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Cool 1800W

1800W Intelligent Modular Power Supply

1800W output Power
Digital Communications and Control
Latest Industrial & Medical Approvals

Excelsys Technologies Ltd

An Advanced Energy Company

Aug 2018

Table of Contents

CoolX1800 Designers Manual

This CoolX1800 Power Supply Designers' Manual has been prepared by Excelsys experts to assist qualified engineers and technicians in understanding the correct system design practices necessary to achieve maximum versatility and performance from any of the CoolX1800 range of Intelligent Modular Configurable power supplies.

Section 1: Overview of CoolX1800

The CoolX1800 Series is the new modular power supply from Excelsys. It provides an incredible 1800W in a compact 5 x 10.5 x 1U package, typically 50% more power than the industry standard. Delivering best in class performance in efficiency and unrivalled reliability, the CoolX1800 offers system designers the most comprehensive feature set and specifications.

The series comprises two base models. The CX18S is certified to IEC60950 2nd edition for industrial applications as well as the upcoming IEC62368-1 standard. The CX18M carries IEC60601-1 3rd edition & IEC60601-1-2 4th edition (EMC) for medical applications. The CoolX1800 can be populated with up to 6 CoolMods, providing up to 12 isolated DC outputs ranging from 2.5V to 58.0V. Continuing the Excelsys tradition of flexibility, the CoolX1800 is completely user and field configurable. Outputs can be adjusted to the required set point voltages and can be configured in parallel or series for higher current and/or higher voltages. CoolPacs can be paralleled for higher power and N+1 Redundancy applications.

Stand-out features for medical applications include suitability for type BF rated (Body Floating) applications, input dual fusing, 2 x MOPP isolation and <300uA leakage current. Other features include 4KV input surge immunity, SEMI F47 compliance, MIL810G compliance and the ability to withstand input voltages of up to 300VAC making it ideal for use in remote locations and those subject to input voltage disturbances. With analog and Digital Communications (PMBus™), the CoolX1800 provides the most flexible, highest specification modular power supply in the market, all backed up by the Excelsys 5 Year Warranty ensuring quality and the lowest total cost of ownership.

A complete power supply is configured by selecting and inserting up to 6 DC output modules called CoolMods into a CoolPac to build a user defined power supply. This offers the advantages of a custom supply but is assembled from standard and modular building blocks. If output requirements change, i.e. more power or a different output voltage is needed, upgrading is easy: remove the lid and the 2 module screws and replace the CoolMod with the preferred alternative. Allowing additional flexibility, CoolMods can be connected in parallel to increase output power, or in series for higher voltages (subject to staying within isolation ratings and giving due consideration to any SELV requirements).

A user-friendly interface on each CoolMod provides control and output sequencing capability, in addition to useful status indicators. Alternatively, Digital control and monitoring is accessible through the PMBus™ interface.

Section 2: Installation Considerations

The CoolX series models may be mounted on any of its three surfaces using standard M4 screws. The chassis comes with four mounting points on the base and two on each side. Maximum allowable torque for mounting screws is 2Nm and maximum allowable penetration depth is 1.5mm. Alternatively, DIN-Rail mounting is also possible using the Excelsys Din-Rail mounting bracket.

Prior to assembling cables to the output terminals of the CoolMods, ALWAYS ensure that the plastic retainer bracket is in place.

Avoid excessive bending of output power cables after they are connected to the CoolMods. For high current outputs, use cable-ties to support heavy cables and minimise mechanical stress on output terminals. Be careful not to short-out to neighbouring output terminals. The maximum torque allowed on output connectors is 2Nm.

The CoolPac should be supplied by a power source of the type indicated on its label, and only used with a suitably rated mains cord. Double pole / neutral fusing is used in the CoolX platform. If the installation is not completely disconnected from power, parts may remain live even if one of the two mains fuses has blown.

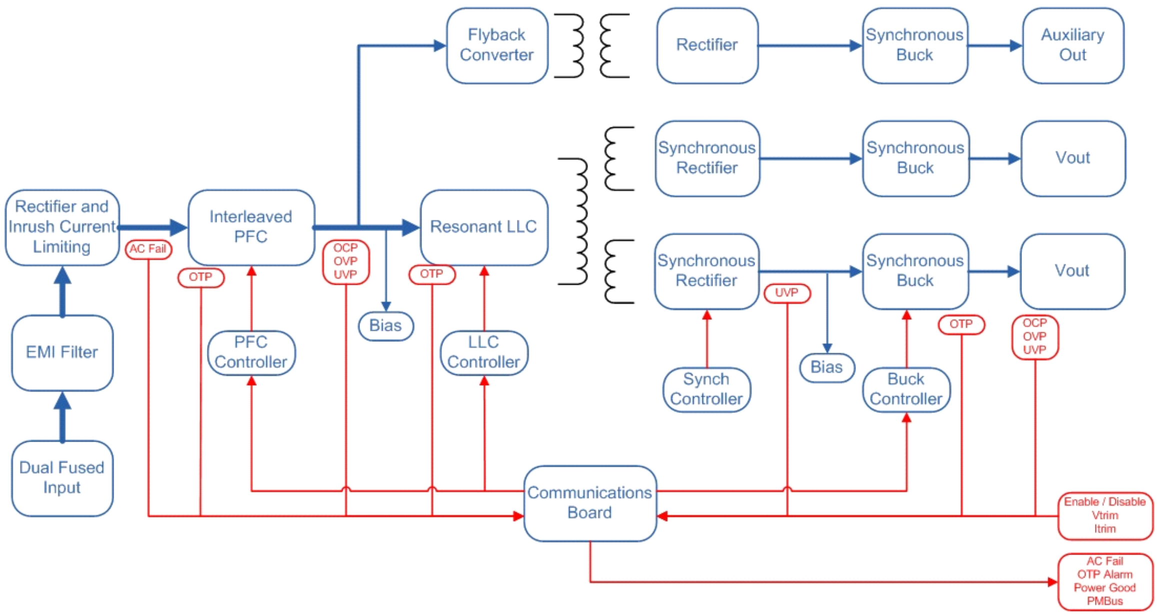
When adding or removing CoolMods from the CoolPac, care must be taken to handle the CoolMods by the output terminals only, ensuring that all the other surface mount components are not unduly damaged.

Parts of the unit will become hot during operation, allow time to cool before handling. After disconnecting the AC source, allow 4 minutes before disassembly to allow capacitors within the unit to discharge.

Section 3: Configuration Considerations

- Do not unplug CoolMods while input power is applied to the CoolPac. The CoolMods are not designed for hot-plug insertion.
- Always ensure that input and output screw terminals are properly torqued before applying power to the CoolX
- Positive and negative power cables should be arranged as a twisted pair to minimise inductance.
- Wait 4 minutes after shutting off power before inserting or removing CoolMods.
- CoolX assemblies do not have user serviceable components. They must be returned to the factory for repairs. Contact Customer Service 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 CoolMods as described in this Designers' Manual.
- Use proper size wires to avoid overheating and excessive voltage drop.
- Take appropriate precautions when touching the CoolX after it has been operating for a period of time. Due to the excellent conduction cooling methods to the chassis, the chassis will remain hot for some time after power has been removed.
- If a CmE or CmF module is to be configured in the CoolX1800, it must be used in Slot 6. This leaves Slot 1, Slot 2 and Slot 3 free for other standard or dual modules.

Section 4: Theory of Operation



The CoolX platforms are comprised of an appropriate CoolPac and a selection of CoolMod DC output modules selected to deliver the exact volts and amps requirements of the system designer. An operational block diagram is shown above.

The CoolPac is made up of an off-line single-phase AC front end, EMI filter, and customer interface and associated housekeeping circuits. Input AC mains voltage (L, N and GND) is applied to either an IEC type input connector or a screw terminal input block (optional) and then through an EMI filter designed to meet EN55022 Class B. Some applications may require an external ferrite on cabling to meet Class B Radiated EMI. Please contact Applications Support for recommendations.

For medical applications, the EMI filter also ensures the power supply meets the low earth leakage current requirements of EN60601-1 3rd Edition. All modules provide medical isolation of 4000VAC (2 MOPP) from input to output and extended isolation of 1850VAC from output to earth (Note: 1 MOPP requirement is 1500VAC). A 24W auxiliary ‘always-on’ isolated bias supply of 12VDC or 5VDC (optional) is provided for peripheral use. This Bias supply also has medical isolation of 4000VAC (2 MOPP). A full suite of monitoring and controls including AC Fail, Global Inhibit/Enable, and Over-Temperature Alarm are provided.

CoolMods provide isolated DC outputs. These can be set to the required voltage setpoints by the user or factory set as required. Each CoolMod has its own discrete Enable/Inhibit control, Voltage Adjust (Vtrim), Current limit adjust (Itrim), and Remote Sense.

A configured CoolX has the following galvanic isolation barriers.

Isolation Barrier	Type	Withstand Voltage
Input to Output	Reinforced (2 x MOPP)	4000VAC
Input to Case (GND)	Basic (1 x MOPP)	1850VAC
Output to Case (GND)	Basic (1 x MOPP)	1850VAC
Output to Output	Basic (1 x MOPP)	1850VAC
Output (V1) to Output (V2) - Dual	Functional	500VAC

Section 5: Configuration (and Reconfiguration)

CoolMods may be easily added, replaced, or moved by plugging the modules in or out of the CoolPac chassis. Prior to removing or installing a CoolMod, remove input power from the CoolPac and wait 4 minutes. Failure to do so can result in personal injury and/or damage to the supply. Take standard ESD precautions when handling the CoolX CoolPac and CoolMods.

Configuring the CoolX to give the exact volts and amps required is as easy as 1, 2, 3!

1. Select the appropriate CoolMods for your application.
2. Calculate the number of CoolPacs required for your power requirements.
3. Select your appropriate CoolPac for your application (Standard or Medical)

Installing CoolMods

CoolMods may be installed in the CoolPac by simply removing the lid and simply plugging the CoolMod module into the CoolPac. The CoolMod is secured to the base of the CoolPac with two mounting screws. Once all CoolMods are fixed in pace, the plastic retainer bar must be fitted across the top of the CoolMods, and finally the lid attached to the chassis.

If a CmE or CmF module is to be configured in the CoolX 1800, it must be used in Slot 6. This leaves Slot 1, Slot 2 and Slot 3 free for other standard or dual modules.

Standard CoolMods may be paralleled for more power using bus bars (Parallel Links) across the positive and negative output terminals. They can also be series connected for applications requiring higher voltages using Series Links.

Note that Dual modules cannot be connected in parallel, and CmE or CmF modules cannot be used in parallel or in series.

Removing CoolMods

CoolMods may be removed by first removing the lid from the CoolPac, and the removing the plastic retainer bar. Remove the two mounting screws on the base of the CoolPac. Once these screws have been removed the CoolMod will plug out of the chassis. Once a CoolMod has been removed, the user can insert another CoolMod, or leave the slot empty.

Section 6: CoolMod Operation

The CoolX has been designed to allow maximum flexibility in meeting the unique requirements of system designers. The inherent flexibility resulting from modular concepts allows users to configure solutions with multiple outputs that can be individually controlled.

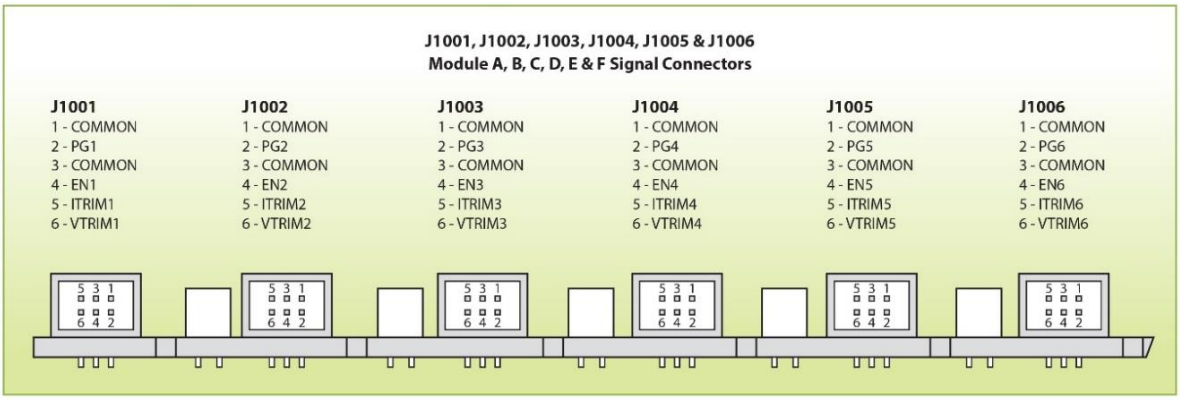
There are 12 CoolMods which provide discrete isolated DC outputs according to the *CoolMod Summary Specifications* table below.

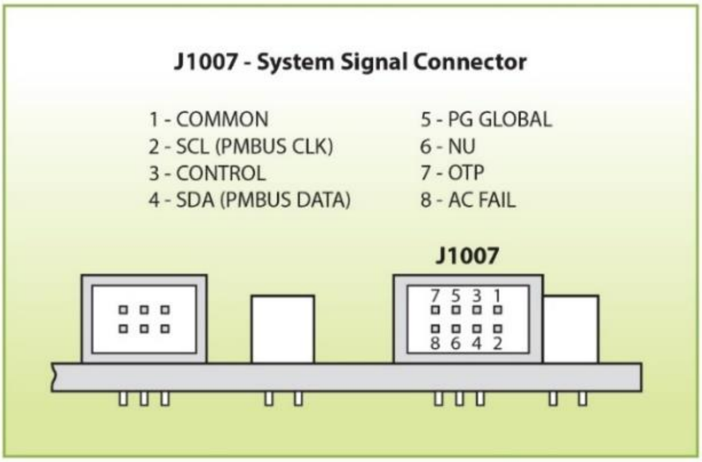
Model	Vnom (V)	Vadjust (V)	OVP tracking % of Vset	OVP*	Imax (A)	Ilim %	Pmax (W)
CmA	5.00	2.5 to 6.0	105 to 125%	110 to 150%	30.00	130 to 160%	150
CmB	12.00	6.0 to 15.0**	105 to 125%	110 to 140%	23.30	120 to 140%	280
CmC	24.00	15.0 to 28.0	105 to 125%	110 to 135%	12.50	110 to 130%	300
CmD	48.00	28.0 to 58.0	105 to 125%	103 to 115%	6.25	110 to 130%	300
CmE	24.00	24 to 25.2	Not Applicable	115 to 125%	37.50	104 to 115%	900
CmF	48.00	48 to 50.4	Not Applicable	115 to 125%	18.75	104 to 115%	900
CmG	24.00 24.00	3.0 to 30.0 3.0 to 30.0	Not Applicable	103 to 130%	4.00 4.00	100 to 260%	200***
CmH	5.00 24.00	3.0 to 6.0 3.0 to 30.0	Not Applicable	130 to 170% 103 to 130%	10.00 4.00	100 to 180% 100 to 260%	180***
CmA-W01	5.00	1.0 to 6.0	105 to 125%	110 to 150%	30.00	130 to 160%	105
CmB-W01	12.00	1.0 to 15.0	105 to 125%	110 to 140%	23.30	120 to 140%	180
CmC-W01	24.00	2.0 to 28.0	105 to 125%	105 to 135%	12.50	110 to 130%	200
CmD-W01	48.00	3.0 to 58.0	105 to 125%	103 to 115%	6.25	110 to 130%	100

*Specified as a percentage of maximum voltage
**Full Dynamic Specifications may not be met at full load when output voltage is trimmed above 13 V
***Total max power of both channels

Voltage Adjustment

The CoolX series CoolMods boast very wide output voltage adjustment ranges. Voltage setting, and dynamic voltage adjustment can be achieved in three ways; by adjusting the on board potentiometer, using the Vtrim pin of the Output Signal Connector (J1001 to J1006) or with PMBus™ commands applied to the System Signal Connector (J1007).





*NU: Not Used or No Connection

On Board Potentiometer (All Modules)

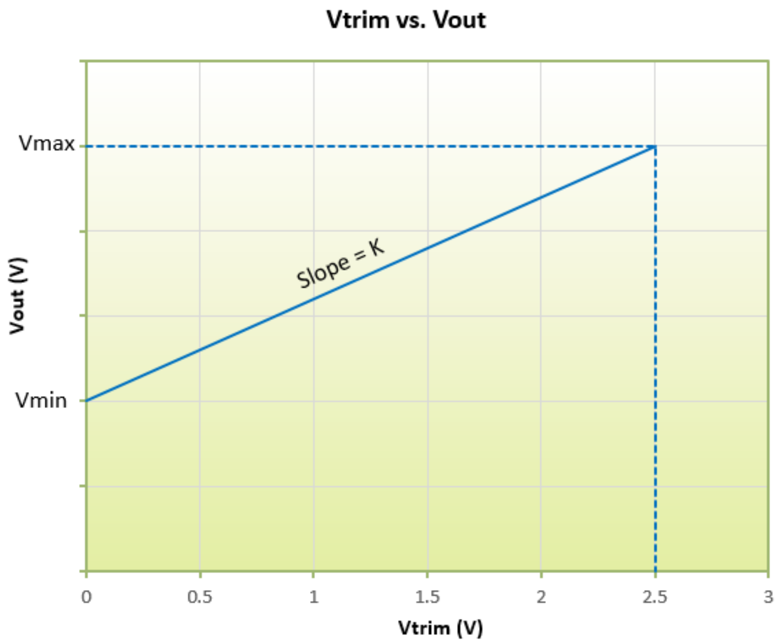
Simply adjust the output voltage to the required level using the multi-turn trim pot present on the CoolMod.

Remote Voltage Adjustment (Standard, Wide-Trim and Bulk Modules modules)

Remote Voltage adjustment is not available on the CmG or CmH CoolMods. The output voltage of the CoolMod can be set by applying a control voltage Vtrim across the Output Signal Connector pins Vtrim (Pin 6) and Common (Pin 1). The Vtrim voltage required for the users desired output voltage can be calculated using the following formula and table.

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

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	-3.90
CmC-W01	12.77	-2.17
CmD-W01	26.25	-6.42



The output voltage of the CoolMod can be set by placing a resistor Rtrim across the Output Signal Connector pins Vtrim (Pin 6) and Common (Pin 1). The Rtrim resistance required for the users desired output voltage can be calculated using the following formula along with the same table used to calculate Vtrim.

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

Voltage control via PMBus™ (Standard, Wide-Trim and Bulk Modules modules)
Please see the CoolX PMBus™ Manual for further details.

Important note regarding Vtrim and adjusting output voltage using PMBus™ :
Vtrim and PMBus™ control can only adjust the output voltage downwards from the on-board potentiometer set voltage. For example, if a CoolMod CmC is set by the potentiometer to 24.0V, Vtrim and PMBus™ will only be able to dynamically adjust/set the output voltage between the ranges of 15.0V to 24.0V. However if the on board potentiometer is set to Vmax of 28.0V, the Vtrim or PMBus™ control can dynamically adjust/set the output voltage over the full range of 15.0 to 28.0V.

This prevents accidental OVP or potentially damaging output voltage in the end application if an incorrect Vtrim voltage is used.

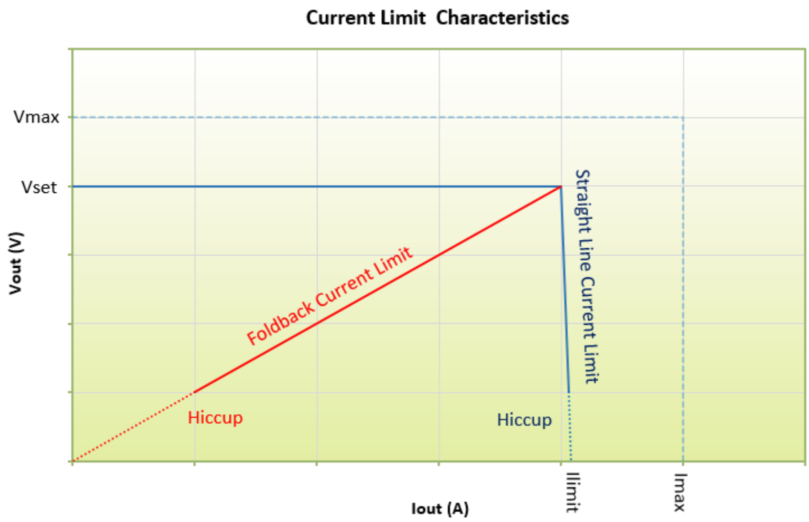
Current Limit Adjustment (Standard and Wide-Trim modules)

A variety of over current protection methods are possible with the CoolX. The default current limit characteristic is Straight Line Current Limit. Simple external application circuits may be used to achieve programmable fold-back current and user programmable reduced current limit levels. See the CoolMod Summary Specifications table (Page 9) for nominal current limit values.

*Note Current Limit adjustment is not available on CmE-H CoolMods.

Programming Current Limit (Standard and Wide-Trim modules)

The current limit can be programmed to your requirements (in both Straight line and Foldback modes).



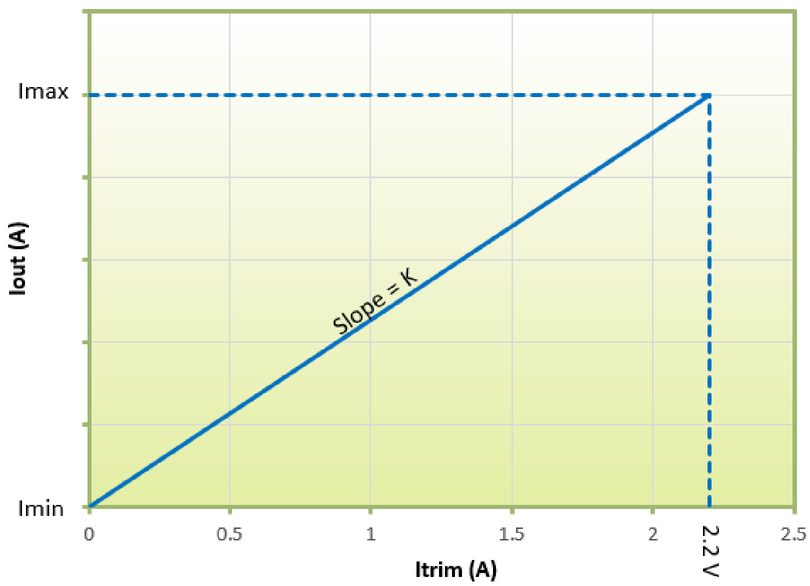
Straight line Current Limit (Standard and Wide-Trim Modules)

The current limit of the CoolMod can bet set by applying a control voltage Itrim across the Output Signal Connector pins Itrim (Pin 5) and Common (Pin 1). The Itrim voltage required for the users desired current limit can be calculated using the following formula and table.

