EXCELSYS FC2500 SERIES

Capacitor Charging and ACDC Power Supply

FLEXICHARGE by Advanced Energy

Advanced Energy's FC25M Power Supply Designers Manual has been prepared by Advanced Energy experts to assist qualified engineers and technicians in understanding the correct design practices necessary to deliver exceptional capacitor charging performance and additional auxiliary power in a single compact package.

AT A GLANCE

Input Voltage

200 to 240 Vac

HV Output Voltage

0 to 1000 Vdc

Output Power

3306 W Total
2500 W on Cap Charger
800 W Max on Modular
6 W on Auxiliary Output

Cooling

Fan cooled

Dimensions

322 x 145 x 106 mm
12.68 x 5.7 x 4.17 inch

Certifications

Medical

- IEC60601-1 3rd edition
  IEC60601-1-2 4th edition (EMC)
- 2 x MOPP from input to modular output
- 1 x MOPP from input to HV output
- Dual fused

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SECTION 1 PRODUCT DESCRIPTIONS

1.1 Overview of FC25M

The FC25M capacitor charger power supply has been developed for general capacitor charging applications and for use in non-contact medical environments. It's design incorporates innovative digital control techniques to reduce switching losses and increase power density. In addition to the 2500W, 10A capacitor charging, earth referenced output (programmable from 0 to 1000 Vdc), up to 800W of auxiliary isolated configurable power is available from 5 slots which accommodate standard CoolX modules.

Stand-out features for medical applications include dual input fusing, 2 x MOPP input to output isolation and <300uA leakage current. Other features include 4000Vac input surge immunity and the ability to withstand input voltages swells of up to 300Vac making it ideal for use in locations subject to input voltage disturbances. With analogue and digital communications (PMBus™), the FC25M provides the only combined capacitor charging and modular power supply in the market, all backed up by the Advanced Energy 2 Years Warranty ensuring quality and the lowest total cost of ownership.

A complete Flexicharge power supply is configured by selecting and inserting up to 5 output modules called CoolMods. This offers the advantages of a custom supply but is assembled from standard modular building blocks. If output requirements change, i.e., more power or a different output voltage is needed, the Flexicharge can be configured with a different module type. 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 analog interface on the high voltage Capacitor Charger output and 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 1 PRODUCT DESCRIPTIONS CON'T

1.2 Theory of Operation

The FC25M unit is comprised of a main board for the AC Input to BULK (400Vdc) section, a non-removable, isolated output Cap Charger section (400 to 1000 Vdc) and a removable configurable modular section for the 5 slots of auxiliary, isolated converter modules. An operational block diagram is shown below. The FC25M can deliver up to 3300W of continuous power: 800W from the modular outputs and 2500W from the High Voltage (HV) Cap Charger output.

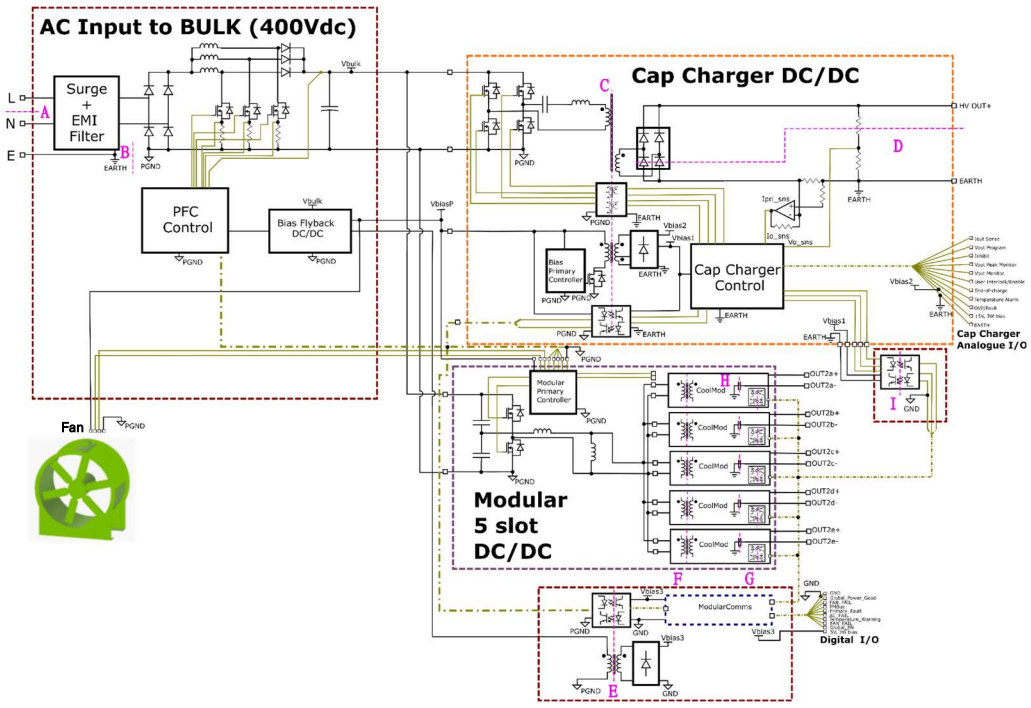


Figure 1 Block diagram

The input EMI filter gives compliance to EN55022 while meeting the low earth leakage current requirements of EN60601-1 3rd Edition. The modular outputs have medical isolation of 4000Vac (2 x MOPP) from input to output and extended isolation of 1850Vac from output to earth (Note: 1 x MOPP requirement is 1500Vac). There is 4000Vac isolation from the input to the HV output.

The System Signal Board (CoolPacComms in the diagram above) communicates with the communication board of each module and with the Cap Charger, to provide a single customer accessible system signal connector. A full suite of monitor and controls including AC Fail, Global Inhibit / Enable, Over-Temperature Alarm and a PMBus™ interface are provided.

A configured FC25M has the following galvanic isolation barriers:

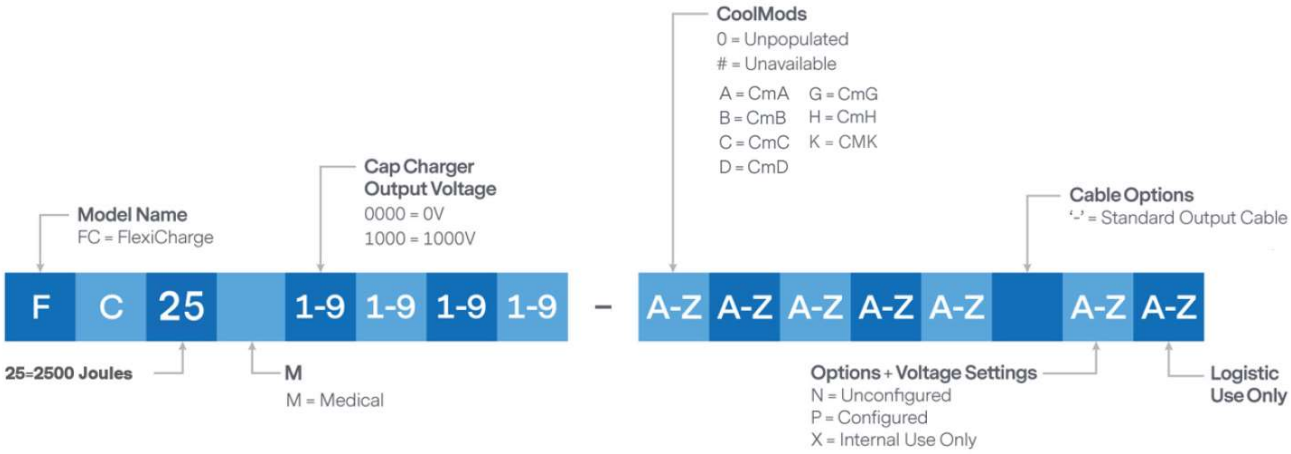
SECTION 1 PRODUCT DESCRIPTIONS CON'T

Isolation Barrier	Type	Withstand Voltage
Input to Case (earth) (B)	Basic (1 x MOPP)	1850Vac
Input to HV Output (C)	Basic (1 x MOOP)	4000Vac
Input to Digital I/O (E)	Reinforced (2 x MOPP)	4000Vac
Input to Modular Output (F)	Reinforced (2 x MOPP)	4000Vac
Modular Output to Digital I/O (G)	Basic (1 x MOPP)	1850Vac
Modular Output to Case (earth) (H)	Basic (1 x MOPP)	1850Vac
Digital I/O to Case (earth) (I)	Basic (1 x MOPP)	1850Vac

SECTION 2 MODEL / ORDERING INFORMATION

2.1 FC25M Nomenclature

The FC25M user configurable power supply part-numbering system is described below.



Model Name

FC25M = 2500W

CoolMods - Output Modules (see section 2.2 for module details)

A = CmA - 5V / 21A, 1 slot
B = CmB - 12V / 15A, 1 slot
C = CmC - 24V / 8.33A, 1 slot
D = CmD - 48V / 4.17A, 1 slot
0 = Unpopulated
G = CmG - 24V / 3A + 24V / 3A, 1 slot
H = CmH - 5V / 6A + 24V / 3A, 1 slot
K = CmK - 200V / 0.66A, 1 slot

Cable Options

'-' = Standard Output Cable

Options + Voltage Settings

N = Standard. No additional configuration. Nominal output voltages
P = Configured. Preset. Voltage adjustment, series, parallel outputs
X = Special configuration (Internal use only)

SECTION 2 MODEL / ORDERING INFORMATION CON'T

2.2 Output Modules

Table 1 Capacitor Charging Output (as Standard)				
Output Voltage	Output Adjust Range	Maximum Current	Maximum Power	Polarity
1000V	0-1000 V	10A	2500W	Positive[1]

Note 1: The negative of the HV output is connected to earth / chassis.

Table 2 FC25M CoolMods Table					
		Output Voltage	Output Adjust Range	Maximum Current	Maximum Power
Single Output Modules (1 Slot)					
CmA		5V	2.5-6.0 V	21.0A	105W
CmB[1]		12V	6.0-15.0 V	15.0A	180W
CmC		24V	15.0-28.0 V	8.33A	200W
CmD		48V	28.0-58.0 V	4.17A	200W
Dual Output Modules (1 Slot)					
CmG[2]	V1	24V	3.0-30.0 V	3.0A	90W
	V2	24V	3.0-30.0 V	3.0A	90W
CmH[3]	V1	5V	3.0-6.0 V	6.0A	36W
	V2	24V	3.0-30.0 V	3.0A	90W
Wide Trim Modules (1 Slot)					
CmA-W01		5V	1.0-6.0 V	21.0A	105W
CmB-W01		12V	1.0-15.0 V[2]	15.0A	180W
CmC-W01		24V	2.0-28.0 V	8.33A	200W
CmD-W01		48V	3.0-58.0 V[3]	4.17A	200W
High Voltage Module (1 Slot)					
CmK		200V	175.0-205.0 V	0.66A	132W

Note 1 - Full dynamic specifications may not be met at full load when output voltage is trimmed above 13V.
Note 2 - For the CmG module the max combined power of both outputs is 120W.
Note 3 - For the CmH module the max combined power of both outputs is 100W.

SECTION 2 MODEL / ORDERING INFORMATION CON'T

2.3 Selecting & Ordering Configured FC25M

Configured FC25M power supplies may be specified and ordered using the part numbering system shown. At our configuration centre, we will assemble the FC25M 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

Required power supply:	2500W / 1000V Capacitor Charger
Outputs:	5V / 10A
	48V / 6A
	22V / 5A
Cabling Option:	Standard

Solution: FC25M part number FC25M1000-ACDD0-P specifies the following product:

FC25M1000: 2500W / 1000V Capacitor Charger

- Slot 1: CmA, 5V / 21A module
- Slot 2: CmC, 24V / 8.33A module
- Slot 3: CmD, 48V / 4.17A module
- Slot 4: CmD, 48V / 4.17A module
- Slot 5: Empty
- Option P: Preset required, Slot 2 trimmed to 22V, Slots 3 and 4 connected in parallel
- Option -: Standard Output Cabling

SECTION 3 ELECTRICAL SPECIFICATIONS

3.1 Input Specifications

Table 3 Input Specifications

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Nominal Input Voltage, AC	47 to 63 Hz	$V_{IN,AC}$	200	-	240	Vac
Operating Input Voltage, AC	47 to 63 Hz	$V_{IN,AC}$	180	-	264	Vac
Maximum Input AC Current		$I_{IN,max}$	-	23.2	-	A
Harmonic Line Currents	All	THD	EN 61000-3-12, Class A			
Power Factor	$V_{IN,AC}$ = 120Vac $P_O = P_{O,max}$		0.98	-	-	
Undervoltage Lockout	Shutdown		157	-	167	Vac
Inrush Current	$V_{IN,AC}$ = 230Vac $P_O = P_{O,max}$	$I_{IN,inrush}$	-	-	50	A
Leakage Current to Earth Ground	Normal Condition (High Line) $V_{IN,AC}$ = 264Vac / 60Hz	$I_{leakage}$	-	-	300	uA
	Single Fault Condition (High Line) $V_{IN,AC}$ = 264Vac / 60Hz	$I_{leakage}$	-	-	3.6	mA
Touch Current to Earth Ground	Normal Condition (High Line) $V_{IN,AC}$ = 264Vac / 60Hz	I_{touch}	-	-	100	uA
	Single Fault Condition (High Line) $V_{IN,AC}$ = 264Vac	I_{touch}	-	-	500	uA
Input Fuses Rating	Dual Fused (Line and Neutral) 500Vac		-	30	-	A
Operating Efficiency @ 25 ^{O}C	Cap charger at max voltage, steady state 4 x CmD modules $P_O = P_{O,max}$	η	-	95	-	%

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

3.2 CAPACITOR CHARGER OUTPUT SPECIFICATIONS

Table 4 Capacitor charger Output Specifications

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Output Voltage[1]	All	V_{oHV}	0	-	1000	Vdc
Output Power	All	P_{oHV}	0	-	2500	W
Output Current[2]	All	I_{oHV}	0	-	10	A
Capacitive Loading	All	C_{extHV}	150	-	-	uF
Pulse-to-pulse Repeatability	All		-2	-	2	Vdc
Output Voltage Adjustment Accuracy[3]	All		-	-	1	%
Output Voltage Drift With Temperature	All		-	-	0.02	%/°C
Output Power Limit Adjustment[4]	All	P_{oHV_Max}	800	-	2750	W
Output Power Limit Adjustment Accuracy	All		-	-	3	%
Turn-On Delay[5]	All		-	-	2,000	mS
Enable Delay[6]	All		-	-	2	mS
Disable Delay[7]	All		-	-	1	mS

Note 1 - The output voltage is adjustable (analogue or digital).
Note 2 - The power limits the maximum output current to < 10A for V_{oHV}, ie $I_{oHV\_Max} = P_{oHV\_Max} / V_{oHV}$ for $V_{oHV} > 275V$.
Note 3 - For $V_{oHV} > 80V$.
Note 4 - Adjustable using 'Ptrim' according to: P_{oHV_Max} = 'Ptrim' x 195W.
Note 5 - Time from application of input AC to output current regulation.
Note 6 - Time from 'Inhibit' > 2V to output current regulation.
Note 7 - Time from 'Inhibit' < 1V to output current turned off.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

