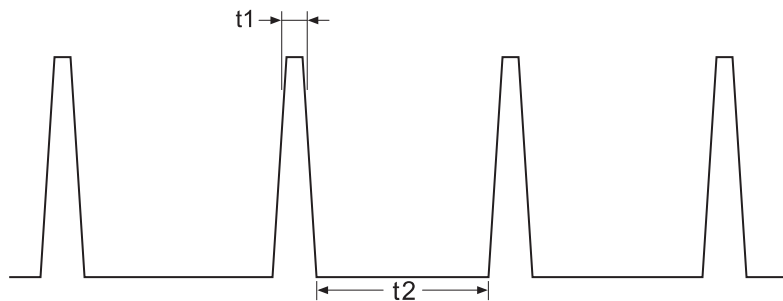
Parameter	Value Type	CmA	CmB	CmC	CmD
Load regulation	Nominal/ Typical	0.2 mV/A	0.3 mV/A	1.2 mV/A	2.4 mV/A
	Maximum	1.0 mV/A	1.6 mV/A	5.8 mV/A	23 mV/A
Load regulation (paralleled)	Minimum	2.4 mV/A	10 mV/A	54 mV/A	202 mV/A
	Maximum	4.3 mV/A	12.6 mV/A	59.2 mV/A	215 mV/A
Line regulation (85 VAC to 264 VAC)	Nominal/ Typical	2 mV	2 mV	4 mV	10 mV
	Maximum	10 mV	12 mV	24 mV	48 mV

All standard modules have a temperature regulation coefficient of 0.02%/°C.

**Table 3-7. Standard module protective limits specifications**

Parameter	Value Type	CmA	CmB	CmC	CmD
Current limit (brick-wall limit, autorecovery)	Minimum	22 A	15.7 A	8.7 A	4.3 A
	Nominal/Typical	23.1 A	16.5 A	9.2 A	4.6 A
	Maximum	27.3 A	19.5 A	10.8 A	5.4 A
Short circuit current (RMS)	Maximum	10.5 A	7.5 A	4.2 A	2.1 A
Power limit (voltage foldback, autorecovery)	Minimum	110 W	190 W	210 W	210 W
	Nominal/Typical	130 W	220.5 W	232 W	230 W
	Maximum	137 W	234 W	260 W	260 W
Overvoltage protection (hiccup, autorecovery)	Minimum	7.5 V	17 V	32 V	62 V
	Nominal/Typical	8 V	19.8 V	35 V	62.2 V
	Maximum	9.6 V	21 V	37 V	69.6 V
Sense lead protection (hiccup, autorecovery)	Maximum	3.1 V	3.1 V	3.1 V	3.1 V

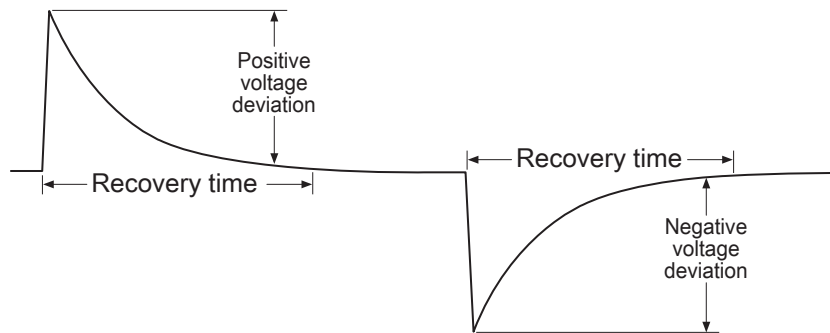
In [Figure 3-2](#), t1 is the hiccup timing (on-time) and t2 is the hiccup timing (off-time). [Table 3-8](#) contains t1 and t2 values for each type of CoolMod module.

**Figure 3-2. Module hiccup characteristics****Table 3-8. Standard module hiccup characteristics specifications**

Parameter	Value Type	CmA	CmB	CmC	CmD
Hiccup timing (on-time)	Minimum	1 ms	1 ms	1 ms	1 ms
	Nominal/Typical	50 ms	50 ms	50 ms	50 ms
	Maximum	100 ms	100 ms	100 ms	100 ms

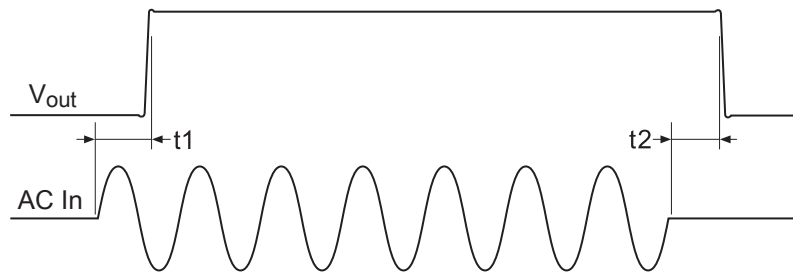
**Table 3-8. Standard module hiccup characteristics specifications (Continued)**

Parameter	Value Type	CmA	CmB	CmC	CmD
Hiccup timing (off-time)	Minimum	900 ms	900 ms	900 ms	900 ms
	Nominal/Typical	1000 ms	1000 ms	1000 ms	1000 ms
	Maximum	1200 ms	1200 ms	1200 ms	1200 ms
Short circuit hiccup level	Minimum	1.0 V	3.5 V	7.2 V	14.3 V
	Nominal/Typical	1.4 V	5.3 V	8.1 V	16.2 V
	Maximum	2.0 V	5.7 V	9.6 V	19.8 V

**Figure 3-3. Module transient response****Table 3-9. Standard module transient response specifications**

Parameter	Value Type	CmA	CmB	CmC	CmD
<b>25% to 75% Load Change</b>					
Voltage deviation	Nominal/Typical	0.2 V	0.3 V	0.4 V	0.7 V
	Maximum	0.3 V	0.48 V	0.96 V	0.96 V
Recovery time	Nominal/Typical	50 $\mu$ s	50 $\mu$ s	50 $\mu$ s	50 $\mu$ s
	Maximum	500 $\mu$ s	500 $\mu$ s	500 $\mu$ s	500 $\mu$ s
<b>10% to 100% Load Change</b>					
Voltage deviation	Nominal/Typical	0.5 V	1 V	1.3 V	1.7 V
	Maximum	0.6 V	1.2 V	1.8 V	2.4 V
Recovery time	Nominal/Typical	100 $\mu$ s	100 $\mu$ s	100 $\mu$ s	100 $\mu$ s
	Maximum	1 ms	1 ms	1 ms	1 ms

In [Figure 3-4](#),  $t_1$  is the turn-on delay and  $t_2$  is the hold-up. [Table 3-10](#) contains  $t_1$  and  $t_2$  values for each type of CoolMod module.

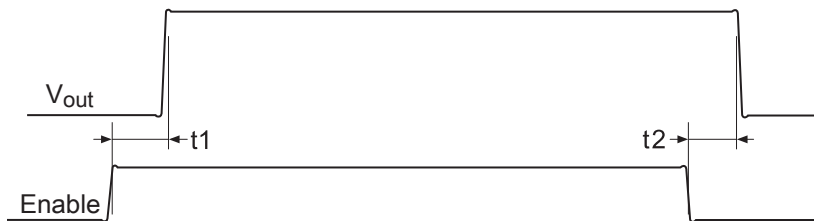


**Figure 3-4.** Module startup/shutdown timing

**Table 3-10.** Standard module startup/shutdown timing specifications

Parameter	Value Type	CmA	CmB	CmC	CmD
Turn-on delay, $t_1$ (from input AC to $V_{out}$ )	Nominal/Typical	640 ms	640 ms	640 ms	640 ms
	Maximum	1000 ms	1000 ms	1000 ms	1000 ms
Hold-up, $t_2$ (from loss of AC to loss of $V_{out}$ )	Minimum	16 ms	16 ms	16 ms	16 ms
	Nominal/Typical	20 ms	20 ms	20 ms	20 ms

In [Figure 3-5](#),  $t_1$  is the enable delay and  $t_2$  is the disable delay. [Table 3-11](#) contains  $t_1$  and  $t_2$  values for each type of CoolMod module.



**Figure 3-5.** Module enable/disable timing

**Table 3-11.** Standard module enable/disable timing specifications

Parameter	Value Type	CmA	CmB	CmC	CmD
Enable delay, $t_1$ (enable to $V_{out}$ )	Nominal/Typical	8.5 ms	8.5 ms	8.5 ms	8.5 ms
	Maximum	15 ms	15 ms	15 ms	15 ms
Rise time (from 10 to 90% of $V_{out}$ )	Minimum	1 ms	1 ms	1 ms	1 ms
	Nominal/Typical	2.5 ms	2.5 ms	2.5 ms	2.5 ms
	Maximum	5 ms	5 ms	5 ms	5 ms

**Table 3-11. Standard module enable/disable timing specifications**  
(Continued)

Parameter	Value Type	CmA	CmB	CmC	CmD
Disable delay, t <sub>2</sub> (from disable to loss of V <sub>out</sub> )	Nominal/ Typical	3 ms	3 ms	3 ms	3 ms
	Maximum	8 ms	8 ms	8 ms	8 ms
Fall time (from 90 to 10% of V <sub>out</sub> )	Minimum	0.1 ms	0.1 ms	0.1 ms	0.1 ms
	Nominal/ Typical	0.35 ms	0.35 ms	0.35 ms	0.35 ms
	Maximum	3 ms	3 ms	3 ms	3 ms

## Bulk Module Specifications

Bulk modules include CmE and CmF modules. The following tables provide specifications for bulk modules.

**Table 3-12. General bulk module outputs**

Model	Nominal Voltage, V <sub>nom</sub> (V)	Setpoint Voltage Adjust, V <sub>set</sub> (V)	OVP Tracking (% of V <sub>set</sub> )	OVP All Module Hiccup (% of V <sub>max</sub> )	Maximum Current, I <sub>max</sub> (A)	Current Limit, I <sub>lim</sub> (%)	Maximum Power, P <sub>max</sub> (W)
CmE	24	24 – 25.2	N/A	107 – 129	25	105 – 130	600
CmF	48	48 – 50.4	N/A	109 – 123	12.5	105 – 130	600

Each type of bulk module has unique specifications. The following figures and tables detail specifications for each type of bulk module.

**Table 3-13. Bulk module ratings specifications**

Parameter	Value Type	CmE	CmF
Output voltage (rated voltage range)	Minimum	24 V	48 V
	Nominal/ Typical	24 V	48 V
	Maximum	25.2 V	50.4 V
Initial setting accuracy, deviation (factory set)	Maximum	20 mV	20 mV
Maximum output current	Maximum	25 A	12.5 A
Maximum output power	Maximum	600 W	600 W
Capacitive loading	Maximum	10 mF	2.5 mF

For an illustration of the module ripple and noise, see [Figure 3-1](#) on page 3-5.

**Table 3-14. Bulk module ripple and noise specifications**

Parameter	Value Type	CmE	CmF
Output ripple and noise (20 MHz bandwidth)	Nominal/Typical	240 mV	480 mV
	Maximum	480 mV	1440 mV
Output ripple frequency <sup>[1]</sup>	Minimum	200 kHz	200 kHz
	Nominal/Typical	240 kHz	240 kHz
	Maximum	350 kHz	350 kHz
<sup>1</sup> Has an additional line frequency component			

**Table 3-15. Bulk module regulation specifications**

Parameter	Value Type	CmE	CmF
Load regulation	Nominal/Typical	TBD	TBD
	Maximum	TBD	TBD
Line regulation (85 VAC to 264 VAC)	Nominal/Typical	50 mV	50 mV
	Maximum	120 mV	240 mV

All bulk modules have a temperature regulation coefficient of 0.02%/°C.

**Table 3-16. Bulk module protective limits specifications**

Parameter	Value Type	CmE	CmF
Current limit (hiccup, autorecovery)	Minimum	26.25 A	13.13 A
	Nominal/Typical	29 A	14 A
	Maximum	32.5 A	16.25 A
Short circuit current limit (measured over 5 hiccup cycles)	Maximum	5 A	2.5 A
Power limit (hiccup, autorecovery)	Minimum	630 W	630 W
	Nominal/Typical	695 W	670 W
	Maximum	780 W	780 W
Overvoltage protection (hiccup, autorecovery)	Minimum	27.5 V	55 V
	Nominal/Typical	30.5 V	59 V
	Maximum	32.5 V	62 V



In [Figure 3-2](#) on page 3-6, t1 is the hiccup timing (on-time) and t2 is the hiccup timing (off-time). [Table 3-17](#) contains t1 and t2 values for each type of bulk module.

**Table 3-17. Bulk module hiccup characteristics specifications**

Parameter	Value Type	CmE	CmF
Hiccup timing (on-time)	Nominal/Typical	0.5 ms	0.5 ms
	Maximum	50 ms	50 ms
Hiccup timing (off-time)	Minimum	950 ms	950 ms
	Nominal/Typical	1000 ms	1000 ms
	Maximum	7000 ms	7000 ms
Short circuit hiccup level	Minimum	26.25 A	13.13 A
	Nominal/Typical	29 A	14 A
	Maximum	32.5 A	16.25 A

For an illustration of the module transient response, see [Figure 3-3](#) on page 3-7.

**Table 3-18. Bulk module transient response specifications**

Parameter	Value Type	CmE (25% to 75% Load Change)	CmF (25% to 100% Load Change)
Voltage deviation	Nominal/Typical	0.5 V	1 V
	Maximum	0.96 V	1.92 V
Recovery time	Nominal/Typical	400 $\mu$ s	400 $\mu$ s
	Maximum	1000 $\mu$ s	1000 $\mu$ s

In [Figure 3-4](#) on page 3-8, t1 is the turn-on delay and t2 is the hold-up. [Table 3-19](#) contains t1 and t2 values for each type of bulk module.