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

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

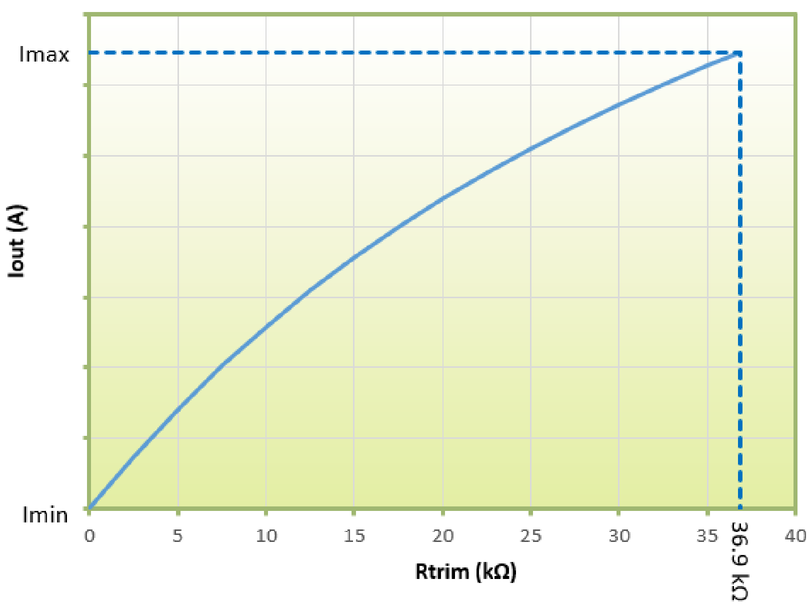
Itrim vs. Iout



The current limit of the CoolMod can bet set by placing a resistor Rtrim across the Output Signal Connector pins Itrim (Pin 5) and Common (Pin 1). The Rtrim resistance required for the users desired output current limit can be calculated using the following formula along with the same table used to calculate Itrim.

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

Rtrim vs. Iout

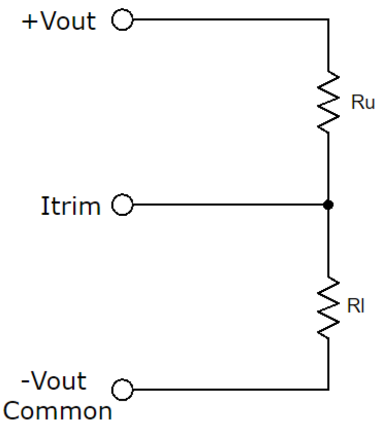


A single control voltage can be used to adjust the current limit of individual modules or modules connected in parallel.

Like setting the output voltage, current limit can be programmed or controlled via the PMBus™ interface. Please see the CoolX PMBus™ Manual for further details.

Foldback current Limit Programming (Standard and Wide-Trim Modules)

Foldback Current Limit can also be achieved with the CoolX but it requires the Common Pin of the Output Connector to be tied to the –V Output Connector of the module (remember that the Common Pin is also –Vo of the Auxiliary Voltage). Foldback Current Limiting can then be implemented by placing a resistor Ru across +Vout and Itrim, and a Resistor Rl across Itrim and –Vout/Common.



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

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

Over Voltage Protection (OVP)

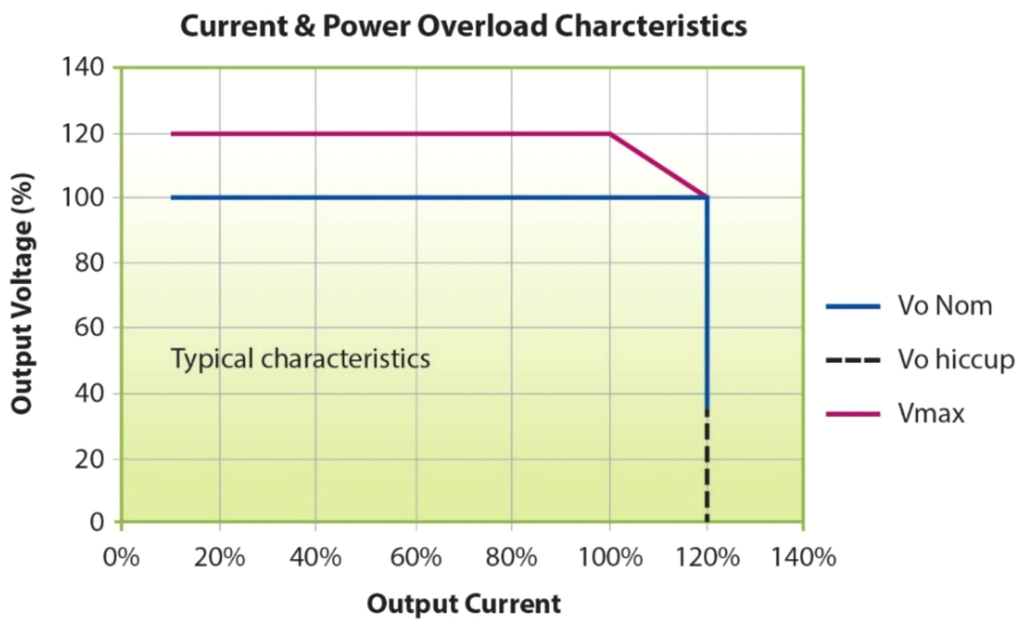
Standard and Wide-Trim moduels have two levels of over-voltage protection (tracking and fixed), while the CmE-H have fixed over-voltage protection only.

The tracking OVP level is relative to the set output voltage and will turn off the CoolMod converter if the actual output voltage exceeds the set output voltage by more than 20%. When the fault condition has been removed the module will auto-recover.

The Fixed OVP level is fixed relative to Vmax and will activate between 103-170% of the maximum output voltage. The Fixed OVP will turn off all outputs of the CoolX1800 and, like the tracking OVP, will hiccup all outputs until the fault condition is removed.

Power Limit

Each CoolMod has a number of levels of protection in order to ensure that CoolX is not damaged if used in overload conditions. Refer to Current and Overload Characteristics Graph.



When Vset is less than or equal to Vnom, current limit is employed at the current limit set point.

For Standard and Wide-Trim modules, if Vset is greater than Vnom, an intelligent power limit method is employed to ensure that the CoolMod does not exceed its power rating.

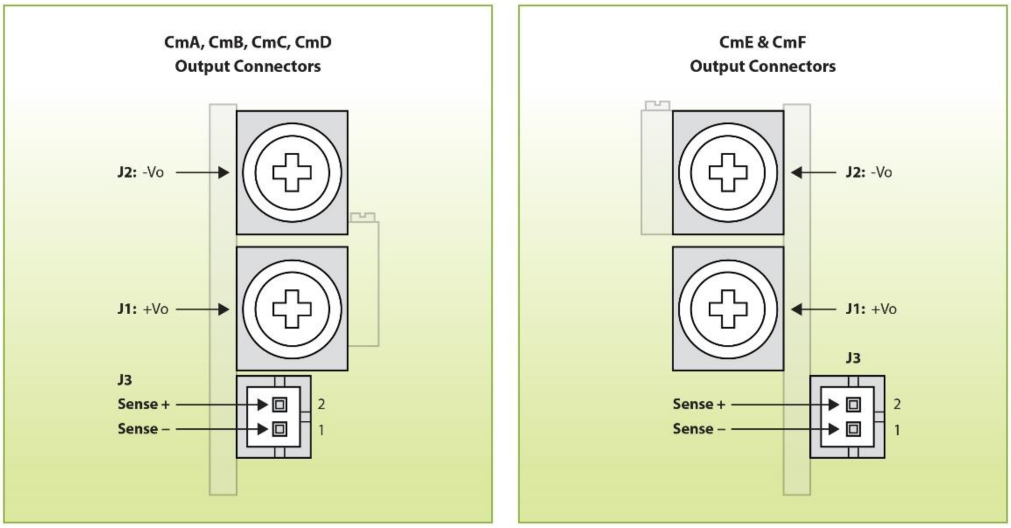
E.g. CmC is adjustable between 15V and 28V, Imax is 12.5A, and Power rating is 300W.

- At 24V the CoolMod can deliver 12.5A continuously, i.e. 300W.
- At 28V, the CoolMod can still deliver 300W, however this equates to 10.7A continuous current.

CmE-H modules do not have a power limit and rely on current limit only.

Remote Sense (Standard, Wide-Trim and Bulk modules)

Remote sensing can be used to compensate for voltage drops in output leads. Remote sensing is available on CoolMods via the J3 Sense Connector. There is no remote sense on the CmG or CmH CoolMods.



Remote sensing may be implemented by connecting the Positive Sense pin (J3 pin2) to the positive side of the remote load and the Negative Sense pin (J3 pin1) to the negative side of the remote load. The maximum line drop, which can be compensated for by remote sensing is 0.5V, subject to not exceeding the maximum module voltage at the output terminals. Observe the following precautions when remote sensing:

- Use separate twisted pairs for power and sense wiring.
- Route the sensing leads to prevent pick up, which may 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 may cause system instability. This system problem can be overcome by using resistors in the sense leads (Positive sense lead: R1 = 10ohm, Negative sense lead: R2=10ohm), together with local AC sensing, by using 22uF capacitors between the remote sense pins and the output terminals.

The resistance of the power cables must be so that the voltage drop across the cables is less than (Rcable) 0.5V (to ensure remote sensing operates correctly).

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

E.g. for a CmA, 5V/30A, the Rcable must be less than 16.7mohms.

Measurement of Ripple & Noise

As with all switched mode power supplies, it is important to ensure that the correct method is used to measure ripple & noise. Care should be taken to ensure that a loop antenna is not formed by the tip and ground lead of the oscilloscope probe as this would lead to erroneous readings consisting mainly of pickup from remnant radiation in the vicinity of the output connectors. Excelsys recommends the use of an x1 probe with the ground sheath of the probe tip used for ground connection. In some applications, further erroneous readings may result from Common Mode currents. These can be reduced by looping a few turns of the scope lead through a suitable high permeability ferrite ring. As most loads powered by a power supply will have at least small values of differential capacitance located near the load, Excelsys also recommends the use of small value of capacitance (approx.. 1uF) positioned at the point of measurement.

For further information refer to Application Note AN1105: Ripple and Noise for additional details on how to measure and reduce output ripple and noise.

Minimising System Noise

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

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

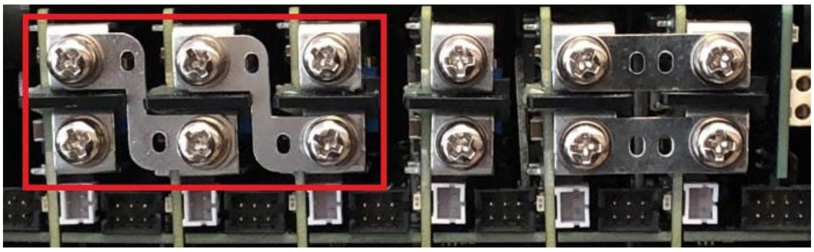
There are some simple steps to eliminate, reduce or identify the causes of high frequency noise;

- Is the noise conducted or radiated? If changing the position of the power supply or screening improves performance, the noise is likely to be radiated. See Section 16: EMC Characteristics.
- Twist all pairs of power and sense cables separately.
- Ground connections (zero Volt) should be made with the shortest possible wiring via a capacitor to the nearest point on the chassis.

Series Connection of CoolMod outputs (Standard and Wide-Trim Modules)

It is possible to connect modules in series to increase output voltage. Single module outputs are rated SELV (Safety Extra Low Voltage), that is, that output voltages are guaranteed to be less than 60V. If putting outputs in series this 60V limit can be exceeded and so appropriate precautions should be taken. It is good practice to stack modules with similar output current limits, so that in case of short circuit the outputs collapse together.

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 (CX18S1) links can be fitted to CoolMods modules to reduce wiring complexity. These Series Links can be fitted by the installer or added at the factory during configuration.



CmE and CmF Modules should not be connected in series. CmF and CmG outputs can be connected in series to each other, but there are no dedicated links for this, and this should be done at a system level.

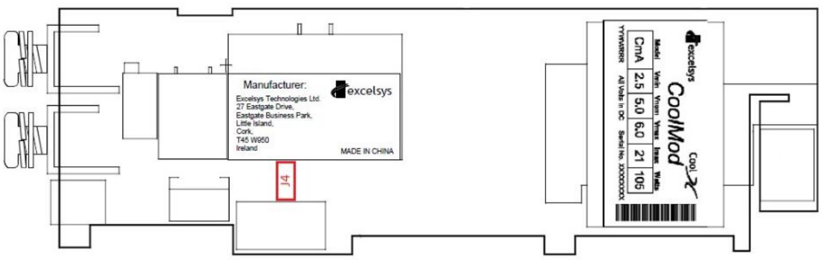
Parallel Connection for CoolMods (Standard and Wide-Trim Modules)

To achieve increased current capacity, simply parallel outputs using the standard parallel links. Excelsys passive current sharing ensures that current hogging is not possible.

Note: There is a 10% derating imposed on parallel modules.

To Parallel Connect CoolMods (Standard and Wide-Trim Modules):

- Turn on current sharing by adding a jumper on J4 Connector.



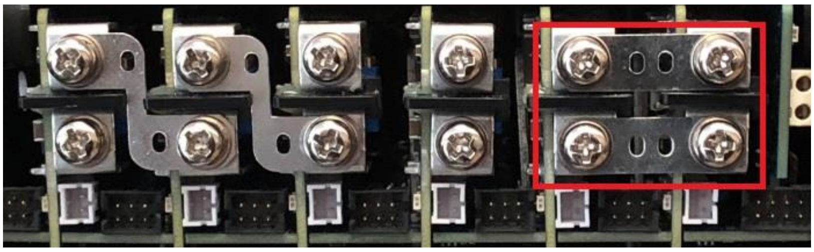
Jumper: Harwin – M22-1900005, 2 x 1 2.00 mm Pitch

- Connect Negative Parallel Links
- Adjust the output voltage of the first CoolMod to the required voltage
- Adjust the voltages of other CoolMods to be within the Parallel Voltage Tolerance (see below) of the first CoolMod output voltage
- Connect Positive Parallel Links

- If remote sensing is used in the application, connect all – Sense lines to the low side of the load and connect all + Sense lines to the high side of the load

Module	Parallel Voltage Tolerance
CmA	±10 mV
CmB	± 10 mV
CmC	±10 mV
CmD	±20 mV
CmA-W01	±10 mV
CmB-W01	±10 mV
CmC-W01	±10 mV
CmD-W01	±20 mV

Special parallel connection links (CX18P1) can be fitted to CoolMod modules to reduce wiring complexity. These Parallel Links can be fitted by the installer or added at the factory during configuration.



Note: CmE, CmF, CmG and CmH module outputs should not be paralleled.

Since all Coolmod signals are isolated from the Coolmod outputs, when CoolMods are connected in series or parallel, all CoolMod analog control functions (Vtrim, Itrim, Enable/Inhibit) can be implemented by paralleling the appropriate signal pins of each CoolMod and providing a single control signal, i.e. connect all the Vtrim pins together and control Vtrim using a single control voltage. This can also be implemented using the PMBus™ interface.

CoolMod Start-Up and Shutdown

CoolMods are designed so that when input power is applied, all outputs rise to their set point voltage simultaneously. Likewise, when input power is removed all outputs commence to turn off simultaneously. Outputs can be sequenced using the enable function in order to allow controlled start up if required.

Turn-On Delays are as follows

From AC	1000ms max
From Global Enable (CONTROL)	15ms max
From CoolMod Enable	15ms max

Power Good output signals from each module can be used to drive CoolMod Enable signals for sequenced outputs.

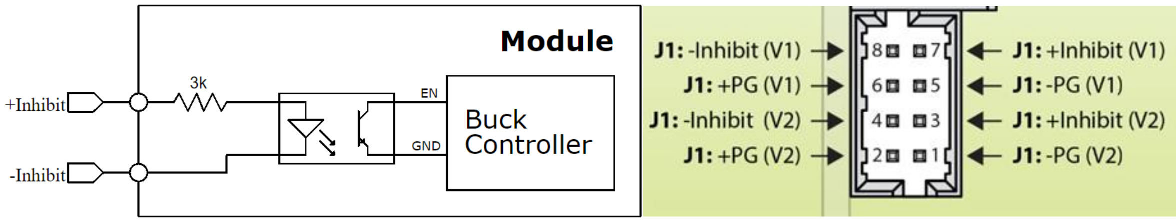
Section 7: CoolMod Signals

CoolMod Enable/Inhibit

Each CoolMod may be enabled/inhibited by means of a logic level signal applied to the enable input on Output Signal Connector J1001-J1006, Pin 4 (Positive), Pin 1 or 3 (Negative). The input has a 1K ohm series resistor and a 100nF filtering capacitor to filter noise on this signal. The input voltage must be limited to no greater than 5 volts. There is a max 15mS Turn-On Delay after application of the signal. When there is no connection, Pin 4 is HIGH (5V) and the module is enabled. Pulling Pin 4 to Common will disable the module.

Disabling CmG-H modules in this way will disable both outputs.

CmG-H Channel Enable/Inhibit



Each individual channel of the CmG or CmH may be enabled/inhibited by means of a signal applied to the Inhibit pins on the Module Signal Connector J1. When the Inhibit pins are floating, or when the +Inhibit pin is tied to the -Inhibit pin, the channel is enabled.

Applying a signal voltage to the Inhibit pins will disable the channel. The specifications of this signal are shown in the table below.

	Inhibit Signal Voltage	Inhibit Signal Current
Maximum	12 V	4.0 mA
Minimum	3 V	0.2 mA

CoolMod Power Good Signal (Standard, Wide-Trim and Bulk modules)

Each CoolMod has a Power Good signal that is the output of an internal comparator which monitors the output voltage and determines whether this voltage is within normal operation 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 3 (Common). There is a 390Ω resistor in series with the collector for current limiting.

When the output voltage is within 10% of Vset the transistor is turned ON. If the output drops out of regulation the transistor turns OFF. This can be used for power sequencing in many applications (enabling another CoolMod output when the first output is within regulation, as well as driving external circuitry.

The maximum collector voltage is 5V, and the maximum collector current is 12mA.

Refer to the implementation circuit and Table of logics below for recommendations for driving Logic Level circuits with open collector signal outputs.

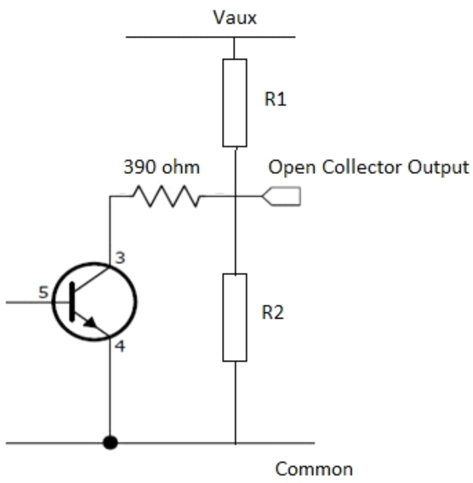


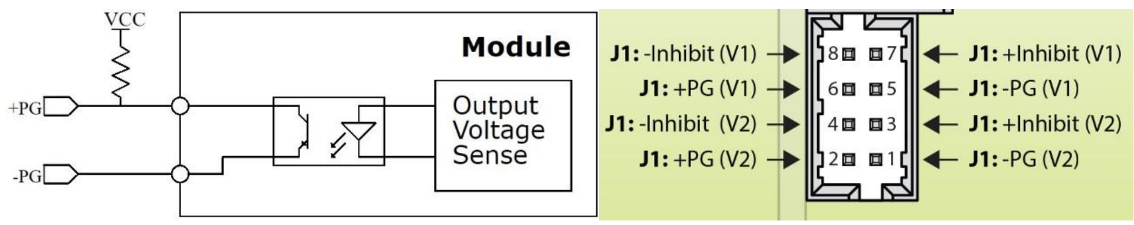
Table of Logics

Auxiliary Voltage	Logic Voltage	R1	R2	Vhigh	Vlow	Isink max
12V	12 Volt Logic	12K Ohms	Open	12V	0.4V	12mA
12V	5 Volt Logic	10K Ohms	7K Ohms	4.9V	0.45V	12mA
12V	3.3 Volt Logic	10K Ohms	3.9K Ohms	3.2V	0.4V	12mA
5V	5 Volt Logic	5K Ohms	Open	5V	0.36V	12mA
5V	3.3 Volt Logic	5K Ohms	10K Ohms	3.3V	0.36V	12mA

CoolMod Power Good Signal (CmG-H)

The Output Signal Connector (J1001-J1006) does not indicate Power Good status of the CmG or CmH modules, each channel has a Power Good signal which indicates if there is a voltage on the output pins.

Note: The dual module power good signal does not impact the global power good status.



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 +PG and the emitter on -PG.

When there is a voltage present on the output pins of the channel the transistor of the optocoupler is turned ON. If the output drops out of regulation the transistor turns OFF.

To monitor the Power Good of a channel, +PG 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.

Section 8: CoolPac Operation

The CoolPac provides the front end input power to the CoolMod. The CoolPac operates of 85-264VAC, 47-440Hz and can withstand 300VAC input voltage for up to 5 secs.

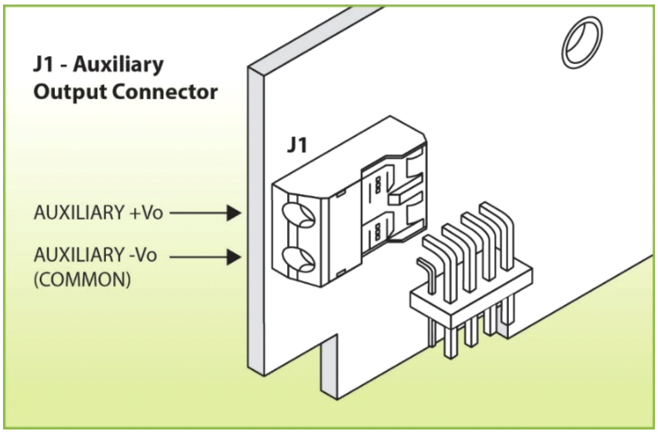
The CoolPac can also operate off DC inputs of 125VDC-300VDC.