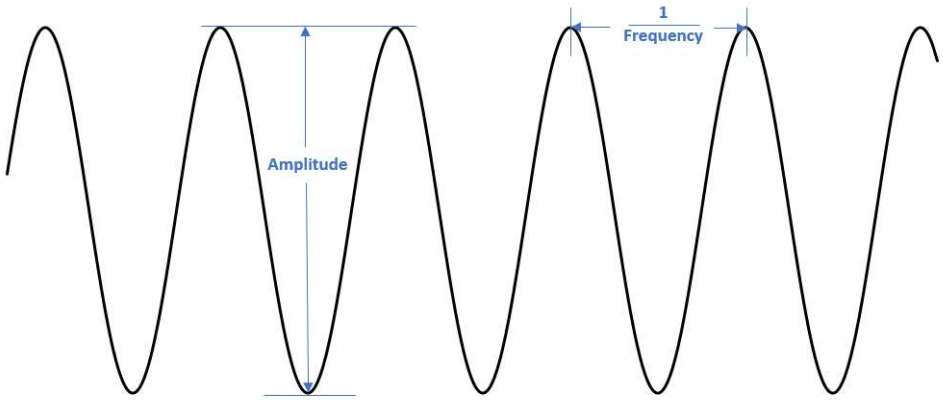
3.3 Standard Modules (CmA-CmD) Output Specifications

Parameter	Module	Symbol	Min	Typ	Max	Unit
Output Voltage	CmA CmB CmC CmD	V_O	2.5 6 15 28	5 12 24 48	6 15[1] 28 58	Vdc
Factory Setting Accuracy	CmA CmB CmC CmD	$V_{O,factory}$	- - - -	- - - -	10 10 20 50	mV
Output Current[2]	CmA CmB CmC CmD	$I_{O,max}$	- - - -	- - - -	21 15 8.33 4.17	A
Output Power[3]	CmA CmB CmC CmD	$P_{O,max}$	- - - -	- - - -	105 180 200 200	W
Capacitive Loading[4]	CmA CmB CmC CmD	$C_{O,max}$	- - - -	- - - -	20000 10000 8000 4700	uF

Note 1 - Full dynamic specifications may not be met at full load when output voltage is trimmed above 13V.
Note 2 - Maximum output current to be derated by 10% when used in parallel.
Note 3 - Maximum output power is derated by 10% when a module is used in parallel.
Maximum output power to be derated when FC25M is used in ambient temperatures greater than 40^{O}C.
Note 4 - Maximum capacitive load of the module to ensure monotonic startup (with no additional load applied). Higher capacitive loading is possible if non-monotonic startup is acceptable. Contact technical support for further details.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Ripple and Noise - CmA, CmB, CmC, CmD



Parameter	Module	Symbol	Min	Typ	Max	Unit
Output Ripple[1]	CmA CmB CmC CmD	$V_{O,ripple}$	- - - -	- - - -	100 150 240 480	mV
Output Ripple Frequency[2]	All Modules	f	220	-	260	KHz

Note 1 - Amplitude of ripple measured at nominal voltage and at 20MHz Bandwidth.

Regulation- CmA, CmB, CmC, CmD

Parameter	Module	Symbol	Min	Typ	Max	Unit
Load Regulation 0 - 100% Load	CmA CmB CmC CmD	V_O	- - - -	- - - -	20 24 48 96	mV
Load Regulation - Paralleled[1] 0 - 100% Load	CmA CmB CmC CmD	V_O	50 150 450 840	- - - -	90 189 491 903	mV
Line Regulation 85 - 264 Vac	CmA CmB CmC CmD	V_O	- - - -	- - - -	10 12 24 48	mV
Temperature Regulation[2]	All Modules		-	-	0.02	% / ^{O}C

Note 1 - Load Regulation is softened in parallel mode to improve current share.
Note 2 - Over ambient temperature change.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

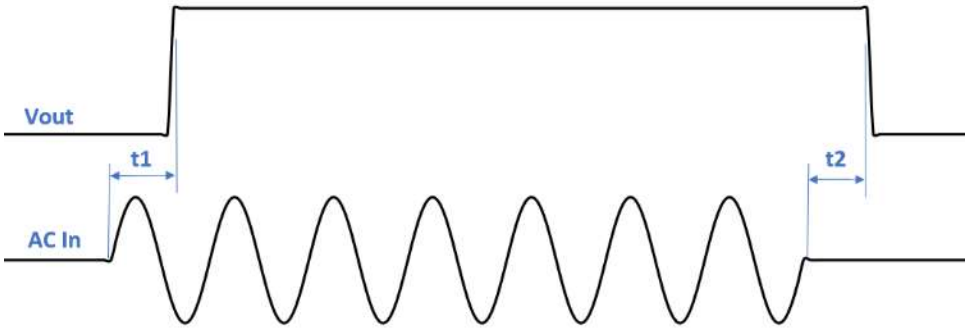
Protective Limits - CmA, CmB, CmC, CmD

Parameter	Module	Symbol	Min	Typ	Max	Unit
Current Limit[1]	CmA CmB CmC CmD	$I_{O,limit}$	22 15.7 8.7 4.3	- - - -	27.3 19.5 10.8 5.4	A
Short-Circuit Current Limit[2]	CmA CmB CmC CmD	$I_{O,short}$	- - - -	- - - -	10.5 7.5 4.2 2.1	A
Power Limit[3]	CmA CmB CmC CmD	$P_{O,limit}$	110 190 210 210	- - - -	137 234 260 260	W
Overvoltage Protection[4]	CmA CmB CmC CmD	V_O	7.5 17 32 62	- - - -	9.6 21.0 37.0 69.6	V
Sense Lead Protection[5]	All Modules		-	-	3.1	V

Note 1 - Constant Current Limit into Hiccup. Auto-Recovery.
Note 2 - Auto-Recovery, Measured over 5 hiccup cycles.
Note 3 - Voltage Foldback into Hiccup, Auto-Recovery.
Note 4 - Hiccup, Auto-Recovery.
Note 5 - Hiccup, Auto-Recovery.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

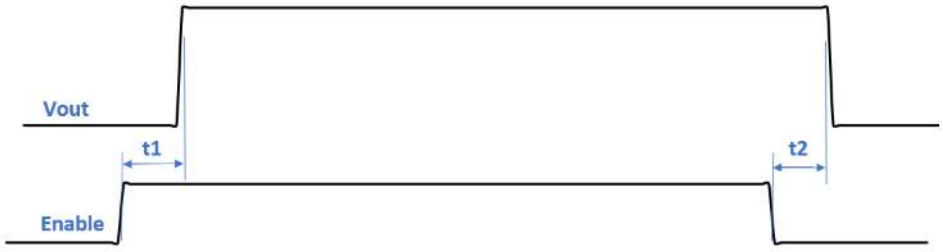
Start-Up / Shut-Down - CmA, CmB, CmC, CmD



Parameter	Module	Symbol	Min	Typ	Max	Unit
Turn-On Delay[1]	All Modules	t1	-	-	2000	mS
Turn-Off Delay[2]	All Modules	t2	16	-	-	mS

Note 1 - Time from application of Input AC to Output Voltage Regulation (t1).
Note 2 - From Loss of AC to Loss of Output Voltage Regulation - Nominal Voltage (t2).

Enable / Disable - CmA, CmB, CmC, CmD

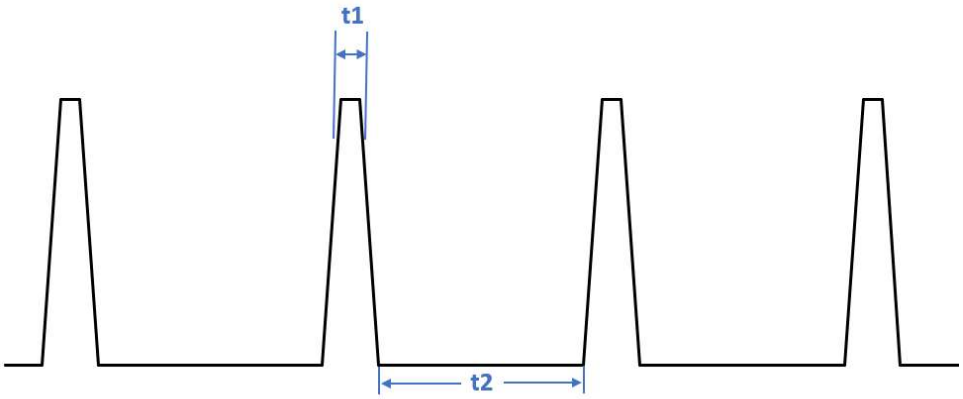


Parameter	Module	Symbol	Min	Typ	Max	Unit
Enable Delay[1]	All Modules	t1	-	-	12	mS
Rise Time[2]	All Modules		1	-	5	mS
Disable Delay[3]	All Modules	t2	-	-	5	mS
Fall Time[4]	All Modules		0.1	-	3	mS

Note 1 - Time from application of Enable signal to output voltage regulation (t1).
Note 2 - Measured from 10 - 90% of Vout.
Note 3 - Time from application of Disable signal to loss of output voltage regulation (t2).
Note 4 - Fully Loaded measured from 90% - 10% of Vout.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Hiccup Characteristics - CmA, CmB, CmC, CmD

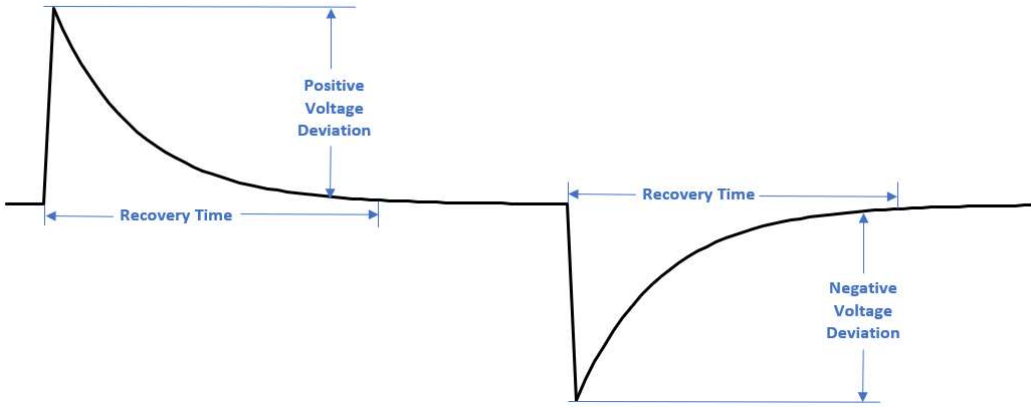


Parameter	Module	Symbol	Min	Typ	Max	Unit
Hiccup On-Time[1]	All Modules	t1	1	-	100	mS
Hiccup Off-Time[2]	All Modules	t2	900	-	1200	mS
Short Circuit Hiccup Level[3]	CmA CmB CmC CmD	$V_{O,short}$	1.0 3.5 7.2 14.3	- - - -	2.0 5.7 9.6 19.8	V

Note 1 - Length of time output is on during hiccup (t1).
Note 2 - Length of time output is off during hiccup (t2).
Note 3 - Output voltage at which module enters hiccup protection.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Transient Response - CmA, CmB, CmC, CmD



Parameter	Module	Symbol	Min	Typ	Max	Unit
Transient Response, Voltage Deviation[1]	CmA CmB CmC CmD	V_O	- - - -	- - - -	0.3 0.48 0.96 0.96	V
Transient Response, Recovery Time[1]	All Modules		-	-	500	uS
Transient Response, Voltage Deviation[2]	CmA CmB CmC CmD	V_O	- - - -	- - - -	0.6 1.2 1.8 2.4	V
Transient Response, Recovery Time[2]	All Modules		-	-	1000	uS

Note 1 - Measured during 25 - 75% and 75 - 25% step load changes.
Note 2 - Measured during 10 - 100% and 100 - 10% step load changes.

Galvanic Isolation - CmA, CmB, CmC, CmD

Parameter	Module	Min	Typ	Max	Unit
Input to Output 2 x MOPP	All Modules	4000	-	-	Vac
Output to Output 1 x MOPP	All Modules	1850	-	-	Vac

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

PMBus™ Communications - CmA, CmB, CmC, CmD

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

Command	Description			
READ_VOUT (0x8B)	The READ_VOUT command is used to return the output voltage measurement of the selected (or paged) module.	Module	Accuracy[1]	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[2]	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^{O}C, while its resolution is 1^{O}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)	Enables or disables the output of the selected (paged) module. When read, this command returns the last OPERATION command sent to the FC25M unit.			
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	

Note 1 - With Respect to Nominal.
Note 2 - With Respect to Maximum.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

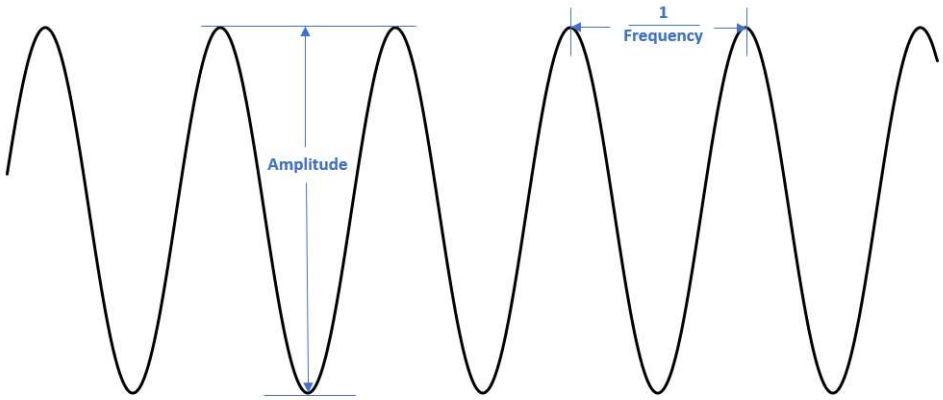
3.4 Dual Modules (CmG-CmH) Output Specifications

Parameter	Module	Symbol	Min	Typ	Max	Unit
Output Voltage	CmG (V1,V2) CmH (V1) CmH (V2)	V_O	3 3 3	24 5 24	30 6 30	Vdc
Factory Setting Accuracy	All Modules	$V_{O,factory}$	-	-	40	mV
Output Current	CmG (V1,V2) CmH (V1) CmH (V2)	$I_{O,max}$	- - -	- - -	3 6 3	A
Output Power per Channel[1]	CmG (V1,V2) CmH (V1) CmH (V2)	$P_{O,max}$	- - -	- - -	90 36 90	W
Total Output Power[1]	CmG CmH	$P_{O,max}$	- -	- -	120 100	W
Capacitive Loading[2]	CmG (V1,V2) CmH (V1) CmH (V2)	$C_{O,max}$	- - -	- - -	6600 13200 6600	uF

Note 1 - Maximum output power to be derated when FC25M is used in ambient temperatures greater than 40^{O}C.
Note 2 - Maximum capacitive load of the module to ensure monotonic startup (with no additional load applied).

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Ripple and Noise - CmG, CmH



Parameter	Module	Symbol	Min	Typ	Max	Unit
Output Ripple[1]	CmG (V1,V2) CmH (V1) CmH (V2)	$V_{O,ripple}$	- - -	- - -	240 100 240	mV
Output Ripple Frequency	All Modules	f	175	-	220	KHz

Note 1 - Amplitude of ripple measured at nominal voltage and at 20MHz Bandwidth.