**Table 3-19. Bulk module startup/shutdown timing specifications**

Parameter	Value Type	CmE	CmF
Turn-on delay, t1 (from input AC to V <sub>out</sub> )	Nominal/Typical	640 ms	640 ms
	Maximum	1000 ms	1000 ms
Hold-up, t2 (from loss of AC to loss of V <sub>out</sub> )	Minimum	16 ms	16 ms
	Nominal/Typical	20 ms	20 ms

In [Figure 3-5](#) on page 3-8, t1 is the enable delay and t2 is the disable delay. [Table 3-20](#) contains t1 and t2 values for each type of bulk module.

**Table 3-20. Bulk module enable/disable timing specifications**

Parameter	Value Type	All Mods
Enable delay, t1 (enable to $V_{out}$ )	Nominal/Typical	6 ms
	Maximum	20 ms
Rise time (from 10% to 90% of $V_{out}$ )	Minimum	2 ms
	Nominal/Typical	4 ms
	Maximum	5 ms
Disable delay, t2 (from disable to loss of $V_{out}$ )	Nominal/Typical	3 ms
	Maximum	10 ms
Fall time (from 90% to 10% of $V_{out}$ )	Minimum	0.01 ms
	Nominal/Typical	0.7 ms
	Maximum	8 ms

## Dual Module Specifications

Dual modules include CmG and CmH modules. The following tables provide specifications for dual modules.

**Table 3-21. General dual module outputs**

Model	Nominal Voltage, $V_{nom}$ (V)	Setpoint Voltage Adjust, $V_{set}$ (V)	OVP Tracking (% of $V_{set}$ )	OVP All Module Hiccup (% of $V_{max}$ )	Maximum Current, $I_{max}$ (A)	Current Limit, $I_{lim}$ (%)	Maximum Power, $P_{max}$ (W)
CmG	24	3 – 30	N/A	110 – 130	3	180 – 330	90 per output
	24				3		120 total
CmH	5	3 – 6	N/A	115 – 125	6	166 – 250	100 total
	24	3 – 30		110 – 130	3	180 – 330	

Each type of dual module has unique specifications. The following figures and tables detail specifications for each type of dual module.

**Table 3-22. Dual module ratings specifications**

Parameter	Value Type	CmG ( $V_1$ and $V_2$ )	CmH ( $V_1$ )	CmH ( $V_2$ )
Output voltage (rated voltage range)	Minimum	3 V	3 V	3 V
	Nominal/Typical	24 V	5 V	24 V

**Table 3-22. Dual module ratings specifications (Continued)**

Parameter	Value Type	CmG (V <sub>1</sub> and V <sub>2</sub> )	CmH (V <sub>1</sub> )	CmH (V <sub>2</sub> )
	Maximum	30 V	6 V	30 V
Initial setting accuracy, deviation (factory set)	Maximum	40 mV	40 mV	40 mV
Maximum output current	Maximum	3 A	6 A	3 A
Maximum output power per channel	Maximum	90 W	36 W	90 W
Total output power (both channels)	Maximum	120 W	100 W	100 W
Capacitive loading	Maximum	6.6 mF/V <sub>o</sub>	13.2 mF/V <sub>o</sub>	6.6 mF/V <sub>o</sub>

For an illustration of the module ripple and noise, see [Figure 3-1](#) on page 3-5.

**Table 3-23. Dual module ripple and noise specifications**

Parameter	Value Type	CmG (V <sub>1</sub> and V <sub>2</sub> )	CmH (V <sub>1</sub> )	CmH (V <sub>2</sub> )
Output ripple and noise (20 MHz bandwidth)	Nominal/ Typical	80 mV	30 mV	80 mV
	Maximum	240 mV	100 mV	240 mV
Output ripple frequency	Minimum	175 kHz	175 kHz	175 kHz
	Nominal/ Typical	200 kHz	200 kHz	200 kHz
	Maximum	220 kHz	220 kHz	220 kHz

**Table 3-24. Dual module regulation specifications**

Parameter	Value Type	CmG (V <sub>1</sub> and V <sub>2</sub> )	CmH (V <sub>1</sub> )	CmH (V <sub>2</sub> )
Load regulation (0% to 100% load)	Nominal/ Typical	35 mV/A	12 mV/A	35 mV/A
	Maximum	160 mV/A	16.6 mV/A	160 mV/A
Line regulation (85 VAC to 264 VAC)	Nominal/ Typical	15 mV	5 mV	15 mV
	Maximum	120 mV	25 mV	120 mV

All dual modules have a temperature regulation coefficient of 0.02%/°C.

**Table 3-25. Dual module protective limits specifications**

Parameter	Value Type	CmG (V <sub>1</sub> and V <sub>2</sub> )	CmH (V <sub>1</sub> )	CmH (V <sub>2</sub> )
Current limit (constant limit into hiccup, autorecovery)	Minimum	5.5 A	10 A	5.5 A
	Maximum	10 A	15 A	10 A
Short circuit current limit (measured over 5 hiccup cycles)	Nominal/Typical	1.5 A	2.8 A	1.5 A
	Maximum	2.5 A	5 A	2.5 A
Overvoltage protection (hiccup, autorecovery)	Minimum	33 V	6.9 V	33 V
	Maximum	39 V	7.5 V	39 V

For an illustration of the module transient response, see [Figure 3-3](#) on page 3-7.

**Table 3-26. Dual module transient response specifications (25% to 75% load change)**

Parameter	Value Type	CmG (V <sub>1</sub> and V <sub>2</sub> )	CmH (V <sub>1</sub> )	CmH (V <sub>2</sub> )
Voltage deviation	Nominal/Typical	400 mV	TBD	400 mV
	Maximum	960 mV	TBD	960 mV
Recovery time	Nominal/Typical	600 μs	600 μs	600 μs
	Maximum	1000 μs	1000 μs	1000 μs

In [Figure 3-4](#) on page 3-8, t<sub>1</sub> is the turn-on delay and t<sub>2</sub> is the hold-up. [Table 3-27](#) contains t<sub>1</sub> and t<sub>2</sub> values for each type of dual module.

**Table 3-27. Dual module startup/shutdown timing specifications**

Parameter	Value Type	All Modules
Turn-on delay, t <sub>1</sub> (from input AC to V <sub>out</sub> )	Nominal/Typical	700 ms
	Maximum	1000 ms
Hold-up, t <sub>2</sub> (from loss of AC to loss of V <sub>out</sub> )	Minimum	16 ms
	Nominal/Typical	20 ms

In [Figure 3-5](#) on page 3-8, t<sub>1</sub> is the enable delay and t<sub>2</sub> is the disable delay. [Table 3-28](#) contains t<sub>1</sub> and t<sub>2</sub> values for each type of dual module.

**Table 3-28. Dual module enable/disable timing specifications**

Parameter	Value Type	All Modules
Enable delay, t <sub>1</sub> (enable to V <sub>out</sub> )	Nominal/Typical	15 ms
	Maximum	100 ms
Rise time (from 10% to 90% of V <sub>out</sub> )	Minimum	8 ms
	Nominal/Typical	14 ms
	Maximum	20 ms
Disable delay, t <sub>2</sub> (from disable to loss of V <sub>out</sub> )	Minimum	0.1 ms
	Nominal/Typical	0.5 ms
	Maximum	5 ms
Fall time (from 90% to 10% of V <sub>out</sub> )	Minimum	0.05 ms
	Nominal/Typical	0.4 ms
	Maximum	1.3 ms

## Wide-trim Module Specifications

Wide-trim modules include CmA-W01, CmB-W01, CmC-W01, and CmD-W01 modules. The following tables provide specifications for wide-trim modules.

**Table 3-29. General wide-trim module outputs**

Model	Nominal Voltage, V <sub>nom</sub> (V)	Setpoint Voltage Adjust, V <sub>set</sub> (V)	OVP Tracking (% of V <sub>set</sub> )	OVP All Module Hiccup (% of V <sub>max</sub> )	Maximum Current, I <sub>max</sub> (A)	Current Limit, I <sub>lim</sub> (%)	Maximum Power, P <sub>max</sub> (W)
CmA-W01	5	1 – 6	103 – 125	112 – 150	21	105 – 130	105
CmB-W01	12	1 – 15	103 – 125	113 – 140	15	105 – 130	180
CmC-W01	24	2 – 28	103 – 125	114 – 132	8.33	105 – 130	200
CmD-W01	48	3 – 58	103 – 125	107 – 115	4.17	105 – 130	200

Each type of wide-trim module has unique specifications. The following figures and tables detail specifications for each type of wide-trim module.

**Table 3-30. Wide-trim module ratings specifications**

Parameter	Value Type	CmA-W01	CmB-W01	CmC-W01	CmD-W01
Output voltage (rated voltage range)	Minimum	1 V	1 V	2 V	3 V
	Nominal/Typical	5 V	12 V	24 V	48 V
	Maximum	6 V	15 V <sup>[1]</sup>	28 V	58 V
Initial setting accuracy, deviation (factory set)	Maximum	20 mV	30 mV	40 mV	100 mV
Maximum output current <sup>[2]</sup>	Maximum	21 A	15 A	8.33 A	4.17 A
Maximum output power <sup>[3]</sup>	Maximum	105 W	180 W	200 W	200 W
Capacitive loading (monotonic startup)	Maximum	20 mF	10 mF	8 mF	4.7 mF
<sup>1</sup> Full dynamic specifications might not be met at full load when you trim a CmB-W01 module above 13 V in a CoolX unit <sup>2</sup> Maximum output current is derated by 5% when a module is used in parallel <sup>3</sup> Maximum output power is derated by 5% when a module is used in parallel					

For an illustration of the module ripple and noise, see [Figure 3-1](#) on page 3-5.

**Table 3-31. Wide-trim module ripple and noise specifications**

Parameter	Value Type	CmA-W01	CmB-W01	CmC-W01	CmD-W01
Output ripple and noise (20 MHz bandwidth)	Nominal/Typical	75 mV	80 mV	90 mV	105 mV
	Maximum	100 mV	150 mV	240 mV	480 mV
Output ripple frequency	Minimum	220 kHz	220 kHz	220 kHz	220 kHz
	Nominal/Typical	240 kHz	240 kHz	240 kHz	240 kHz
	Maximum	260 kHz	260 kHz	260 kHz	260 kHz

**Table 3-32. Wide-trim module regulation specifications**

Parameter	Value Type	CmA-W01	CmB-W01	CmC-W01	CmD-W01
Load regulation	Nominal/Typical	0.2 mV/A	0.3 mV/A	1.2 mV/A	2.4 mV/A
	Maximum	0.95 mV/A	3.2 mV/A	11.5 mV/A	46 mV/A

**Table 3-32. Wide-trim module regulation specifications (Continued)**

Parameter	Value Type	CmA-W01	CmB-W01	CmC-W01	CmD-W01
Load regulation (paralleled)	Minimum	2.3 mV/A	10.3 mV/A	48 mV/A	153 mV/A
	Maximum	4.3 mV/A	15.4 mV/A	67 mV/A	230 mV/A
Line regulation	Nominal/Typical	2 mV	2 mV	4 mV	10 mV
	Maximum	12.5 mV	30 mV	60 mV	120 mV

All wide-trim modules have a temperature regulation coefficient of 0.02%/°C.

**Table 3-33. Wide-trim module protective limits specifications**

Parameter	Value Type	CmA-W01	CmB-W01	CmC-W01	CmD-W01
Current limit (constant current limit into hiccup, autorecovery)	Minimum	22 A	15.7 A	8.7 A	4.3 A
	Nominal/Typical	23.1 A	16.5 A	9.2 A	4.6 A
	Maximum	27.3 A	19.5 A	10.8 A	5.4 A
Short circuit current limit (measured over 5 hiccup cycles)	Nominal/Typical	1 A	0.7 A	1 A	0.5 A
	Maximum	15.75 A	11.25 A	6.25 A	3.12 A
Power limit (voltage foldback into hiccup, autorecovery)	Minimum	110 W	190 W	210 W	210 W
	Nominal/Typical	130 W	220 W	230 W	230 W
	Maximum	137 W	234 W	260 W	260 W
Overvoltage protection (hiccup, autorecovery)	Minimum	7.5 V	17 V	32 V	62 V
	Nominal/Typical	8 V	19.8 V	35 V	62.2 V
	Maximum	9.6 V	21 V	37 V	69.6 V
Sense lead protection (shutdown, autorecovery)	Maximum	3.1 V	3.1 V	3.1 V	3.1 V

In [Figure 3-2](#), t1 is the hiccup timing (on-time) and t2 is the hiccup timing (off-time). [Table 3-34](#) contains t1 and t2 values for each type of wide-trim module.

**Table 3-34.** Wide-trim module hiccup characteristics specifications

Parameter	Value Type	CmA-W01	CmB-W01	CmC-W01	CmD-W01
Hiccup timing (on-time)	Minimum	1 ms	1 ms	1 ms	1 ms
	Nominal/Typical	5 ms	5 ms	5 ms	5 ms
	Maximum	200 ms	200 ms	200 ms	200 ms
Hiccup timing (off-time)	Minimum	900 ms	900 ms	900 ms	900 ms
	Nominal/Typical	990 ms	990 ms	990 ms	990 ms
	Maximum	1200 ms	1200 ms	1200 ms	1200 ms
Short circuit hiccup level	Minimum	0.4 V	0.4 V	0.5 V	1.1 V
	Minimum	0.9 V	0.9 V	1.8 V	2.5 V

For an illustration of the module transient response, see [Figure 3-3](#) on page 3-7.

**Table 3-35.** Wide-trim module transient response specifications

Parameter	Value Type	CmA-W01	CmB-W01	CmC-W01	CmD-W01
<b>25% to 75% Load Change</b>					
Voltage deviation	Nominal/Typical	0.2 V	0.3 V	0.4 V	0.7 V
	Maximum	0.5 V	0.5 V	1 V	1 V
Recovery time	Nominal/Typical	50 $\mu$ s	50 $\mu$ s	50 $\mu$ s	50 $\mu$ s
	Maximum	500 $\mu$ s	500 $\mu$ s	500 $\mu$ s	500 $\mu$ s
<b>10% to 100% Load Change</b>					
Voltage deviation	Nominal/Typical	0.5 V	1 V	1.3 V	1.7 V
	Maximum	0.6 V	1.2 V	1.8 V	2.4 V
Recovery time	Nominal/Typical	100 $\mu$ s	100 $\mu$ s	100 $\mu$ s	100 $\mu$ s
	Maximum	1 ms	1 ms	1 ms	1 ms

In [Figure 3-4](#) on page 3-8, t1 is the turn-on delay and t2 is the hold-up. [Table 3-36](#) contains t1 and t2 values for each type of wide-trim module.