There are two CoolPac versions.

- CX18S for Industrial and Hi Rel Applications
- CX18M for Medical Applications

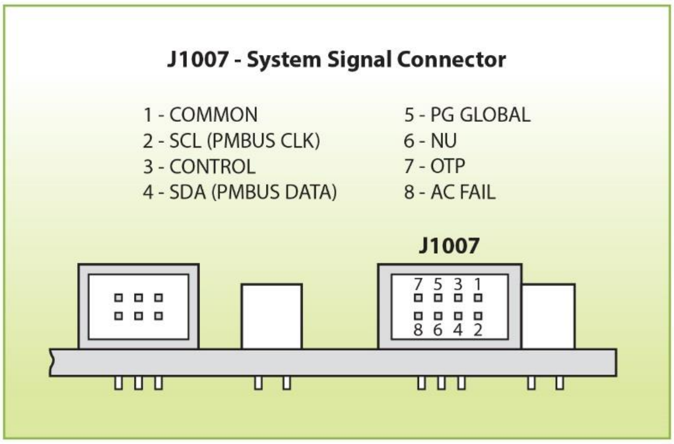
Auxiliary Voltage (Bias)

Each CoolPac has a SELV isolated 24W auxiliary (always on) voltage of 12V/1.97A or 5V/4.7A (optional). This is available through the J1 connector. This Bias supply output has 4000VAC isolation from the primary and is ideal for powering displays, system housekeeping, control circuits or may be used as an additional output voltage. Please note that the negative of the auxiliary (-Vo) is connected to the Common of the System Signal Connector.



Section 9: Global Signals

The CoolX Global Signals are available on the J1007 System Signal Connector.



*NU: Not Used or No Connection

AC Fail

The CoolPac AC Fail Signal indicates that the input voltage has failed or has dropped below 70VAC. The AC Mains Fail signal is controlled with an NPN transistor providing 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 390Ω 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 70Vac, the transistor is turned OFF at least 1mS before loss of output voltage regulation.

The maximum collector voltage is 5V, and the maximum collector current is 12mA.

Refer to the implementation circuit and Table of logics at end of Section 9 for recommendations for driving Logic Level circuits with open collector signal outputs.

Global Power Good

A Global Power Good signal is controlled with an NPN transistor providing 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 is activated when all enabled CoolMods report individual Power Good for their outputs. There is a 390Ω resistor in series with the collector for current limiting. When the output of ALL CoolMods are within 10% of Vset, the transistor is turned on. When the output of any enabled CoolMod is >10% outside of Vset, the transistor is turned off.

Note: The status of Dual modules are not included in Global Power Good

The maximum collector voltage is 5V, and the maximum collector current is 12 mA.

Refer to the implementation circuit and Table of logics at end of Section 9 for recommendations for driving Logic Level circuits with open collector signal outputs.

Global Inhibit/Enable (CONTROL)

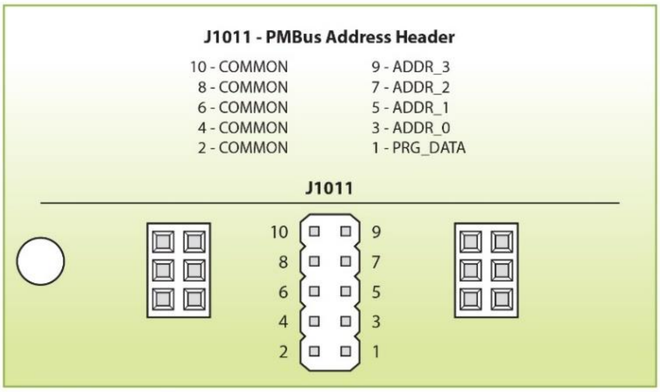
All CoolMod outputs may be enabled/inhibited simultaneously by means of an appropriate signal applied to the CONTROL input on J1007, between Pin 3 (Control) and Pin 1 (Common). Under normal conditions Pin 3 is pulled to 5V internally (logic high) and all modules are enabled. To disable all modules simply pull Pin 3 to Common (logic low). There is a max 15ms delay from change in signal logic to change in output voltage.

The input has a 1K ohm series resistor and a 100nF filtering capacitor to filter noise on this signal. The maximum allowable voltage on Pin 3 is 5V.

Reversing CoolMod Inhibit/Enable Logic

The logic of the CoolMod Inhibit/Enable signals can be reversed by shorting pins 1 and 2 of J1011 (which is located in the centre of the Comms board between slot 2 and slot 3) with a jumper, and applying a logic low signal between the CONTROL pin of J1007 (Pin 3) and Common (Pin 1).

The recommended jumper for the J1011 connector is a Harwin M22-1900005 2mm Jumper Socket.



When these two signals are applied to the CoolX the default condition of all CoolMods is disabled. You can enable CoolMods by applying a logic low signal to the enable input on the output signal connector J100x (where x indicates J1001 to J1006) between pin 4 (positive), and pin 1 or pin 3 (negative).

J1011 Pin2 / Pin 1 Jumper		J1007 Control Signal	J100x CoolMod Enable Signal	CoolMod Status
J1011 Pin2 / Pin 1 Jumper	Fitted	0	0	Enabled
		0	1	Disabled
		1	0	Disabled
		1	1	Disabled
	Not Fitted	0	0	Disabled
		0	1	Disabled
		1	0	Disabled
		1	1	Enabled

Over Temperature Protection

The CoolX monitors internal temperatures on the power supply to ensure that component temperatures do not exceed their ratings. The OTP warning signal 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 390Ω resistor in series with the collector for current limiting. During normal operation the transistor is turned off. If an Over Temperature condition is detected, the OTP signal will be pulled low via a 390ohm resistor as a pre-warning of a possible shutdown of the power supply. If the OTP condition persists for a further 2 seconds, the CoolX will shut down. The CoolX will auto recover when temperatures reach normal operating level.

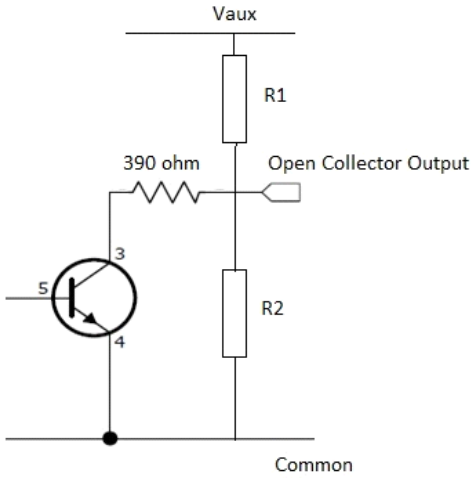
Shut down from over temperature signal is dependent on environment, and this signal can be used to turn on an external fan or to shed loads both of which would reduce the temperature rise in the power supply.

The maximum collector voltage is 5V, and the maximum collector current is 12 mA.

Refer to the implementation circuit and Table of logics at end of Section 9 for recommendations for driving Logic Level circuits with open collector signal outputs.

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 390Ω resistor in series with the collector for current limiting. These outputs can safely sink up to 12mA and have a breakdown voltage of greater than 25V. Pull up resistors should be chosen to keep the sink current under 12mA. The table below shows some resistor combinations translating the Open Collector output into a voltage level suitable for various logic types with using either the 12V or 5V Auxiliary voltage. Other voltages can be used to bias these circuits with adjustments taking into account the 12mA max sink current and the 390Ω resistance in series with the collector.

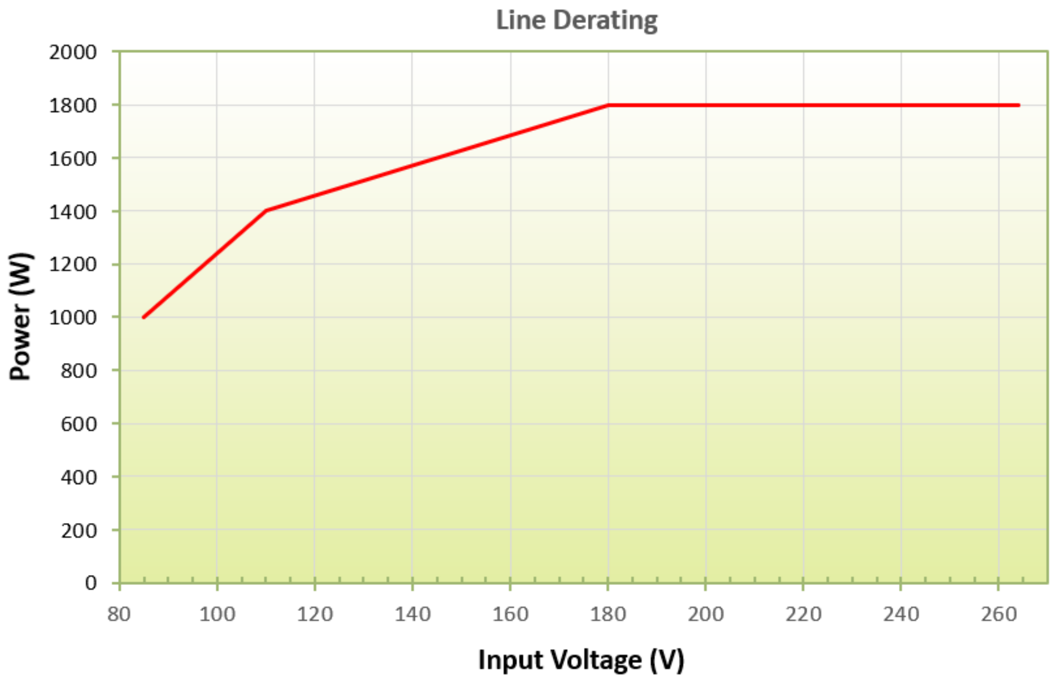


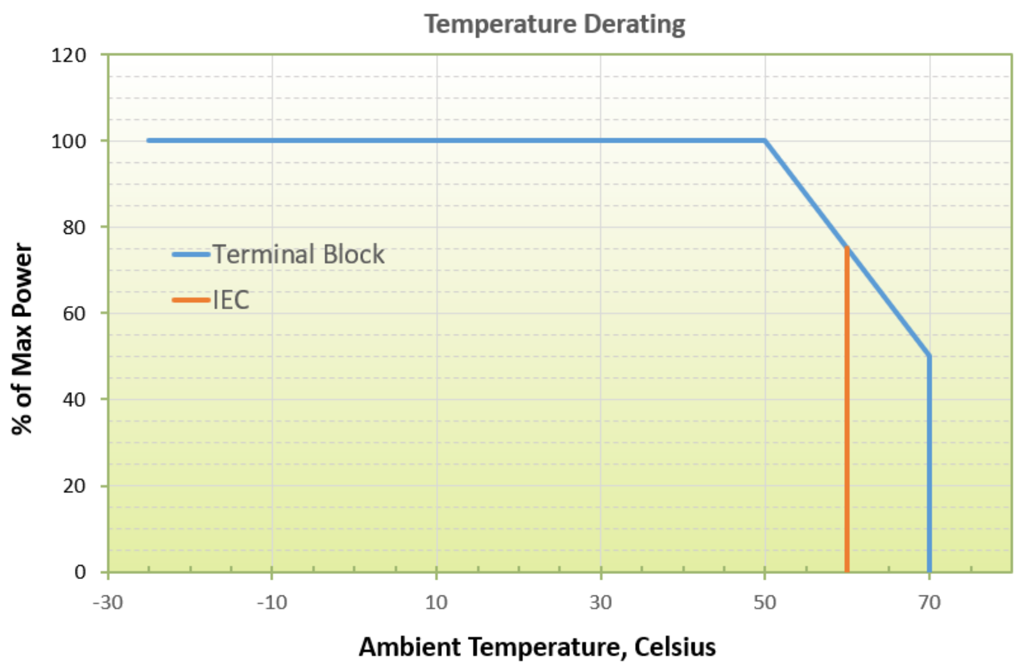
<u>Table of Logics</u>

Auxiliary Voltage	Logic Voltage	R1	R2	Vhigh	Vlow	Isink max
12V	12 Volt Logic	12K Ohms	Open	12V	0.4V	12mA
12V	5 Volt Logic	10K Ohms	7K Ohms	4.9V	0.45V	12mA
12V	3.3 Volt Logic	10K Ohms	3.9K Ohms	3.2V	0.4V	12mA
5V	5 Volt Logic	5K Ohms	Open	5V	0.36V	12mA
5V	3.3 Volt Logic	5K Ohms	10K Ohms	3.3V	0.36V	12mA

Section 10: Power Ratings

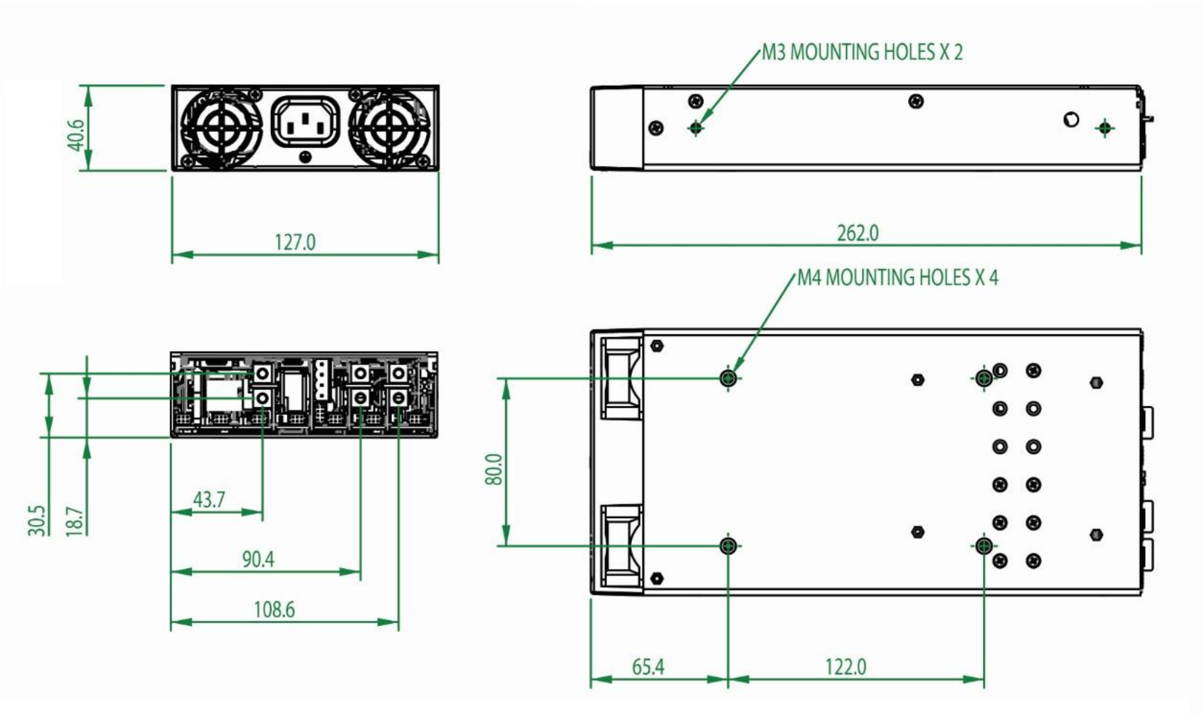
When selecting a power supply for an application it is necessary to ensure it operates within its power capabilities by taking into account both Temperature Derating and Input Voltage Derating. Input Voltage Derating and Temperature Derating curves are shown below. Line Derating applies to the CoolPac only while Temperature Derating applies to both the CoolPac and the CoolMods.





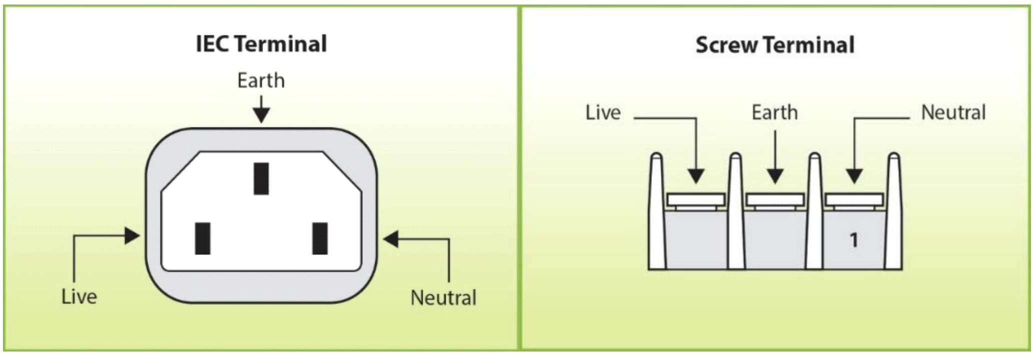
Section 11: Mechanical Information

The CoolX mechanical outline is shown below. Full 3D and STEP files can be downloaded from www.excelsys.com or alternatively contact Excelsys for details.



Connectors: Input Connectors (CoolPac)

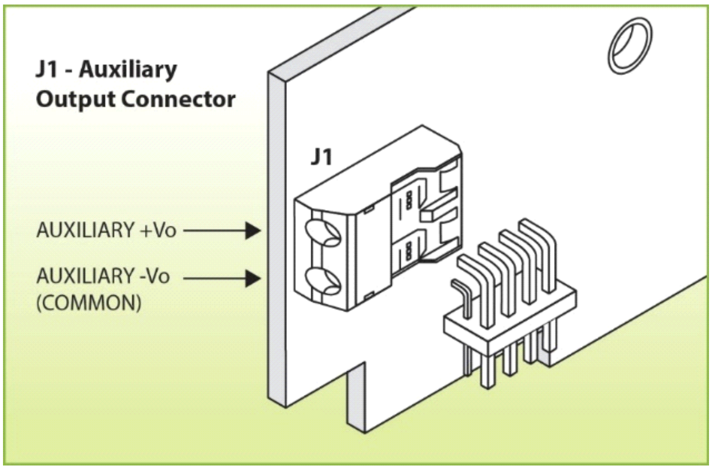
AC mains is applied to the CoolX via the 3 Screw Terminal Block or the optional IEC320 inlet terminal.



Auxiliary Bias Supply Voltage

Auxiliary Bias Supply Voltage

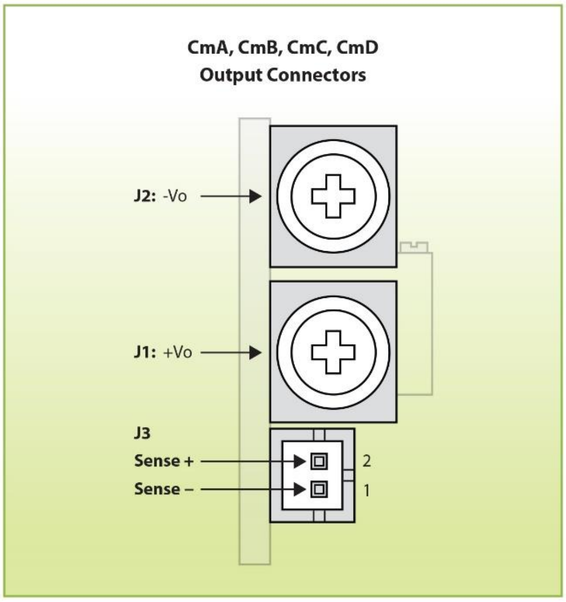
The Auxiliary Bias supply (always ON) of 12V/1.97A or 5V/4.7A (optional) is provided on J1 connector.

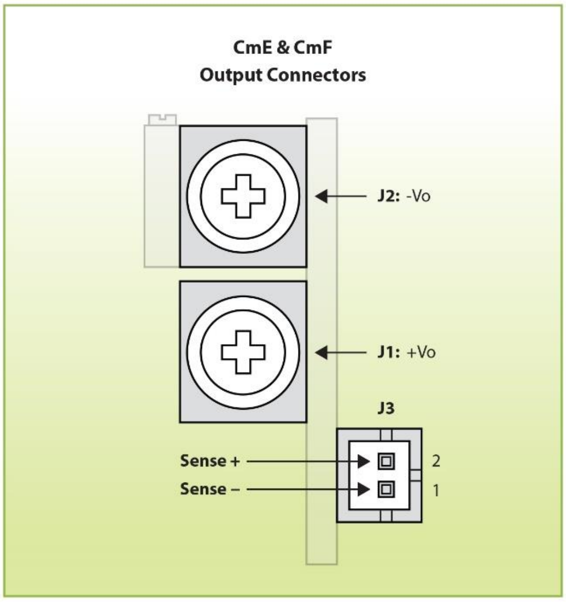


J1 Auxiliary Output Connector Molex 104188-0210

Output Power and Sense Connectors (Standard, Wide-Trim and Bulk Modules)

Each CoolMod (CmA-F and CmE-F) has Power Terminals (J1 and J2) and a Remote Sense Connector (J3).