Regulation - CmG, CmH

Parameter	Module	Symbol	Min	Typ	Max	Unit
Load Regulation 0 - 100% Load	CmG (V1,V2) CmH (V1) CmH (V2)	V_O	- - -	- - -	480 100 480	mV
Line Regulation 85 - 264 Vac	CmG (V1,V2) CmH (V1) CmH (V2)	V_O	- - -	- - -	120 25 120	mV
Temperature Regulation[1]	All Modules		-	-	0.02	% / ^{O}C

Note 1 - Over ambient temperature change.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

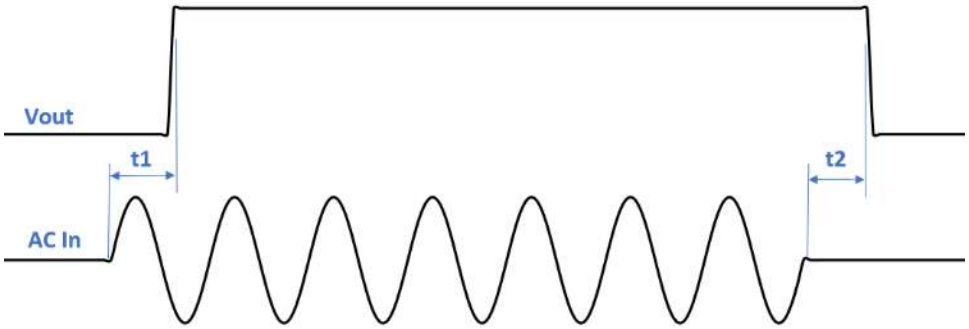
Protective Limits - CmG, CmH

Parameter	Module	Symbol	Min	Typ	Max	Unit
Current Limit[1]	CmG (V1,V2) CmH (V1) CmH (V2)	$I_{O,limit}$	5.5 10 5.5	- - -	10 15 10	A
Short-Circuit Current Limit[2]	CmG (V1,V2) CmH (V1) CmH (V2)	$I_{O,short}$	- - -	- - -	2.5 5.0 2.5	A
Overvoltage Protection[3]	CmG (V1,V2) CmH (V1) CmH (V2)	V_O	33 6.9 33	- - -	39 7.5 39	V

Note 1 - Hiccup, Auto-Recovery.
Note 2 - Measured over 5 hiccup cycles.
Note 3 - Shutdown, Auto-Recovery.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

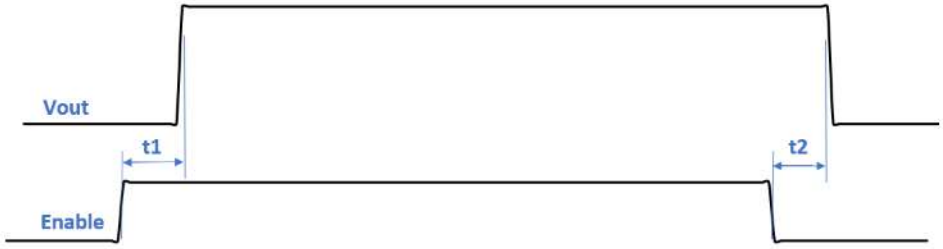
Start-Up / Shut-Down - CmG, CmH



Parameter	Module	Symbol	Min	Typ	Max	Unit
Turn-On Delay[1]	All Modules	t1	-	-	2000	mS
Turn-Off Delay[2]	All Modules	t2	16	-	-	mS

Note 1 - Time from Application of Input AC to Output Voltage Regulation (t1).
Note 2 - From Loss of AC to Loss of Output Voltage Regulation - Nominal Voltage (t2).

Enable / Disable - CmG, CmH

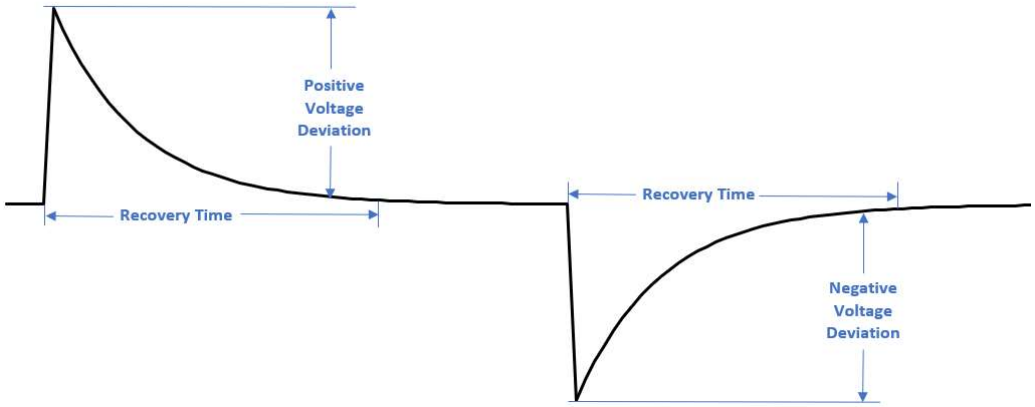


Parameter	Module	Symbol	Min	Typ	Max	Unit
Enable Delay[1]	All Modules	t1	-	-	100	mS
Rise Time[2]	All Modules		8	-	20	mS
Disable Delay[3]	All Modules	t2	0.1	-	8	mS
Fall Time[4]	All Modules		0.05	-	1.3	mS

Note 1 - Time from application of Enable signal to output voltage regulation (t1).
Note 2 - Measured from 10 - 90% of Vout.
Note 3 - Time from application of Disable signal to loss of output voltage regulation (t2).
Note 4 - Fully Loaded measured from 90% - 10% of Vout.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Transient Response - CmG, CmH



Parameter	Module	Symbol	Min	Typ	Max	Unit
Transient Response, Voltage Deviation[1]	CmG (V1,V2) CmH (V1) CmH (V2)	V_O	- - -	- - -	960 500 960	mV
Transient Response, Recovery Time[1]	All Modules		-	-	1000	uS

Note 1 - Measured during 25% - 75% and 75% - 25% Step Load Changes.

Galvanic Isolation - CmG, CmH

Parameter	Module	Min	Typ	Max	Unit
Input to Output 2 x MOPP	All Modules	4000	-	-	Vac
Output to Output of Another Module 1 x MOPP	All Modules	1850	-	-	Vac
Output to Output of the Same Module	All Modules	500	-	-	Vac

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

PMBus™ Communications - CmG, CmH

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

Command	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 both outputs of the Dual 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).

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

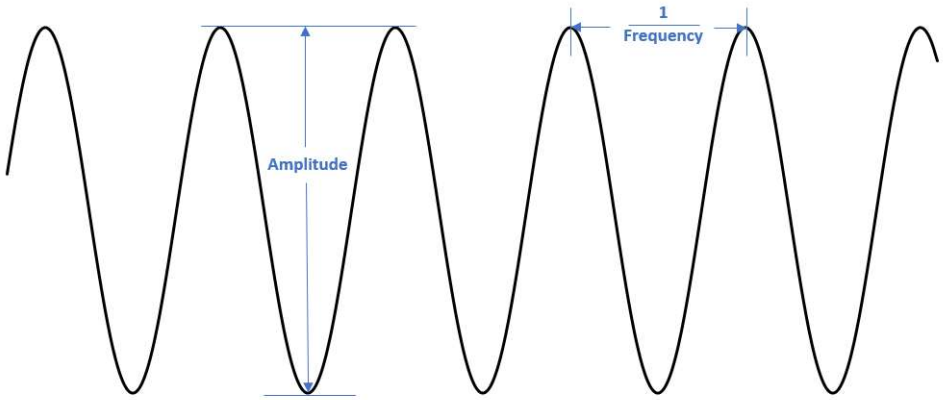
3.5 Wide Trim Modules (CmA-W01 to CmD-W01) Output Specifications

Parameter	Module	Symbol	Min	Typ	Max	Unit
Output Voltage	CmA - W01 CmB - W01 CmC - W01 CmD - W01	V_O	1 1 2 3	5 12 24 48	6 15[1] 28 58	Vdc
Factory Setting Accuracy	CmA - W01 CmB - W01 CmC - W01 CmD - W01	$V_{O,factory}$	- - - -	- - - -	20 30 40 100	mV
Output Current[2]	CmA - W01 CmB - W01 CmC - W01 CmD - W01	$I_{O,max}$	- - - -	- - - -	21 15 8.33 4.17	A
Output Power[3]	CmA - W01 CmB - W01 CmC - W01 CmD - W01	$P_{O,max}$	- - - -	- - - -	105 180 200 200	W
Capacitive Loading[4]	CmA - W01 CmB - W01 CmC - W01 CmD - W01	$C_{O,max}$	- - - -	- - - -	20000 10000 8000 4700	uF

Note 1 - Full Dynamic Specifications of the CmB-W01 module may not be met at full load when the CmB-W01 module is trimmed above 13V in the FC25M.
Note 2 - Maximum output current to be derated by 10% when used in parallel.
Note 3 - Maximum output power to be derated when FC25M is used in ambient temperatures greater 40^{O}C.
Note 4 - Maximum capacitive load of the module to ensure monotonic startup (with no additional load applied). Higher capacitive loading is possible if non-monotonic startup is acceptable. Contact technical support for further details.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Ripple and Noise - CmA-W01, CmB-W01, CmC-W01, CmD-W01



Parameter	Module	Symbol	Min	Typ	Max	Unit
Output Ripple[1]	CmA - W01 CmB - W01 CmC - W01 CmD - W01	$V_{O,ripple}$	- - - -	- - - -	100 150 240 480	mV
Output Ripple Frequency	All Modules	f	220	-	260	KHz

Note 1 - Amplitude of ripple measured at nominal voltage and at 20MHz Bandwidth.

Regulation - CmA-W01, CmB-W01, CmC-W01, CmD-W01

Parameter	Module	Symbol	Min	Typ	Max	Unit
Load Regulation 0 - 100% Load	CmA - W01 CmB - W01 CmC - W01 CmD - W01	V_O	- - - -	- - - -	20 48 96 192	mV
Load Regulation - Paralleled 0 - 100% Load	CmA - W01 CmB - W01 CmC - W01 CmD - W01	V_O	48 155 400 638	- - - -	90 231 558 959	mV
Line Regulation 85 - 264 Vac	CmA - W01 CmB - W01 CmC - W01 CmD - W01	V_O	- - - -	- - - -	12.5 30 60 120	mV
Temperature Regulation[1]	All Modules		-	-	0.02	% / ^{O}C

Note 1 - Over ambient temperature change.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

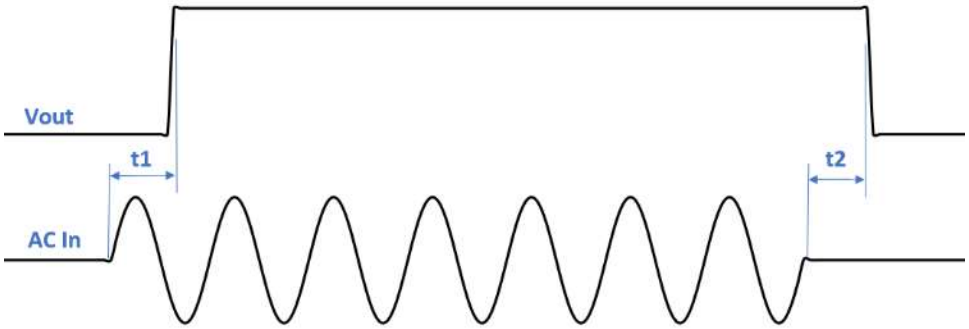
Protective Limits - CmA-W01, CmB-W01, CmC-W01, CmD-W01

Parameter	Module	Symbol	Min	Typ	Max	Unit
Current Limit[1]	CmA - W01 CmB - W01 CmC - W01 CmD - W01	$I_{O,limit}$	22 15.7 8.7 4.3	- - - -	27.3 19.5 10.8 5.4	A
Short-Circuit Current Limit[2]	CmA - W01 CmB - W01 CmC - W01 CmD - W01	$I_{O,short}$	- - - -	- - - -	15.75 11.25 6.25 3.12	A
Power Limit[3]	CmA - W01 CmB - W01 CmC - W01 CmD - W01	P_O	110 190 210 210	- - - -	137 234 260 260	W
Overvoltage Protection[4]	CmA - W01 CmB - W01 CmC - W01 CmD - W01	V_O	6.7 17 32 62	- - - -	9.6 21 37 69.6	V
Sense Lead Protection[5]	All Modules		-	-	3.1	V

Note 1 - Constant Limit into Hiccup, Auto-Recovery.
Note 2 - Measured over 5 hiccup cycles.
Note 3 - Voltage Foldback into Hiccup, Auto-Recovery.
Note 4 - Shutdown (All outputs), Auto-Recovery.
Note 5 - Shutdown, Auto-Recovery.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

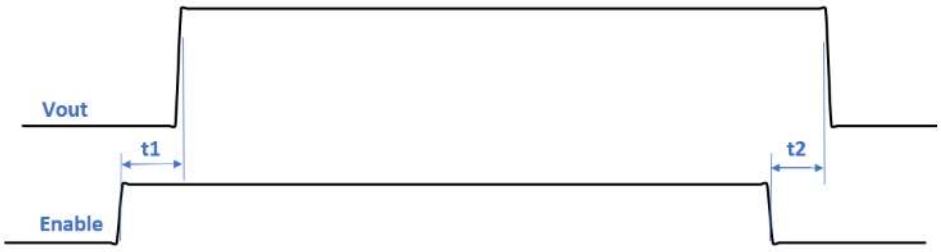
Start-Up / Shut-Down - CmA-W01, CmB-W01, CmC-W01, CmD-W01



Parameter	Module	Symbol	Min	Typ	Max	Unit
Turn-On Delay[1]	All Modules	t1	-	-	2000	mS
Turn-Off Delay[2]	All Modules	t2	16	-	-	mS

Note 1 - Time from Application of Input AC to Output Voltage Regulation (t1).
Note 2 - From Loss of AC to Loss of Output Voltage Regulation - Nominal Voltage (t2).

Enable / Disable - CmA-W01, CmB-W01, CmC-W01, CmD-W01

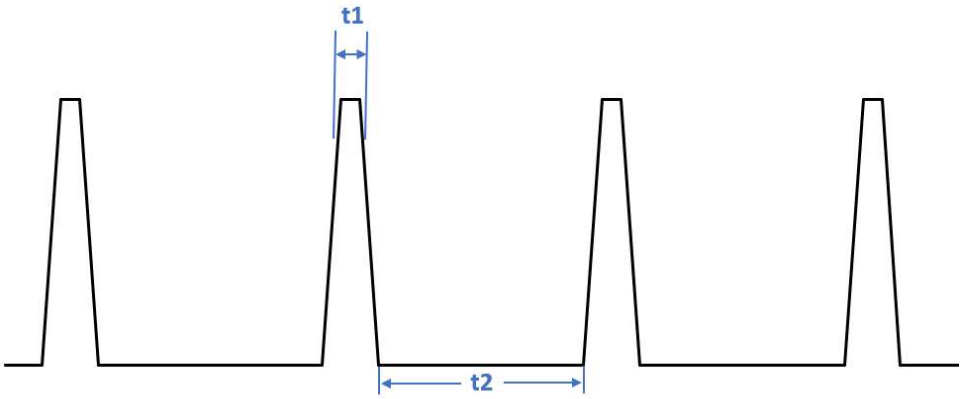


Parameter	Module	Symbol	Min	Typ	Max	Unit
Enable Delay[1]	All Modules	t1	-	-	15	mS
Rise Time[2]	All Modules		1	-	5	mS
Disable Delay[3]	All Modules	t2	-	-	8	mS
Fall Time[4]	All Modules		0.01	-	3	mS

Note 1 - Time from application of Enable signal to output voltage regulation (t1).
Note 2 - Measured from 10 - 90% of Vout.
Note 3 - Time from application of Disable signal to loss of output voltage regulation (t2).
Note 4 - Fully Loaded measured from 90% - 10% of Vout.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Hiccup Characteristics - CmA-W01, CmB-W01, CmC-W01, CmD-W01