**Table 3-36.** Wide-trim module startup/shutdown timing specifications

Parameter	Value Type	All Modules
Turn-on delay, t1 (from input AC to $V_{out}$ )	Nominal/Typical	640 ms
	Maximum	1000 ms
Hold-up, t2 (from loss of AC to loss of $V_{out}$ )	Minimum	16 ms
	Nominal/Typical	20 ms

In [Figure 3-5](#) on page 3-8, t1 is the enable delay and t2 is the disable delay. [Table 3-37](#) contains t1 and t2 values for each type of wide-trim module.

**Table 3-37.** Wide-trim module enable/disable timing specifications

Parameter	Value Type	All Modules
Enable delay, t1 (enable to $V_{out}$ )	Nominal/Typical	10 ms
	Maximum	15 ms
Rise time (from 10% to 90% of $V_{out}$ )	Minimum	1 ms
	Nominal/Typical	2.5 ms
	Maximum	5 ms
Disable delay, t2 (from disable to loss of $V_{out}$ )	Nominal/Typical	3 ms
	Maximum	8 ms
Fall time (from 90% to 10% of $V_{out}$ )	Minimum	0.01 ms
	Nominal/Typical	0.35 ms
	Maximum	3 ms

## ENVIRONMENTAL SPECIFICATIONS

CoolX units are designed for indoor use. The following tables describe the environmental specifications for CoolX units.

**Table 3-38.** Environmental standard specifications

Description	Specification
Material group	IIIb
Pollution degree	2
Installation category	2
Class	I
Shock and vibration	MIL-STD810G Method 514.6

**Table 3-39. Climatic specifications**

Description	Specification
<b>External Ambient Temperature</b>	
Operating	<p>–20°C to 40°C (–4°F to 104°F)</p> <ul style="list-style-type: none"><li>• Operates to specification below –20°C (–4°F) after 10 min warmup</li><li>• Higher ambient temperatures can be achieved with applicable derating and/or external cooling methods (fans/base-plate cooling)</li></ul>
Storage	–40°C to 85°C (–40°F to 185°F)
<b>Humidity</b>	
Operating	5% to 95% non-condensing
<b>Atmospheric Pressure</b>	
Operating	<p>–155 m to 5000 m equivalent altitude</p> <p>(–509' to 16,404' equivalent altitude)</p>

# Configuration

## TO DETERMINE AN APPROPRIATE CONFIGURATION

Before ordering a CoolX unit, determine the appropriate configuration for your application using the following steps:

- Select the appropriate CoolMod modules for your application.

Refer to “[Electrical Specifications](#)” on page 3-2 for information about module outputs.

- Select the appropriate CoolPac chassis for your application (CX10S or CX10M).

Refer to “[Electrical Specifications](#)” on page 3-2 for CoolPac specifications.

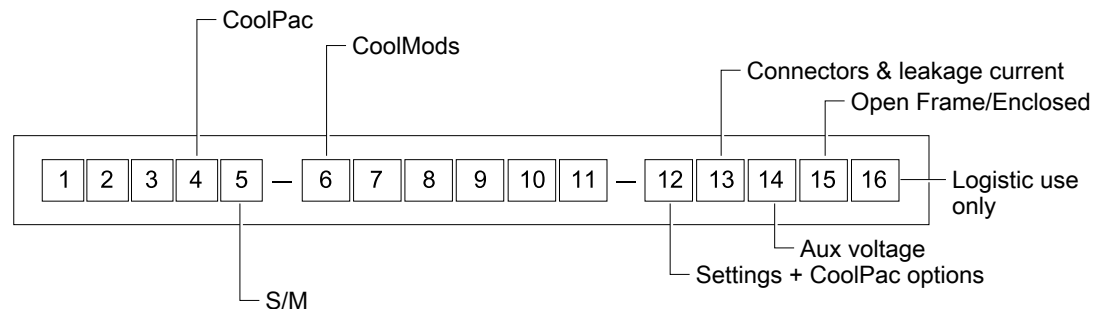
- Calculate the number of chassis required for your power requirements.

Refer to “[Electrical Specifications](#)” on page 3-2 for CoolPac specifications.

Once you have determined the appropriate configuration for your application, use “[CoolX Configuration Part Numbers](#)” on page 4-1 and “[Selecting and Ordering a Configured CoolX Unit](#)” on page 4-4 to produce a part number for your specified configuration. Use this part number to order your desired CoolX unit configuration.

## COOLX CONFIGURATION PART NUMBERS

Part numbers for CoolX configurations have four constant digits followed by 11 user-specified digits and one factory-use-only digit, with the format shown in the following figure:



**Figure 4-1.** CoolX part number format

## To Configure a CoolX Part Number

Use [Table 4-1](#) to identify options on your CoolX unit:

1. Find the appropriate digit of the part number using the left column.
2. Identify the desired unit option using the right-most column.

The first four digits of the part number are CX10 for every configuration. The options for the part number are as follows:

**Table 4-1. Part number digit description**

Part Number Digit	Feature	Options and Descriptions
1	Reserved	C
2	Reserved	X
3	Reserved	1
4	Reserved	0
5	CoolPac type	S = Standard IEC60950 2nd Edition and EN62386-1  M = Medical IEC60601-1 3rd Edition
6	Module in slot 1	See <a href="#">“Specifying Modules in the Part Number”</a> for details.
7	Module in slot 2	See <a href="#">“Specifying Modules in the Part Number”</a> for details.
8	Module in slot 3	See <a href="#">“Specifying Modules in the Part Number”</a> for details.
9	Module in slot 4	See <a href="#">“Specifying Modules in the Part Number”</a> for details.
10	Module in slot 5	See <a href="#">“Specifying Modules in the Part Number”</a> for details.
11	Module in slot 6	See <a href="#">“Specifying Modules in the Part Number”</a> for details.
12	Settings and CoolPac options	N = Standard; no additional configuration, nominal output voltages

**Table 4-1. Part number digit description (Continued)**

Part Number Digit	Feature	Options and Descriptions
		P = Preset; voltage adjustments, series, parallel outputs  X = Wide-trim variant of standard module used in configuration
13	Connectors and leakage	- = Input screw terminal connector, nominal leakage current  1 = IEC 320 input terminal  4 = Input screw terminal connector, 150 $\mu$ A leakage current  5 = IEC 320 input terminal, 150 $\mu$ A leakage current
14	Aux voltage	A = 12 V/1.97 A isolated bias supply voltage  B = 5 V/4.7 A isolated bias supply voltage
15	Frame type	Not used or - = Standard, open-framed  L = Covered
16	Reserved	Not included in configuration order

## Specifying Modules in the Part Number

Digits 6 – 11 in a CoolX part number specify the modules in the chassis slots 1 – 6. The following sections detail how to specify the different types of modules in a CoolX part number.

### Standard, Dual, and Wide-trim Modules

You can specify all standard, dual, and wide-trim modules using the third letter of the type of module (for example, "A" for a CmA module). Put the letter in the part number digit that corresponds to the appropriate chassis slot.

For example, a CoolX unit with a CmB module in slot 3 would have "B" in the eighth digit of the unit part number. A CoolX unit with a CmD module in slot 1

would have "D" in the sixth digit of the unit part number. [Table 4-1](#) on page 4-2 specifies which part number digit corresponds to which chassis slot.

If you use a wide-trim module in the configuration, you must set the Settings and CoolPac Options digit to "X" and maintain a record for the part number. Contact Advanced Energy for details.

### Bulk Modules

You can only use a bulk module in slot 6 of a chassis. A bulk module takes up three slots in a chassis.

When specifying a bulk module in a CoolX unit part number, use the third letter of the type of module (for example, "E" for a CmE module) in the eleventh digit of the part number. In addition to specifying the module type in the eleventh digit, include hash symbols/pound signs (the "#" character) in the ninth and tenth digits of the part number. The pound sign indicates that a slot cannot be used because the module in slot 6 is a bulk module. [Table 4-1](#) on page 4-2 specifies which part number digit corresponds to which chassis slot.

The examples in [“Selecting and Ordering a Configured CoolX Unit”](#) further demonstrate how to specify modules in a CoolX unit part number.

## Selecting and Ordering a Configured CoolX Unit

Configured CoolX power supplies can be specified and ordered using the part numbering system previously described. The CoolX unit will be assembled as specified by the part number.

### CONFIGURATION EXAMPLE 1

Required power supply: 100 VAC to 240 VAC input, IEC 60950 and IEC 62368 approved

Outputs: 5 V/10 A, 24 V/6 A, 48 V/2 A, 24 V/25 A

Auxiliary bias supply 12 V/1 A

Solution: CoolX part number CX10S-ACD##E-N-A specifies the following product:

- CX10S—1000 W IEC60950, 62368-1 approved
- Slot 1: CmA, 5 V/21 A module
- Slot 2: CmC, 24 V/8.33 A module
- Slot 3: CmD, 48 V/4.17 A module
- Slot 4: Unusable because slot 6 contains a CmE module
- Slot 5: Unusable because slot 6 contains a CmE module
- Slot 6: CmE, 24 V/25 A module
- Option N: Nominal output voltage settings
- Option A: 12 V/1.97 A bias supply voltage

## CONFIGURATION EXAMPLE 2

Required power supply: 100 VAC to 240 VAC input, IEC 60601-1 3rd Edition approved

Outputs: 5 V/10 A, 12 V/10 A, 24 V/10 A, 48 V/2 A, 5 V/6 A, 24 V/1 A

Auxiliary bias supply 5 V/4.7 A

150  $\mu$ A leakage current

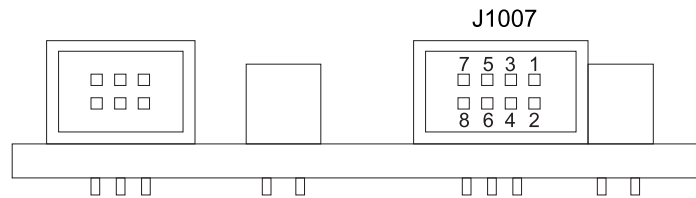
Solution: CoolX part number CX10M-ABCCDH-P4B specifies the following product:

- CX10M—1000 W IEC60601-1 approved
- Slot 1: CmA, 5 V/10 A module
- Slot 2: CmB, 12 V/15 A module
- Slot 3: CmC, 24 V/8.33 A module
- Slot 4: CmC, 24 V/8.33 A module
- Slot 5: CmD, 48 V/4.17 A module
- Slot 6: CmH, 5 V/6 A and 24 V/3 A dual module
- Option P: Preset required. Slot 3 and Slot 4 connected in parallel.
- Option 4: 150  $\mu$ A leakage current
- Option B: 5 V/4.7 A bias supply voltage

# Communication Controls

## GLOBAL SIGNALS

The CoolX global signals apply to the entire CoolX system. Global signals are available on the J1007 system signal connector.



**Figure 5-1.** J1007 system signal connector

The J1007 system signal connector pins are assigned as shown in the following table:

**Table 5-1.** J1007 system signal connector pin assignments

Pin	Assignment
1	Common
2	SCL (PMBus CLK)
3	Control
4	SDA (PMBus DATA)
5	PG Global
6	NU (not used or no connection)
7	OTP
8	AC Fail

## CoolPac Open Collector Driving Common Logic Levels

Each CoolPac logic output (*GLOBAL POWER GOOD*, *AC FAIL*, and *OTP*) is an open collector driver to common with a 390  $\Omega$  resistor in series with the collector for current limiting. These outputs can safely sink up to 12 mA and have a breakdown voltage of greater than 25 V. Pull up resistors should be chosen to keep the sink current under 12 mA. [Table 5-2](#) shows some resistor combinations. These combinations translate the open collector output into a voltage level suitable for various logic types, and use either the 12 V or 5 V auxiliary voltage. Other voltages can be used to bias these circuits with adjustments that account for the 12 mA maximum sink current and the 390  $\Omega$  resistance in series with the collector.



Figure 5-2 and Table 5-2 provide recommendations for driving logic level circuits with open collector signal outputs.

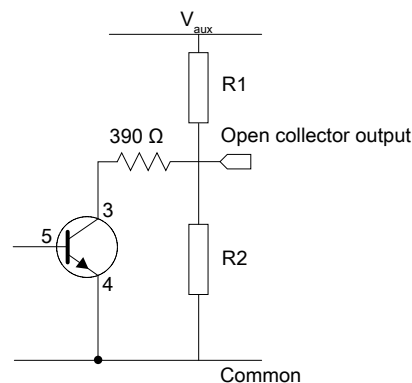


Figure 5-2. CoolMod power good implementation circuit

Table 5-2. Table of logics

Auxiliary Voltage	Logic Voltage (Volt Logic)	R1 (kΩ)	R2 (kΩ)	V <sub>high</sub> (V)	V <sub>low</sub> (V)	I <sub>sink</sub> Max (mA)
12 V	12	12	Open	12	0.4	12
12 V	5	10	7	4.9	0.45	12
12 V	3.3	10	3.9	3.2	0.4	12
5 V	5	5	Open	5	0.36	12
5 V	3.3	5	10	3.3	0.36	12

## AC FAIL Signal

The CoolPac *AC FAIL* signal indicates that the input voltage has dropped below 70 VAC or has entered a protective state, such as overtemperature or overcurrent. The *AC FAIL* signal is an unbiased open collector that is available on the J1007 system signal connector via the collector on pin 8 and the emitter on pin 1 (common). There is a 390 Ω resistor in series with the collector for current limiting. During normal operation the transistor is on. When the input voltage is lost or goes below 70 VAC, the transistor turns off at least 1 ms before loss of output voltage regulation.



### Important

The maximum collector voltage is 30 V, and the maximum collector current is 5 mA.