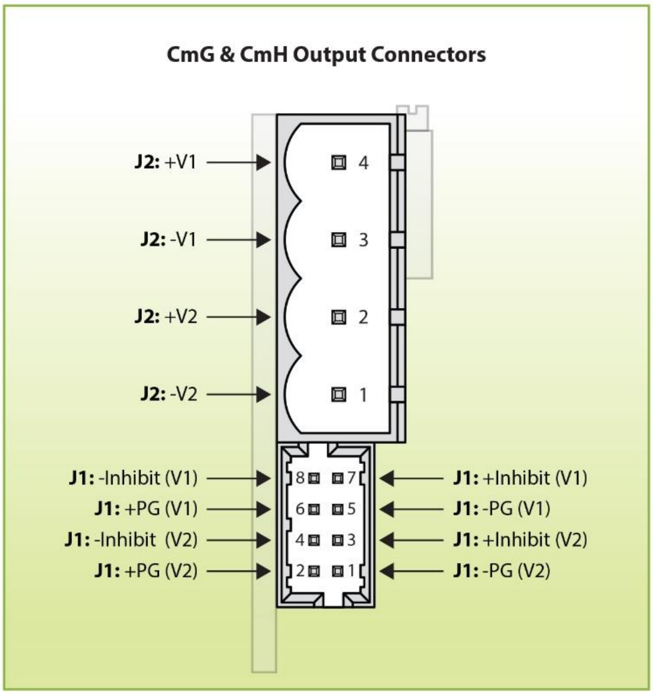




J1 & J2 DC Output Terminals	M4 Screws
J3 Sense Connector	JST - S2BPH-K-S (LF) (SN)
J3 Mating Connector	JST PHR-2, Crimp: JST BPH-002T-P0.5S or SPH-002T-P0.5S

Output Power and Signal Connectors (CmG-H)

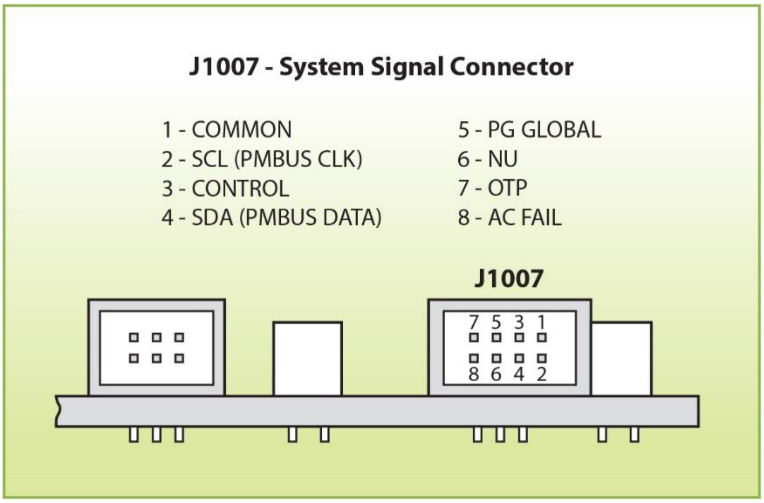
The CmG and CmH modules have a Dual Power Terminal J2 and a Signal Connector J1.



J1 CmG/CmH Signal Connector:	8-way Molex: 87833-0831
Mating Connector J1:	Locking Molex: 51110-0860,
	Non-Locking Molex: 51110-0850;
	Locking and Polarizing: 51110-856
	Crimp Terminal: Molex p/n 50394
J2 Power Terminal:	Camden: CTB9350/4A
	Wurth Elektronik: 691 313 710 004
Mating Connector J2:	Camden: CTB9200/4A
	Wurth Elektronik: 691 352 710 004

Global System Signal Connector

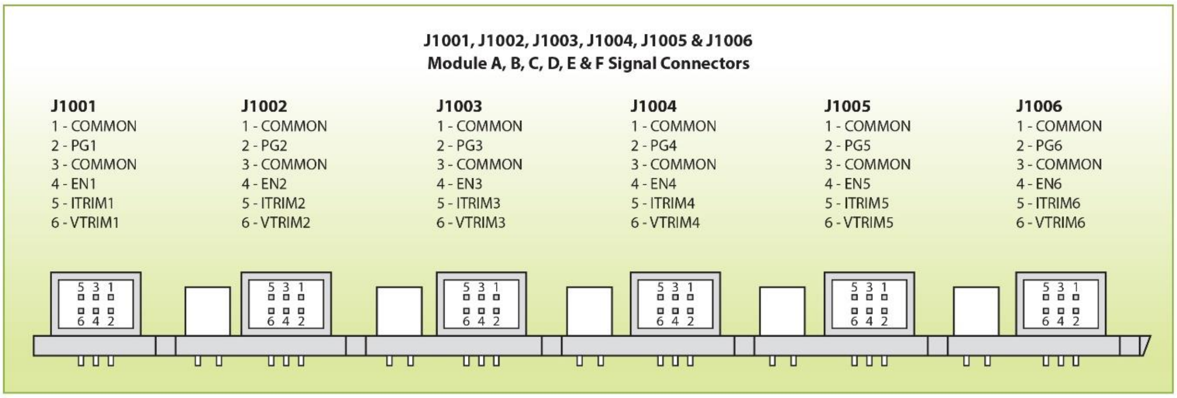
The System Signal Connector contains all the Global signals including AC Fail, Power Good, and Over-Temperature Alarm.



J1007 System Signal Connector	8-way Molex: 87833-0831
Mating Connector J1007:	Locking Molex: 51110-0860, Non-Locking Molex: 51110-0850; Locking and Polarizing Molex: 51110-0856 Crimp Terminal: Molex p/n 50394

DC Output Signals and Control Connectors

The DC Output Signals Connectors contain the individual Output Signals and Control Signals, including, Power Good, Inhibit/Enable, Vtrim, Itrim.



J1001-J1006	6-way Molex: 87833-0831
Mating Connectors J1001-J1006:	Locking Molex: 51110-0660; Non-Locking Molex 51110-0650; Locking and Polarizing Molex Crimp Terminal: Molex p/n 50394, or Molex 51110-0656 which includes Locking Tab & Polarization Keying,

Mounting Options

Base Plate Mounting

The CoolX can be mounted in the system via the 4 mounting holes on the base of the power supply. See mechanical drawings for mounting hole positions. Use M4 mounting screws and ensure that maximum screw penetration from base does not exceed 1.5mm.

Side Mounting

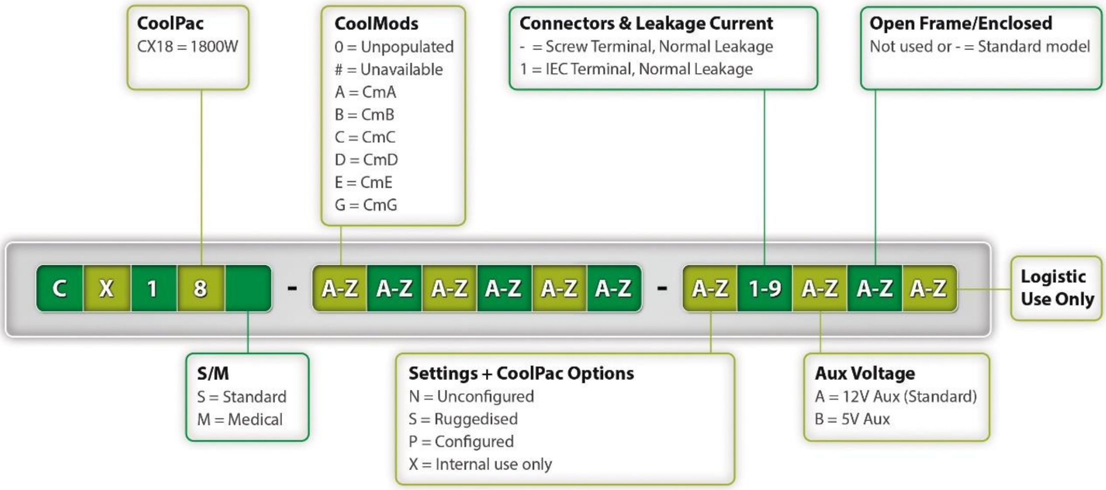
The CoolX can be mounted in the system via the 2 mounting holes on each side of the CoolX. See mechanical drawings for mounting hole positions. Use M3 mounting screws and ensure that maximum screw penetration from base does not exceed 2mm.

DIN-Rail Mounting

The CoolX can be mounted on the Excelsys DIN-Rail mounting bracket (Z744).

Section 12: CoolX Nomenclature

The CoolX user configurable power supply combines feature rich AC input front-ends (CoolPacs) with plug-in DC output modules (CoolMods). The plug and play system allows system designers to define and build 'instant' custom power solutions.



S/M (Standard of Medical CoolPac)

S= Standard IEC60950 2nd Edition and IEC62368-1
M= Medical IEC60601-1 3rd Edition

Settings and CoolPac Options

N: Standard. No additional configuration. Nominal output voltages
S: Conformal Coating and Extra Ruggedisation for Shock and Vibration
P: Preset. Voltage Adjustments, Series, Parallel Outputs

Connectors and Leakage Options

-: Input Screw Terminal Connector, Nominal Leakage Current
1: IEC 320 Input Terminal

Auxiliary Voltage

A: 12V/1.97A isolated Bias Supply Voltage
B: 5V/4.7A isolated Bias Supply Voltage

Selecting & Ordering Configured CoolX

Configured CoolX power supplies may be specified and ordered using the part numbering system shown. At our configuration centre, we will assemble the CoolX as specified by you accounting for slot preferences and also for preferred settings (Voltage/Series/Parallel etc.), and also incorporating any Options required.

Configuration Example 1

Required power supply: 100-240VAC input, IEC60950 approved
Outputs: 5V/10A, 24V/30A, 48V/4A, 24V/2A, 24V/2A
Auxiliary Bias Supply 12V/1A

Solution: CoolX part number CX18S-ADG##E-N-A specifies the following product;

- CX18S 1800W IEC60950 approved
- Slot 1: CmA: 5V/10A
- Slot 2: CmD: 48V/4A
- Slot 3: CmG: Dual output 24V/2A, 24V/2A
- Slot 4: Not Available (CmE is three slot CoolMod module)
- Slot 5: Not Available (CmE is three slot CoolMod module)
- Slot 6: CmE: 24V/30A
- Option N: Nominal Output voltage settings
- Option A: 12V/1A Bias Supply Voltage

Configuration Example 2

Required power supply: 100-240VAC input, IEC60601-1 3rd edition approved
Outputs: 5V/10A, 24V/10A, 45V/4A, 12V/5A, 19V/15A
Auxiliary Bias Supply 5V/2A

Solution: CoolX part number CX18M-BABBDC-N-B specifies the following product;

- CX18M 1800W IEC60601-1 approved
- Slot 1: CmB: 12 V/5A
- Slot 2: CmA: 5V/10A
- Slot 3: CmB: Series connection with Slot 4
- Slot 4: CmB: 19V/15A
- Slot 5: CmD: 45V/4A
- Slot 6: CmC: 24V/10A
- Option N: Nominal Output voltage settings.
- Option B: 5V/2A Bias Supply Voltage

Section 13: Reliability

The 'bath-tub' curve shows how the failure rate of a power supply develops over time. It is made up of three separate stages. Immediately after production, some units fail due to defective components or production errors. To ensure that these early failures do not happen while in the possession of the user, Excelsys carries out a full burn-in on each unit, designed to ensure that all these early failures are detected at Excelsys. After this period, the power supplies fail very rarely, and the failure rate during this period is fairly constant. The reciprocal of this failure rate is the MTBF (Mean Time Between Failures).

At some time, as the unit approaches its end of life, the first signs of wear appear and failures become more frequent. Generally 'lifetime' is defined as that time where the failure rate increases to five times the statistical rate from the flat portion of the curve. In summary, the MTBF is a measurement of how many devices fail in a period of time (i.e. a measure of reliability), before signs of wear set in. On the other hand, the lifetime is the time after which the units fail due to wear appearing. The MTBF may be calculated mathematically as follows: MTBF = Total x t / Failure, where

- Total is the total number of power supplies operated simultaneously.
- Failure is the number of failures.
- t is the observation period.

MTBF may be established in two ways, by actual statistics on the hours of operation of a large population of units, or by calculation from a known standard such as latest Telecordia SR-332.

Determining MTBF by Calculation

MTBF, when calculated in accordance with Telecordia, and other reliability tables 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.

Total FPMH = FPMH1 + FPMH2 + …………. +FPMHn
MTBF (hours) = 1,000,000 ÷ FPMH

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

CoolMod (CmA-D): 0.52 failures per million hours
CoolPac: 0.33 failures per million hours

Example: What is the MTBF of CX18S-BCCD00-N-A?

CX18S	FPMH = 0.33
CMA, B, C, D	FPMH = 0.52 each

Total FPMH = 0.33 + (4 x 0.52) = 2.41 FPMH.
MTBF = 414,938 hours at 40°C

MTBF and Temperature

Reliability and MTBF are highly dependent on operating temperature. The figures above are given at 40°C. For each 10°C decrease, the MTBF increases by a factor of approximately 2.

Conversely, however, for each 10°C increase, the MTBF reduces by a similar factor. Therefore, when comparing manufacturer's 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, and as such Excelsys recommends that the maximum shelf life for our platform designs is two years.

Section 14: Safety Approvals

CoolX is compliant with the latest Safety approvals, and is also compliant with future changes in safety standards for Medical, Industrial and ITE equipment.

CX18S is certified to **IEC60950 2nd Edition** and is compliant with the upcoming IEC62368-1 Safety approvals.

CX18M is certified to **IEC60601-1 3rd Edition** and **IEC60601-1-2 4th Edition** for medical applications.

Additional medical features include **suitability for type BF rated applications, 300µA (optional 150µA), 2 x MOPP.** Galvanic isolation levels are shown below

Input to Output	Reinforced (2 x MOPP)	4000VAC
Input to Case (GND)	Basic (1 x MOPP)	1850VAC
Output to Case (GND)	Basic (1 x MOPP)	1850VAC
Output to Output	Basic (1 x MOPP)	1850VAC

Low Voltage Directive (LVD) 2006/95/EC

The LVD applies to equipment with an AC input voltage of between 50V and 1000V or a DC input voltage between 75V and 1500V. The CoolX series is CE marked to show compliance with the LVD. The relevant European standard for CoolX is EN60950 2nd Edition (Information technology). The relevant European standard for CoolX is EN60601-1 3rd Edition (Medical Devices Directive).

The full table of Safety certifications are listed below

CX18S	IEC/EN 60950-1 Edition 2 and all national deviations	UL 60950-1/CSA C22.2 No 60950-1 Edition 2 5000m (16,400ft) altitude, 100-240VAC ±10%
	IEC 62368 Edition 2	IEC 62368-1 (2014) Edition 2 5000m (16,400ft) altitude, 100-240VAC ±10%
CX18M	IEC/EN 60601-1 Edition 3 and all national deviations	IEC 60601-1(2005), EN 60601-1(2006) ANSI/AAMI ES 60601-1(2005) CAN/CSA C22.2 No. 60601-1 (2008) 5000m (16,400ft) altitude, 100-240VAC ±10%

Section 15: 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, since performance is critically dependent on the final system configuration. System compliance with the EMC directive is facilitated by Excelsys products compliance with several of the requirements as outlined in the following paragraphs. Although the CoolX meets these requirements, the CE mark does not cover this area.

The table below outlines the EMC characteristics of the CoolX power supply under load conditions.

A full EN60601-1-2 4th Edition test report is available on request. Contact Excelsys for details.

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, 8kV Contact, 15kV air	A
Radiated Immunity	EN61000-4-3, Level 3, 10V/m	A
Electrical Fast Transient	EN61000-4-4, Level 4, ±4kV	A
Surge Immunity	EN61000-4-5, Level 4, 2kV DM, 4kV CM	A
Conducted RF Immunity	EN61000-4-6, Level 3, 10Vrms	A
Power Frequency Magnetic Field	EN61000-4-8, Level 4, 30A/m	A

Radiated EMI should be tested in a system environment, Radiated EMI performance in a system will vary significantly from a stand-alone power supply due to the system enclosure which will provide additional shielding.

Criteria Explained.

There are 4 Criteria levels, each referring to a specific performance level of the product / apparatus during and after the EMC phenomenon is applied. These are specifically observed during Immunity testing and are outlined below:

Criteria A: The apparatus shall continue to operate as intended. No degradation of performance or loss of function is observed during or after the test.

Criteria 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 is self-recoverable.

Criteria C: Temporary loss of function is allowed during and after the test that require operator intervention to restore the product/apparatus to normal operation.

Criteria D: During the test, Loss of function which is not recoverable.

Additional EMI characterisation

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

Guidelines for Optimal EMC Performance

All Excelsys products are designed to comply with European Normative limits (EN) for conducted and radiated emissions and immunity when correctly installed in a system. See performance levels attained above. However, power supply compliance with these limits is not a guarantee of system compliance. System EMC performance can be impacted by a number and combination items. Design consideration such as PCB layout and tracking, cabling arrangements and orientation of the power supply amongst 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 minimise current carrying loops that can radiate, and to minimise 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 minimise their interaction

- Keep all cable lengths as short as possible
- Minimise the area of power carrying loops to minimise radiation, by using twisted pairs of power cables with the maximum twist possible.
- Run PCB power tracks back to back.
- Minimise noise current induced in signal carrying lines, by twisted pairs for sense cables with the maximum twist possible.
- Do not combine power and sense cables in the same harness.
- Ensure good system grounding. System Earth should be a “starpoint”. Input earth of the equipment should be directed to the “starpoint” as soon as possible. The power supply earth should be connected directly to the “starpoint”. All other earths should go to the ‘starpoint”.

Section 16: Environmental Parameters

The CoolX series are designed for the following parameters

- Material Group IIIb, Pollution Degree 2
- Installation Category 2
- Class I
- Indoor use (installed, accessible to Service Engineers only).
- Altitude: -155 metres to +5000 metres from sea level.
- Humidity: 5 to 95% non-condensing.
- Operating temperature -20°C to 70°C (higher ambient temperatures can be achieved with applicable derating and/or external cooling methods (fans/base-plate cooling).

In addition, CoolX is compliant with the following directives:

WEEE	Waste Electrical and Electronic Directive (WEEE) 2002/96/EC
RoHS 3	EU Directive 2015/863 RoHS compliancy
REACH	Compliant

Additional Information

Additional information such as Application Note, White Papers, Safety Certificates etc. are available at www.excelsys.com. Alternatively please do not hesitate to contact Excelsys if you have any further questions or need additional information.

For Technical Support email support@excelsys.com

Sales Enquiries for North America email salesusa@excelsys.com
All other sales enquiries email sales@excelsys.com

Excelsys Technologies Ltd
27 Eastgate Drive
Eastgate Business Park
Little Island
Co. Cork
Ireland
t: +353 21 4354716
f: +353 21 4354864
e: sales@excelsys.com

Excelsys Technologies
80 Bricketts Mill Road,
Hampstead,
New Hampshire
03841
USA
t: +1 972 771 4544
f: +1 972 421 1805
e: salesusa@excelsys.com

Appendix 1: Detailed Output Specifications

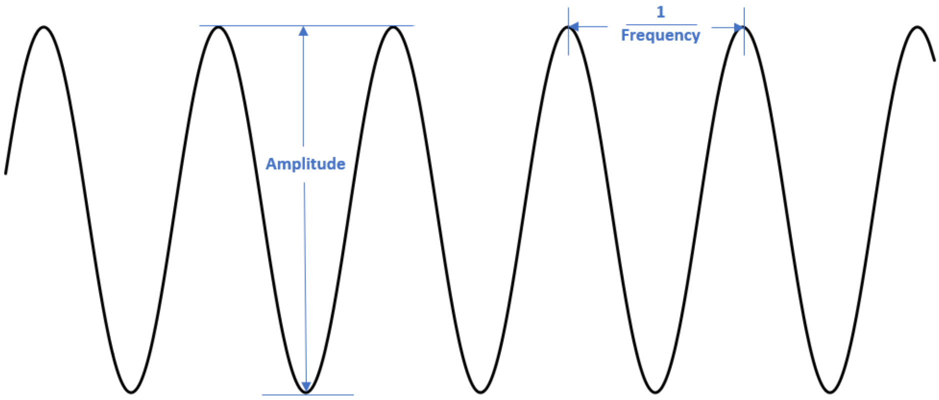
Standard Modules (CmA-CmD)

Ratings

Parameter	Description		Module	Min	Nom / Typical	Max
Output Voltage (V)	Output voltage range for which the module is rated for operation		CmA	2.5	5	6
			CmB	6	12	15*
			CmC	15	24	28
			CmD	28	48	58
Factory Setting Accuracy (mV)	Maximum deviation from target output voltage setting when CoolX is initially configured.		CmA			10
			CmB			10
			CmC			20
			CmD			50
Output Current (A)	Maximum output current for which the module is rated for operation. (Maximum output current to be derated by 5% when used in parallel)	CoolX600	CmA			21
			CmB			15
			CmC			8.33
			CmD			4.17
		CoolX1800	CmA			30
			CmB			23.3
			CmC			12.5
			CmD			6.25
Output Power (W)	Maximum output power for which the module is rated for operation. (Maximum output power to be derated when CoolX is used in ambient temperatures greater than 40 °C – see Appendix 2: Thermal Derating for further details)	CoolX600	CmA			105
			CmB			180
			CmC			200
			CmD			200
		CoolX1800	CmA			150
			CmB			280
			CmC			300
			CmD			300
Capacitive Loading (mF)	Maximum capacitive load of the module to ensure monotonic startup (with no additional load applied)		CmA			20
			CmB			10
			CmC			8
			CmD			4.7

*Full Dynamic Specifications of the CmB module may not be met at full load when the CmB module is trimmed above 13 V in the CoolX1800

Ripple and Noise



Parameter	Description	Module	Min	Nom / Typical	Max
Output Ripple (mV)	Amplitude of ripple measured at nominal voltage and at 20 MHz Bandwidth	CmA		75	100
		CmB		80	150
		CmC		90	240
		CmD		105	480
Output Ripple Frequency (kHz)	Frequency of output ripple (all modules synchronised to same frequency)	All Mods	180	240	400

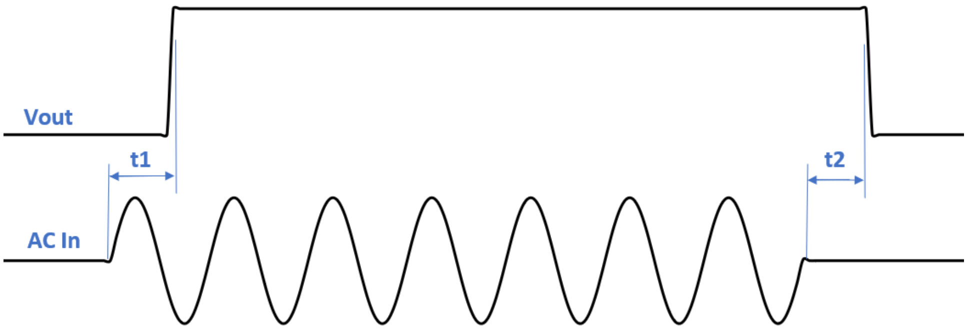
Regulation

Parameter	Description	Module	Min	Nominal / Typical	Max
Load regulation (mV/A)	0 – 100% Load	CmA		0.2	0.5
		CmB		0.3	1.6
		CmC		1.2	5.8
		CmD		2.4	23
Load Regulation – Paralleled (mV/A)	0 – 100% Load (Load Regulation is softened in parallel mode to improve current share)	CmA	2.4		4.3
		CmB	12		13
		CmC	30		36
		CmD	52		61
Line Regulation (mV)	85 – 264 Vac	CmA		2	5
		CmB		2	12
		CmC		4	24
		CmD		10	48
Temperature Regulation (%/°C)	Over ambient temperature change	All Mods			0.02