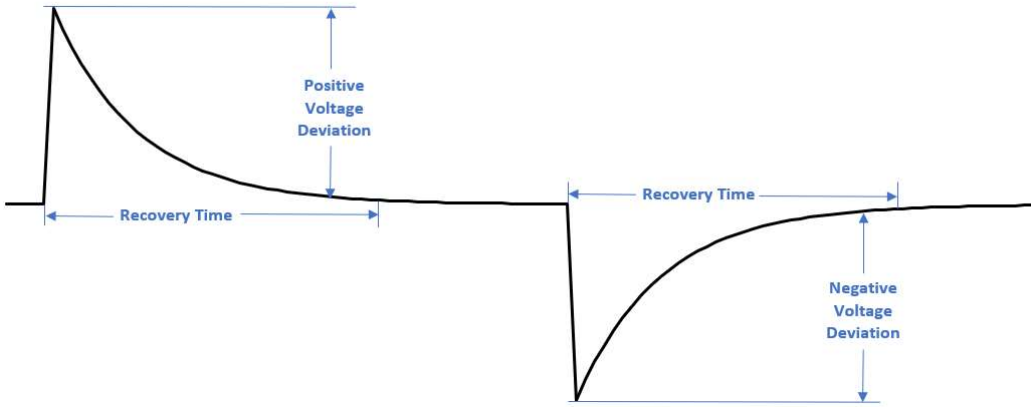


Parameter	Module	Symbol	Min	Typ	Max	Unit
Hiccup On-Time[1]	All Modules	t1	1	-	200	mS
Hiccup Off-Time[2]	All Modules	t2	900	-	1200	mS
Short Circuit Hiccup Level[3]	CmA - W01 CmB - W01 CmC - W01 CmD - W01	V_O	0.4 0.4 0.5 1.1	- - - -	0.9 0.9 1.8 2.5	V

Note 1 - Length of time output is on during hiccup (t1).
Note 2 - Length of time output is off during hiccup (t2).
Note 3 - Output voltage at which module enters hiccup protection.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Transient Response - CmA-W01, CmB-W01, CmC-W01, CmD-W01



Parameter	Module	Symbol	Min	Typ	Max	Unit
Transient Response, Voltage Deviation[1]	CmA - W01 CmB - W01 CmC - W01 CmD - W01	V_O	- - - -	- - - -	0.3 0.48 0.96 0.96	V
Transient Response, Recovery Time[1]	All Modules		-	-	500	uS
Transient Response, Voltage Deviation[2]	CmA - W01 CmB - W01 CmC - W01 CmD - W01	V_O	- - - -	- - - -	0.6 1.2 1.8 2.4	V
Transient Response, Recovery Time[2]	All Modules				1000	uS

Note 1 - Measured during 25% - 75% and 75% - 25% Step Load Changes.
Note 2 - Measured during 10% - 100% and 100 - 10% Step Load Changes.

Galvanic Isolation - CmA-W01, CmB-W01, CmC-W01, CmD-W01

Parameter	Module	Min	Typ	Max	Unit
Input to Output 2 x MOPP	All Modules	4000	-	-	Vac
Output to Output 1 x MOPP	All Modules	1850	-	-	Vac

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

PMBus™ Communications - CmA-W01, CmB-W01, CmC-W01, CmD-W01

Wide Trim modules can be monitored and controlled with the following PMBus Commands (for further details see the PMBUS Manual available for download from the Advanced Energy website.

<table>
<tr><th>Command</th><th>Description</th><th colspan="3"></th></tr>
<tr><td rowspan="5">READ_VOUT (0x8B)</td><td rowspan="5">The READ_VOUT command is used to return the output voltage measurement of the selected (or paged) module.</td><td>Module</td><td>Accuracy[1]</td><td>Resolution</td></tr>
<tr><td>CmA-W01</td><td>+/- 4%</td><td>6.6 mV</td></tr>
<tr><td>CmB-W01</td><td>+/- 4%</td><td>16.5 mV</td></tr>
<tr><td>CmC-W01</td><td>+/- 4%</td><td>44.3 mV</td></tr>
<tr><td>CmD-W01</td><td>+/- 4%</td><td>82.4 mV</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[2]</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^{O}C, while its resolution is 1^{O}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">Enables or disables the output of the selected (paged) module. When read, this command returns the last OPERATION command sent to the FC25M unit.</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">The MODULE_ID command is used to return a code representing the model type of the selected (or paged) CoolMod.</td><td colspan="2">Module</td><td>ID Code</td></tr>
<tr><td colspan="2">CmA-W01</td><td>0x22</td></tr>
<tr><td colspan="2">CmB-W01</td><td>0x42</td></tr>
<tr><td colspan="2">CmC-W01</td><td>0x62</td></tr>
<tr><td colspan="2">CmD-W01</td><td>0x82</td></tr>
</table>

Note 1 - With Respect to Nominal.
Note 2 - With Respect to Maximum.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

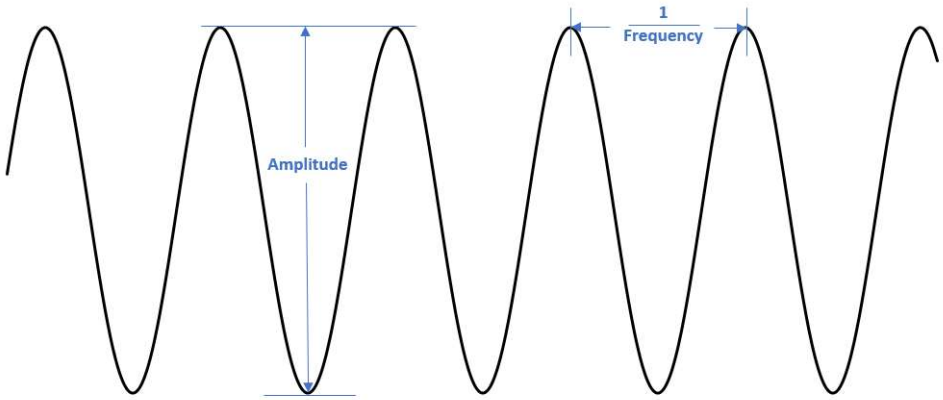
3.6 High Voltage Modules (CmK) Output Specifications

Parameter	Module	Symbol	Min	Typ	Max	Unit
Output Voltage	CmK	V_O	175	200	205	Vdc
Factory Setting Accuracy	CmK	$V_{O,factory}$	-	-	40	mV
Output Current[1]	CmK	$I_{O,max}$	-	-	0.66	A
Output Power[2]	CmK	$P_{O,max}$	-	-	132	W
Capacitive Loading[3]	CmK	$C_{O,max}$	-	-	100	uF

Note 1 - Maximum output current to be derated by 10% when used in parallel.
Note 2 - Maximum output power to be derated when FC25M is used in ambient temperatures greater than 40^{O}C.
Note 3 - Maximum capacitive load of the module to ensure monotonic startup (with no additional load applied). Higher capacitive loading is possible if non-monotonic startup is acceptable. Contact technical support for further detail.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Ripple and Noise - CmK



Parameter	Module	Symbol	Min	Typ	Max	Unit
Output Ripple[1]	CmK	$V_{O,ripple}$	-	-	2000	mV
Output Ripple Frequency[2]	CmK	f	220	-	260	KHz

Note 1 - Amplitude of ripple measured at nominal voltage and at 20MHz Bandwidth.

Regulation - CmK

Parameter	Module	Symbol	Min	Typ	Max	Unit
Load Regulation	CmK	V_O	-	-	2000	mV
Load Regulation Paralleled[1]	CmK	V_O	-	-	4000	mV
Line Regulation	CmK	V_O	-	-	1000	mV
Temperature Regulation[2]	CmK	V_O	-	-	0.02	% / ^{O}C

Note 1 - Load Regulation is softened in parallel mode to improve current share.
Note 2 - Over ambient temperature change.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

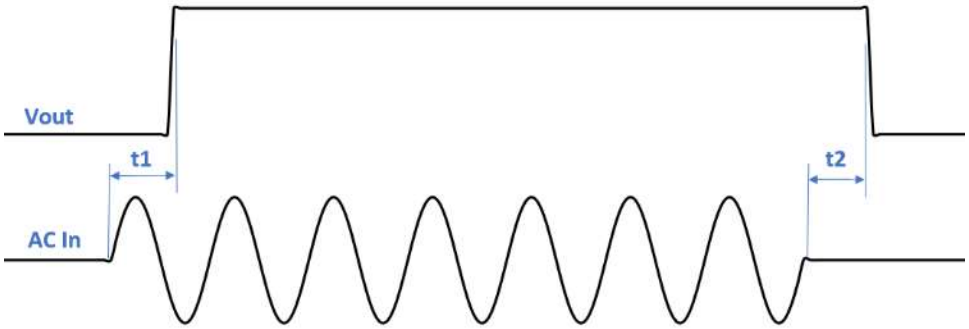
Protective Limits - CmK

Parameter	Module	Symbol	Min	Typ	Max	Unit
Current Limit[1]	CmK	$I_{O,limit}$	0.69	-	0.86	A
Short-Circuit Current Limit[2]	CmK	$I_{O,short}$	-	-	1	A
Power Limit[3]	CmK	$P_{O,limit}$	138	-	175	W
Overvoltage Protection[4]	CmK	V_O	230	-	250	V

Note 1 - Constant Current Limit into Hiccup. Auto-Recovery.
Note 2 - Auto-Recovery. Measured over 5 hiccup cycles.
Note 3 - Voltage Foldback into Hiccup. Auto-Recovery.
Note 4 - Shutdown (All outputs). Auto-Recovery.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

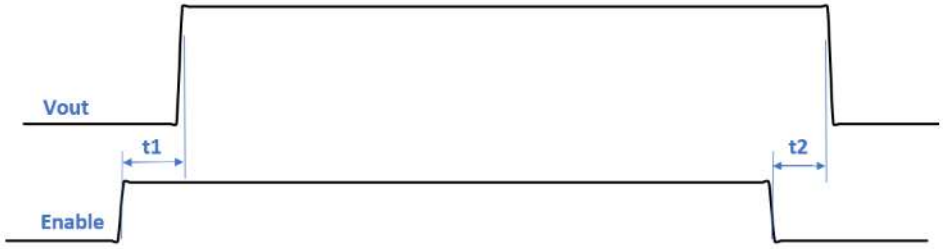
Start-Up / Shut-Down - CmK



Parameter	Module	Symbol	Min	Typ	Max	Unit
Turn-On Delay[1]	CmK	t1	-	-	2000	mS
Turn-Off Delay[2]	CmK	t2	16	-	-	mS

Note 1 - Time from Application of Input AC to Output Voltage Regulation (t1).
Note 2 - From Loss of AC to Loss of Output Voltage Regulation - Nominal Voltage (t2).

Enable / Disable - CmK

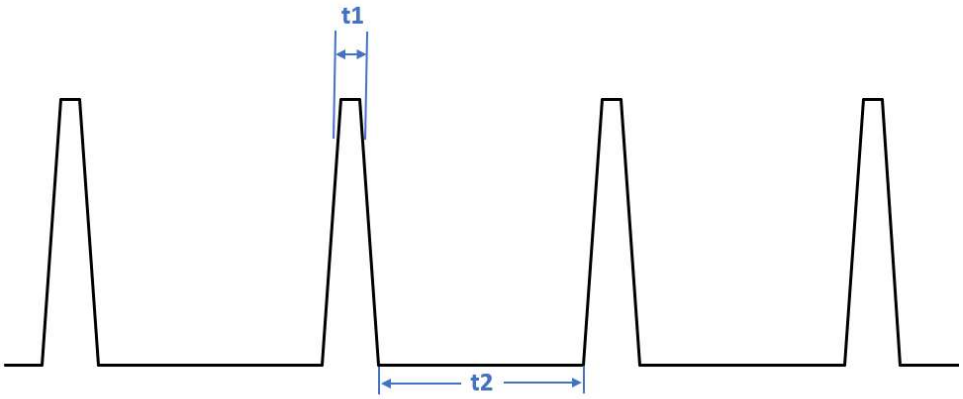


Parameter	Module	Symbol	Min	Typ	Max	Unit
Enable Delay[1]	CmK	t1	-	-	30	mS
Rise Time[2]	CmK		4	-	20	mS
Disable Delay[3]	CmK	t2		-	30	mS
Fall Time[4]	CmK		0.01	-	3	mS

Note 1 - Time from application of Enable signal to output voltage regulation (t1).
Note 2 - Measured from 10 - 90% of Vout.
Note 3 - Time from application of Disable signal to loss of output voltage regulation (t2).
Note 4 - Fully Loaded measured from 90% - 10% of Vout.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Hiccup Characteristics - CmK

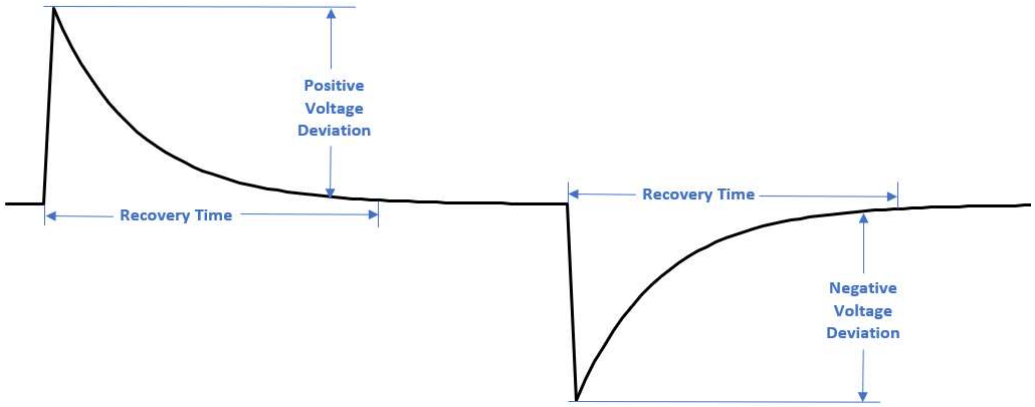


Parameter	Module	Symbol	Min	Typ	Max	Unit
Hiccup On-Time[1]	CmK	t1	1	-	100	mS
Hiccup Off-Time[2]	CmK	t2	900	-	1200	mS
Short Circuit Hiccup Level[3]	CmK	$V_{O,Short}$	37	-	53	V

Note 1 - Length of time output is on during hiccup (t1).
Note 2 - Length of time output is off during hiccup (t2).
Note 3 - Output voltage at which module enters hiccup protection.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Transient Response - CmK



Parameter	Module	Symbol	Min	Typ	Max	Unit
Transient Response, Voltage Deviation[1]	CmK	V_O	-	-	7.5	V
Transient Response, Recovery Time[1]	CmK		-	-	1000	uS
Transient Response, Voltage Deviation[2]	CmK	V_O	-	-	7.5	V
Transient Response, Recovery Time[2]	CmK		-	-	500	uS

Note 1 - Measured during 25% - 75% and 75% - 25% Step Load Changes.
Note 2 - Measured during 10% - 100% and 100% - 10% Step Load Changes.

Galvanic Isolation - CmK

Parameter	Module	Min	Typ	Max	Unit
Input to Output 2 x MOPP	CmK	4000	-	-	Vac
Output to Output 1 x MOPP	CmK	1850	-	-	Vac

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

PMBus™ Communications - CmK

High Voltage modules can be monitored and controlled with the following PMBus Commands (for further details see the PMBus™ Manual available for download from the Advanced Energy website.