Figure 5-2 and Table 5-2 provide recommendations for driving logic level circuits with open collector signal outputs.

## GLOBAL POWER GOOD Signal

The *GLOBAL POWER GOOD* signal is an unbiased open collector signal that is available on the J1007 system signal connector via the collector on pin 5 and the emitter on pin 1 (common). This signal is activated when all standard, bulk, and wide-trim modules report individual *POWER GOOD* signals for their outputs. There is a 390  $\Omega$  resistor in series with the collector for current limiting. When all modules have an output within 10% of  $V_{set}$ , the transistor turns on. The transistor turns off when the output of any module is outside 10% of  $V_{set}$ .



### Important

The maximum collector voltage is 30 V, and the maximum collector current is 5 mA.



### Important

The status of any dual modules does not impact the *GLOBAL POWER GOOD* signal.

Figure 5-2 and Table 5-2 provide recommendations for driving logic level circuits with open collector signal outputs.

## Global Enable/Inhibit (Control)

You can enable or inhibit all module outputs simultaneously by using the control pin input on the J1007 system signal connector, between pin 3 (control) and pin 1 (common). Under normal conditions, pin 3 is pulled to 5 V internally (logic high) and all modules are enabled. To disable all modules, pull pin 3 to common (logic low). There is up to a 20 ms delay from change in signal logic to change in output voltage. Pulling the control pin to common for 5 seconds or more enables deep-sleep standby mode. In this mode, the CoolX unit minimizes power consumption to approximately 5 W. Enabling from deep-sleep standby mode takes a maximum of 700 ms.

The input has a 1 k $\Omega$  series resistor and a 100 nF filtering capacitor to filter noise on this signal. The maximum allowable voltage on pin 3 is 5 V.

## Overtemperature Protection

The CoolX unit monitors internal temperatures on the power supply to ensure that component temperatures do not exceed their ratings. The *OVERTEMPERATURE PROTECTION* (OTP) warning signal is an unbiased open collector signal that is available on the J1007 system signal connector via the collector on pin 7 and the emitter on pin 1 (common). There is a 390  $\Omega$  resistor in series with the collector for current limiting.

During normal operation, the transistor is turned off. If an overtemperature condition is detected, the *OVERTEMPERATURE PROTECTION* signal will be pulled low via the 390  $\Omega$  resistor as a warning of a possible shutdown of the power supply. If the unit temperature continues to rise, the CoolX unit will shut down. The unit will auto-recover when temperatures reach the normal operating level.

The time between the *OVERTEMPERATURE PROTECTION* signal and shutdown depends on the environment. This signal can be used to turn on an external fan or to shed loads, both of which would reduce the temperature rise in the power supply.



### Important

The maximum collector voltage is 30 V, and the maximum collector current is 5 mA.

Figure 5-2 and Table 5-2 provide recommendations for driving logic level circuits with open collector signal outputs.

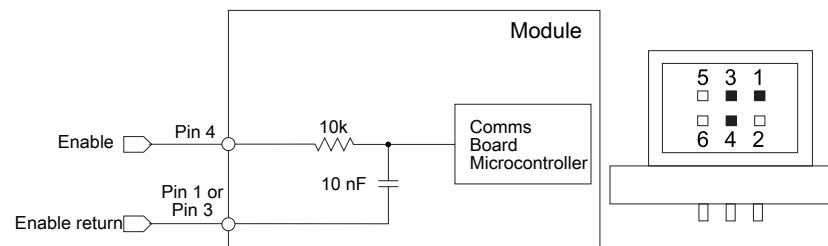
## MODULE SIGNALS

Each module has the following discrete controls:

- “Module Enable/Inhibit”
- “CoolMod Power Good Signal”

### Module Enable/Inhibit

You can enable or inhibit each module by applying a logic level signal to the enable input on output signal connector (J1001-J1006) pin 4 (positive) and pin 1 or pin 3 (negative). The input has a 1 kΩ series resistor and a 100 nF filtering capacitor to filter noise on this signal. The enable and inhibit feature on dual modules works differently; see “Dual Module Enable/Inhibit” on page 5-5 for more information and for the dual module enable/inhibit wiring diagram.



**Figure 5-3.** CoolMod enable/inhibit wiring diagram

There is a maximum 20 ms turn-on delay after application of the signal. When there is no connection, pin 4 is high (5 V) and the module is enabled.

To inhibit the module, pull pin 4 to common. Note that disabling a dual module in this way will disable both outputs. See “Dual Module Enable/Inhibit” on page 5-5 for information about inhibiting single channels on a dual module.



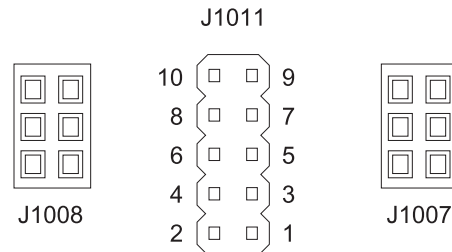
### Important

The input voltage must be no greater than 5 V.

## REVERSING ENABLE/INHIBIT LOGIC

You can reverse the logic of the module *INHIBIT* and *ENABLE* signals by shorting pin 1 and pin 2 of the PMBus address header J1011 with a jumper, and applying a logic low signal between pin 3 (control) and pin 1 (common) of the J1007 system signal connector.

Advanced Energy recommends a Harwin® M22-1900005 2 mm jumper socket for the J1011 connector.



**Figure 5-4.** PMBus address header

When this signal is applied to the CoolX unit, the default condition of all modules is disabled. You can enable modules by applying a logic low signal to the enable input on the output signal connector (J1001-J1006), between pin 4 (positive) and pin 1 or pin 3 (negative).

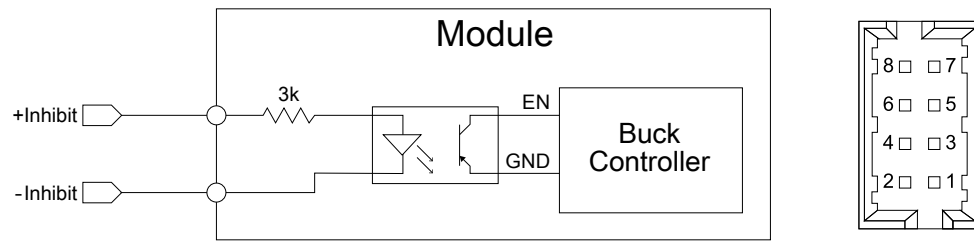
**Table 5-3.** Module status with and without a jumper between pins 1 and 2 of J1011

J1007 Control Signal	J100x CoolMod Enable Signal	Module Status
<b>J1011 Pin 2 / Pin 1 Jumper Fitted</b>		
0	0	Enabled
0	1	Disabled
1	0	Disabled
1	1	Disabled
<b>J1011 Pin 2 / Pin 1 Jumper Not Fitted</b>		
0	0	Disabled
0	1	Disabled
1	0	Disabled
1	1	Enabled

## DUAL MODULE ENABLE/INHIBIT

You can enable or inhibit each individual channel of a dual module by applying a signal to the inhibit pins on the module signal connector J1. When the inhibit pins are floating or when the positive inhibit pin is tied to the negative inhibit pin for a

channel, the channel is disabled. There is a maximum 100 ms turn-on delay after the application of the signal.



**Figure 5-5.** Dual module enable/inhibit wiring diagram

Applying a signal voltage to the inhibit pins disables the channel. The specifications for this signal are detailed in the following table:

**Table 5-4.** Dual module enable/inhibit specifications

Value Type	Voltage	Current
Minimum	3 V	0.2 mA
Maximum	12 V	4.0 mA

## CoolMod *POWER GOOD* Signal

The module *POWER GOOD* signal is the output of an internal comparator. The internal comparator monitors the output voltage and determines whether it is within normal operational limits. The *POWER GOOD* signal is an unbiased open collector that is available on the output signal connector (J1001-J1006) via the collector on pin 2 and the emitter on pin 1 or pin 3 (common). There is a 390  $\Omega$  resistor in series with the collector for current limiting.

When the output voltage is within 10% of  $V_{set}$ , the transistor turns on. If the output drops out of regulation, the transistor turns off.



### Important

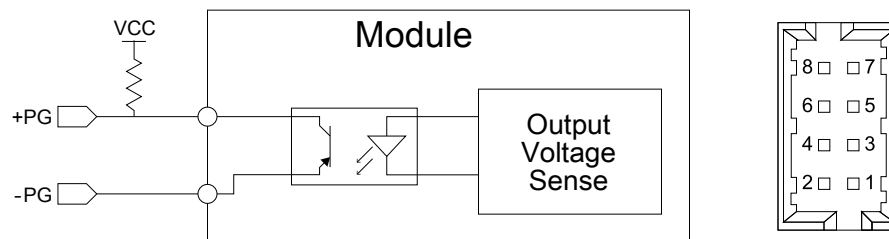
The maximum collector voltage is 30 V, and the maximum collector current is 5 mA.

Figure 5-2 and Table 5-2 provide recommendations for driving logic level circuits with open collector signal outputs.

The module *POWER GOOD* signal is not compatible with dual modules.

## DUAL MODULE *POWER GOOD* SIGNAL

The output signal connector (J1001 – J1006) does not indicate the power status of a dual module. Rather, each dual module channel has a *POWER GOOD* signal that indicates if there is a voltage on the channel output pins.



**Figure 5-6.** Dual module *POWER GOOD* wiring diagram

The *POWER GOOD* signal is the unbiased open collector of an optocoupler that is available on the module signal connector J1 via the collector on the positive PG pin and the emitter on the negative PG pin.

When there is a voltage present on the output pins of the output channel, the transistor of the optocoupler is turned on. When there is no voltage present on the output pins, the transistor turns off.

To monitor the *POWER GOOD* status of a channel, the positive PG pin should be pulled up to a reference voltage with a pull-up resistor. The pull-up resistor should be chosen to limit collector current to 0.5 mA or less. For example, if the reference voltage is 5 V, the pull-up resistor should be 10 kΩ or higher.

## PMBUS COMMUNICATIONS

Each module can be monitored and controlled with the following PMBus commands. For further details, refer to the unit-specific PMBus manual that is available for download from <http://www.advancedenergy.com>.

**Table 5-5.** Applicable PMBus commands for standard and wide-trim modules

Command	Description		
<b>READ_VOUT</b> (0x8B)	Returns the output voltage measurement of the selected (paged) module.  Accuracy: $\pm 4\%$	<b>Module</b>	<b>Resolution (mV)</b>
		CmA	6.6
		CmB	16.5
		CmC	44.3
		CmD	82.4
		CmA-W01	6.6
		CmB-W01	16.5
		CmC-W01	44.3
		CmD-W01	82.4
<b>READ_IOUT</b> (0x8C)	Returns the output current measurement of the selected (paged) module.	<b>Module</b>	<b>Resolution (mA)</b>
		CmA	40

**Table 5-5. Applicable PMBus commands for standard and wide-trim modules (Continued)**

Command	Description		
	Accuracy: $\pm 4\%$	CmB	29
		CmC	16
		CmD	8
		CmA-W01	40
		CmB-W01	29
		CmC-W01	16
		CmD-W01	8
<b>READ_TEMPERATURE_1</b> (0x8D)	Returns the temperature measurement of the selected (paged) module in degrees Celsius. <ul style="list-style-type: none"> <li>Accuracy: <math>\pm 10^{\circ}\text{C}</math></li> <li>Resolution: <math>1^{\circ}\text{C}</math> (<math>1.8^{\circ}\text{F}</math>)</li> </ul>		
<b>STATUS_WORD</b> (0x79)	Checks for the presence of fault conditions such as <i>OVERTEMPERATURE PROTECTION</i> (OTP) signal and <i>POWER GOOD</i> (PG) fail.		
<b>PAGE</b> (0x00)	Selects which module the subsequent commands will affect. When read, this command returns the currently selected (paged) module number.		
<b>OPERATION</b> (0x01)	Enables or disables the output of the selected (paged) module. When read, this command returns the last <b>OPERATION</b> command sent to the CoolX unit.		
<b>VOUT_MODE</b> (0x20)	Returns the 5-bit exponent used to interpret extended linear format readings for the selected (paged) module.		
<b>VOUT_COMMAND</b> (0x21)	Sets the output voltage of the selected (paged) module to the commanded value. When read, this command returns the last <b>VOUT_COMMAND</b> value sent to the CoolX unit.		
<b>ILIMIT_TRIM</b> (0xD1)	Sets the current limit of the selected (paged) module to the commanded value. When read, this command returns the last <b>ILIMIT_TRIM</b> value sent to the CoolX unit.		
<b>MODULE_ID</b> (0xD0)	Returns a code representing the model type of the selected (paged) module.	<b>Module</b>	<b>ID Code</b>
		CmA	0x20
		CmB	0x40
		CmC	0x60

**Table 5-5. Applicable PMBus commands for standard and wide-trim modules (Continued)**

Command	Description		
		CmD	0x80
		CmA-W01	0x22
		CmB-W01	0x42
		CmC-W01	0x62
		CmD-W01	0x82

**Table 5-6. Applicable PMBus commands for bulk modules**

Command	Description		
<b>READ_VOUT</b> (0x8B)	Returns the output voltage measurement of the selected (paged) module.  Accuracy: $\pm 4\%$	<b>Module</b>	<b>Resolution (mV)</b>
		CmE	31
		CmF	60
<b>READ_IOUT</b> (0x8C)	Returns the output current measurement of the selected (paged) module.  Accuracy: $\pm 4\%$	<b>Module</b>	<b>Resolution (mA)</b>
		CmE	45
		CmF	22
<b>READ_TEMPERATURE_1</b> (0x8D)	Returns the temperature measurement of the selected (paged) module in degrees Celsius.  <ul style="list-style-type: none"> <li>Accuracy: <math>\pm 10^{\circ}\text{C}</math></li> <li>Resolution: <math>1^{\circ}\text{C}</math> (<math>1.8^{\circ}\text{F}</math>)</li> </ul>		
<b>STATUS_WORD</b> (0x79)	Checks for the presence of fault conditions such as <i>OVERTEMPERATURE PROTECTION</i> (OTP) signal and <i>POWER GOOD</i> (PG) fail.		
<b>PAGE</b> (0x00)	Selects which module the subsequent commands will affect. When read, this command returns the currently selected (paged) module number.		
<b>OPERATION</b> (0x01)	Enables or disables the output of the selected (paged) module. When read, this command returns the last <b>OPERATION</b> command sent to the CoolX unit.		
<b>VOUT_MODE</b> (0x20)	Returns the 5-bit exponent used to interpret extended linear format readings for the selected (paged) module.		