Protective Limits

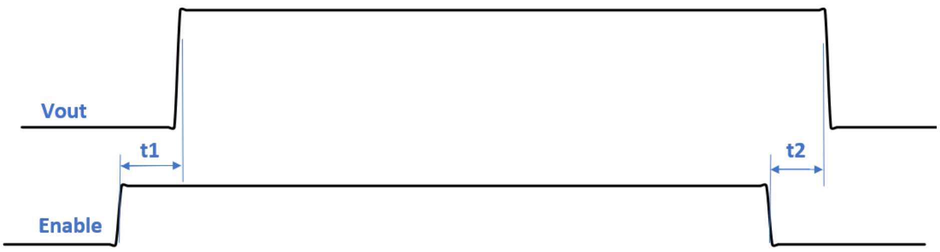
Parameter	Description		Module	Min	Nom / Typical	Max
Current Limit (A)	Constant Current Limit into Hiccup. Auto-Recovery	CoolX600	CmA	23.1	25.2	27.3
			CmB	16.5	18.1	19.5
			CmC	9.2	9.7	10.8
			CmD	4.6	4.9	5.4
		CoolX1800	CmA	40.7	44.4	48.1
			CmB	27.5	30	32.5
			CmC	13.8	15	16.2
			CmD	6.9	7.5	8.1
Short-Circuit Current Limit (A)	Measured over 5 hiccup cycles	CoolX600	CmA			4.2
			CmB			3
			CmC			1.7
			CmD			0.9
		CoolX1800	CmA			6
			CmB			4.7
			CmC			2.5
			CmD			1.25
Power Limit (W)	Voltage Foldback into Hiccup, Auto-Recovery	CoolX600	CmA	115	130	137
			CmB	198	220	234
			CmC	220	230	260
			CmD	220	230	260
		CoolX1800	CmA	185		230
			CmB	315		420
			CmC	305		420
			CmD	315		375
Overvoltage Protection (V)	CoolX600: Shutdown, Latch-off CoolX1800: Shutdown, Auto-Recovery		CmA	6.8	8	9
			CmB	17	19.8	21
			CmC	32	35	37
			CmD	60	62.2	66
Sense Lead Protection (V)	Shutdown, Auto-Recovery		All Mods			3.1

Start-Up / Shut-Down



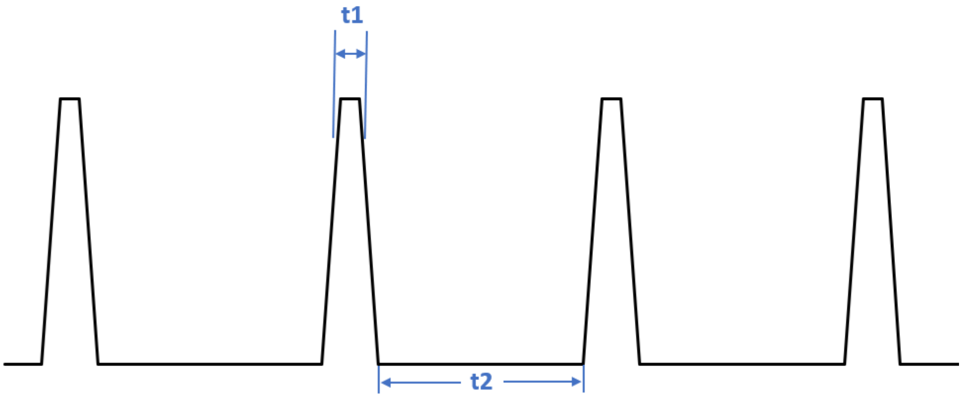
Parameter	Description	Module	Min	Nom / Typical	Max
Turn-On Delay (ms)	Time from Application of Input AC to Output Voltage Regulation (t1)	All Mods		640	800
Turn-Off Delay (ms)	From Loss of AC to Loss of Output Voltage Regulation – Nominal Voltage (t2)	All Mods	16	20	

Enable / Disable



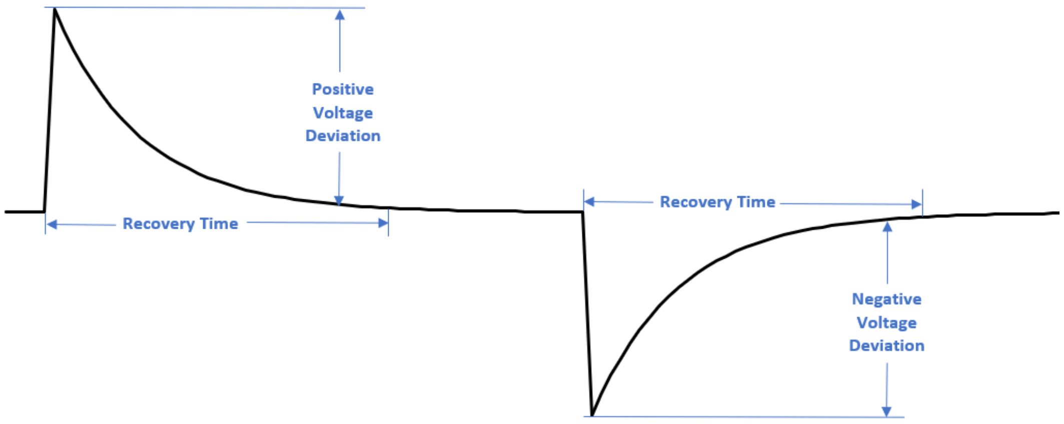
Parameter	Description	Module	Min	Nom / Typical	Max
Enable Delay (ms)	Time from application of Enable signal to Output Voltage regulation (t1)	All Mods		8.5	10
Rise Time (ms)	Measured from 10 – 90% of Vout	All Mods	2	2.5	5
Disable Delay (ms)	Time from application of Disable signal to loss of Output Voltage Regulation (t2)	All Mods		3	5
Fall Time (ms)	Measured from 90 – 10% of Vout	All Mods	0.1	0.35	3

Hiccup Characteristics



Parameter	Description	Module	Minimum	Nominal / Typical	Maximum
Hiccup On-Time (ms)	Length of time output is on during hiccup (t1)	All Mods	1	50	100
Hiccup Off-Time (ms)	Length of time output is off during hiccup (t2)	All Mods	900	1000	1200
Short Circuit Hiccup Level (V)	Output voltage at which module enters hiccup protection	CmA	1	1.4	2
		CmB	3.5	5.3	5.7
		CmC	7.2	8.1	9.6
		CmD	14.3	16.2	19.8

Transient Response



Parameter	Description	Module	Minimum	Nominal / Typical	Maximum
Transient Response, Voltage Deviation (V)	Measured during 25 – 75% and 75 – 25% Step Load Changes	CmA		0.2	0.25
		CmB		0.3	0.48
		CmC		0.4	0.96
		CmD		0.7	0.96
Transient Response, Recovery Time (us)	Measured during 25 – 75% and 75 – 25% Step Load Changes	All Mods		300	500
Transient Response, Voltage Deviation (V)	Measured during 0 – 100% and 100 – 0% Step Load Changes	CmA		0.5	0.6
		CmB		1.0	1.2
		CmC		1.3	2.4
		CmD		1.7	4.8
Transient Response, Recovery Time (ms)	Measured during 0 – 100% and 100 – 0% Step Load Changes	All Mods		4.0	7.0

Galvanic Isolation

Parameter	Description	Module	Minimum	Nominal / Typical	Maximum
Input to Output (Vac)	Reinforced (2 MOPP)	All Mods	4000		
Output to Output (Vac)	Basic (1 MOPP)	All Mods	1850		

PMBus Communications

Standard modules can be monitored and controlled with the following PMBus Commands (for further details see the PMBUS Manual available for download from the Excelsys website.

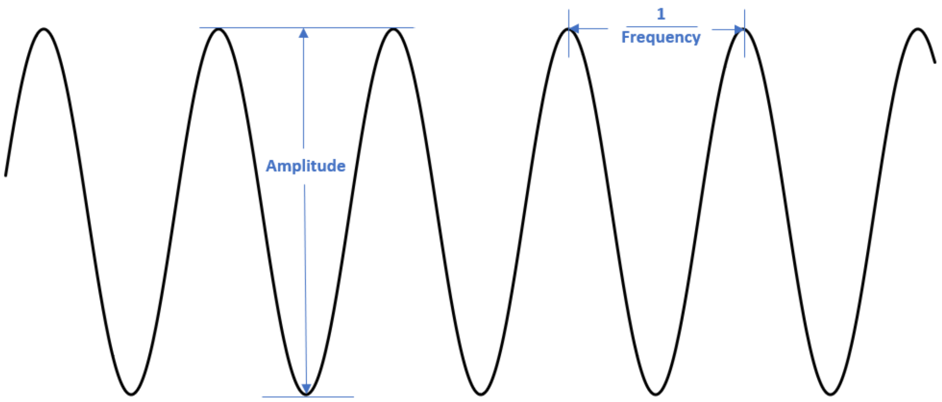
Specification	Description			
READ_VOUT (0x8B)	The READ_VOUT command is used to return the output voltage measurement of the selected (or paged) module.	*Module*	*Accuracy*	*Resolution*
		CmA	+/- 4%	6.6 mV
		CmB	+/- 4%	16.5 mV
		CmC	+/- 4%	44.3 mV
		CmD	+/- 4%	82.4 mV
READ_IOUT (0x8C)	The READ_IOUT command is used to return the output current measurement of the selected (or paged) module.	*Module*	*Accuracy*	*Resolution*
		CmA	+/- 4%	40 mA
		CmB	+/- 4%	29 mA
		CmC	+/- 4%	16 mA
		CmD	+/- 4%	8 mA
READ_TEMPERATURE_1 (0x8D)	The READ_TEMPERATURE_1 command is used to return the temperature measurement of the selected (or paged) module in Degrees Celsius. The accuracy of the READ_TEMPERATURE_1 command is +/- 10 ˚C, while its resolution is 1 ˚C.			
STATUS_WORD (0x79)	The STATUS_WORD command is used to check for the presence of fault conditions such as OTP (Overtemperature Protection) and PG (Power Good) fail.			
PAGE (0x00)	The PAGE command is used to select which of the modules subsequent commands are to be applied to. When read, this command shall return the currently selected page number.			
OPERATION (0x01)	The OPERATION command is used to enable or disable the output of any module.			
VOUT_COMMAND (0x21)	The VOUT_COMMAND command is used to explicitly set the output voltage of the selected (or paged) module to the commanded value.			
ILIIMIT_TRIM (0xD1)	The ILIMIT_TRIM command is used to explicitly set the current limit of the selected (or paged) module to the commanded value.			
MODULE_ID (0xD0)	The MODULE_ID command is used to return a code representing the model type of the selected (or paged) CoolMod.	*Module*	*ID Code*	
		CmA	0x20	
		CmB	0x40	
		CmC	0x60	
		CmD	0x80	
FIRMWARE_REVISION (0xD2)	The FIRMWARE_REVISION command is used to return a string of integers that identifies the firmware revision of the subsystems within a CoolX system.			

Bulk Modules (CmE-CmF)

Ratings

Parameter	Description		Module	Min	Nom / Typical	Max
Output Voltage (V)	Output voltage range for which the module is rated for operation		CmE	24	24	25.2
			CmF	48	48	50.4
Factory Setting Accuracy (mV)	Maximum deviation from target output voltage setting when CoolX is initially configured.		CmE			40
			CmF			40
Output Current (A)	Maximum output current for which the module is rated for operation. (Maximum output current to be derated by 5% when used in parallel)	CoolX600	CmE			25
			CmF			12.5
		CoolX1800	CmE			37.5
			CmF			18.75
Output Power (W)	Maximum output power for which the module is rated for operation. (Maximum output power to be derated when CoolX is used in ambient temperatures greater than 40 °C – see Appendix 2: Thermal Derating for further details)	CoolX600	CmE			600
			CmF			600
		CoolX1800	CmE			900
			CmF			900
Capacitive Loading (mF)	Maximum capacitive load of the module to ensure monotonic startup (with no additional load applied)		CmE			10
			CmF			10

Ripple and Noise



Parameter	Description	Module	Min	Nom / Typical	Max
Output Ripple (mV)	Amplitude of ripple measured at nominal voltage and at 20 MHz Bandwidth	CmE		240	320
		CmF		480	620
Output Ripple Frequency (kHz)	Frequency of output ripple (all modules synchronised to same frequency)	All Mods	180	240	400

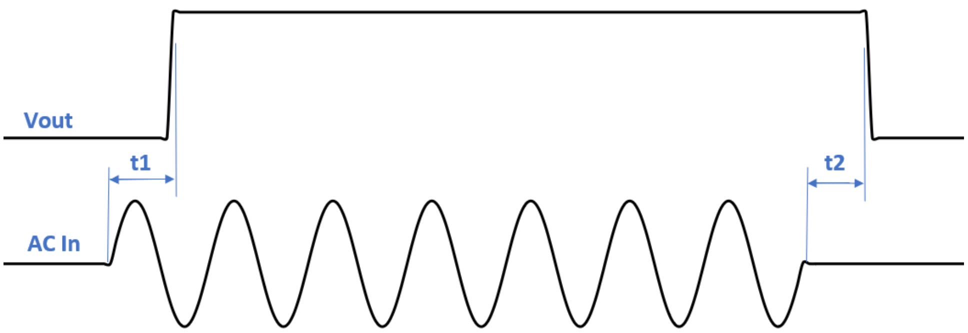
Regulation

Parameter	Description	Module	Min	Nominal / Typical	Max
Load regulation (mV/A)	0 – 100% Load	CmE		2.8	4.8
		CmF		6.8	19.2
Line Regulation (mV)	85 – 264 Vac	CmE		50	120
		CmF		50	240
Temperature Regulation (%/°C)	Over ambient temperature change	All Mods			0.02

Protective Limits

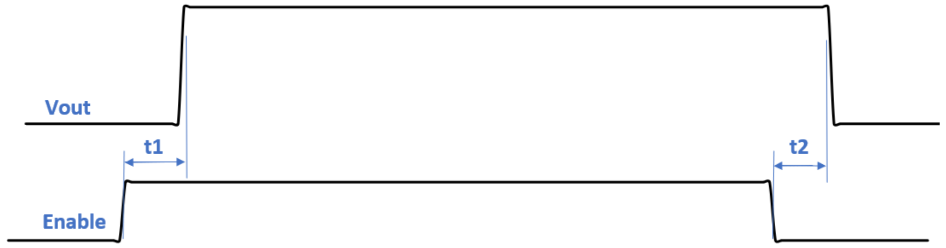
Parameter	Description		Module	Min	Nom / Typical	Max
Current Limit (A)	Hiccup. Auto-Recovery	CoolX600	CmE	27	29	30
			CmF	13.5	14	15
		CoolX1800	CmE	39	41	43
			CmF	19.5	20.5	21.5
Short-Circuit Current Limit (Arms)	Measured over 5 hiccup cycles		CmE			5
			CmF			2.5
Power Limit (A)	Hiccup, Auto Recovery	CoolX600	CmE	615	695	755
			CmF	615	670	755
		CoolX1800	CmE	890	985	1080
			CmF	890	985	1080
Overvoltage Protection (V)	CoolX600: Shutdown, Latching CoolX1800: Shutdown, Auto-Recovery		CmE	29	30.5	31.5
			CmF	55	59	62
Sense Lead Protection (V)	CoolX600: Shutdown, Latching CoolX1800: Shutdown, Auto-Recovery		All Mods			7

Start-Up / Shut-Down



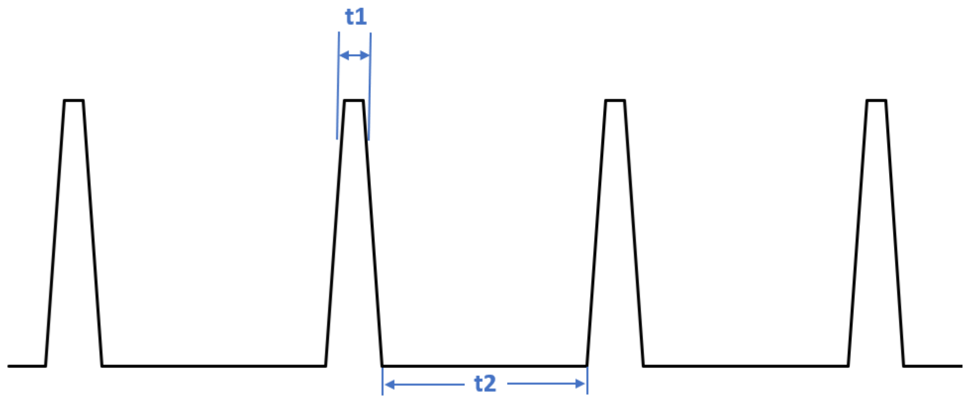
Parameter	Description	Module	Min	Nom / Typical	Max
Turn-On Delay (ms)	Time from Application of Input AC to Output Voltage Regulation (t1)	All Mods		640	800
Turn-Off Delay (ms)	From Loss of AC to Loss of Output Voltage Regulation – Nominal Voltage (t2)	All Mods	16	20	

Enable / Disable



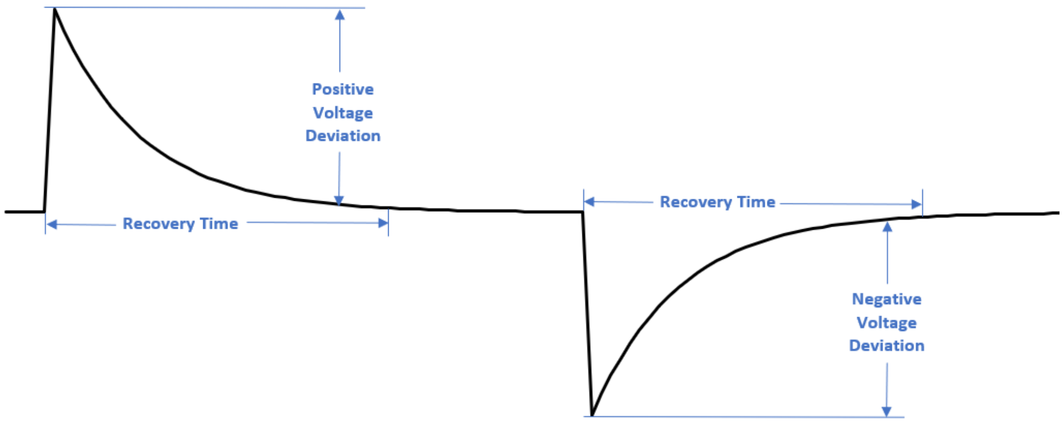
Parameter	Description	Module	Min	Nom / Typical	Max
Enable Delay (ms)	Time from application of Enable signal to Output Voltage regulation (t1)	All Mods		13	20
Rise Time (ms)	Measured from 10 – 90% of Vout	All Mods	0.5	5	8
Disable Delay (ms)	Time from application of Disable signal to loss of Output Voltage Regulation (t2)	All Mods		5	10
Fall Time (ms)	Measured from 90 – 10% of Vout	All Mods	0.1	0.7	4

Hiccup Characteristics



Parameter	Description		Module	Minimum	Nominal / Typical	Maximum
Hiccup On-Time (ms)	Length of time output is on during hiccup (t1)		All Mods	1	10	200
Hiccup Off-Time (ms)	Length of time output is off during hiccup (t2)		All Mods	500	1000	7000
Short Circuit Hiccup Level (A)	Output current at which module enters hiccup protection	CoolX600	CmE	27	29	30
		CoolX600	CmF	13.5	14	15
		CoolX1800	CmE	39	41	43
		CoolX1800	CmF	19.5	20.5	21.5

Transient Response



Parameter	Description	Module	Minimum	Nominal / Typical	Maximum
Transient Response, Voltage Deviation (V)	Measured during 25 – 75% and 75 – 25% Step Load Changes	CmE		1	1.9
		CmF		1.5	3.8
Transient Response, Recovery Time (us)	Measured during 25 – 75% and 75 – 25% Step Load Changes	All Mods		400	1000

Galvanic Isolation

Parameter	Description	Module	Minimum	Nominal / Typical	Maximum
Input to Output (Vac)	Reinforced (2 MOPP)	All Mods	4000		
Output to Output (Vac)	Basic (1 MOPP)	All Mods	1850		

PMBus Communications

Bulk modules can be monitored and controlled with the following PMBus Commands (for further details see the PMBUS Manual available for download from the Excelsys website.