Command	Description			
READ_VOUT (0x8B)	The READ_VOUT command is used to return the output voltage measurement of the selected (or paged) module.	Module	Accuracy[1]	Resolution
		CmK	+/- 4%	280 mV
READ_IOUT (0x8C)	The READ_IOUT command is used to return the output current measurement of the selected (or paged) module.	Module	Accuracy[2]	Resolution
		CmK	+/- 4%	2 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^{O}C, while its resolution is 1^{O}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)	Enables or disables the output of the selected (paged) module. When read, this command returns the last OPERATION command sent to the FC25M unit.			
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.			
ILIMIT_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	
		CmK	0xA0	

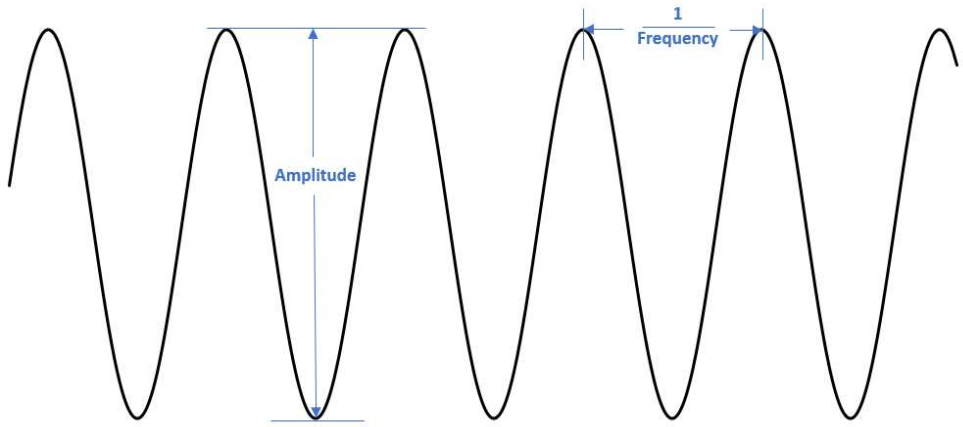
Note 1 - With Respect to Nominal.
Note 2 - With Respect to Maximum.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

3.7 Auxiliary Output Specifications

Parameter	Output	Symbol	Min	Typ	Max	Unit
Output Voltage	Output A Output B	V_{AUX}	14.70 4.80	15.00 5.00	15.30 5.20	Vdc
Output Current	Output A Output B	$I_{AUX,max}$	- -	- -	0.2 0.6	A
Output Power	Output A Output B	$P_{AUX,max}$	- -	- -	3.0 3.0	W
Capacitive Loading	Output A Output B	$C_{AUX,max}$	- -	- -	100 1000	uF

Ripple and Noise - Auxiliary Output



Parameter	Output	Symbol	Min	Typ	Max	Unit
Output Ripple[1]	Output A Output B	$V_{AUX,ripple}$	- -	- -	150 200	mV mV

Note 1 - Amplitude of ripple measured at nominal voltage and at 20MHz Bandwidth.

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

Regulation - Auxiliary Output

Parameter	Output	Symbol	Min	Typ	Max	Unit
Load Regulation 0-100% Load	Output A Output B	V_{AUX}	- -	- -	300 100	mV
Line Regulation 85-264 Vac	Output A Output B	V_{AUX}	- -	- -	75 25	mV

Protective Limits - Auxiliary Output

Parameter	Output	Symbol	Min	Typ	Max	Unit
Current Limit[1]	Output A Output B	$I_{AUX,limit}$	0.21 0.63	- -	0.26 0.84	A
Power Limit[2]	Output A Output B	P_{AUX}	3.15 3.15	- -	3.9 4.2	W

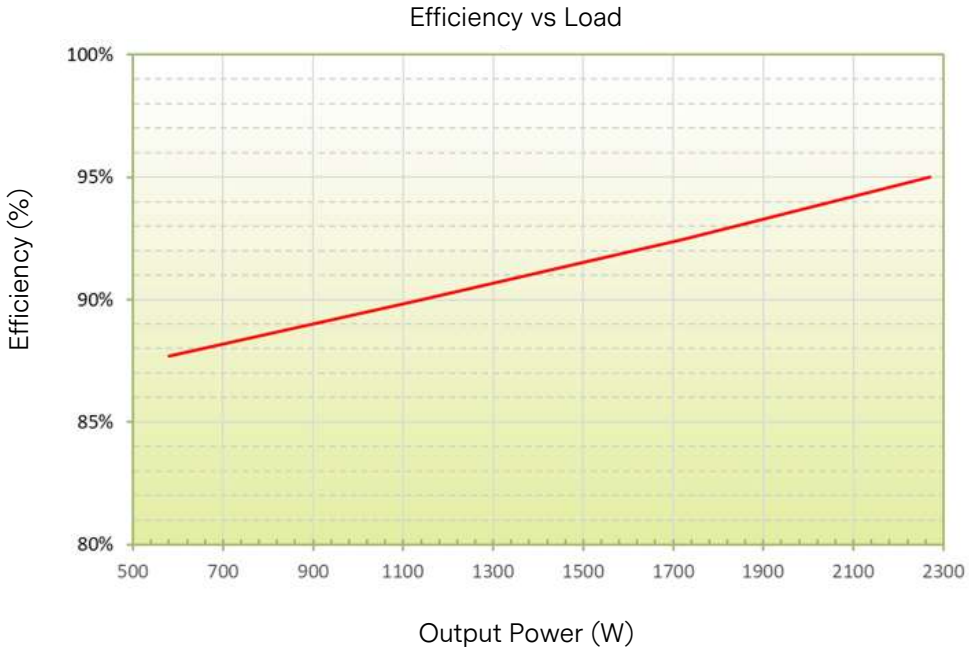
Note 1 - Hiccup, Auto-Recovery.
Note 2 - Hiccup, Auto-Recovery.

Galvanic Isolation - Auxiliary Output

Parameter	Output	Min	Typ	Max	Unit
Input to Output 1 x MOPP 2 x MOPP	 Output A Output B	 1500 4000	 - -	 - -	Vac

SECTION 3 ELECTRICAL SPECIFICATIONS CON'T

3.8 Efficiency Curve



Test conditions: 230 Vin

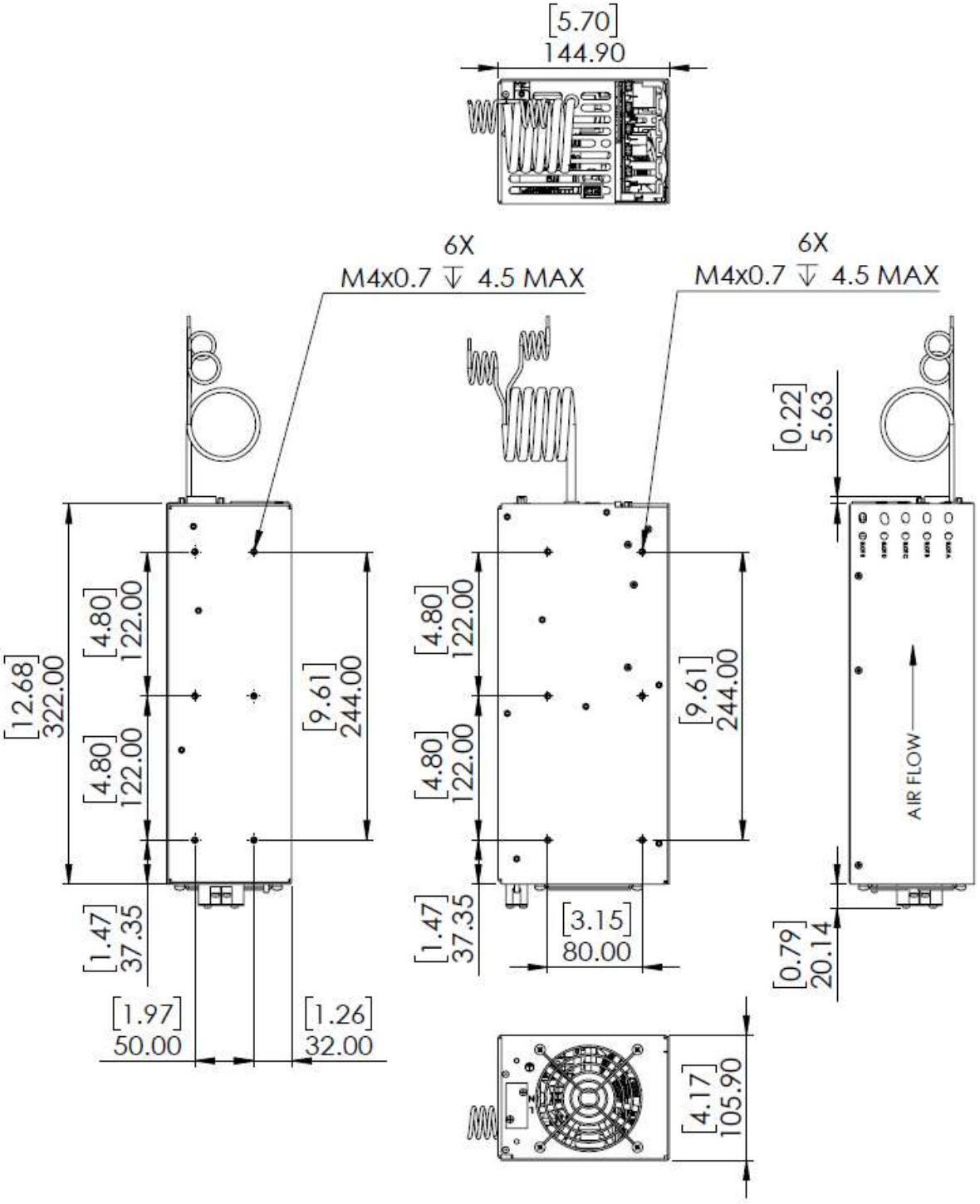
Load split between modules (35%) and capacitor charger (65%)

Capacitor charger operating at 400 V steady state

SECTION 4 MECHANICAL SPECIFICATIONS

4.1 Mechanical Information

The FC25M mechanical outline is shown below.

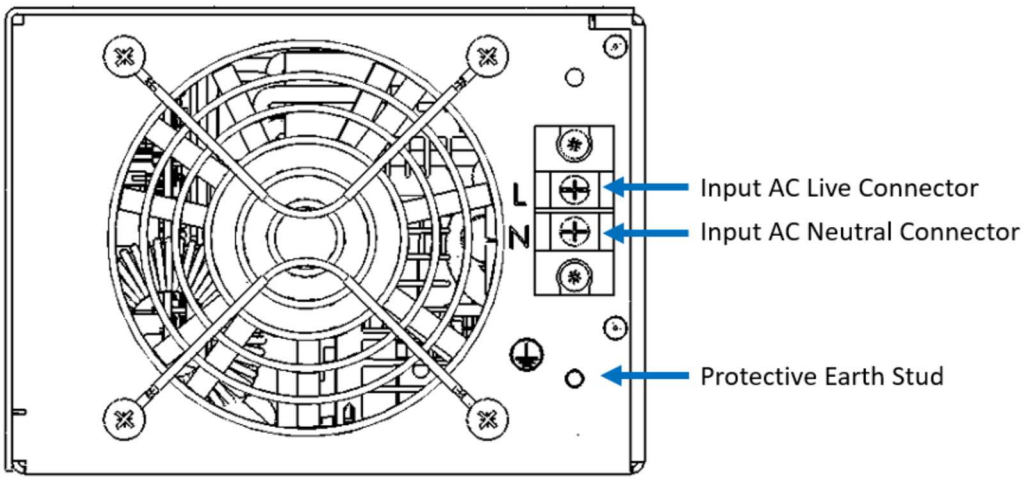


SECTION 4 MECHANICAL SPECIFICATIONS CON'T

4.2 Connectors Definition and Mating Connector

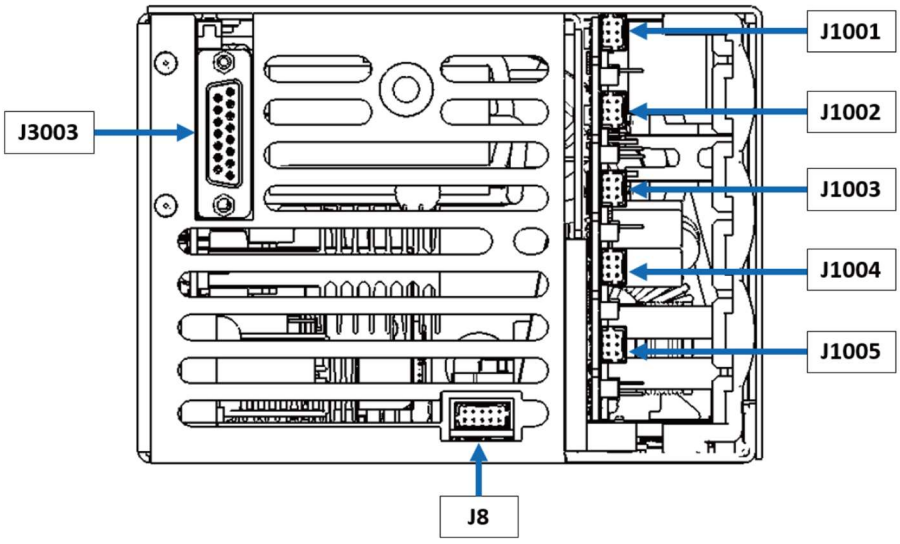
Input Connectors

AC mains is applied to the FC25M via the 2 Screw Terminal connector, with a Protective Earth Stud located on the chassis.



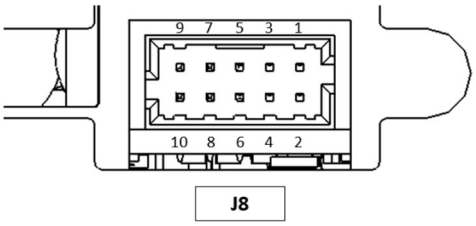
Connectors	Description
AC/DC Input Terminal Block	DINKLE 0168-1502

Signal Connectors



SECTION 4 MECHANICAL SPECIFICATIONS CON'T

Global Signal Connector

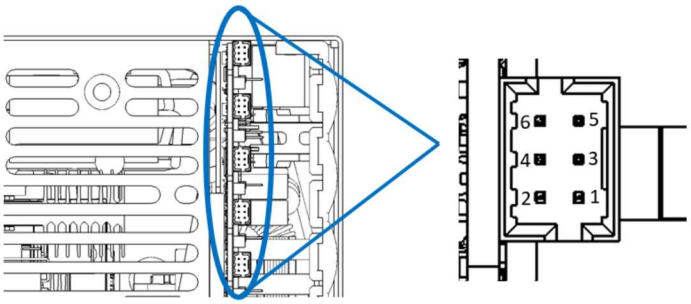


J8 Connector		
Pin	Name	Function
1	Common	Common ground
2	SCL	Communications port
3	LV Global EN	External global enable and disable of modules
4	SDA	Communications port
5	LV Global PG	Power Good signal for all modules
6	LV AC Fail	Primary fault status in which the modules must turn off
7	LV OTP	Warning that shutdown may occur due to over temperature
8	HV AC Fail	Primary fault status in which the cap charger output must turn off
9	Fan Fail	Primary fault status in which the fan fault has occurred must turn off
10	+5V Aux	5V, 3W Auxiliary output_B

Reference	On Power Supply	Mating Connector or Equivalent
J8 System Signal Connector	10-way Molex: 87833-1031	Locking: Molex 51110-1060 Non-Locking: Molex 51110-1050 Locking and Polarizing: Molex 51110-1056 Crimp Terminal: Molex 50394

SECTION 4 MECHANICAL SPECIFICATIONS CON'T

Module Signal Connector



Connector J100m which controls slot n	
Connector	Slot
J1001	A
J1002	B
J1003	C
J1004	D
J1005	E

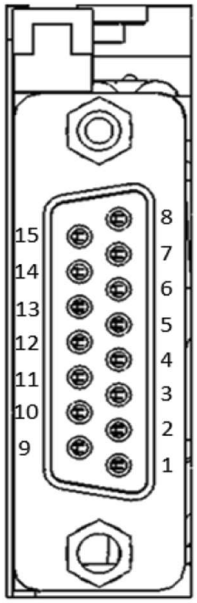
Note: 'm' indicates 1,2,3,4,5;
'n' indicates A,B,C,D,E