**Table 5-6. Applicable PMBus commands for bulk modules (Continued)**

Command	Description		
<b>VOUT_COMMAND</b> (0x21)	Sets the output voltage of the selected (paged) module to the commanded value. When read, this command returns the last <b>VOUT_COMMAND</b> value sent to the CoolX unit.		
<b>ILIMIT_TRIM</b> (0xD1)	Sets the current limit of the selected (paged) module to the commanded value. When read, this command returns the last <b>ILIMIT_TRIM</b> value sent to the CoolX unit.		
<b>MODULE_ID</b> (0xD0)	Returns a code representing the model type of the selected (paged) module.	<b>Module</b>	<b>ID Code</b>
		CmE	0xBC
		CmF	0xBD

**Table 5-7. Applicable PMBus commands for dual modules**

Command	Description
<b>PAGE</b> (0x00)	Selects which module the subsequent commands will affect. When read, this command returns the currently selected (paged) module number.
<b>OPERATION</b> (0x01)	Enables or disables the output of the selected (paged) module. When read, this command returns the last <b>OPERATION</b> command sent to the CoolX unit.
<b>MODULE_ID</b> (0xD0)	Returns a code representing the model type of the selected (paged) module. Please note this command returns the same code for both types of dual module:  0xDD = Dual module

**Table 5-8. Applicable PMBus commands for chassis**

Command	Description
<b>READ_TEMPERATURE_1</b> (0x8D)	Returns the temperature measurement of the selected (paged) module in degrees Celsius. <ul style="list-style-type: none"> <li>• Accuracy: <math>\pm 10^{\circ}\text{C}</math></li> <li>• Resolution: <math>1^{\circ}\text{C}</math> (<math>1.8^{\circ}\text{F}</math>)</li> </ul>
<b>PAGE</b> (0x00)	Selects the chassis for subsequent commands.

*Table 5-8. Applicable PMBus commands for chassis (Continued)*

Command	Description
<b>OPERATION</b> (0x01)	Enables or disables all module outputs when the chassis is selected (paged).
<b>READ_VIN</b> (0x88)	Returns the input voltage measurement of the CoolX unit.
<b>MFR_ID</b> (0x99)	Returns a string that identifies the manufacturer of the system.
<b>MFR_MODEL</b> (0x9A)	Returns a string that identifies the model of the system.
<b>PMBUS_STANDBY</b> (0xD4)	Disables all modules and puts the unit into a low power consumption mode, regardless of which module is paged. When read, this command returns the last <b>PMBUS_STANDBY</b> value sent to the CoolX unit.

# Installation, Setup, and Operation

## PREPARING TO INSTALL THE UNIT

### Installation Considerations

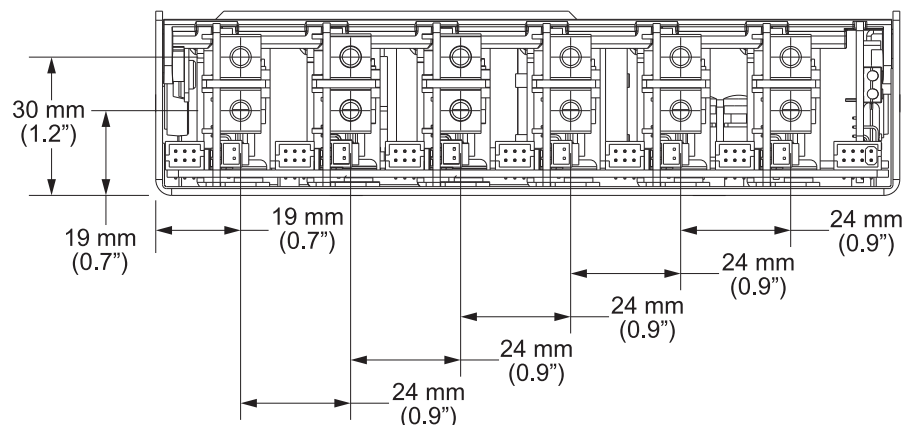
The CoolX unit can be mounted on any of its three surfaces. The side surface uses M3 screws, and the bottom surface uses M4 screws. The chassis comes with four mounting points on the base and two mounting points on each side. Maximum allowable torque for M3 mounting screws is 0.63 Nm (5.6 in-lb), maximum allowable torque for M4 mounting screws is 1.48 Nm (13.1 in-lb), and maximum allowable penetration depth is 1.5 mm (0.06") for both M3 and M4 screws. DIN-rail mounting is also possible using the Excelsys DIN-rail mounting bracket.

Avoid excessive bending of output power cables after they are connected to the modules. For high current outputs, use cable ties to support heavy cables and minimize mechanical stress on output terminals. Be careful not to short out to neighboring output terminals. The maximum torque allowed on output connectors is 0.74 Nm (6.5 in-lb).

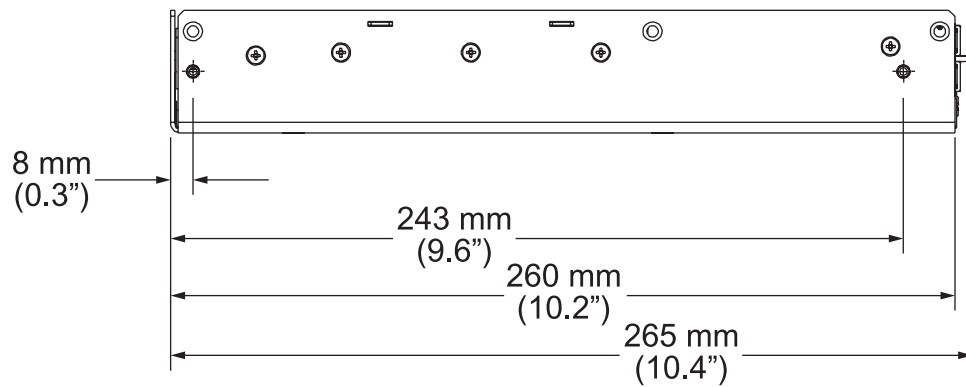
### Mechanical Information

#### UNIT DIMENSIONAL DRAWINGS

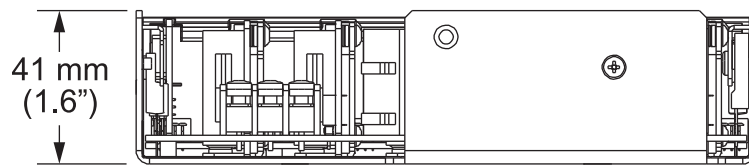
The CoolX mechanical outlines follow. You can download full 3D and STEP files from <https://www.advancedenergy.com>, or contact AE Global Services for details.



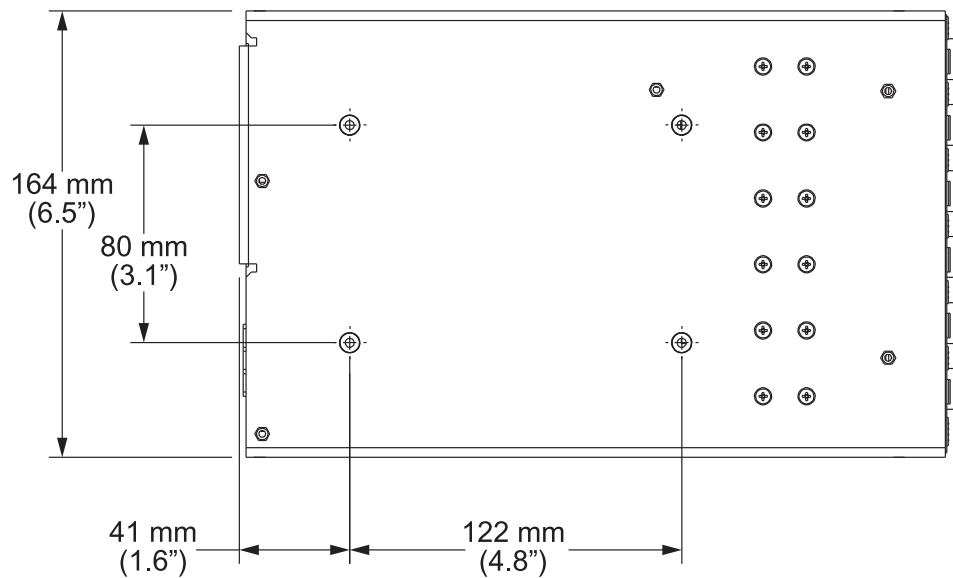
**Figure 6-1.** CoolX unit dimensions, DC outputs view



**Figure 6-2.** CoolX unit dimensions, side view



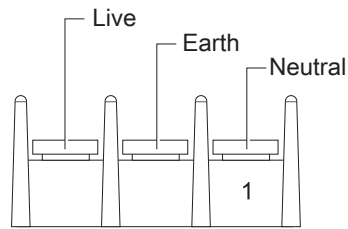
**Figure 6-3.** CoolX unit dimensions, AC input view



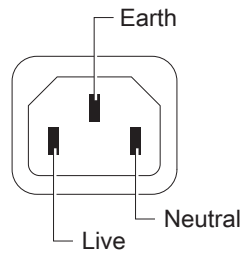
**Figure 6-4.** CoolX unit dimensions, bottom view

## COOLPAC INPUT CONNECTORS

AC mains is applied to the CoolX unit via the 3-screw terminal block or the optional IEC320 inlet terminal.



**Figure 6-5.** Three screw terminal block



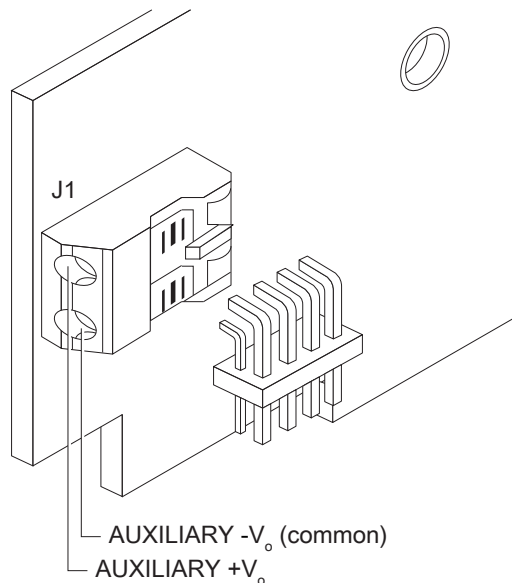
**Figure 6-6.** Optional IEC320 inlet terminal

**Table 6-1.** Options for connecting AC mains input to the CoolX unit

Input Option	Terminal Type
AC/DC input terminal block	TE 2-1347667-S, DT-31-B01W-03
AC/DC IEC input (option 1)	IEC 320 inlet

## AUXILIARY BIAS SUPPLY VOLTAGE

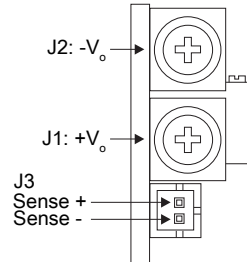
The auxiliary bias supply (always on) of 12 V/1.97 A or 5 V/4.7 A (optional) is provided on the J1 connector.



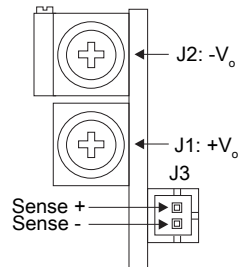
**Figure 6-7.** J1 auxiliary output connector

## COOLMOD OUTPUT POWER AND SENSE CONNECTORS

Each standard and wide-trim module DC output has power terminals (J1 and J2) and a sense connector (J3).



**Figure 6-8.** Standard and wide-trim module power terminals and sense connector



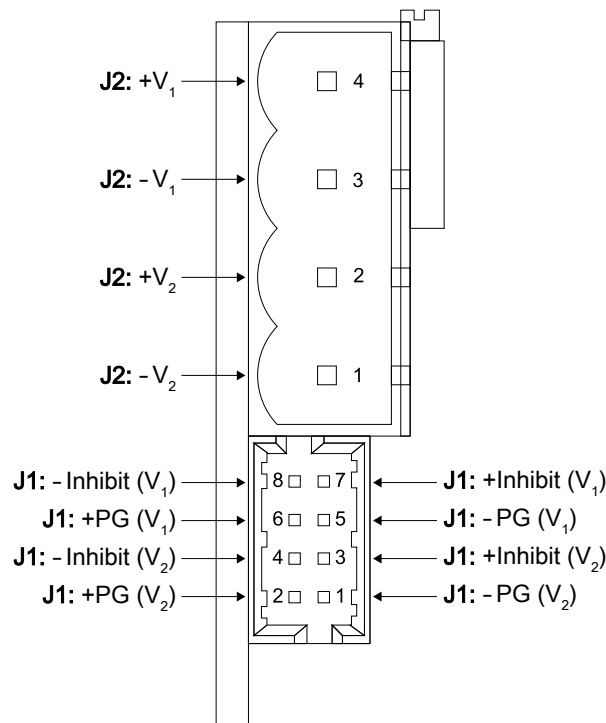
**Figure 6-9.** Bulk module power terminals and sense connector

**Table 6-2.** Output power and sense connector details for all modules

Terminal or Connector	Terminal or Connector Type
J1 and J2 DC output terminals	M4 screws
J3 sense connector	JST - S2BPH-K-S (LF) (SN)
J3 mating connector	JST PHR-2  Crimp: JST BPH-002T-P0.5S or SPH-002T-P0.5S

## DUAL MODULE OUTPUT POWER AND SIGNAL CONNECTORS

Dual modules have a signal connector (J1) and a dual power terminal (J2).