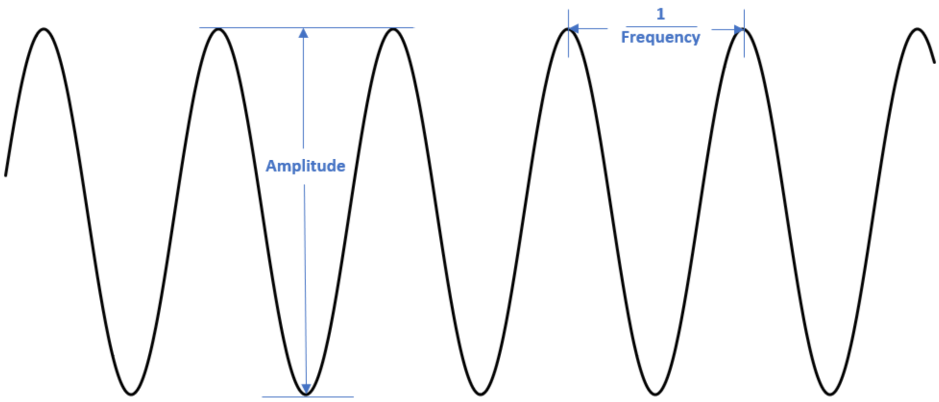
<table>
<tr><th>Specification</th><th>Description</th></tr>
<tr><td>READ_VOUT (0x8B)</td><td>The READ_VOUT command is used to return the output voltage measurement of the selected (or paged) module.<table><tr><th>Module</th><th>Accuracy</th><th>Resolution</th></tr><tr><td>CmE</td><td>+/- 4%</td><td>31 mv</td></tr><tr><td>CmF</td><td>+/- 4%</td><td>60 mV</td></tr></table></td></tr>
<tr><td>READ_IOUT (0x8C)</td><td>The READ_IOUT command is used to return the output current measurement of the selected (or paged) module.<table><tr><th>Module</th><th>Accuracy</th><th>Resolution</th></tr><tr><td>CmE</td><td>+/- 4%</td><td>45 mA</td></tr><tr><td>CmF</td><td>+/- 4%</td><td>22 mA</td></tr></table></td></tr>
<tr><td>READ_TEMPERATURE_1 (0x8D)</td><td>The READ_TEMPERATURE_1 command is used to return the temperature measurement of the selected (or paged) module in Degrees Celsius. The accuracy of the READ_TEMPERATURE_1 command is +/- 10 ˚C, while its resolution is 1 ˚C.</td></tr>
<tr><td>STATUS_WORD (0x79)</td><td>The STATUS_WORD command is used to check for the presence of fault conditions such as OTP (Overtemperature Protection) and PG (Power Good) fail.</td></tr>
<tr><td>PAGE (0x00)</td><td>The PAGE command is used to select which of the modules subsequent commands are to be applied to. When read, this command shall return the currently selected page number.</td></tr>
<tr><td>OPERATION (0x01)</td><td>The OPERATION command is used to enable or disable the output of any module.</td></tr>
<tr><td>VOUT_COMMAND (0x21)</td><td>The VOUT_COMMAND command is used to explicitly set the output voltage of the selected (or paged) module to the commanded value.</td></tr>
<tr><td>MODULE_ID (0xD0)</td><td>The MODULE_ID command is used to return a code representing the model type of the selected (or paged) CoolMod.<table><tr><th>Module</th><th>ID Code</th></tr><tr><td>CmE</td><td>0xBC</td></tr><tr><td>CmF</td><td>0xBD</td></tr></table></td></tr>
<tr><td>FIRMWARE_REVISION (0xD2)</td><td>The FIRMWARE_REVISION command is used to return a string of integers that identifies the firmware revision of the subsystems within a CoolX system.</td></tr>
</table>

Dual Modules (CmG-CmH)

Ratings

Parameter	Description	Product	Module	Min	Nom / Typical	Max
Output Voltage (V)	Output voltage range for which the module channel is rated for operation		CmG (V1+V2)	3	24	30
			CmH (V1)	3	5	6
			CmH (V2)	3	24	30
Factory Setting Accuracy (mV)	Maximum deviation from target output voltage setting when CoolX is initially configured.		All Mods			40
Output Current (A)	Maximum output current for which the channel is rated for operation.	CoolX600	CmG (V1+V2)			3
		CoolX600	CmH (V1)			6
		CoolX600	CmH (V2)			3
		CoolX1800	CmG (V1+V2)			4
		CoolX1800	CmH (V1)			10
		CoolX1800	CmH (V2)			4
Output Power per Channel (W)	Maximum output power for which each channel of the module is rated for operation. (Maximum output power to be derated when CoolX is used in ambient temperatures greater than 40 °C – Appendix 2: Thermal Derating for further details)	CoolX600	CmG (V1+V2)			90
		CoolX600	CmH (V1)			36
		CoolX600	CmH (V2)			90
		CoolX1800	CmG (V1+V2)			120
		CoolX1800	CmH (V1)			60
		CoolX1800	CmH (V2)			120
Total Output Power (W)	Maximum total output power for which the module (both channels) is rated for operation. (Maximum output power to be derated when CoolX is used in ambient temperatures greater than 40 °C – see Appendix 2: Thermal Derating for further details)	CoolX600	CmG			120
		CoolX600	CmH			120
		CoolX1800	CmG			200
		CoolX1800	CmH			180
Capacitive Loading (mF/V_o)	Maximum capacitive load of the module to ensure monotonic startup (with no additional load applied)		CmG (V1+V2)			6.6
			CmH (V1)			13.2
			CmH(V2)			6.6

Ripple and Noise



Parameter	Description	Module	Min	Nom / Typical	Max
Output Ripple (mV)	Amplitude of ripple measured at nominal voltage and at 20 MHz Bandwidth	CmG (V1+V2)		80	150
		CmH (V1)		30	80
		CmH (V2)		80	150
Output Ripple Frequency (kHz)	Frequency of output ripple, all modules synchronised to same frequency	All Mods	180	200	220

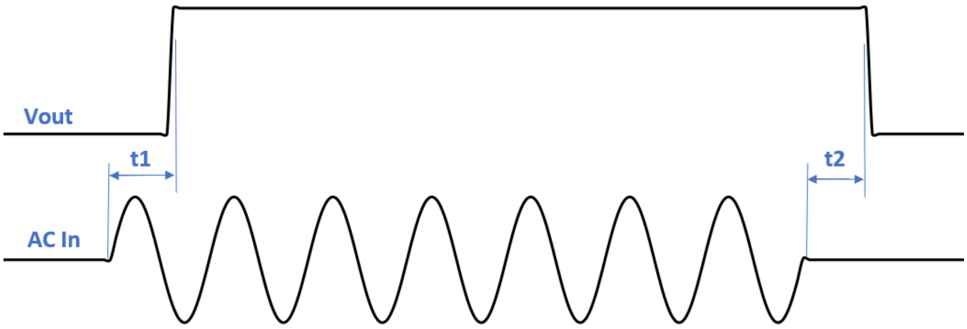
Regulation

Parameter	Description	Module	Min	Nom / Typical	Max
Load regulation (mV/A)	0 – 100% Load	CmG (V1+V2)		30	80
		CmH (V1)		20	33
		CmH (V2)		25	80
Line Regulation (mV)	85 – 264 Vac	CmG (V1+V2)		15	120
		CmH (V1)		5	25
		CmH (V2)		15	120
Temperature Regulation (%/°C)	Over ambient temperature change	All Mods			0.2

Protective Limits

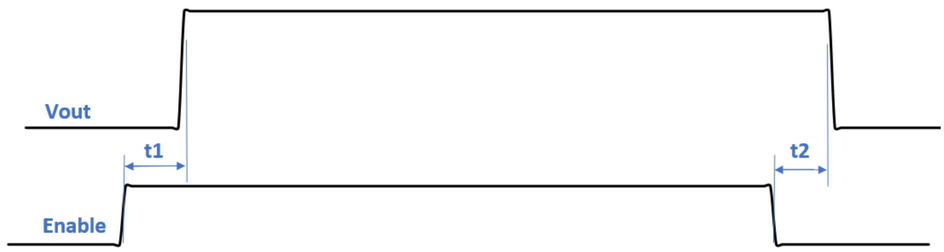
Parameter	Description	Module	Min	Nom / Typical	Max
Current Limit (A)	Constant Limit into Hiccup, Auto-Recovery	CmG (V1+V2)	4	5	10.5
		CmH (V1)	10	16	18
		CmH (V2)	4	5.5	10.5
Short-Circuit Current Limit (A)	Measured over 5 hiccup cycles	CmG (V1+V2)		1.5	2.5
		CmH (V1)		2.8	5
		CmH (V2)		1.5	2.5
Overvoltage Protection (V)	CoolX600: Shutdown, Latching CoolX1800: Shutdown, Auto-Recovery	CmG (V1+V2)	31	36	39
		CmH (V1)	8	9	10
		CmH (V2)	31	36	39

Start-Up / Shut-Down



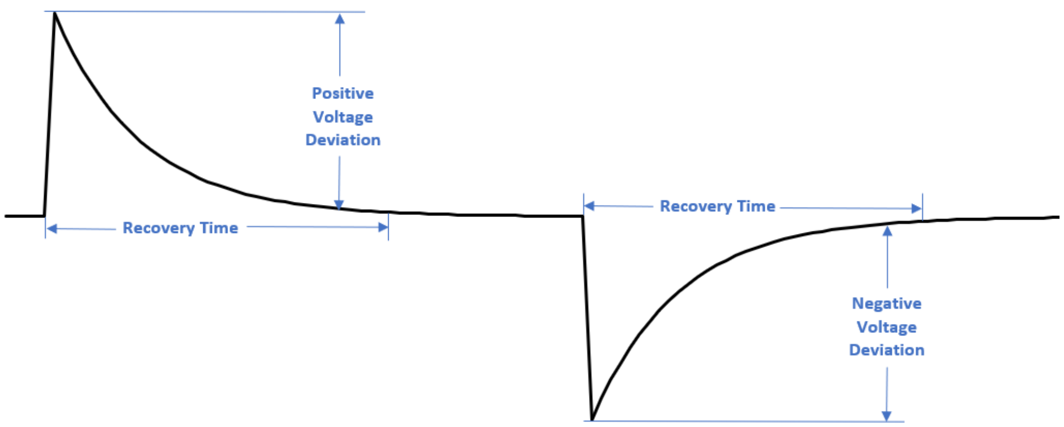
Parameter	Description	Module	Min	Nom / Typical	Max
Turn-On Delay (ms)	Time from Application of Input AC to Output Voltage Regulation – Nominal Voltage (t1)	All Mods		700	800
Turn-Off Delay (ms)	From Loss of AC to Loss of Output Voltage Regulation – Nominal Voltage (t2)	All Mods	16	20	

Enable / Disable



Parameter	Description	Module	Min	Nom / Typical	Max
Enable Delay (ms)	Time from application of Enable signal to Output Voltage regulation (t1)	All Mods		15	20
Rise Time (ms)	Measured from 10 – 90% of Vout	All Mods	8	14	20
Disable Delay (ms)	Time from application of Disable signal to loss of Output Voltage Regulation (t2)	All Mods	0.1	0.5	5
Fall Time (ms)	Measured from 90 – 10% of Vout	All Mods	0.1	0.4	1.3

Transient Response



Parameter	Description	Module	Min	Nom / Typical	Max
Transient Response, Voltage Deviation (mV)	Measured during 25 – 100% and 25 – 100% Step Load Changes	CmG (V1+V2)		400	960
		CmH (V1)		350	960
		CmH (V2)		400	960
Transient Response, Recovery Time (us)	Measured during 25 – 100% and 100 – 25% Step Load Changes	All Mods		600	1000

Galvanic Isolation

Parameter	Description	Module	Min	Nom / Typical	Max
Input to Output (Vac)	Reinforced (2 MOPP)	All Mods	4000		
Output to Output of Another Module (Vac)	Basic (1 MOPP)	All Mods	1850		
Output to Output of the Same Module (Vac)	Functional	All Mods	500		

PMBus Communications

Standard modules can be monitored and controlled with the following PMBus Commands (for further details see the PMBUS Manual available for download from the Excelsys website.

Specification	Description
PAGE (0x00)	The PAGE command is used to select which of the modules subsequent commands are to be applied to. When read, this command shall return the currently selected page number.
OPERATION (0x01)	The OPERATION command is used to enable or disable the output of any module.
MODULE_ID (0xD0)	The MODULE_ID command is used to return a code representing the model type of the selected (paged) CoolMod. The ID code of a Dual CoolMod is 0xDD. (Please note that this is the same for all modules that do not come with the full suite of PMBus communications)

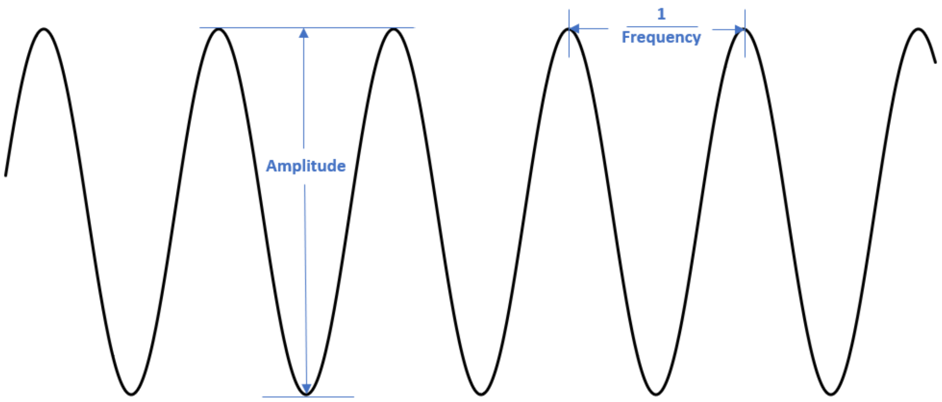
Wide Trim Modules (CmA-W01 - CmD-W01)

Ratings

Parameter	Description		Module	Min	Nom / Typical	Max
Output Voltage (V)	Output voltage range for which the module is rated for operation		CmA-W01	1	5	6
			CmB-W01	1	12	15*
			CmC-W01	2	24	28
			CmD-W01	3	48	58
Factory Setting Accuracy (mV)	Maximum deviation from target output voltage setting when CoolX is initially configured.		CmA-W01			20
			CmB-W01			20
			CmC-W01			40
			CmD-W01			100
Output Current (A)	Maximum output current for which the module is rated for operation. (Maximum output current to be derated by 5% when used in parallel)	CoolX600	CmA-W01			21
			CmB-W01			15
			CmC-W01			8.33
			CmD-W01			4.17
		CoolX1800	CmA-W01			30
			CmB-W01			23.3
			CmC-W01			12.5
			CmD-W01			6.25
Output Power (W)	Maximum output power for which the module is rated for operation. (Maximum output power to be derated when CoolX is used in ambient temperatures greater than 40 °C – see Appendix 2: Thermal Derating for further details)	CoolX600	CmA-W01			105
			CmB-W01			180
			CmC-W01			200
			CmD-W01			200
		CoolX1800	CmA-W01			150
			CmB-W01			280
			CmC-W01			300
			CmD-W01			300
Capacitive Loading (mF)	Maximum capacitive load of the module to ensure monotonic startup (with no additional load applied)		CmA-W01			20
			CmB-W01			10
			CmC-W01			8
			CmD-W01			4.7

*Full Dynamic Specifications of the CmA-W01 module may not be met at full load when the CmA-W01 module is trimmed above 13 V in the CoolX1800

Ripple and Noise



Parameter	Description	Module	Min	Nom / Typical	Max
Output Ripple (mV)	Amplitude of ripple measured at nominal voltage and at 20 MHz Bandwidth	CmA-W01		75	100
		CmB-W01		80	150
		CmC-W01		90	240
		CmD-W01		105	480
Output Ripple Frequency (kHz)	Frequency of output ripple (all modules synchronised to same frequency)	All Mods	180	240	400

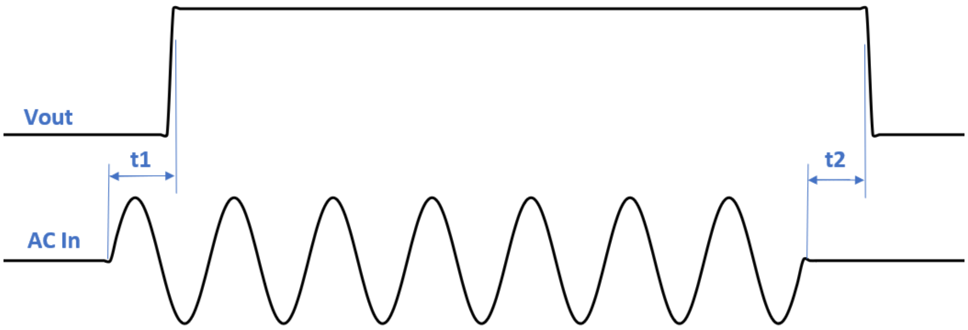
Regulation

Parameter	Description	Module	Min	Nominal / Typical	Max
Load regulation (mV/A)	0 – 100% Load	CmA-W01		0.2	0.5
		CmB-W01		0.3	1.6
		CmC-W01		1.2	5.8
		CmD-W01		2.4	23
Load Regulation – Paralleled (mV/A)	0 – 100% Load (Load Regulation is softened in parallel mode to improve current share)	CmA-W01	2.4		4.3
		CmB-W01	12		13
		CmC-W01	30		36
		CmD-W01	52		61
Line Regulation (mV)	85 – 264 Vac	CmA-W01		2	5
		CmB-W01		2	12
		CmC-W01		4	24
		CmD-W01		10	48
Temperature Regulation (%/°C)	Over ambient temperature change	All Mods			0.02

Protective Limits

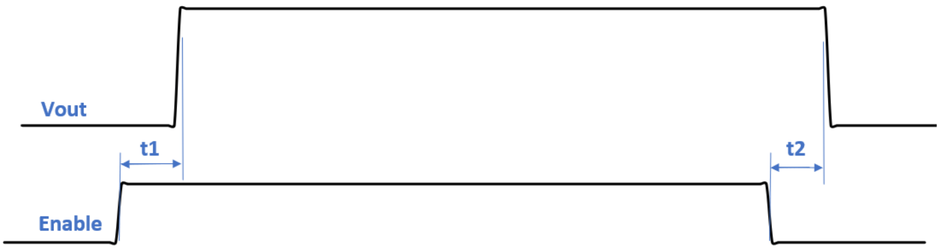
Parameter	Description		Module	Min	Nom / Typical	Max
Current Limit (A)	Constant Current Limit into Hiccup. Auto-Recovery	CoolX600	CmA-W01	23.1	25.2	27.3
			CmB-W01	16.5	18.1	19.5
			CmC-W01	9.2	9.7	10.8
			CmD-W01	4.6	4.9	5.4
		CoolX1800	CmA-W01	40.7	44.4	48.1
			CmB-W01	27.5	30	32.5
			CmC-W01	13.8	15	16.2
			CmD-W01	6.9	7.5	8.1
Short-Circuit Current Limit (A)	Measured over 5 hiccup cycles	CoolX600	CmA-W01			
			CmB-W01			
			CmC-W01			
			CmD-W01			
		CoolX1800	CmA-W01			
			CmB-W01			
			CmC-W01			
			CmD-W01			
Power Limit (W)	Voltage Foldback into Hiccup, Auto-Recovery	CoolX600	CmA-W01	115	130	137
			CmB-W01	198	220	234
			CmC-W01	220	230	260
			CmD-W01	220	230	260
		CoolX1800	CmA-W01	185		230
			CmB-W01	315		420
			CmC-W01	305		420
			CmD-W01	315		375
Overvoltage Protection (V)	CoolX600: Shutdown, Latching CoolX1800: Shutdown, Auto-Recovery		CmA-W01	6.8	8	9
			CmB-W01	17	19.8	21
			CmC-W01	32	35	37
			CmD-W01	60	62.2	66
Sense Lead Protection (V)	Shutdown, Auto-Recovery		All Mods			3.1

Start-Up / Shut-Down



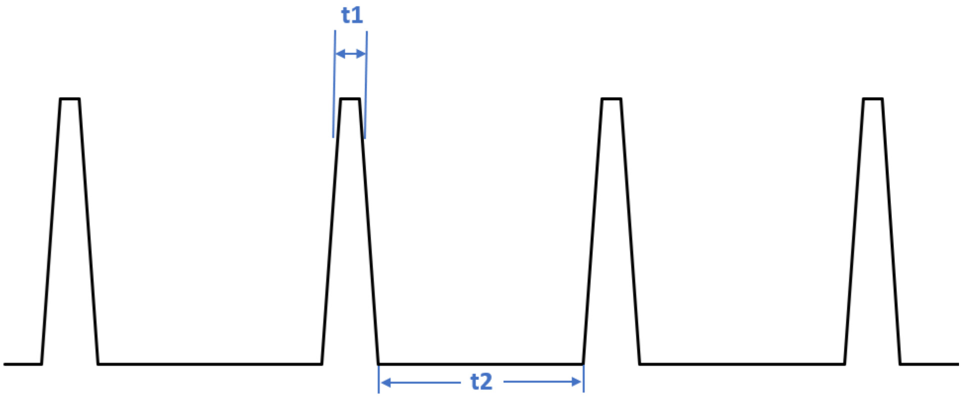
Parameter	Description	Module	Min	Nom / Typical	Max
Turn-On Delay (ms)	Time from Application of Input AC to Output Voltage Regulation (t1)	All Mods		640	800
Turn-Off Delay (ms)	From Loss of AC to Loss of Output Voltage Regulation – Nominal Voltage (t2)	All Mods	16	20	

Enable / Disable



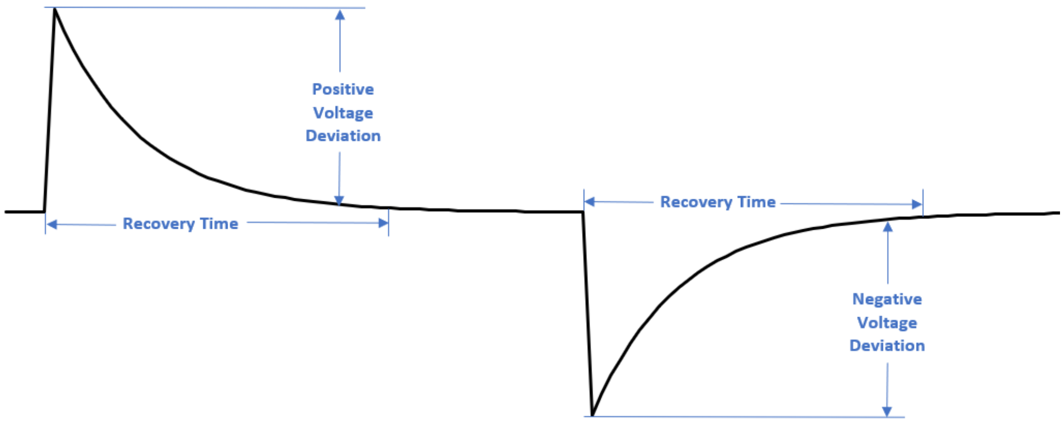
Parameter	Description	Module	Min	Nom / Typical	Max
Enable Delay (ms)	Time from application of Enable signal to Output Voltage regulation (t1)	All Mods		10	12
Rise Time (ms)	Measured from 10 – 90% of Vout	All Mods	2	2.5	5
Disable Delay (ms)	Time from application of Disable signal to loss of Output Voltage Regulation (t2)	All Mods		3	5
Fall Time (ms)	Measured from 90 – 10% of Vout	All Mods	0.1	0.35	3

Hiccup Characteristics



Parameter	Description	Module	Minimum	Nominal / Typical	Maximum
Hiccup On-Time (ms)	Length of time output is on during hiccup (t1)	All Mods	1	5	100
Hiccup Off-Time (ms)	Length of time output is off during hiccup (t2)	All Mods	950	990	1100
Short Circuit Hiccup Level (V)	Output voltage at which module enters hiccup protection	CmA-W01	0.6		0.9
		CmB-W01	0.6		0.9
		CmC-W01	0.6		0.9
		CmD-W01	1.1		2.0

Transient Response



Parameter	Description	Module	Minimum	Nominal / Typical	Maximum
Transient Response, Voltage Deviation (V)	Measured during 25 – 75% and 75 – 25% Step Load Changes	CmA-W01		0.2	0.4
		CmB-W01		0.3	0.5
		CmC-W01		0.4	1.0
		CmD-W01		0.7	1.0
Transient Response, Recovery Time (us)	Measured during 25 – 75% and 75 – 25% Step Load Changes	All Mods		300	500
Transient Response, Voltage Deviation (V)	Measured during 0 – 100% and 100 – 0% Step Load Changes	CmA-W01		0.5	0.6
		CmB-W01		1.0	1.2
		CmC-W01		1.3	2.4
		CmD-W01		1.7	4.8
Transient Response, Recovery Time (ms)	Measured during 0 – 100% and 100 – 0% Step Load Changes	All Mods		4.0	7.0

Galvanic Isolation

Parameter	Description	Module	Minimum	Nominal / Typical	Maximum
Input to Output (Vac)	Reinforced (2 MOPP)	All Mods	4000		
Output to Output (Vac)	Basic (1 MOPP)	All Mods	1850		

PMBus Communications

Standard modules can be monitored and controlled with the following PMBus Commands (for further details see the PMBUS Manual available for download from the Excelsys website.