Connector J100m which controls slot n		
Pin	Name	Function
1	Common	Common ground
2	PG	Power Good signal for module
3	Common	Common ground
4	EN	External global enable and disable module
5	Itrim	Connect voltage source to control level of current limit of module
6	Vtrim	Connect voltage source to control the output voltage level

Reference	On Power Supply	Mating Connector or Equivalent
J1001 – J1005	6-way Molex: 87833-0631	Locking: Molex 51110-0660 Non-Locking: Molex 51110-0650 Locking and Polarizing: Molex 51110-0650 Crimp Terminal: Molex 50394

SECTION 4 MECHANICAL SPECIFICATIONS CON'T

Capacitor Charger Signal Connector



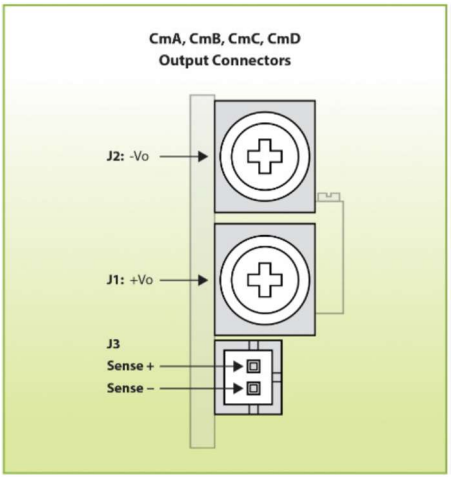
J3003

J3003 Connector		
Pin	Name	Function
1	Inhibit	Inhibit
2	Ptrim	Power limit adjustment
3	HV OTP	High voltage over temperature warning
4	Imonitor	Output current sense signal
5	Vprogram	Output voltage setting
6	HV Fault	High voltage output fault detect
7	VPeakHold	Output voltage peak level
8	Vmonitor	Output voltage sense
9	+15V Aux	15V, 3W Auxiliary output_A
10	Not used	
11	+15V Aux	15V, 3W Auxiliary output_A
12	Not used	
13	End of Charge	End-of-Charge indicator
14	Earth	Earth
15	Enable	Enable

SECTION 4 MECHANICAL SPECIFICATIONS CON'T

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

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

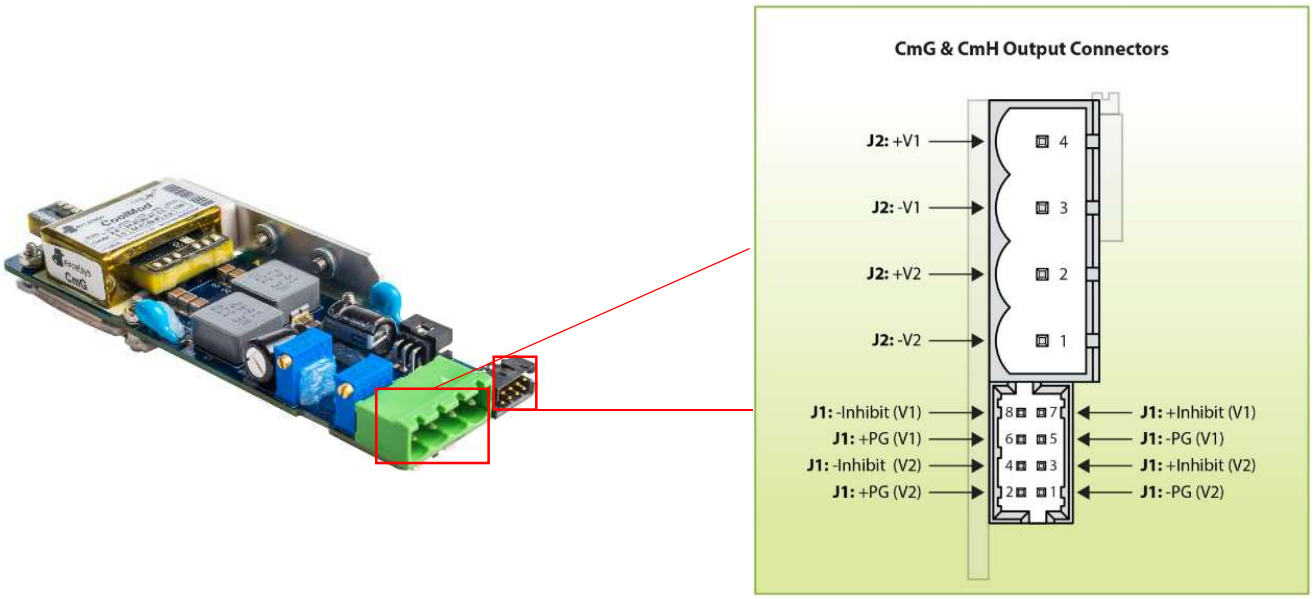


Reference	On Power Supply	Mating Connector or Equivalent
J1 & J2 Output Connectors	Terminals	M4 Screws
J3 Sense Connector	JST - S2BPH-K-S (LF) (SN)	JST PHR-2, Crimp: JST BPH-002T-P0.5S or SPH-002T-P0.5S

Output Power and Signal Connectors (CmG-H)

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

SECTION 4 MECHANICAL SPECIFICATIONS CON'T



Reference	On Power Supply	Mating Connector or Equivalent
J1 CmG/CmH Signal Connector	8-way Molex: 87833-0831	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	Camden: CTB9200/4A Wurth Elektronik: 691 352 710 004

Output Power and Signal Connectors (CmK)

The CmK module has Power Terminals (J1 and J2) but with no sense connector.

Mounting Options

Base Plate Mounting

The FC25M can be mounted in the system via the 6 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 4.5 mm. The recommended torque for the screws is 1.4 Nm.

Side Mounting

The FC25M can be mounted in the system via the 3 mounting holes on each side of the case. See mechanical drawings for mounting hole positions. Use M3 mounting screws and ensure that maximum screw penetration from base does not exceed 4.5 mm. The recommended torque for the screws is 1.4 Nm.

SECTION 5 ENVIRONMENTAL SPECIFICATIONS

5.1 Environmental Parameters

The FC25M 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 meters to +3000 meters from sea level
- Humidity: 5 to 90% non-condensing
- Operating temperature $0^{O}C$ to $40^{O}C$

In addition, FC25M is compliant with the following directives:

RoHS 3.0	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.advancedenergy.com. Alternatively, please do not hesitate to contact productsupport.ep@aei.com if you have any further questions or need additional information.

SECTION 5 ENVIRONMENTAL SPECIFICATIONS CON'T

5.2 EMC Characteristics

EMC Directive 2004 / 108 / EC

Component Power Supplies such as the FC25M 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 AE products compliance with several of the requirements as outlined in the following paragraphs. Although the FC25M meets these requirements, the CE mark does not cover this area.

The table below outlines the EMC characteristics of the FC25M power supply under load conditions.

A full EN60601-1-2 4th edition test report is available on request. Contact Advanced Energy for details.

Parameter	Conditions / Descriptions	Criteria
Radiated Emissions[1]	EN55011, EN55022 and FCC, Class A	Compliant
Conducted Emissions	EN55011, EN55022 and FCC, Class A	Compliant
Power Line Harmonics	EN61000-3-12, Class A	Compliant
Voltage Flicker	EN61000-3-11	Compliant
ESD	EN61000-4-2, Level 4, 8kV Contact, 15kV air	A
Radiated Immunity	EN61000-4-3, Level 3, 10V / m 80-2700 MHz	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, 10Vemf 150KHz - 80MHz	A
Power Frequency Magnetic Field	EN61000-4-8, Level 4, 30A / m	A
Voltage Dips & Interruptions	EN61000-4-11	A & B Compliant[2]

Note1: 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.
Note2: Criteria dependent on load and dip duration

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.

SECTION 5 ENVIRONMENTAL SPECIFICATIONS CON'T

Additional EMI Characterization

FC25M is compliant with SEMI F47 for voltage dips and interruptions. Input voltage must be >180Vac.

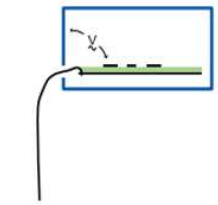
Guidelines for Optimal EMC Performance

FC25M is 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 in previous page. 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.

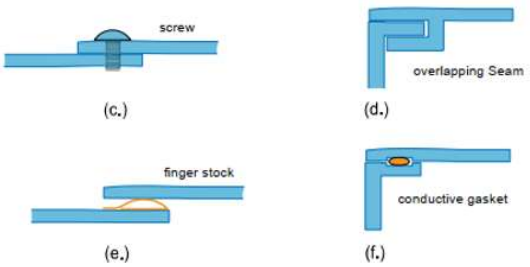
Cabling arrangements and PCB tracking layouts are the greatest contributing factors to system EMC performance. It is important that PCB tracks and power cables are arranged to minimise current carrying loops that can radiate, and to minimise loops that could have noise currents induced into them. All cables and PCB tracks should be treated as radiation sources and antenna and every effort should be made to minimise their interaction.

- Route all cables as close as possible to a well earthed sheet of metal.
- 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".

If the power supply is enclosed in a larger system enclosure, it is preferable to use a conductive metal enclosure and that all seams have a good conductive bond using one of these methods.



System enclosure

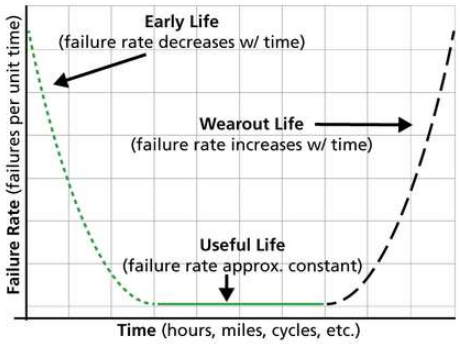


Treatment of Seams

SECTION 5 ENVIRONMENTAL SPECIFICATIONS CON'T

5.3 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, carries out a full burn-in on each unit, designed to ensure that all these early failures are detected at Advanced Energy. 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.

Coolmod (CmA-D)	0.11 FPMH
FC25M Pack + Capacitor Charger	1.11 FPMH
Example:	FC25M1000-ABCDD-P
FC25M1000	FPMH = 1.11
CmA, B, C, D	FPMH = 0.11 FPMH
Total FPMH	1.11 + (5 x 0.11) = 1.66 FPMH
MTBF	602,410 hours

SECTION 5 ENVIRONMENTAL SPECIFICATIONS CON'T

MTBF and Temperature

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

Conversely, however, for each 10^{O}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 Advanced Energy recommends that the maximum shelf life for our platform designs is two years.

SECTION 6 SAFETY APPROVALS / CERTIFICATION

6.1 Safety Approvals

Safety is of the utmost importance when operating a high voltage power supply and to that end the PSU is designed to meet the requirements of the Low Voltage Directive LVD, 2006 / 95 / EC, by complying with IEC 60601-1:2005+A1:2012 (E230761) (subject to the installation requirements of the standard).

Furthermore, all components and materials used meet or exceed the requirements of UL94-V0 for flammability.

A configured FC25M has the following galvanic isolation barriers

Isolation Barrier	Type	Withstand Voltage
Input to Case (earth) (B)	Basic (1 x MOPP)	1650Vac
Input to HV Output (C)	Basic (1 x MOOP)	4000Vac
Input to Digital I/O (E)	Reinforced (2 x MOPP)	4000Vac
Input to Modular Output (F)	Reinforced (2 x MOPP)	4000Vac
Modular Output to Digital I/O (G)	Basic (1 x MOPP)	1850Vac
Modular Output to Case (earth) (H)	Basic (1 x MOPP)	1850Vac
Digital I/O to Case (earth) (I)	Basic (1 x MOPP)	1850Vac

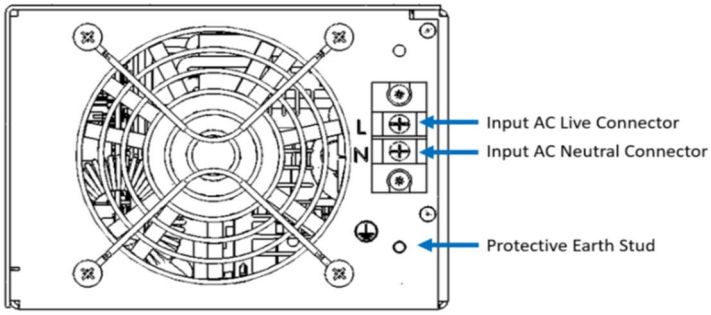
SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION

7.1 FC25M Operation

The FC25M Pack provides the front-end input power to the Capacitance Charging and Modular Outputs. The Pack operates of 85-264Vac, 47-63Hz and can withstand 300Vac input voltage for up to 5 secs.

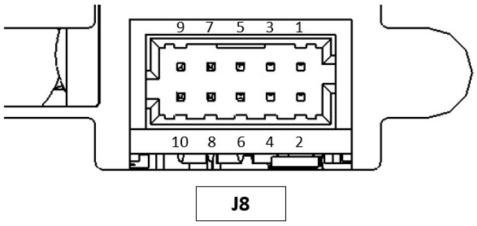
7.2 Input Power

AC Input Connector



7.3 System / Global Output / Signal

J8 - System Signal Connector



J8 Connector		
Pin	Name	Function
1	Common	Common ground
2	SCL	Communications port
3	LV Global EN	External global enable and disable of modules
4	SDA	Communications port
5	LV Global PG	Power Good signal for all modules
6	LV AC Fail	Primary fault status in which the modules must turn off
7	LV OTP	Warning that shutdown may occur due to over temperature
8	HV AC Fail	Primary fault status in which the cap charger output must turn off
9	Fan Fail	Primary fault status in which the fan fault has occurred must turn off
10	+5V Aux	5V, 3W Auxiliary output_B

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION

Common - (Pin 1 of J8)

Ground reference of the system signal. Note that this is the same ground reference as the module signal connector and the 5V Auxiliary Output B supply.

SCL, SDA - PMBUS CLK and PMBUS DATA - (Pins 2, 4 of J8)

PMBus serial clock and data bus - These pins should be pulled-up by the user to a 3.3V or 5V bus. A resistor value of 2k - 10k is recommended.

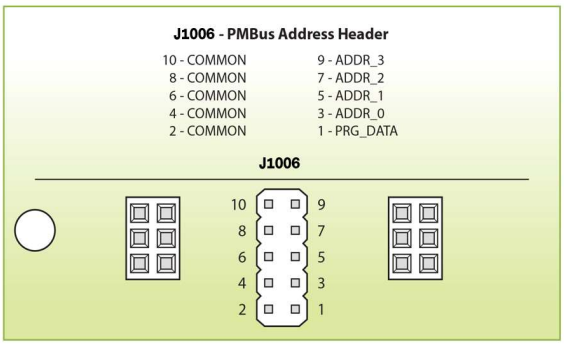
LV Global EN - Module Global Enable / Inhibit - (Pin 3 of J8)

All outputs will be enabled / inhibited simultaneously by means of an appropriate signal applied to the control input on J8, between Pin 3 (LV Global EN) 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 30ms (100ms for Dual Modules) delay from change in signal logic to change in output voltage.

The control pin 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 J1006 (which is located in the centre of the Comms board behind Slot 4) with a jumper and applying a logic low signal between the LV Global EN pin of J8 (Pin 3) and Common (Pin 1).
The recommended jumper for the J1006 connector is a Harwin M22-1900005 2mm Jumper Socket.



When these two signals are applied to the FC25M 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 J1005) between pin 4 (positive), and pin 1 or pin 3 (negative).