**Figure 6-10.** Dual module power terminals and signal connector

**Table 6-3.** Dual module output power and sense connector specifications

Terminal or Connector	Terminal or Connector Type
J1 output terminal	8-way Molex 87833-0831
J1 mating connector	Locking Molex 51110-0860, non-locking Molex 51110-0850, locking and polarizing Molex 51110-856 Crimp terminal: Molex p/n 50394
J2 power terminal	Camden CTB9350/4A, WE Wuerth Elektronik® 691 313 710 004
J2 mating connector	Camden CTB9200/4A, WE Wuerth Elektronik 691 352 710 004

## GLOBAL SYSTEM SIGNAL CONNECTOR

The system signal connector controls all the global signals, including *AC FAIL*, *POWER GOOD*, and *OVERTEMPERATURE PROTECTION*. Refer to “[Global Signals](#)” on page 5-1 for J1007 system signal connector information.

**Table 6-4.** J1007 system signal connector types

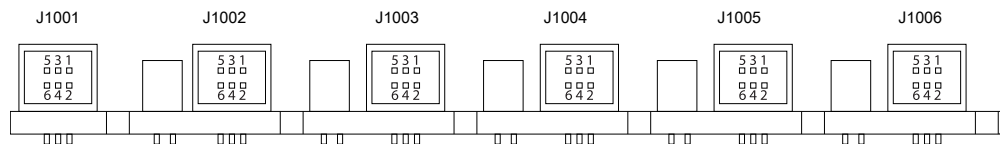
Connector	Connector Type
J1007 system signal connector	8-way Molex 87833-0831

**Table 6-4. J1007 system signal connector types (Continued)**

Connector	Connector Type
J1007 mating connector	Locking Molex 51110-0860, non-locking Molex 51110-0850, or locking and polarizing Molex 51110-0856  Crimp terminal: Molex p/n 50394

## DC OUTPUT SIGNALS AND CONTROL CONNECTORS

The DC output signal connectors contain the individual output signals and control, including Power Good, Inhibit/Enable,  $V_{trim}$ , and  $I_{trim}$ .

**Figure 6-11. CoolMod signal connectors**

In the following table, possible values of  $x$  range from 1 through 6, representing module signal connectors J1001 through J1006, respectively.

**Table 6-5. CoolMod signal connector pin assignments**

Pin	J100x Assignment
1	Common
2	PGx
3	Common
4	ENx
5	$I_{trimx}$
6	$V_{trimx}$

**Table 6-6. CoolMod output signal connector types**

Connector	Connector Type
J1001-J1006 connectors	6-way Molex 87833-0831
J1001-J1006 mating connectors	Locking Molex 51110-0660, non-locking Molex 51110-0650, or locking and polarizing Molex 51110-0650  Crimp terminal: Molex p/n 50394



# INSTALLING THE UNIT

## To Install CoolMod Modules

1. Plug one module into the CoolPac chassis.
2. Secure the module to the base of the chassis with two mounting screws.
3. Plug in and secure the rest of the modules.
4. Fit the plastic retainer bar across the top of the modules.

The plastic retainer bar improves the ruggedness of the CoolX unit and increases its resistance to shock and vibrations.

## SERIES CONNECTION OF MODULE OUTPUTS

You can connect modules in series, using series links, to increase output voltage.



### Important

Single module outputs are rated SELV (Safety Extra Low Voltage): Output voltages are guaranteed to be less than 60 V. This 60 V limit can be exceeded if outputs are connected in series. Take appropriate precautions.

It is good practice to stack modules with similar output current limits, so that in case of a short circuit the outputs collapse together.

## To Connect Outputs in Series

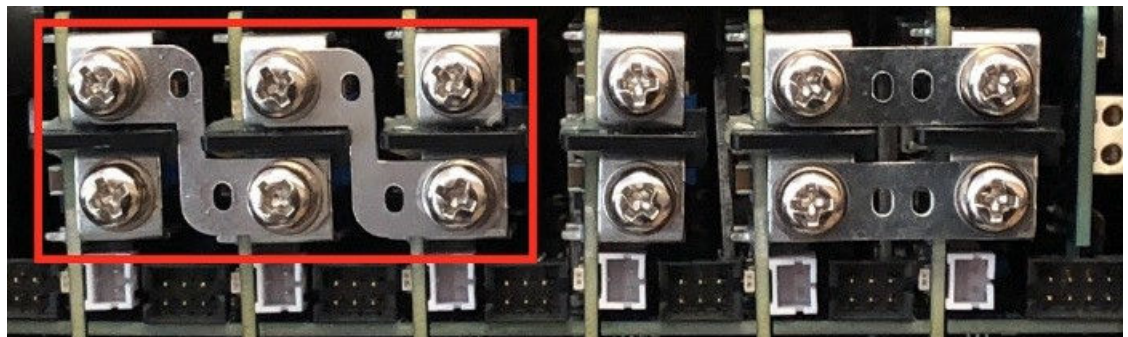
1. Connect the series link. Refer to [Figure 6-12](#).
2. Adjust the module output voltages to the desired level.

If remote sensing is required, the positive remote sense of the highest module and negative remote sense of the lowest module should be connected to the load. Special series connection links can be fitted to modules to reduce wiring complexity. These links can be specified and fitted by the installer or added at the factory.



### Important

You can connect dual modules in series, but there are no dedicated links on the modules. You must connect dual modules at a system level.



**Figure 6-12.** Modules connected in series with a series connection link

## PARALLEL CONNECTION OF COOLMOD OUTPUTS

You can connect standard modules in parallel, using standard parallel links, to increase output current. Excelsys passive current sharing ensures that current hogging is not possible. When connecting modules in parallel, you must use the same type of module. For example, you can only connect CmA modules in parallel with other CmA modules.



### Important

You cannot connect dual modules in parallel.

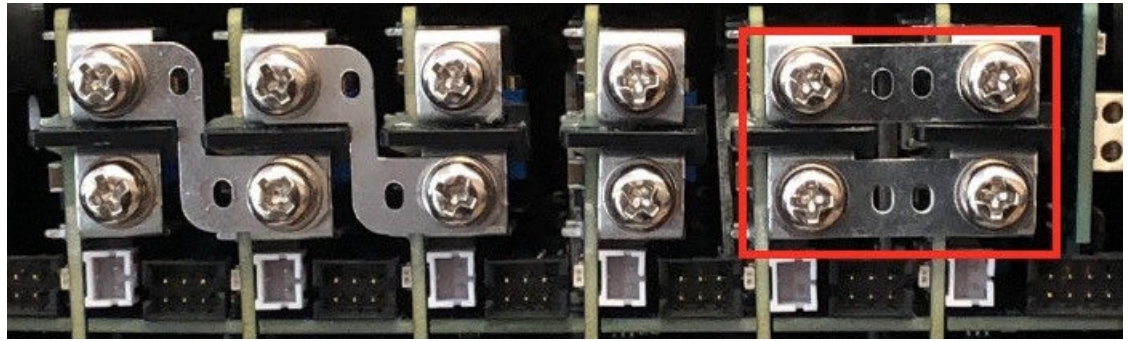
### To Parallel Connect Outputs

1. Enable current sharing by adding LK1 jumpers on the J4 connectors of the modules.
2. Connect parallel links to the negative terminals of the modules.
3. Adjust output voltages of the first module to the required voltage.
4. Adjust the voltages of any other modules to within the parallel voltage tolerance of the first module output voltage. See [Table 6-7](#).
5. Connect parallel links to the positive terminals of the modules.
6. If your application uses remote sensing, connect the sense lines to the load.
  - a. Connect negative sense lines to the low side of load.
  - b. Connect positive sense lines to the high side of load.

**Table 6-7. Standard and wide-trim module parallel voltage tolerances**

Module	Parallel Voltage Tolerance (mV)
CmA	± 10
CmB	± 10
CmC	± 20
CmD	± 50
CmA-W01	± 20
CmB-W01	± 30
CmC-W01	± 40
CmD-W01	± 100

Special parallel connection links can be fitted to modules to reduce wiring complexity. These links can be specified and fitted by the installer or added at the factory.



**Figure 6-13.** Modules connected in parallel with parallel connection links

All module signals are isolated from the module outputs. When modules are connected in series or parallel, you can implement any module analog control function for all the modules by paralleling the appropriate signal pins of each module and providing a single control signal.

For example, if you connect all the  $V_{\text{trim}}$  pins together, you can control  $V_{\text{trim}}$  across all the modules by using a single control voltage.

## Mounting the CoolPac Chassis

There are three ways to mount the CoolPac chassis:

- Base plate mounting

Use the four mounting holes on the base of the power supply. Refer to the mechanical drawings for mounting hole positions. Use M4 mounting screws, and ensure that maximum screw penetration from base does not exceed 1.5 mm (0.06").

- Side mounting

Use the two mounting holes on each side of the CoolPac chassis. Refer to the mechanical drawings for mounting hole positions. Use M3 mounting screws, and ensure that maximum screw penetration from base does not exceed 1.5 mm (0.06").

- DIN-rail mounting

Mount the CoolPac chassis on the DIN-rail mounting bracket (Z744).

## FIRST TIME OPERATION

Refer to the unit-specific instruction manual prior to first time operation. The manual is available on <http://www.advancedenergy.com>.

# NORMAL OPERATION

## CoolMod Operation

There are four types of modules (standard, bulk, dual, and wide-trim) that can be used with either CoolPac option. These modules provide discrete isolated DC outputs that can be individually controlled. For module output specifications, refer to “[Electrical Specifications](#)” on page 3-2.

## COOLMOD STARTUP AND SHUTDOWN

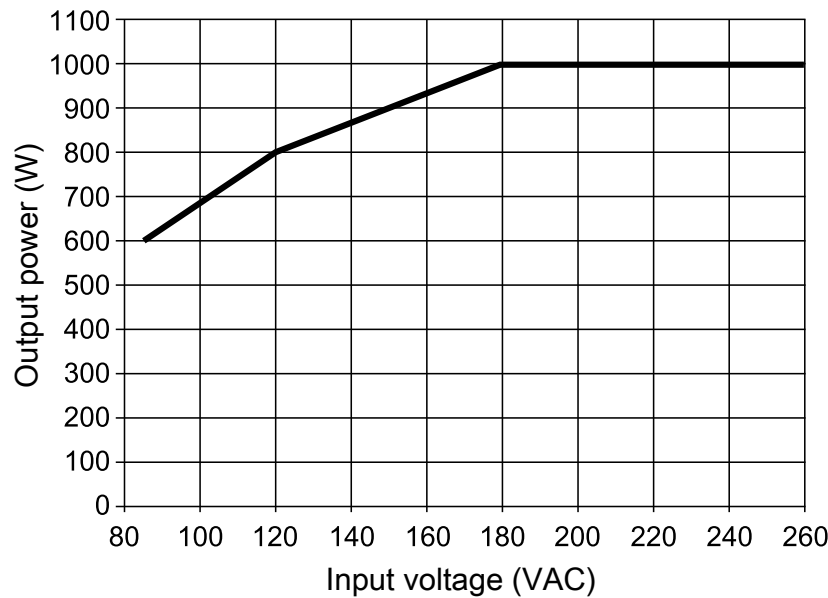
When input power is applied, standard CoolMod outputs rise to their setpoint voltage simultaneously. When input power is removed, standard CoolMod outputs begin turning off simultaneously. Outputs can be sequenced using the enable function in order to allow controlled start up if required. The following table contains the maximum startup delays for all modules.

**Table 6-8.** *Startup delays for modules*

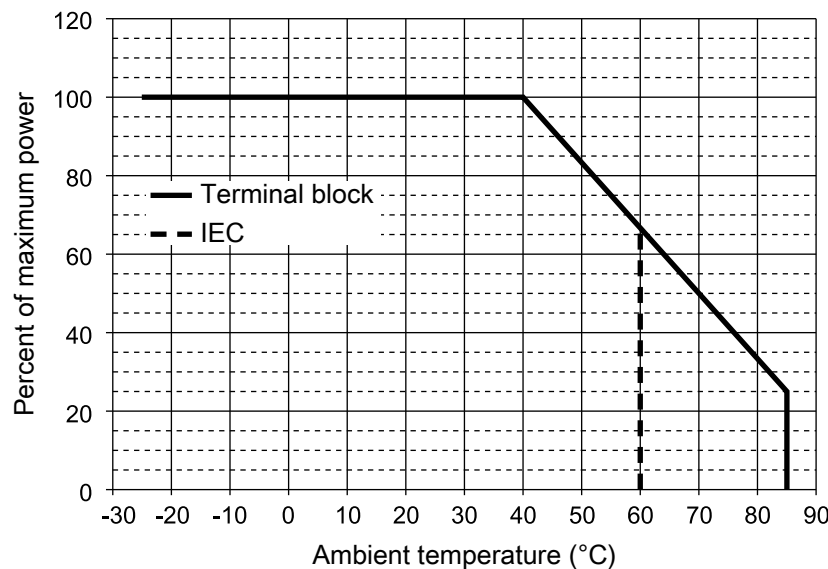
Startup Condition	Maximum Startup Delay (ms)
From AC	1000
From global <i>ENABLE</i> (control)	20
From module <i>ENABLE</i>	20

## POWER RATINGS

When selecting a power supply for an application, it is necessary to ensure that the supply operates within its power capabilities. You must consider both temperature derating and input voltage derating. The CoolX unit will deliver 100% rated power from  $-20^{\circ}\text{C}$  to  $40^{\circ}\text{C}$  ( $-4^{\circ}\text{F}$  to  $104^{\circ}\text{F}$ ) in free air (natural convection cooling) with no external fans, and will deliver 25% output power up to  $85^{\circ}\text{C}$  ( $185^{\circ}\text{F}$ ). Input voltage derating and temperature derating curves follow.



**Figure 6-14.** Chassis line derating with unit placed on steel baseplate



**Figure 6-15.** Chassis and module temperature derating

### Extended Temperature Operation

The CoolX unit will deliver up to 1000 W output power at 40°C (104°F) in free air. Each module will deliver its maximum power as per the module specification tables. The following optional additions to the CoolX unit can affect the optimum temperature range for normal operation.