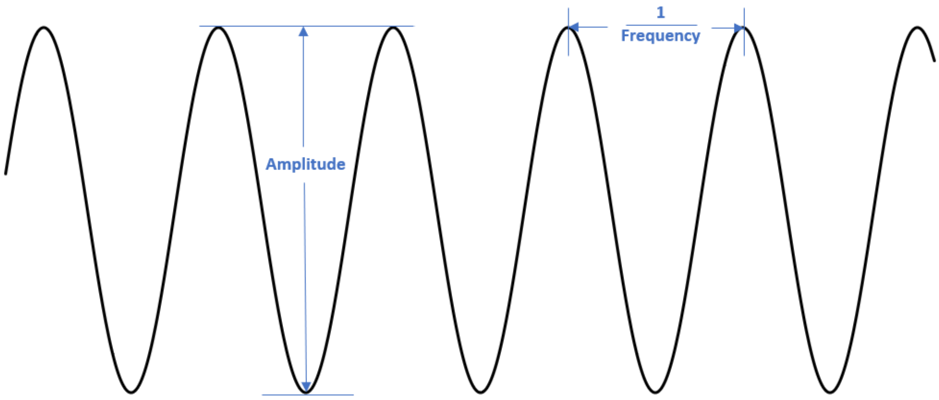
<table>
<tr><th>Specification</th><th>Description</th><th>Module</th><th>Accuracy</th><th>Resolution</th></tr>
<tr><td rowspan="4">READ_VOUT (0x8B)</td><td rowspan="4">The READ_VOUT command is used to return the output voltage measurement of the selected (or paged) module.</td><td>CmA-W01</td><td>+/- 4%</td><td></td></tr>
<tr><td>CmB-W01</td><td>+/- 4%</td><td></td></tr>
<tr><td>CmC-W01</td><td>+/- 4%</td><td></td></tr>
<tr><td>CmD-W01</td><td>+/- 4%</td><td></td></tr>
<tr><td rowspan="5">READ_IOUT (0x8C)</td><td rowspan="5">The READ_IOUT command is used to return the output current measurement of the selected (or paged) module.</td><td>Module</td><td>Accuracy</td><td>Resolution</td></tr>
<tr><td>CmA-W01</td><td>+/- 4%</td><td>40 mA</td></tr>
<tr><td>CmB-W01</td><td>+/- 4%</td><td>29 mA</td></tr>
<tr><td>CmC-W01</td><td>+/- 4%</td><td>16 mA</td></tr>
<tr><td>CmD-W01</td><td>+/- 4%</td><td>8 mA</td></tr>
<tr><td>READ_TEMPERATURE_1 (0x8D)</td><td colspan="4">The READ_TEMPERATURE_1 command is used to return the temperature measurement of the selected (or paged) module in Degrees Celsius. The accuracy of the READ_TEMPERATURE_1 command is +/- 10 ˚C, while its resolution is 1 ˚C.</td></tr>
<tr><td>STATUS_WORD (0x79)</td><td colspan="4">The STATUS_WORD command is used to check for the presence of fault conditions such as OTP (Overtemperature Protection) and PG (Power Good) fail.</td></tr>
<tr><td>PAGE (0x00)</td><td colspan="4">The PAGE command is used to select which of the modules subsequent commands are to be applied to. When read, this command shall return the currently selected page number.</td></tr>
<tr><td>OPERATION (0x01)</td><td colspan="4">The OPERATION command is used to enable or disable the output of any module.</td></tr>
<tr><td>VOUT_COMMAND (0x21)</td><td colspan="4">The VOUT_COMMAND command is used to explicitly set the output voltage of the selected (or paged) module to the commanded value.</td></tr>
<tr><td>ILIIMIT_TRIM (0xD1)</td><td colspan="4">The ILIMIT_TRIM command is used to explicitly set the current limit of the selected (or paged) module to the commanded value.</td></tr>
<tr><td rowspan="5">MODULE_ID (0xD0)</td><td rowspan="5" colspan="2">The MODULE_ID command is used to return a code representing the model type of the selected (or paged) CoolMod.</td><td>Module</td><td>ID Code</td></tr>
<tr><td>CmA-W01</td><td>0x22</td></tr>
<tr><td>CmB-W01</td><td>0x42</td></tr>
<tr><td>CmC-W01</td><td>0x62</td></tr>
<tr><td>CmD-W01</td><td>0x82</td></tr>
<tr><td>FIRMWARE_REVISION (0xD2)</td><td colspan="4">The FIRMWARE_REVISION command is used to return a string of integers that identifies the firmware revision of the subsystems within a CoolX system.</td></tr>
</table>

Auxiliary Output

Ratings

Parameter	Description	Aux Option	Min	Nom / Typical	Max
Output Voltage (V)	Output voltage of the Auxiliary Output	5 V	4.85	5	5.15
		12 V	11.6	12	12.4
Output Current (A)	Maximum output current for which the Auxiliary Output is rated for operation	5 V			4.7
		12 V			2
Output Power (W)	Maximum output power for which the Auxiliary Output is rated for operation.	5 V			23.5
		12 V			23.5

Ripple and Noise



Parameter	Description	Aux Option	Min	Nom / Typical	Max
Output Ripple (mV)	Amplitude of ripple measured at nominal voltage and at 20 MHz Bandwidth	5 V			100
		12 V			480
Output Ripple Frequency (kHz)	Frequency of output ripple.	Both Options	180	200	220

Regulation

Parameter	Description	Aux Option	Min	Nom / Typical	Max
Load regulation (mV)	0 – 100% Load	5 V			100
		12 V			240
Line Regulation (mV)	85 – 264 Vac	5 V			15
		12 V			36

Protective Limits

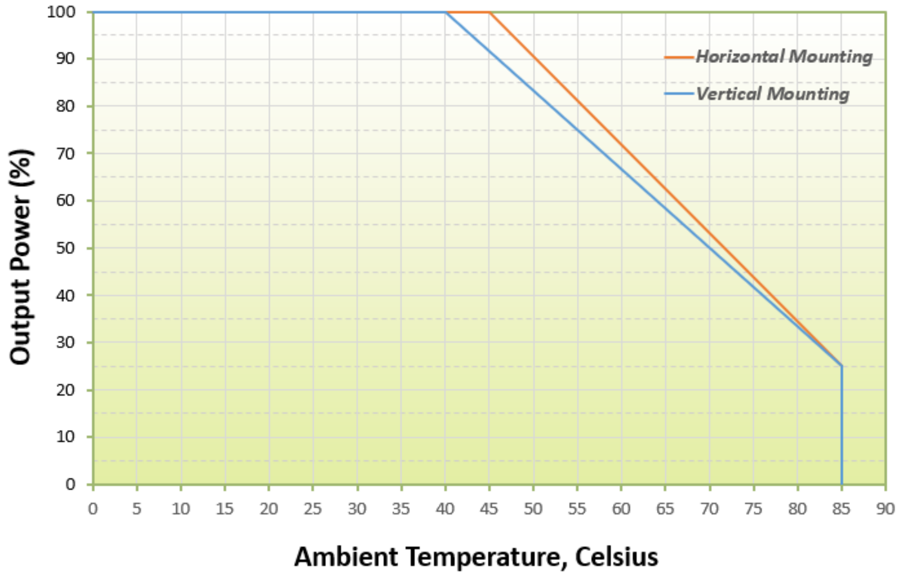
Parameter	Description	Aux Option	Min	Nom / Typical	Max
Current Limit (A)	Hiccup. Auto-Recovery	5 V	5		5.8
		12 V	2.3		2.8
Short-Circuit Current Limit (Arms)	Measured over 5 hiccup cycles	5 V			2.4
		12 V			1
Power Limit (W)	Hiccup, Auto-Recovery	5 V	25		29
		12 V	27.6		33.6

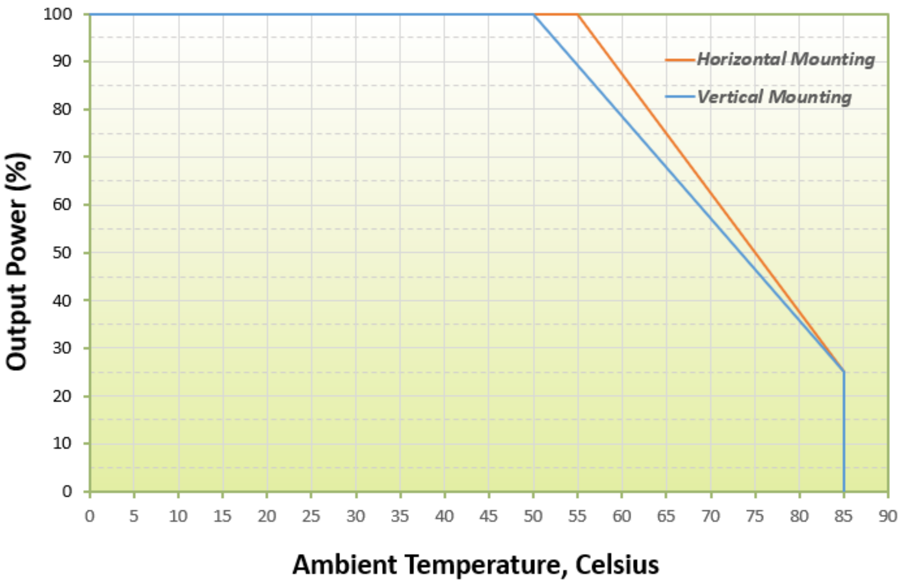
Galvanic Isolation

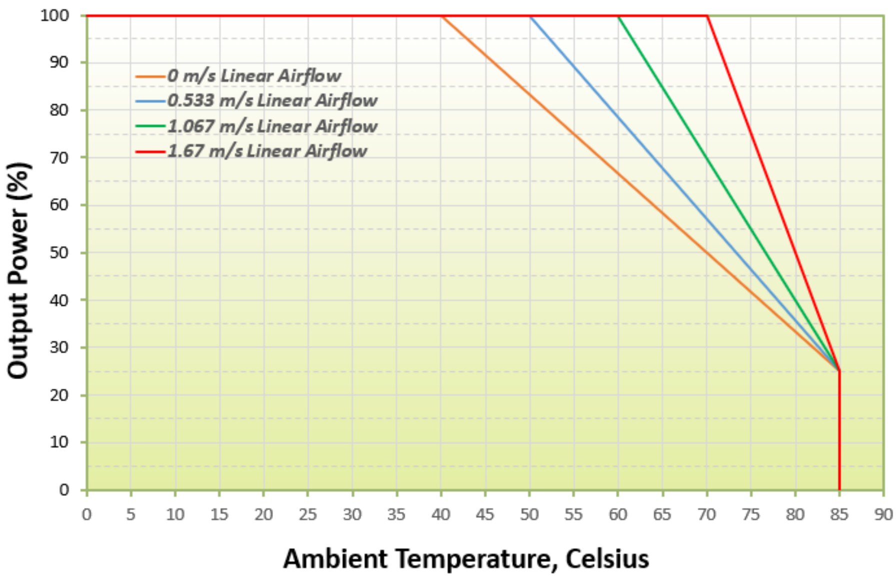
Parameter	Description	Aux Option	Min	Nom / Typical	Max
Input to Output (Vac)	Reinforced (2 MOPP)	Both Options	4000		
Output to Output (Vac)	Basic (1 MOPP)	Both Options	1850		

Appendix 2: Thermal Derating

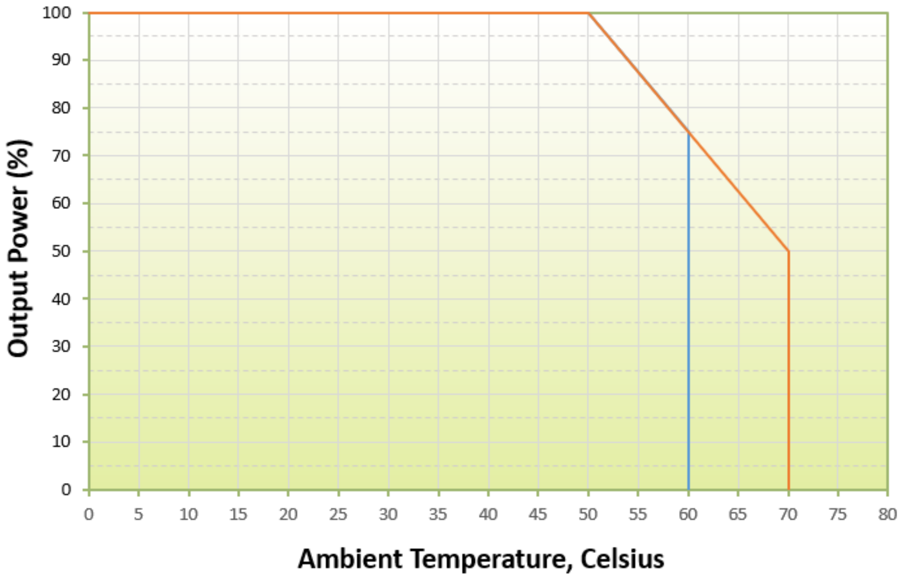
CoolX600

Test Condition	Derating
Convection Cooling Only Applies to CoolX600 and all CoolX Modules fitted in the CoolX600 Horizontal Mounting: Derate by 1.67%/°C above 40 °C ambient Vertical Mounting: Derate by 1.88%/°C above 45 °C ambient	

Test Condition	Derating
Conduction Cooling (1 kW Heatsink) Applies to CoolX600 and Standard CoolX Modules fitted in CoolX600 Performance of Bulk and Dual modules to be confirmed Horizontal Mounting: Derate by 2.14%/°C above 50 °C ambient Vertical Mounting: Derate by 2.5%/°C above 55 °C ambient	

Test Condition	Derating
Forced Air Cooling Applies to CoolX600 and Standard CoolX Modules fitted in CoolX600 Performance of Bulk and Dual modules to be confirmed 0 m/s Linear Airflow: Derate by 1.67%/°C above 40 °C ambient 0.533 m/s Linear Airflow: Derate by 2.14%/°C above 50 °C ambient 1.067 m/s Linear Airflow: Derate by 3%/°C above 60 °C ambient 1.67 m/s Linear Airflow: Derate by 5%/°C above 70 °C ambient	

CoolX1800

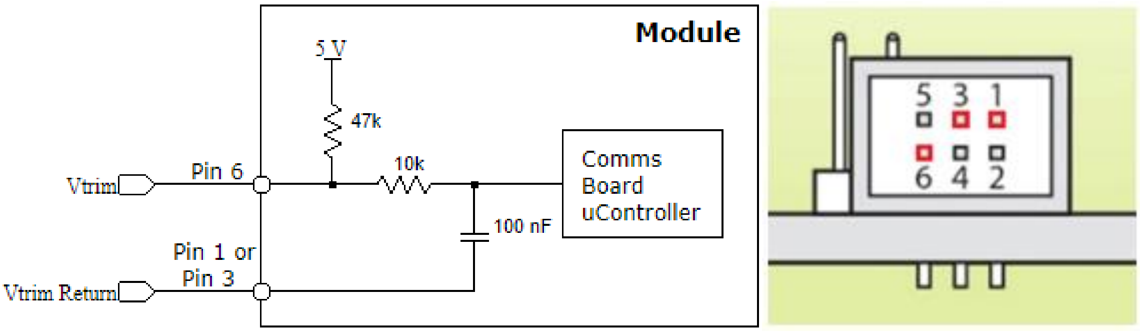
Test Condition	Derating
Normal Operation Applies to CoolX1800 and all CoolX Modules fitted in CoolX1800 Derate by 2.5%/°C above 50 °C ambient Max ambient operating temperature for a CoolX1800 fitted with an IEC AC input connector is 60 °C Max ambient operating temperature for a CoolX1800 fitted with a Screw Terminal AC input connector is 70 °C	

Appendix 3: Analog Communications

The output characteristics of standard modules can also be monitored and controlled with analog signals via the J100x connectors.

Remote Voltage Setting (Using External Voltage)

Available On: Standard Modules (CmA-CmD), Bulk Modules (CmE-CmF), Wide-Trim Modules



The output voltage of the module can be set by applying a control voltage Vtrim across the Output Signal Connector (J100x) pins Vtrim (Pin 6) and Common (Pin 1 or Pin 3). The Vtrim voltage required for the users desired output voltage can be calculated using the following formula.

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

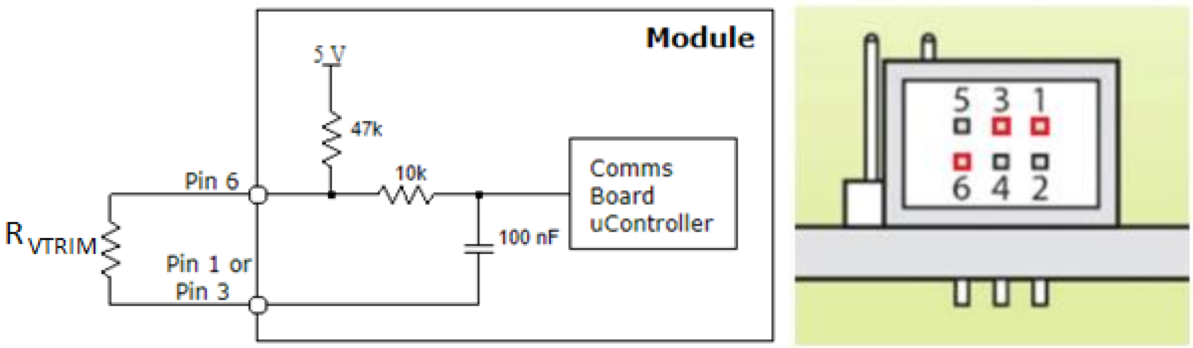
Where:

Module	F	K
CmA	2.43	1.59
CmB	5.85	3.84
CmC	13.82	6.3
CmD	26.13	13.2
CmE	22.45	1.19
CmF	43.06	0.28
CmA-W01	3.23	-1.61
CmB-W01	7.84	-3.90
CmC-W01	12.77	-2.17
CmD-W01	26.25	-6.42

Please note that the upper range of remote trimmable voltage is limited by the potentiometer setting.

Remote Voltage Setting (Using External Resistance)

Available On: Standard Modules (CmA-CmD), Bulk Modules (CmE-CmF), Wide-Trim Modules (CmA-W01-CmD-W01)



The output voltage of the module can be set by placing a resistor R_{VTRIM} across the Output Signal Connector pins Vtrim (Pin 6) and Common (Pin 1 or Pin 3). The R_{VTRIM} resistance required for the users desired output voltage can be calculated using the following formula.

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

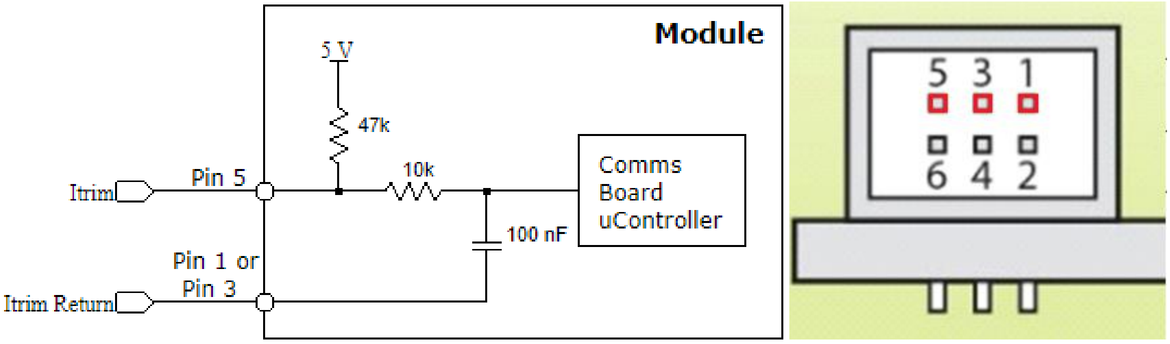
Where:

Module	F	K
CmA	2.43	1.59
CmB	5.85	3.84
CmC	13.82	6.3
CmD	26.13	13.2
CmE	22.45	1.19
CmF	43.06	0.28
CmA-W01	3.23	-1.61
CmB-W01	7.84	-3.90
CmC-W01	12.77	-2.17
CmD-W01	26.25	-6.42

Please note that the upper range of remote trimmable voltage is limited by the potentiometer setting.

Remote Current Limit Setting (Using External Voltage)

Available On: Standard Modules (CmA-CmD), Wide-Trim Modules (CmA-W01-CmD-W01)



The current limit of the CoolMod can bet set by applying a control voltage Itrim across the Output Signal Connector (J100x) pins Itrim (Pin 5) and Common (Pin 1 or Pin 3). The Itrim voltage required for the users desired current limit with the module can be calculated using the following formula.