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

	J1006 Pin 1 PRG_DATA	J8 Pin 3 Control Signal	J100x Pin 4 CoolMod Enable Signal	CoolMod Status
Reverse Polarity	Pin 1 to 2 short	0	0	Enabled
		0	1 or open	Disabled
		1 or open	0	Disabled
		1 or open	1 or open	Disabled
Normal Polarity	Pin 1 to 2 open	0	0	Disabled
		0	1 or open	Disabled
		1 or open	0	Disabled
		1 or open	1 or open	Enabled

LV Global PG - Module Global Power Good - (Pin 5 of J8)

The LV Global PG signal is controlled with an NPN transistor providing an unbiased open collector signal that is available on the J8 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 390ohm resistor in series with the collector for current limiting. When the output of any enabled CoolMod is >10% outside if Vset, the transistor is turned OFF.

Note: The status of dual modules and Capacitance Charging Output are not included in LV Global PG.

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

Refer to the implementation circuit and table of logics for recommendations for driving logic level circuits with open collector signal outputs.

LV AC Fail - (Pin 6 of J8)

The LV AC Fail signal indicates that a primary fault (such as the input voltage dropping below 70Vac) has occurred, and the Modules will turn off. The LV AC Fail signal is controlled with an NPN transistor providing an unbiased open collector that is available on the J8 System Signal Connector via the collector on Pin 8 and the emitter on Pin 1 (Common). There is a 390 ohm resistor in series with the collector for current limiting. During normal operation the transistor is ON, when a primary fault has been detected, the transistor is turned OFF at least 1mS before loss of output voltage regulation.

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

Refer to the implementation circuit and table of logics for recommendations for driving logic level circuits with open collector signal outputs.

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

LV OTP - Over Temperature Warning - (Pin 7 of J8)

The FC25M monitors internal temperatures on the power supply to ensure that component temperatures do not exceed their ratings. The LV OTP signal an unbiased open collector signal that is available on the J8 System Signal Connector via the collector on Pin 7 and the emitter on Pin 1 (Common). There is a 390 ohm 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 LV OTP signal will be pulled low via a 390 ohm resistor as a pre-warning of a possible shutdown of the power supply. If the LV OTP condition persists for a further 2 seconds, the FC25M will shut down. The FC25M 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 30V, and the maximum collector current is 5mA.

Refer to the implementation circuit and table of logics for recommendations for driving logic level circuits with open collector signal outputs.

HV AC Fail - (Pin 8 of J8)

The HV AC Fail signal indicates that a primary fault (such as the input voltage dropping below 70Vac) has occurred, and the Capacitance Charging output will turn off. The HV AC Fail signal is controlled with an NPN transistor providing an unbiased open collector that is available on the J8 System Signal Connector via the collector on Pin 8 and the emitter on Pin 1 (Common). There is a 390 ohm resistor in series with the collector for current limiting. During normal operation the transistor is ON, when a primary fault has been detected, the transistor is turned OFF at least 1mS before loss of output voltage regulation.

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

Refer to the implementation circuit and table of logics for recommendations for driving logic level circuits with open collector signal outputs.

Fan Fail - (Pin 9 of J8)

The Fan Fail signal indicates that the fan is not functioning correctly. The Fan Fail signal is controlled with an NPN transistor providing an unbiased open collector that is available on the J8 System Signal Connector via the collector on Pin 9 and the emitter on Pin 1 (Common). There is a 390 ohm resistor in series with the collector for current limiting. During normal operation the transistor is ON, when a fan failure is detected, the transistor is turned OFF before loss of output voltage regulation.

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

Refer to the implementation circuit and table of logics for recommendations for driving logic level circuits with open collector signal outputs.

+5V Aux - 5V, 3W Auxiliary Output_B - (Pin 10 of J8)

A 5V, 3W always on auxiliary voltage is available on Pin 10 of the J8 connector. This auxiliary output has 4000 Vac isolation from the primary.

The return of the 5V output is Pin 1 (Common).

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

Open Collector Driving Common Logic Levels for System Signals

Each module status signal (LV Global PG, LV AC Fail, LV OTP, HV AC Fail, Fan Fail) is an Open Collector driver to Common with a 390 ohm resistor in series with the collector for current limiting.

These outputs can safely sink up to 5mA. Pull up resistors should be chosen to keep the sink current under 5mA. The table below shows some resistor combinations translating the Open Collector output into a voltage level suitable for 5V and 3.3V logic types.

Other voltages can be used to bias these circuits with adjustments taking into account the 5mA max sink current and the 390 ohm resistance in series with the collector.

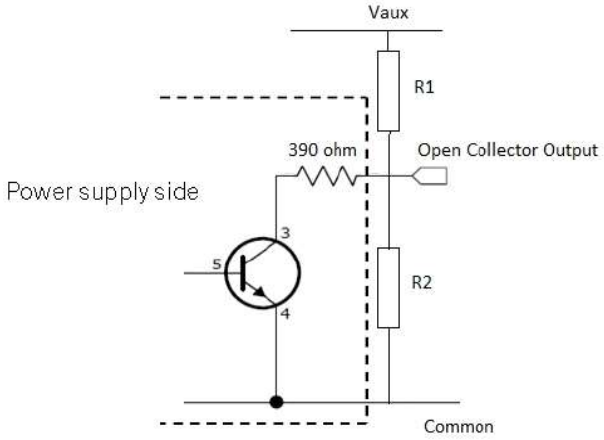


Table of Logics

Auxiliary Voltage	Logic Voltage	R1	R2	V_{high}	V_{low}	$I_{sink\ max}$
5V	5 Volt Logic	5K ohm	Open	5V	0.36V	5mA
5V	3.3 Volt Logic	5K ohm	10K ohm	3.3V	0.36V	5mA

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

7.4 Low Voltage Module Operation

The FC25M has been designed with a modular set of outputs 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.

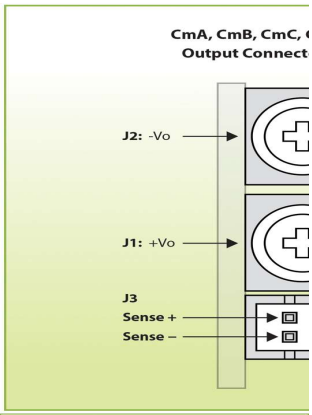
There are 11 CoolMods which provide discrete isolated DC outputs according to the CoolMod Summary Specifications table below.

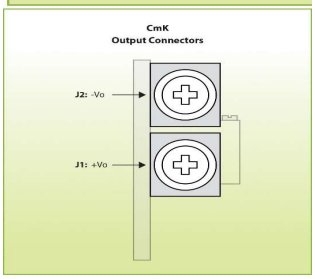
Model	V_O (V)	$V_{O,adjust}$ (V)	OVP of Vset	OVP[1]	$I_{O,max}$ (A)	OCP	$P_{O,max}$ (W)
CmA	5.00	2.5 to 6.0	103 to 125%	125 to 160%	21.00	105 to 130%	105
CmB	12.00	6.0 to 15.0[2]	103 to 125%	113 to 140%	15.00	105 to 130%	180
CmC	24.00	15.0 to 28.0	103 to 125%	114 to 132%	8.33	105 to 130%	200
CmD	48.00	28.0 to 58.0	103 to 125%	107 to 120%	4.17	105 to 130%	200
CmG	24.00 24.00	3.0 to 30.0 3.0 to 30.0	NA	110 to 130%	3.00 3.00	180 to 330%	120[3]
CmH	5.00 24.00	3.0 to 6.0 3.0 to 30.0	NA	115 to 125% 110 to 130%	6.00 3.00	166 to 250% 180 to 330%	100[3]
CmA-W01	5.00	1.0 to 6.0	103 to 125%	113 to 160%	21.00	105 to 130%	105
CmB-W01	12.00	1.0 to 15.0	103 to 125%	113 to 140%	15.00	105 to 130%	180
CmC-W01	24.00	2.0 to 28.0	103 to 125%	114 to 132%	8.33	105 to 130%	200
CmD-W01	48.00	3.0 to 58.0	103 to 125%	107 to 115%	4.17	105 to 130%	200
CmK	200.00	175.0 to 205.0	103 to 125%	112 to 122%	0.66	105 to 130%	132

Note 1 - Specified as a percentage of maximum voltage.
Note 2 - Full Dynamic Specifications may not be met at full load when output voltage is trimmed above 13 V.
Note 3 - Total max power of both channels.

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

7.5 Low Voltage Module Output / Signal





CmA to CmD and CmK Modules

J1 &J2 - Module Output Connector

J1 - +Vo - +Main Output

J2 - -Vo - Main Output Return

CmA to CmD Modules

J3 - Module Sense Connector

1 - Sense - - Module Remote Sense Return

2 - Sense + - Module Remote sense

Remote sensing can be used to compensate for voltage drops in output leads. Remote sensing is available on Modules via the J3 Sense Connector. There is no remote sense on dual or high voltage modules.

Remote sensing will 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.
- When using Remote Sense, output voltage should be set on the Sense Pins, not the Output Terminals

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.

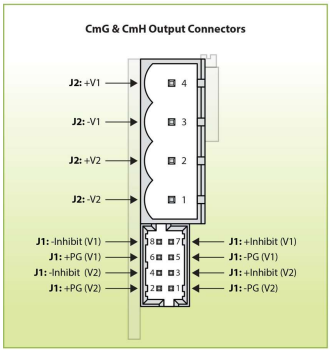
The resistance of the power cables must be so that the voltage drop across the cables is less than (Rcable) 0.5V (to ensure remote sensing operates correctly).

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

E.g. for a CmA, 5V / 21A, the Rcable must be less than 23.8 mohm.

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

CmG / CmH Modules



J2 - Dual Output Module Output Connector

1 - -V2 - Output 2 Return

2 - +V2 - Output 2

3 - -V1 - Output 1 Return

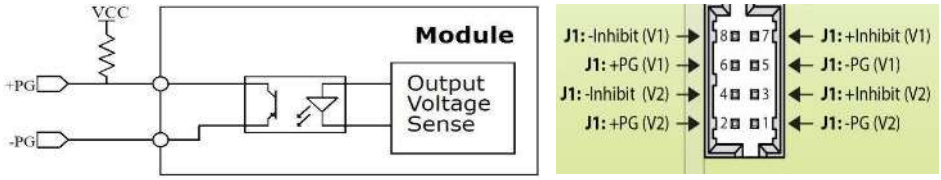
4 - +V1 - Output 1

J1 - Dual Output Module Signal Connector

+/- PG - Dual Output Module Power Good Signal - (Pins 1,2,5,6 of J1)

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

Note: The dual output module Power Good signal good status does not impact the global power



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.

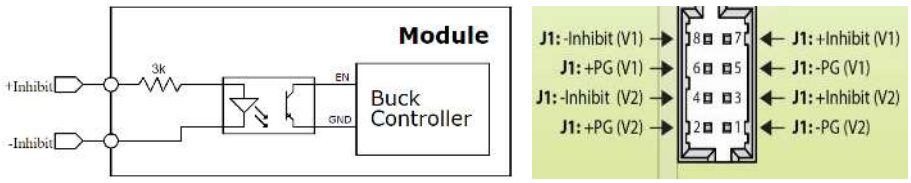
When there is a voltage present on the output pins of each output the transistor of the optocoupler is turned ON. If the output drops out of regulation the transistor turns OFF.

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 0.5mA or less. For example, if the reference voltage is 5V, the pull up resistor should be 10K ohm or higher.

+/- Inhibit - Dual Output Module Enable / Inhibit - (Pins 3,4,7,8 of J1)

Each individual output voltage of the Dual Module will 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.

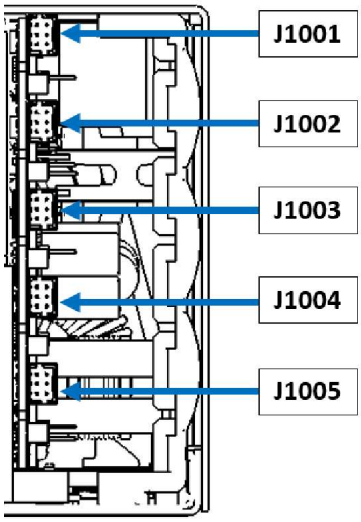


SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

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

J1x - Single Module DC Output Signal Connector

The FC25M Single Module Output Signals are available on the J100x Connector. (x = 1 to 5)



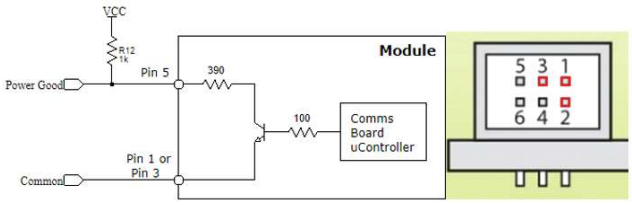
COMMON - (Pin 1, Pin 3 of J100x)

Ground reference of the system signal, this is connected to V- of the 5V auxiliary output.

PGx - Module Power Good Signal (all modules but Dual Modules) - (Pin 2 of J100x)

Each 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 PG signal is an unbiased open collector that is available on the Output Signal Connector (J1x) via the collector on Pin 2 and the emitter on Pin 1 or 3 (Common).

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T



When the output voltage is within 10% of $V_{O, set}$ 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.

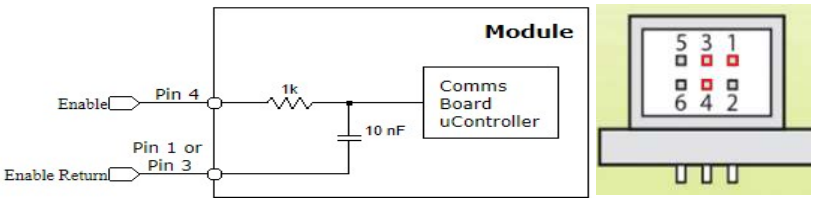
Refer to the implementation circuit and table of logics for recommendations for driving logic level circuits with open collector signal outputs.

ENx - Module Enable / Inhibit - (Pin 4 of J100x)

Each module will be enabled / inhibited by means of a logic level signal applied to the enable input on Output Signal Connector J11-J15, 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.

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-CmH modules in this way will disable both outputs.



The logic of the module Inhibit / Enable signals will be reversed if pins 1 and 2 of J1006 (which is located in the centre of the Comms board behind slot 4) are shorted with a jumper, and a logic low signal is applied between the CONTROL pin of J8 (Pin 3) and Common (Pin 1).
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 J1006 connector is a Harwin M22-1900005 2mm Jumper Socket.

ITRIMx - Module Set Current Limit - (Pin 5 of J100x)

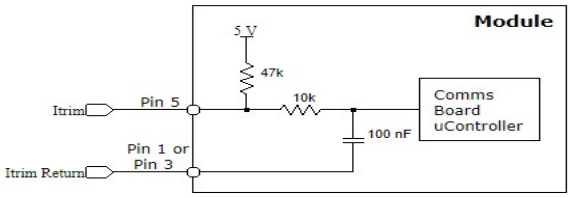
The current limit of the CoolMod can be set by applying a control voltage ITRIM across the Output Signal Connector pins ITRIM (Pin 5) and Common (Pin 1). The ITRIM voltage required for the users desired current limit can be calculated using the formula and table at below.

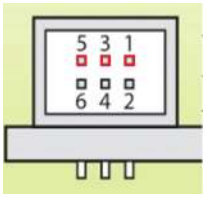
Note: Current limit adjustment is not available on CmG-CmH CoolMods.

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

Remote Current Limit Setting (Using External Voltage)

Available On: Standard Modules (CmA-CmD), Wide-Trim Modules (CmA-W01 to CmD-W01), High Voltage Module (CmK).