#### EXTERNAL SYSTEM COOLING FANS

If there are cooling fans present in the system that provide air flow over the power supply, the CoolX unit is capable of delivering 1000 W output power at ambient temperatures higher than 40°C (104°F).

## BASE PLATE COOLING

If the power supply is mounted via its base to a larger metal base plate or metal chassis of the system, the CoolX unit is capable of delivering 1000 W output power at ambient temperatures higher than 40°C (104°F).

## OPTIONAL COVER

The CoolX unit is an open frame, convection-cooled power supply. An optional cover can be ordered using the part number CX10-Cover. You must derate the output power of the unit by 10% when using the cover in free air (natural convection). If there are system fans providing air flow over the unit, or additional base plate cooling, higher power ratings can be achieved.

Contact AE Global Services to learn how to extend the operating temperature of the CoolX unit in your system.

## VOLTAGE ADJUSTMENT

You can achieve voltage setting and dynamic voltage adjustment as follows:

- Adjust the onboard potentiometer. Refer to [“Onboard Potentiometer”](#).
- Use the  $V_{\text{trim}}$  pin of the output signal connector (J1001 to J1006). Refer to [“Remote Voltage Adjustment Using External Voltage”](#) and [“Remote Voltage Adjustment Using External Resistance”](#).

A single control voltage can be used to adjust the output voltage of individual modules or modules connected in parallel or in series.

- Use PMBus commands applied to the system signal connector (J1007). Refer to [“Voltage Control via PMBus”](#).

[Figure 5-1](#) and [Figure 6-11](#) show the output and system signal connectors.

### Onboard Potentiometer

Adjust the output voltage to the required level using the multi-turn trim potentiometer present on the module.

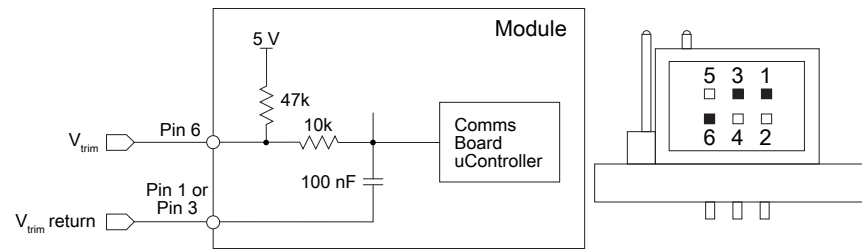
### Remote Voltage Adjustment Using External Voltage

The control voltage  $V_{\text{trim}}$  should be applied across the output signal connector pins: pin 6 ( $V_{\text{trim}}$ ) and pin 1 or pin 3 (common).



#### Important

Remote voltage adjustment is not available on dual modules.



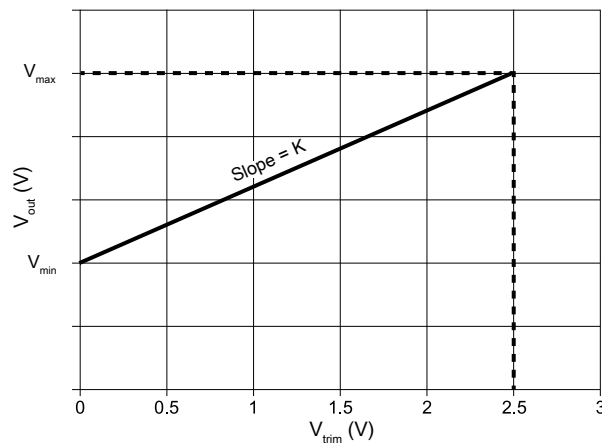
**Figure 6-16.** CoolMod wiring diagram for remote voltage setting using external voltage

The  $V_{trim}$  voltage required for your desired output voltage can be calculated using the following formula and table:

$$V_{trim} = \frac{V_{out} - F}{K}$$

**Table 6-9.**  $K$  and  $F$  values for calculating  $V_{trim}$

Module	K	F
CmA	1.59	2.43
CmB	3.84	5.85
CmC	6.30	13.82
CmD	13.20	26.13
CmE	1.19	22.45
CmF	0.28	43.06
CmA-W01	3.23	-1.61
CmB-W01	7.84	-3.9
CmC-W01	12.77	-2.17
CmD-W01	26.25	-6.42



**Figure 6-17.**  $V_{trim}$  versus  $V_{out}$

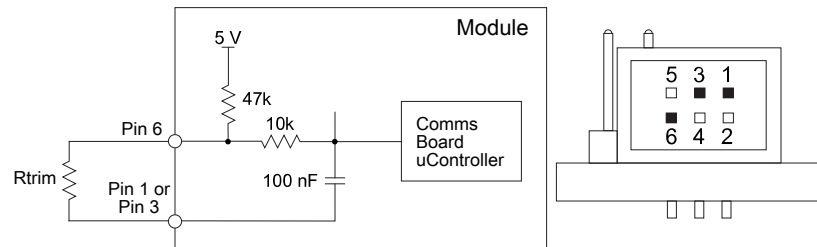
## Remote Voltage Adjustment Using External Resistance

To set the output voltage of a module with a resistor, place a resistor,  $R_{trim}$ , across the output signal connector pins: pin 6 ( $I_{trim}$ ) and pin 1 or pin 3 (common).



### Important

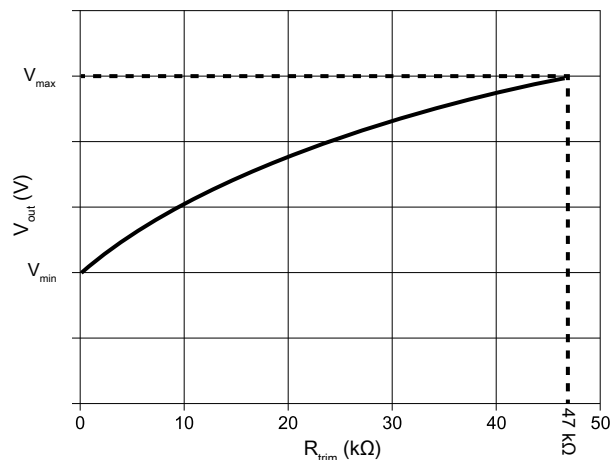
Remote voltage adjustment is not available on CmG and CmH modules.



**Figure 6-18.** CoolMod wiring diagram for remote voltage setting using external resistance

You can calculate the  $R_{trim}$  resistance required for your desired output voltage by using [Table 6-9](#) and the following formula:

$$R_{trim} = \frac{47000(V_{out} - F)}{F + 5K - V_{out}}$$



**Figure 6-19.**  $R_{trim}$  versus  $V_{out}$

## Voltage Control via PMBus

Refer to “[PMBus Communications](#)” and the CoolX PMBus manual for further details.

### CONSIDERATIONS WHEN ADJUSTING OUTPUT VOLTAGE USING $V_{TRIM}$ AND PMBUS

$V_{trim}$  and PMBus control can only adjust the output voltage downward from the onboard potentiometer set voltage. For example, if a CmC module is set by the potentiometer to 24 V,  $V_{trim}$  and PMBus will only be able to dynamically set and adjust the output voltage over the range of 15 V to 24 V. However, if the onboard



potentiometer is set to  $V_{\max}$  of 28 V, the  $V_{\text{trim}}$  or PMBus control can dynamically set and adjust the output voltage over the full range of 15 V to 28 V.

This prevents accidental OVP or potentially damaging output voltage in the end application because of an incorrect  $V_{\text{trim}}$  signal or command.

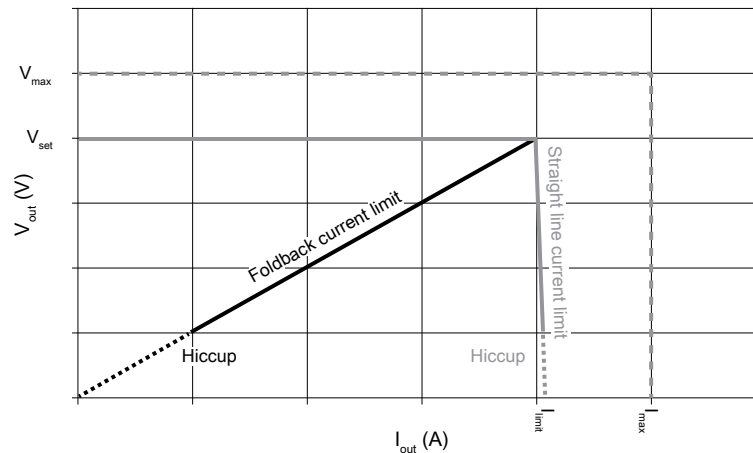
## CURRENT LIMIT ADJUSTMENT

The CoolX unit has two methods of overcurrent protection: straight line current limit and foldback current limit. The default current limit characteristic is straight line current limit. Simple external application circuits can be used to achieve programmable foldback current and user programmable reduced current limit levels. Refer to [Table 3-2](#) on page 3-2 for nominal current limit values.



### Important

Current limit adjustment is not available on dual modules or bulk modules.



**Figure 6-20.** Current limit characteristics

## Straight Line Current Limit

The straight line current limit of standard and wide-trim modules can be set remotely in two ways: with a control voltage ( $I_{\text{trim}}$ ) or with a resistor ( $R_{\text{trim}}$ ) across the output signal connector pins.

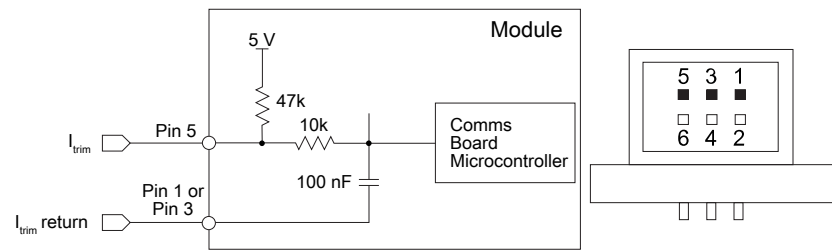
### REMOTE CURRENT ADJUSTMENT USING EXTERNAL VOLTAGE

The control voltage ( $I_{\text{trim}}$ ) should be applied across the output signal connector pins: pin 5 ( $I_{\text{trim}}$ ) and pin 1 (common).



### Important

Current limit adjustment is not available on CmG and CmH modules.



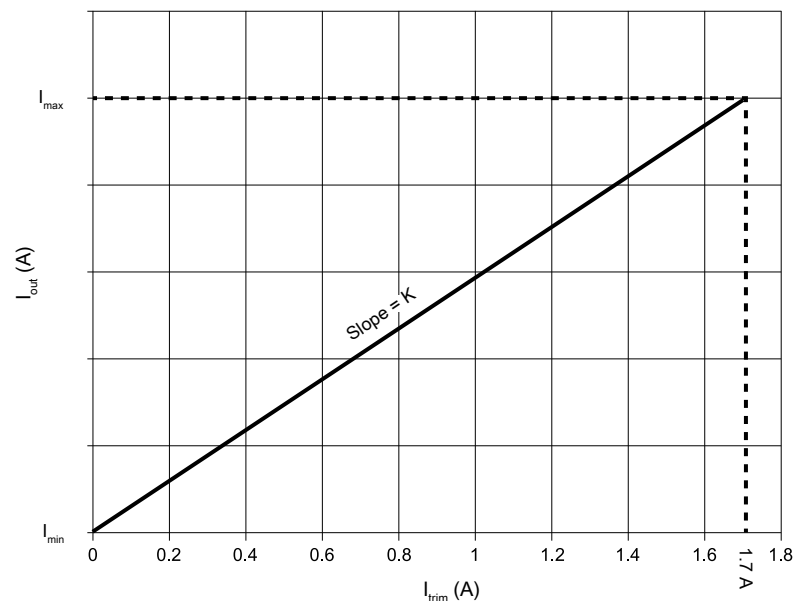
**Figure 6-21.** CoolMod wiring diagram for remote current setting using external voltage

The  $I_{trim}$  voltage required for your desired current limit can be calculated using the following formula and table:

$$I_{trim} = \frac{I_{out}}{K}$$

**Table 6-10.**  $K$  values for calculating  $I_{trim}$

Module	$K$
CmA	14.79
CmB	10.65
CmC	5.75
CmD	2.89
CmA-W01	14.79
CmB-W01	10.65
CmC-W01	5.75
CmD-W01	2.89



**Figure 6-22.**  $I_{trim}$  versus  $I_{out}$

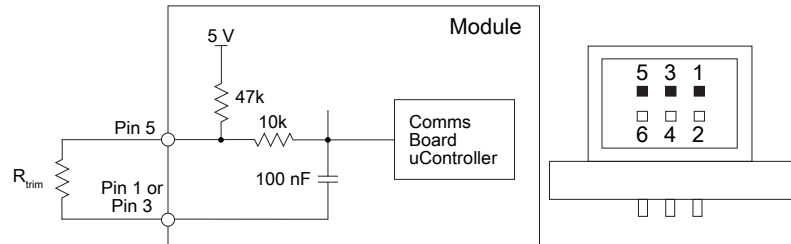
### REMOTE CURRENT ADJUSTMENT USING EXTERNAL RESISTANCE

The current limit of a standard or wide-trim module can be set by placing a resistor ( $R_{trim}$ ) across the output signal connector pins: pin 5 ( $V_{trim}$ ) and pin 1 (common).



#### Important

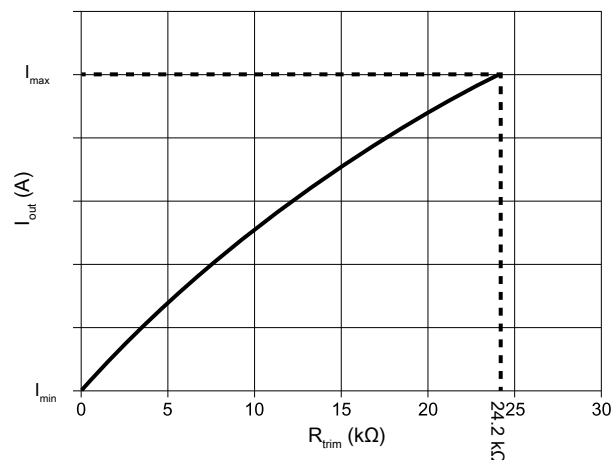
Current limit adjustment is not available on dual modules.