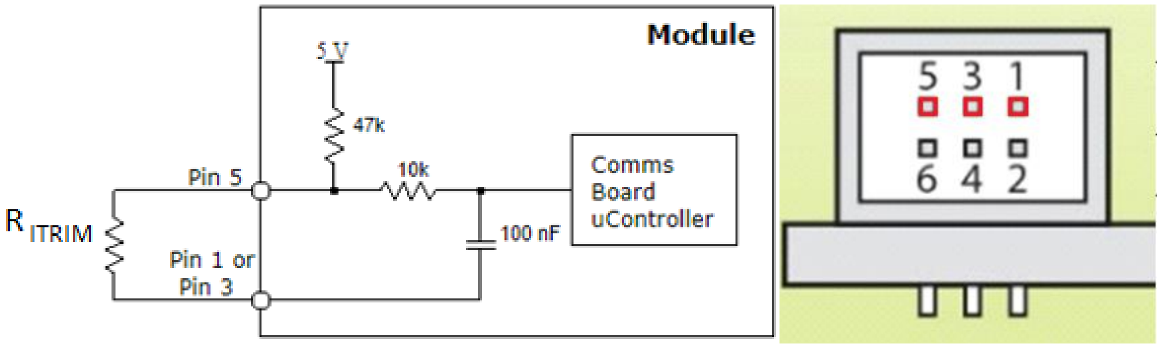
$$I_{trim} = \frac{I_{out}}{K}$$

Where:

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

Remote Current Limit Setting (Using External Resistance)

Available On: Standard Modules (CmA-CmD), Wide-Trim Modules (CmA-W01-CmD-W01)



The current limit of the CoolMod can bet set by placing a resistor R_{ITRIM} across the Output Signal Connector (J100x) pins Itrim (Pin 5) and Common (Pin 1 or Pin3). The R_{ITRIM} resistance required for the users desired output current limit can be calculated using the following formula along with the same table used to calculate Itrim.

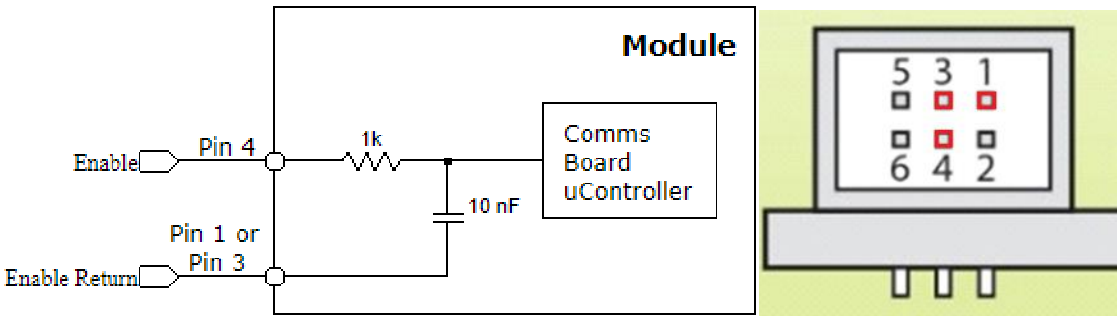
$$R_{ITRIM} = \frac{47000 \times I_{out}}{K - I_{out}}$$

Where:

Module	K
CmA	73.95
CmB	53.25
CmC	28.75
CmD	14.45
CmA-W01	73.95
CmB-W01	53.25
CmC-W01	28.75
CmD-W01	14.45

Enable / Disable

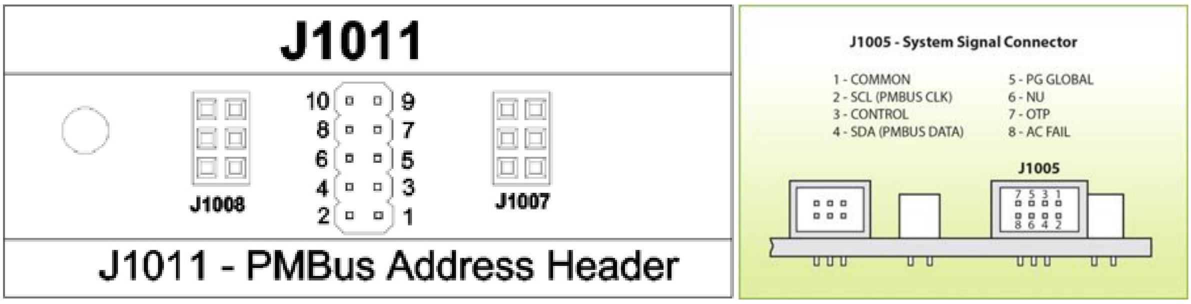
Available On: All Modules



The module may be enabled/inhibited by means of a logic level signal applied to the enable input on Output Signal Connector J100x, Pin 4 (Positive), Pin 1 or 3 (Negative). The input voltage must be limited to no greater than 5 volts. When there is no connection, Pin 4 is HIGH (5V) and the module is enabled. Pulling Pin 4 to Common will disable the module.

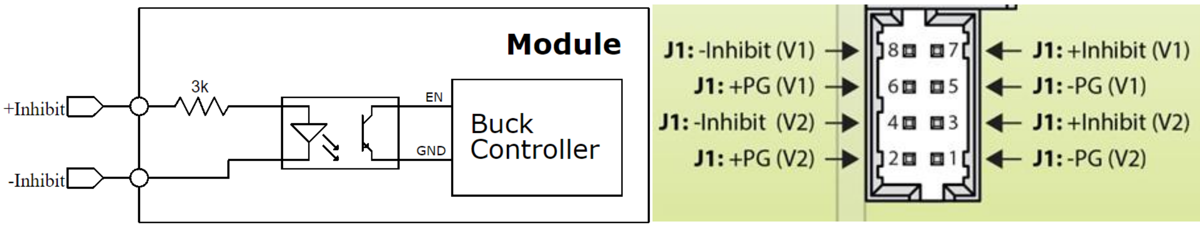
The logic of the Module Inhibit/Enable signals will be reversed if pins 1 and 2 of J1011 (which is located in the centre of the Comms board between slot 2 and slot 3) are shorted with a jumper, and a logic low signal is applied between the CONTROL pin of J100x (Pin 3) and Common (Pin 1) – where J100x is J1005 for the CoolX600 and J1007 for the CoolX1800. Now when Pin 4 is HIGH, the module is disabled, and pulling Pin 4 to Common will enable the module.

The recommended jumper for the J1011 connector is a Harwin M22-1900005 2mm Jumper Socket.



Channel Enable / Disable

Available On: Dual Modules (CmG-H)



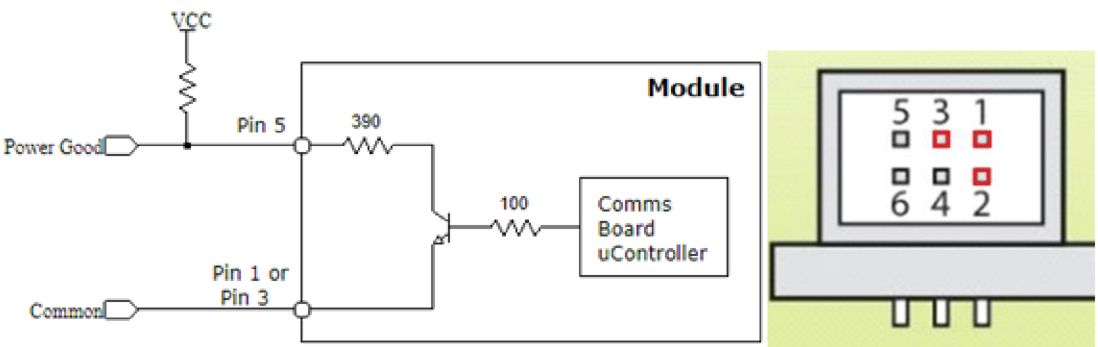
Each individual channel of the Dual Module may be enabled/inhibited by means of a signal applied to the Inhibit pins on the Module Signal Connector J1. When the Inhibit pins are floating, or when the +Inhibit pin is tied to the -Inhibit pin, the channel is enabled.

Applying a signal voltage to the Inhibit pins will disable the channel. The specifications of this signal are shown in the table below.

	Inhibit Signal Voltage	Inhibit Signal Current
Maximum	12 V	4.0 mA
Minimum	3 V	0.2 mA

Power Good

Available On: Standard Modules (CmA-CmD), Bulk Modules (CmE-CmF), Wide-Trim Modules (CmA-W01-CmD-W01)



The module has a Power Good signal that is the output of an internal comparator which monitors the output voltage and determines whether this voltage is within normal operation limits. The Power Good signal is an unbiased open collector that is available on the Output Signal Connector (J100x) via the collector on Pin 2 and the emitter on Pin 1 or 3 (Common).

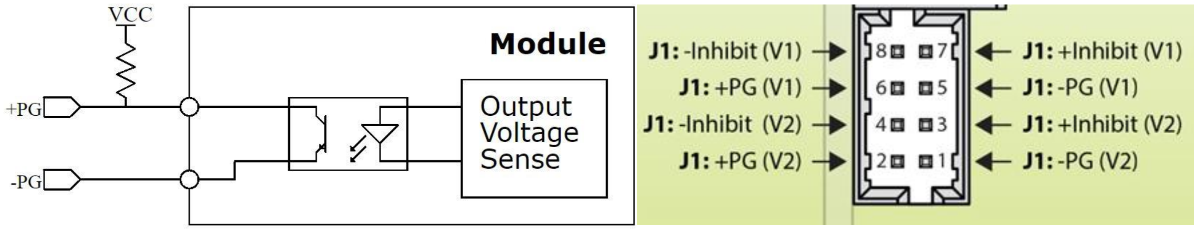
When the output voltage is within 10% of Vset the transistor is turned ON. If the output drops out of regulation the transistor turns OFF. This can be used for power sequencing in many applications (enabling another CoolMod output when the first output is within regulation, as well as driving external circuitry.

The maximum collector voltage is 5V, and the maximum collector current is 12mA.

The dual module power good signal does not impact the global power good status.

Channel Power Good

Available On: Dual Modules (CmG-H)



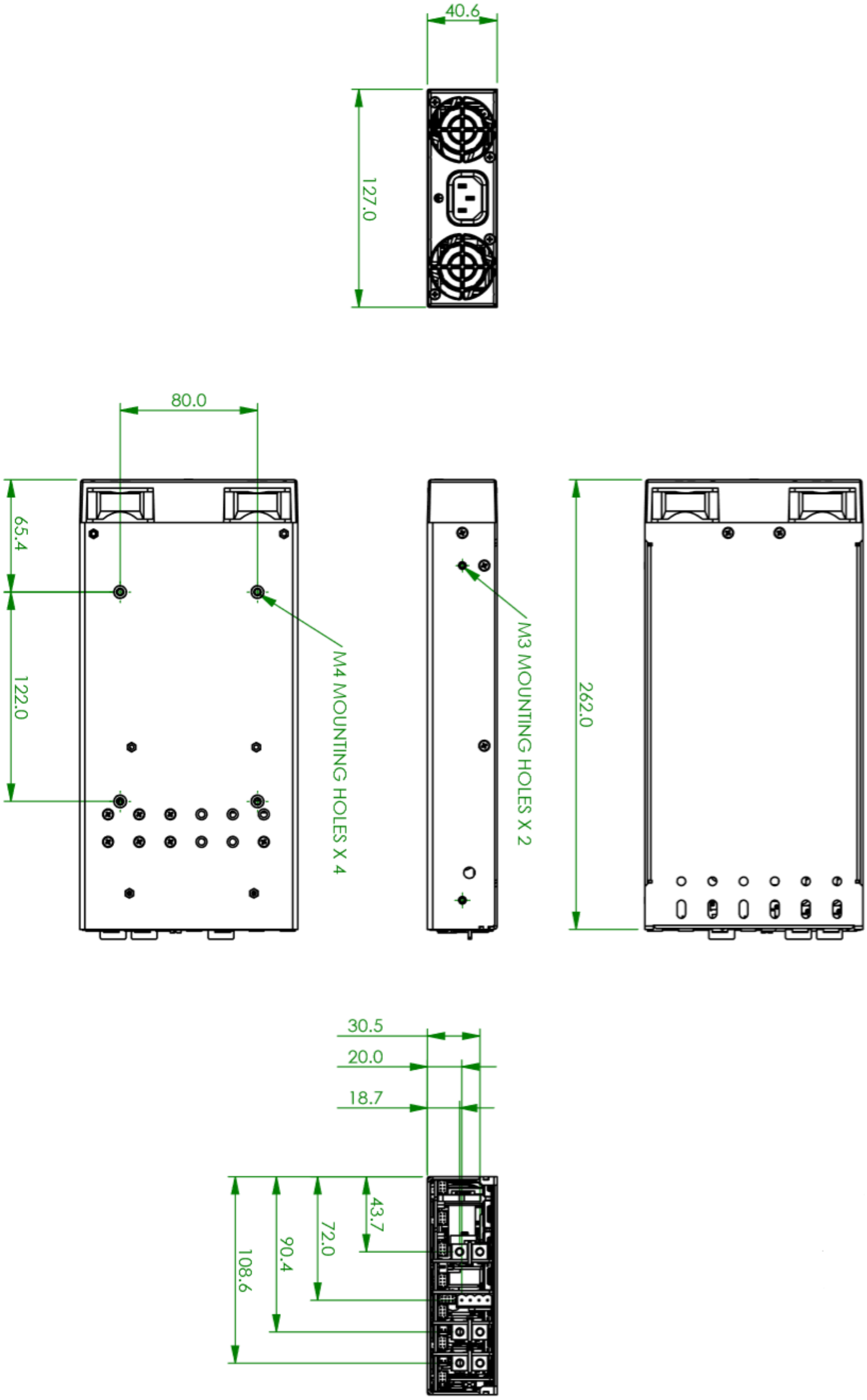
Each channel of the Dual Module has a Power Good signal which indicates if there is a voltage on the output pins. The Power Good signal is the unbiased open collector of an optocoupler that is available on the Module Signal Connector J1 via the collector on +PG and the emitter on -PG.

When there is a voltage present on the output pins of the channel the transistor of the optocoupler is turned ON. If the output drops out of regulation the transistor turns OFF. This can be used for power sequencing in many applications (enabling another CoolMod output when the first output high, as well as driving external circuitry).

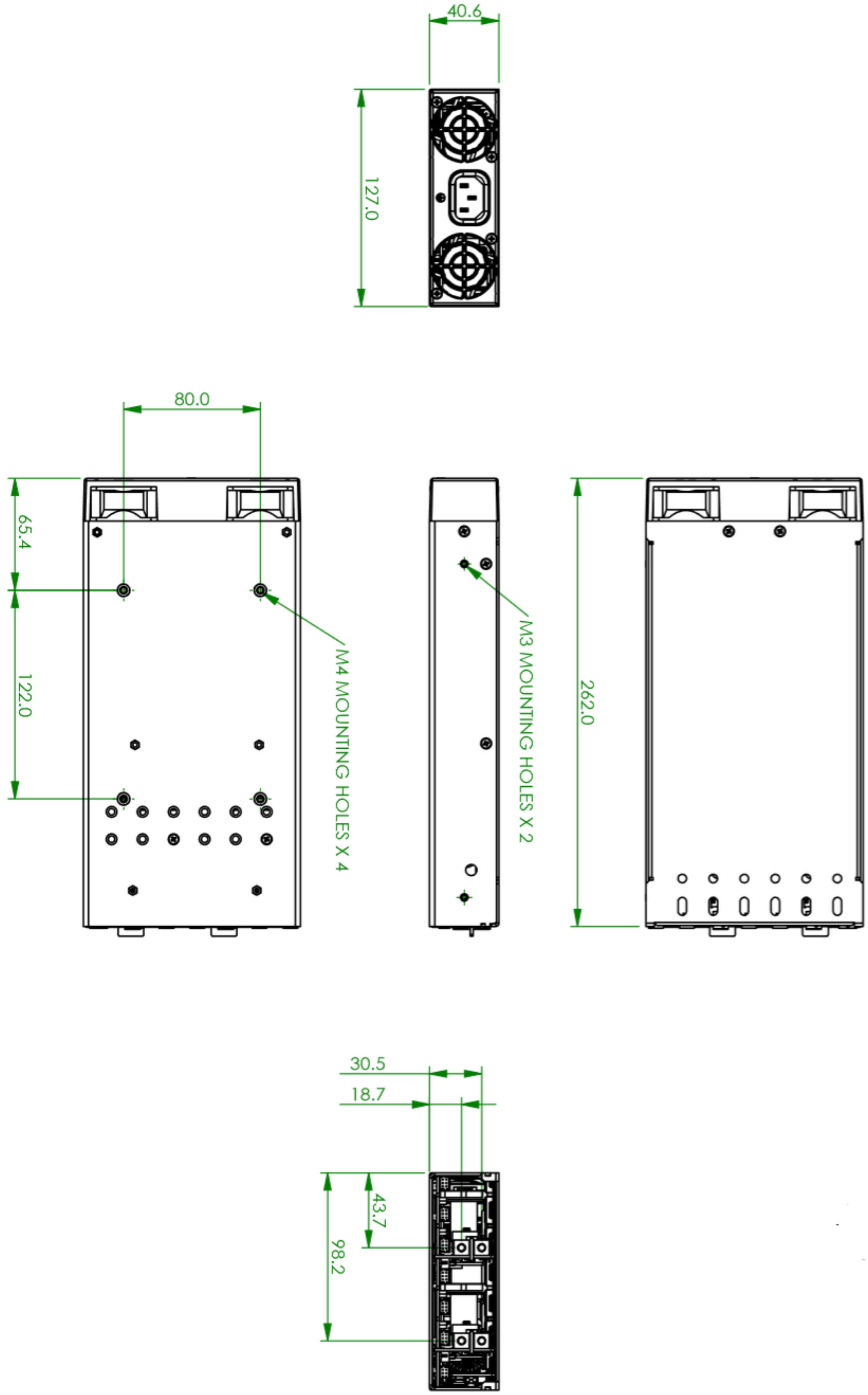
To monitor the Power Good of a channel, +PG should be pulled up to a reference voltage with a pull-up resistor. The pull up resistor should be chosen to limit collector current to 0.5 mA or less. For example, if the reference voltage is 5 V, the pull up resistor should be 10 kΩ or higher.

Appendix 4: Mechanical Drawings

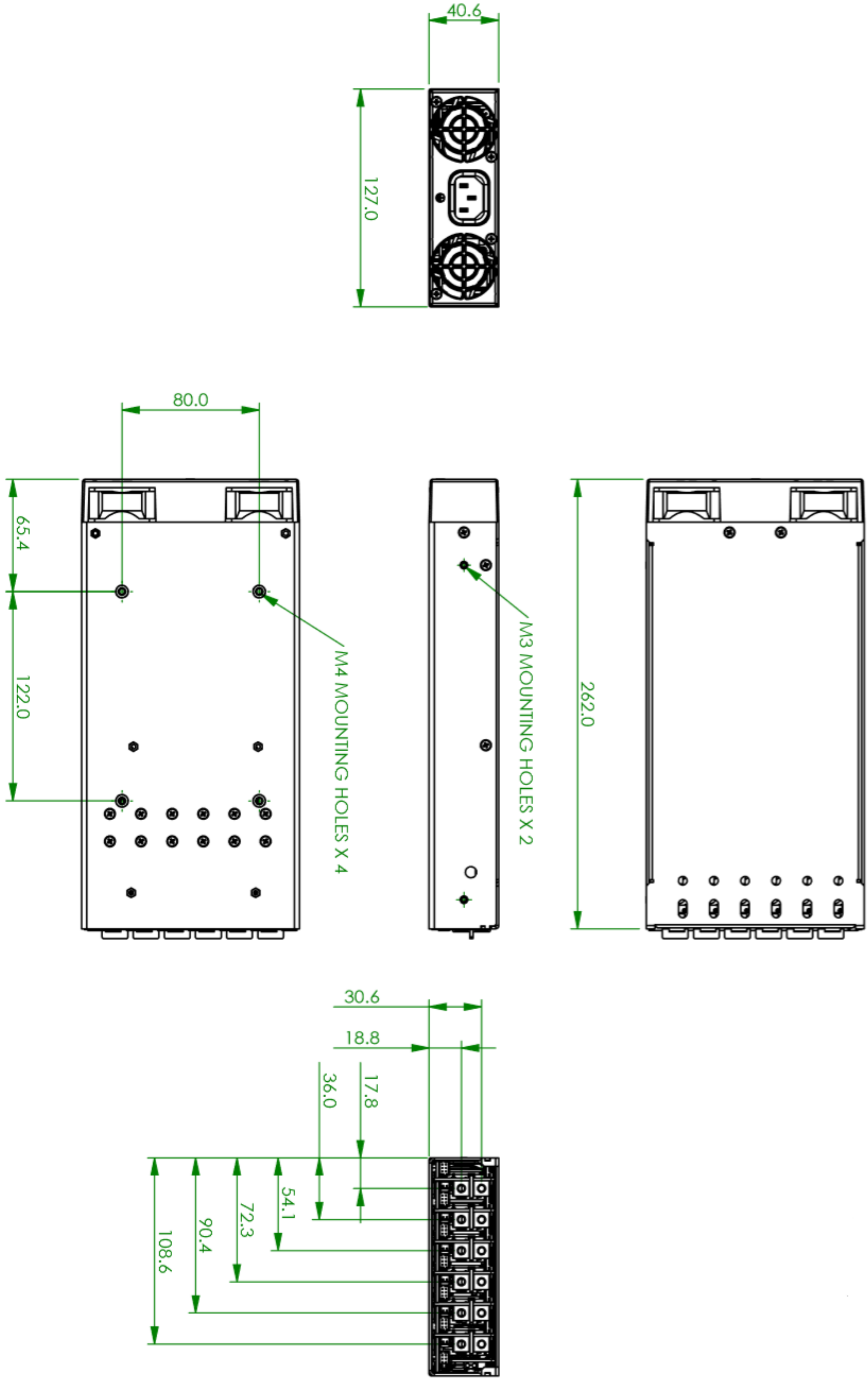
CoolX1800 (1 x Bulk Module, 1 x Dual Module, 2 x Standards Modules)



CoolX1800 (2 x Bulk Modules)



CoolX1800 – (6 x Standard Modules)



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