**Figure 6-23.** CoolMod wiring diagram for remote current setting using external resistance

You can calculate the  $R_{trim}$  resistance required for your desired output voltage by using [Table 6-10](#) and the following formula:

$$R_{trim} = \frac{47000 \times I_{out}}{5K - I_{out}}$$

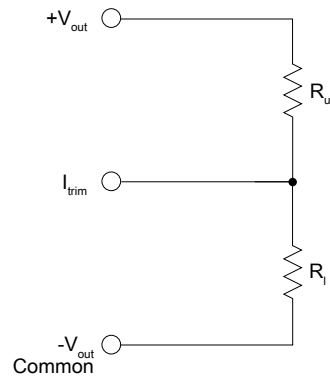


**Figure 6-24.**  $R_{trim}$  versus  $I_{out}$

A single control voltage can be used to adjust the current limit of individual modules or modules connected in parallel.

### Foldback Current Limit Programming

Foldback current limit requires the common pin of the output connector to be tied to the  $-V$  output connector of the module (the common pin is also  $-V_o$  of the auxiliary voltage). Foldback current limiting can then be implemented by placing a resistor,  $R_u$ , across  $+V_{out}$  and  $I_{trim}$ , and a resistor,  $R_l$ , across  $I_{trim}$  and  $-V_{out}/common$ .



**Figure 6-25.** Foldback current limit circuit

$$R_l = \frac{23500 \times I_{out}}{5K - I_{out}}$$

$$R_u = \frac{47000 \times R_l \times \left( V_{out} - \frac{I_{out}}{K} \right)}{R_l \times I_{trim} - 5R_l + 47000 \times \frac{I_{out}}{K}}$$



### Important

This capability is not available on dual modules or bulk modules.

## OVERVOLTAGE PROTECTION (OVP)

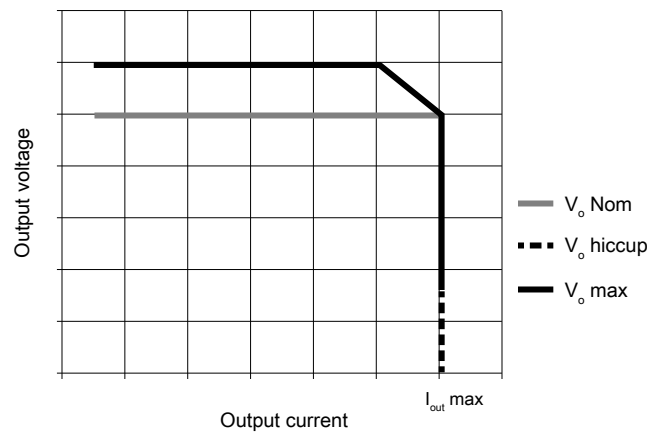
For standard and wide-trim modules, there are two levels of overvoltage protection implemented on each module output: the tracking OVP level and the fixed OVP level. Dual and bulk modules only have fixed overvoltage protection.

The tracking OVP level is relative to the set output voltage. This level turns off the module converter if the actual output voltage exceeds the set output voltage by more than 20%. The module recovers if the output voltage falls back within the set voltage (this operation will be limited by the fixed OVP at high output voltages).

The fixed OVP level is fixed relative to  $V_{max}$ , and activates between 125% and 160% of the maximum output voltage. This OVP inhibits all outputs for at least one second, after which the unit attempts to restart. If the fault condition is still present, the unit will shut down for another second. The unit repeats this process until the fault is removed and a successful restart occurs.

## POWER LIMIT

Each module has multiple levels of protection to ensure that the CoolX unit is not damaged if used in overload conditions. Refer to the following figure:



**Figure 6-26.** Current and power overload characteristics

When  $V_{set}$  is less than or equal to  $V_{nom}$ , current limit is employed at the current limit setpoint. However, for standard and wide-trim modules, if  $V_{set}$  is greater than  $V_{nom}$ , an intelligent power limit method is employed to ensure that the module does not exceed its power rating.

For example, a CmC module is adjustable from 15 V to 28 V, its  $I_{max}$  is 8.33 A, and its power rating is 200 W.

- At 24 V, the module can deliver 8.33 A continuously (that is, 200 W).
- At 28 V, the module can still deliver 200 W, which equates to 7.14 A continuous current.

## REMOTE SENSE

Remote sensing can be used to compensate for voltage drops in output leads, and is available on all modules via the J3 sense connector. Refer to [Figure 6-8](#) on page 6-4.



### Important

Remote sensing is not available on dual modules.

Remote sensing is implemented by connecting pin 1 (positive sense) on J3 to the positive side of the remote load and pin 2 (negative sense) on J3 to the negative side of the remote load. The maximum line drop that remote sensing can compensate for is 0.5 V. However, remote sensing cannot cause the maximum module voltage to be exceeded at the output terminals. Observe the following precautions when using remote sensing:

- Use separate twisted pairs for power and sense wiring.
- Route the sensing leads to prevent pickup, which might appear as ripple on the output.
- Never disconnect the output power rail with the sensing still connected to the load.

In certain applications where there is a high dynamic impedance along the power leads to the sensing point, remote sensing might cause system instability. This system

problem can be overcome by using resistors in the sense leads (positive sense lead:  $R_1 = 10\ \Omega$ , negative sense lead:  $R_2 = 10\ \Omega$ ) and local AC sensing (using  $22\ \mu\text{F}$  capacitors between the remote sense pins and the output terminals).

The resistance of the power cables ( $R_{\text{cable}}$ ) must be such that the voltage drop across the cables is less than  $0.5\ \text{V}$  (to ensure remote sensing operates correctly).

$$R_{\text{cable}} < \frac{0.5}{I_{\text{out}}}$$

For example, the  $R_{\text{cable}}$  for a CmA module,  $5\ \text{V}/21\ \text{A}$ , must be less than  $23.8\ \Omega$ .

## MEASUREMENT OF RIPPLE AND NOISE

It is important to use the correct method to measure ripple and noise. Take care to prevent forming a loop antenna with the tip and ground lead of the oscilloscope probe. Such a loop would cause erroneous readings from pickup of remnant radiation near the output connectors. Advanced Energy recommends that you use an x1 probe with the ground sheath of the probe tip used for ground connection.

In some applications, common-mode currents can cause further erroneous readings. To reduce these readings, loop a few turns of the scope lead through a suitable high-permeability ferrite ring. Most loads powered by a power supply will have at least small values of differential capacitance located near the load. Advanced Energy recommends the use of a small value of capacitance (approximately  $1\ \mu\text{F}$ ) positioned at the point of measurement.

Refer to “[Minimizing System Noise](#)” on page 7-1 and Application Note AN1105: Ripple and Noise for additional details about how to measure and reduce output ripple and noise.

## MAINTENANCE

### To Remove CoolMod Modules



#### Important

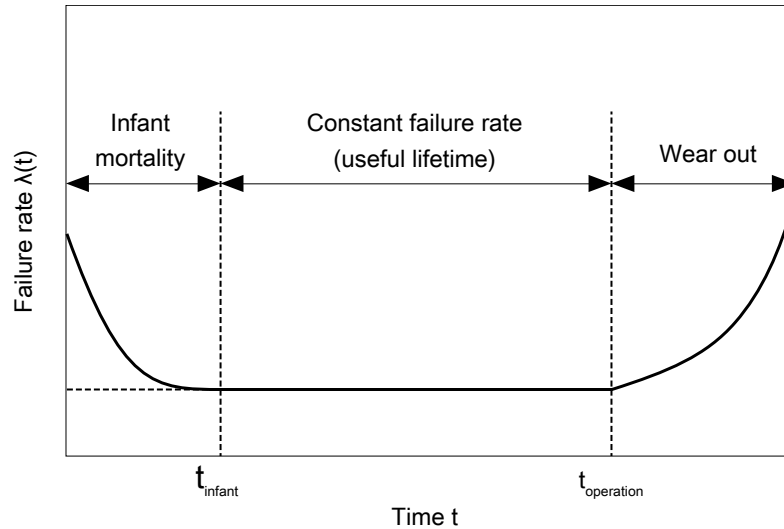
CoolX units do not have user-serviceable components; the units must be returned to the factory for repairs. Contact AE Global Services for an RMA number before returning the unit. Do not attempt to repair or modify the power supply in any manner other than the exchange of CoolMod modules as described in this manual.

1. Unscrew and remove the plastic retainer bar.
2. Remove the two mounting screws from the base of the CoolPac chassis.
3. Unplug the module from the chassis.

Once a module has been removed, you can either insert another module or leave the slot empty.

## Reliability

The bathtub curve in [Figure 6-27](#) shows how the failure rate of a power supply develops over time.



**Figure 6-27.** Failure rate of a power supply

The failure rate comprises three stages:

- Infant mortality—immediately after production, some units fail due to defective components or production errors.
- Constant failure rate—the useful lifetime of a product.

Power supplies rarely fail during this period.

- Wear out—units begin to fail due to wear.

As the unit approaches its end of life, the first signs of wear appear and failures become more frequent. The lifetime of a unit is generally defined as the time when the failure rate increases to five times the statistical rate of the flat portion of the bathtub curve in the previous figure. The lifetime is the time after which the unit fails due to wear appearing.

The MTBF is a measurement of how many devices fail in a period of time (that is, a measure of reliability) before signs of wear appear. The MTBF can be calculated mathematically as follows:

$$\text{MTBF} = \frac{\text{Total} \times t}{\text{Failure}}$$

Where:

- Total = the total number of power supplies operated simultaneously
- $t$  = the observation period
- Failure = the number of failures

MTBF can be established in two ways:

- By actual statistics on the hours of operation of a large population of units
- By calculation from a known standard such as Telecordia SR-332 and MIL-HDBK-217 and its revisions

## CALCULATING MTBF

When calculated in accordance with Telecordia, MILHDBK- 217 and other reliability tables, MTBF involves the summation of the failure rates of each individual component at its operating temperature. The failure rate of each component is determined by multiplying a base failure rate for that component by its operating stress level. The result is FPMH, the failure rate per million operating hours for that component. Then FPMH for an assembly is simply the sum of the individual component FPMH.

$$\text{Total FPMH} = \text{FPMH}_1 + \text{FPMH}_2 \dots + \text{FPMH}_n$$

$$\text{MTBF(hours)} = \frac{1000000}{\text{Total FPMH}}$$

In this manner, MTBF can be calculated at any temperature.



### Important

The following values are preliminary.

- Module: 0.52 failures per million hours
- Chassis: 3.01 failures per million hours

Example:

- CX10S chassis FPMH = 3.01
- CmA, CmB, CmC, CmD module FPMH = 0.52 each

$$\text{Total FPMH} = 3.01 + 4 \times 0.52 = 5.09 \text{ FPMH}$$

$$\text{MTBF} = 196,463 \text{ hours at } 40^{\circ}\text{C} (104^{\circ}\text{F})$$

## MTBF AND TEMPERATURE

Reliability and MTBF are highly dependent on operating temperature. The MTBF figures are based on an operation ambient temperatures of 40°C (104°F). For each 10°C (18°F) decrease, the MTBF increases by a factor of approximately 2.

Conversely, for each 10°C (18°F) increase, the MTBF reduces by a similar factor. Therefore, when comparing manufacturer quoted MTBF figures, look at the temperature information provided.

## SHELF LIFE OF POWER SUPPLIES

If electrolytic capacitors are stored without voltage for an extended period of time, the oxide film on the anode foil can deteriorate, which will result in higher than



specified leakage current when voltage is applied. This has a negative impact on the ripple current on the capacitor, which results in additional heating of the component and has a direct impact on reliability. According to published research, the commencement of this chemical reaction can occur after a two year period of an unpowered unit, so the recommended maximum shelf life for Excelsys platform designs is two years.

# Troubleshooting and Global Services

Before calling AE Global Services, perform recommended checks and troubleshooting procedures. If you are still unable to resolve the issue and resume normal operation after following these checks and procedures, contact AE Global Services.

## MINIMIZING SYSTEM NOISE

There are a number of causes of poor system noise performance. Some of the more common causes are listed below.

- Insufficient decoupling on the PCB or load
- Faulty wiring connection or poor cable terminations
- Poor system earthing, system level grounding, and shielding issues

There are some simple steps to eliminate, reduce, or identify the causes of high frequency noise:

- Is the noise conducted or radiated? If changing the position of the power supply or screening improves performance, the noise is likely radiated. Refer to [“EMC Characteristics”](#).
- Twist all pairs of power and sense cables separately.
- Ground connections (0 V) should be made with the shortest possible wiring via a capacitor to the nearest point on the chassis.



### Important

CoolX units do not have user-serviceable components; the units must be returned to the factory for repairs. Contact AE Global Services for an RMA number before returning the unit. Do not attempt to repair or modify the power supply in any manner other than the exchange of CoolMod modules as described in this manual.

## AE GLOBAL SERVICES

Please contact AE Global Services if you have questions or problems, or if you need customer support. Before contacting AE Global Services, please work through the provided troubleshooting. When you contact Global Services, please include the unit serial number and part number. These numbers are available on unit labels.

**Important**

For returns and repairs, please contact AE Global Services to get the correct shipping address.

## Primary Contact Information

Visit the Advanced Energy website for local service and support contact information:

<http://www.advancedenergy.com>

Click on the service link at the top of the page.

## Alternate Contact Information

If you do not have access to the Advanced Energy website, then use one of the following:

- Phone (24 hrs/day, 7 days/week):  
800.446.9167  
or  
+1.970.221.0108
- Email: (We will respond to email by the next business day.)  
<mailto:technical.support@aei.com>
- AE World Headquarters  
1625 Sharp Point Drive  
Fort Collins, CO 80525 USA

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