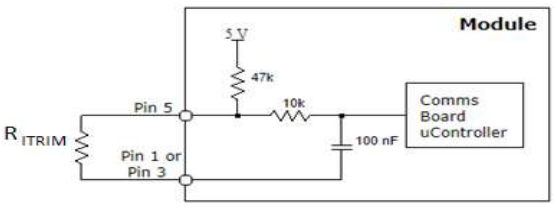
The current limit of the CoolMod can bet set by applying a control voltage I_{TRIM} across the Output Signal Connector (J100x) pins ITRIM (Pin 5) and Common (Pin 1 or Pin 3). The I_{TRIM} voltage required for the users desired current limit with the module can be calculated using the following formula.

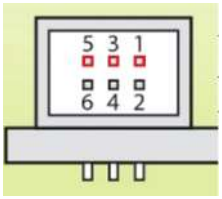
$$I_{TRIM} = \frac{I_{out}}{K}$$

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
CmK	0.46

Remote Current Limit Setting (Using External Resistance)

Available On: Standard Modules (CmA-CmD), Wide-Trim Modules (CmA-W01 to CmD-W01), High Voltage Module (CmK).





SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

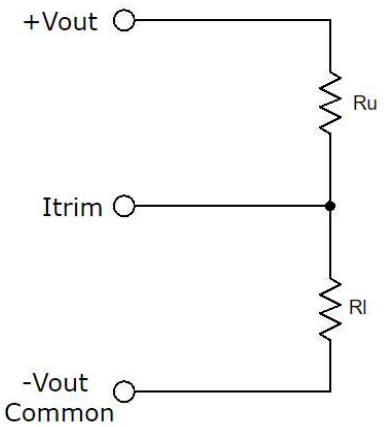
The current limit of the CoolMod can bet set by placing a resistor R_{ITRIM} across the Output Signal Connector (J100x) pins ITRIM (Pin 5) and Common (Pin 1 or Pin 3). The R_{ITRIM} resistance required for the users desired output current limit can be calculated using the following formula along with the same table used to calculate ITRIM .

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

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
CmK	0.46

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

Foldback Current Limit can also be achieved with the FC25M 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.



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

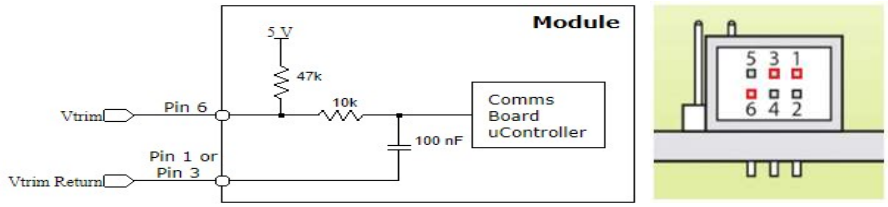
$$R_u = \frac{\left(47000(R_l)\right)\left(V_{out} - \frac{I_{out}}{K}\right)}{R_l(I_{trim}) - 5(R_l) + 47000\left(\frac{I_{out}}{K}\right)}$$

VTRIMx - CoolMod Voltage Adjustment - (Pin 6 of J100x)

The FC25M series modules 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 (J11 to J15) or with PMBus™ commands applied to the System Signal Connector (J8).

Remote Voltage Setting (Using External Voltage)

Available On: Standard Modules (CmA-CmD), Wide-Trim Modules (CmA-W01 to CmD-W01), High Voltage Module (CmK).



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.

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

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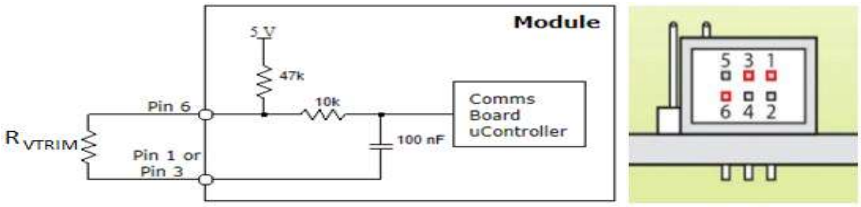
Module	K	F
CmA	1.59	2.43
CmB	3.84	5.85
CmC	6.30	13.82
CmD	13.20	26.13
CmA-W01	3.23	-1.61
CmB-W01	7.84	-3.9
CmC-W01	12.77	-2.17
CmD-W01	26.25	-6.42
CmK	20.47	154

Remote Voltage Setting (Using External Resistance)

Available On: Standard Modules (CmA-CmD), Wide-Trim Modules (CmA-W01 to CmD-W01), High Voltage Module (CmK).



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.

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

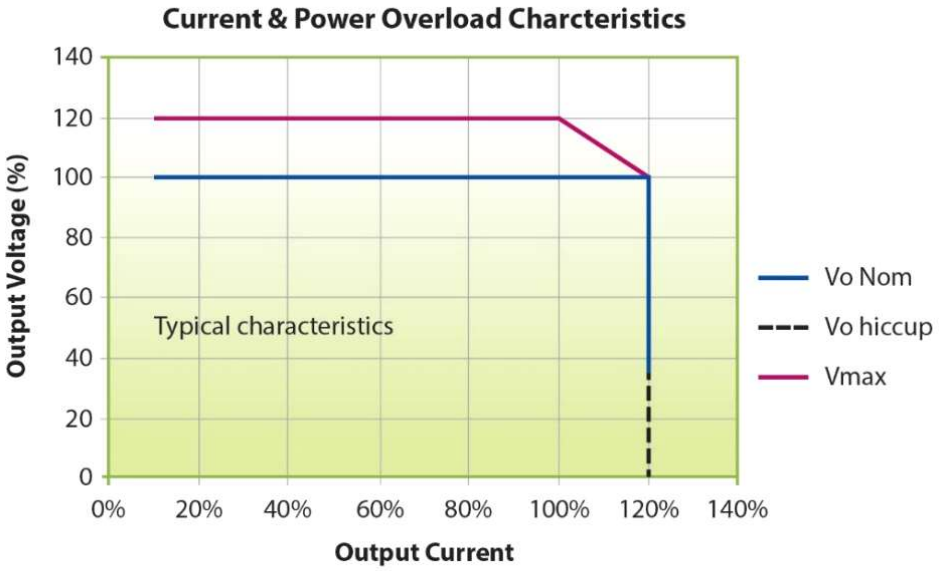
SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

Module	K	F
CmA	1.59	2.43
CmB	3.84	5.85
CmC	6.30	13.82
CmD	13.20	26.13
CmA-W01	3.23	-1.61
CmB-W01	7.84	-3.9
CmC-W01	12.77	-2.17
CmD-W01	26.25	-6.42
CmK	20.47	154

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

7.6 Low Voltage Module Power Limit

Each FC25M module has a number of levels of protection in order to ensure that FC25M is not damaged if used in overload conditions. Refer to Current and Overload Characteristics Graph.



When $V_{O,set}$ is less than or equal to $V_{O,nom,}$ current limit is employed at the current limit set point.

For Standard and Wide-Trim modules, if $V_{O,set}$ is greater than $V_{O,\ nom,}$ 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, $I_{O,max}$ is 8.33A, and Power rating is 200W.

- At 24V the CoolMod can deliver 8.33A continuously, i.e. 200W.
- At 28V the CoolMod can still deliver 200W, however this equates to 7.14A continuous current.

CmG-CmH modules do not have a power limit and rely on current limit only.

SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

7.7 High Voltage Capacitor Charge Operation

Prior to the application of input voltage:

1. Connect the HV output cable to the load. A minimum of 50uF load capacitance is required to avoid protective shut-down due to open load.

2. Keep 'Inhibit' (pin 1 of J3003) high (> 2V) to keep the HV output turned off. It is pulled high be default.

After application of input voltage:

1. Set 'Enable' (pin 15 of J3003) high (> 2V), it is pulled to 0V by default. This pin is code independent so can be used for system interlocking. 'Vo_User' is also code independent so can be used for protection functionality. The HV output will be turned on with 'Enable' high and 'Inhibit' low.

2. Set 'Vprogram' to the required output voltage.

3. Set 'Inhibit' low to turn on the HV output. The units acts to maintain V_{oHV} at the level set by 'Vprogram' when 'Inhibit' goes low. In order to adjust the setting of V_{oHV} to a new level of 'Vprogram', it is necessary to toggle 'Inhibit'.

4. 'Ptrim' (pin 2 of J3003) is pulled up to > 10V by default setting the peak charging power to 1650W provided the charging current < 6A. The charging power can be reduced linearly using this pin down to 850W at 0V.

7.8 High Voltage Output Signals

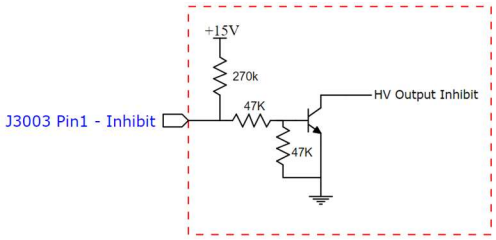
Inhibit - High Voltage Inhibit / Enable - (Pin 1 of J3003)

The HV Output of the FLEXICHARGE can be enabled / inhibited with a signal applied to the Inhibit pin of the HV Output Signal Connector (Pin 1), which is referred to Pin 14 (Earth).

Inhibit is internally pulled up to a 15V reference to inhibit the HV Output when the pin is floating.

The HV Output is enabled by pulling the Inhibit pin below 1V when the Enable pin has been driven high.

The Inhibit signal has a response time of < 1ms.



SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

PTrim - Power Limit Adjustment - (Pin 2 of J3003)

When charging a load capacitance from 0V, the HV Output will charge at a constant average current of 6A, until it reaches its power limit.

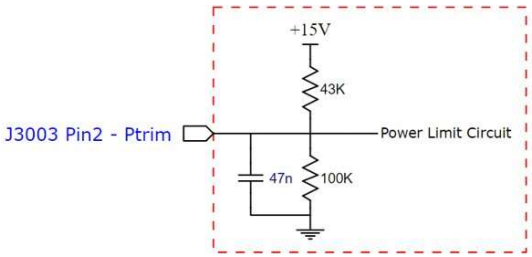
From there on, the Flexicharge will charge the load capacitance at its power limit until the target voltage - set by Vprogram (Pin 5) - is reached.

The HV Output power limit can be adjusted with an analog signal voltage applied to the Ptrim pin of the HV Output Signal Connector (Pin 2) which is referred to Pin 14 (Earth).

10V or more on the Ptrim pin sets the peak charge power to 1650 W, while 0V decreases the peak power charge to 800W. The peak charge power adjusts linearly from 0-10 V with a bandwidth 100Hz and a ±50W accuracy.

Reducing the power limit of the HV Output of the Flexicharge will result in a slower load capacitance charge but allows the user to free up power for the LV Output Loads in applications where input power is a limiting factor.

The Ptrim is internally pulled up to 11V so that the HV Output peak charge power is set to 1650W when the pin is floating.

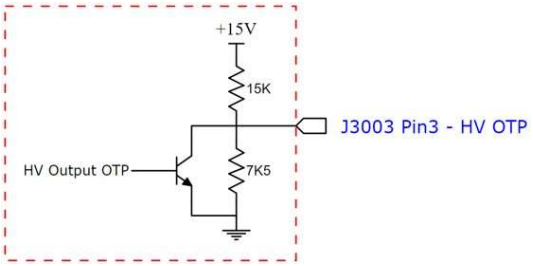


HV OTP - Over Temperature Warning - (Pin 3 of J3003)

HV OTP (Pin 3) is an open collector signal referred to Pin 14 (Earth) that gives the user an advanced warning of an impending HV Output shutdown due to an Over Temperature condition in the HV Output circuitry.

Note that HV OTP does not disable the HV Output. It allows the user to take corrective actions to avoid shutdown such as shedding output power.

HV OTP is normally 5V (potentially divided from an internal 15V reference) and is pulled down to < 1V prior to Over Temperature shutdown.



SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

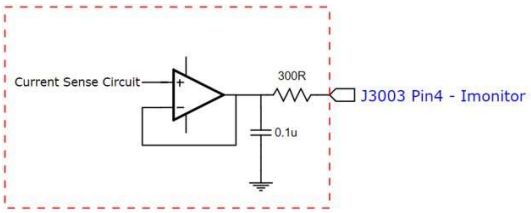
Imonitor - Output Current Sense Signal - (Pin 4 of J3003)

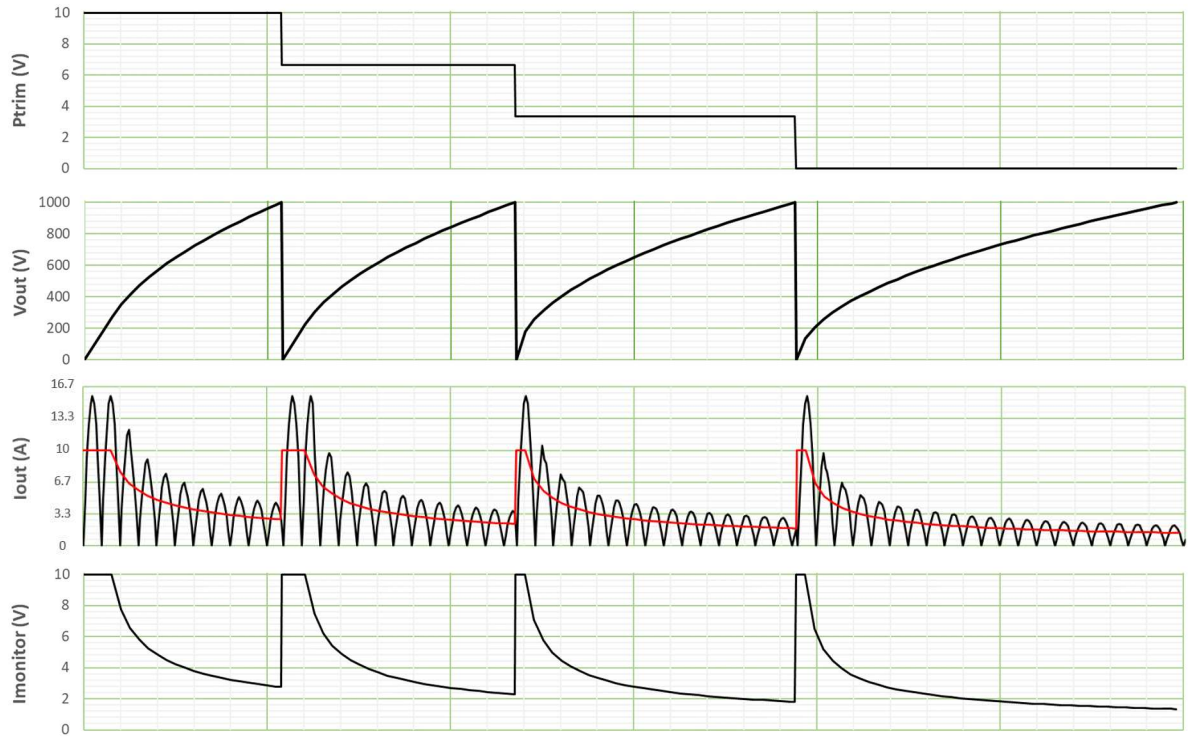
The Flexicharge outputs a rectified sine wave charging current at approximately 130kHz with varying amplitude.

Imonitor (Pin 4) provides a 0-10 V analog signal voltage reffered to Earth (Pin 14) that represents the average current of the HV Output with a gain of 1V/A (10V = 10A).

For best accuracy, it is recommended to sink as little current as possible from the Imonitor pin by using a high impedance sensing circuit.

Imonitor has a typical accuracy of ±5% of rated current, or ±300mA.





SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

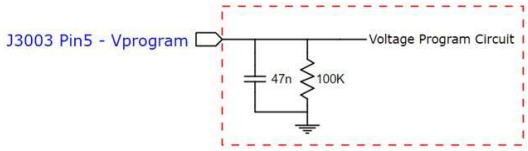
Vprogram - Output Voltage Setting - (Pin 5 of J3003)

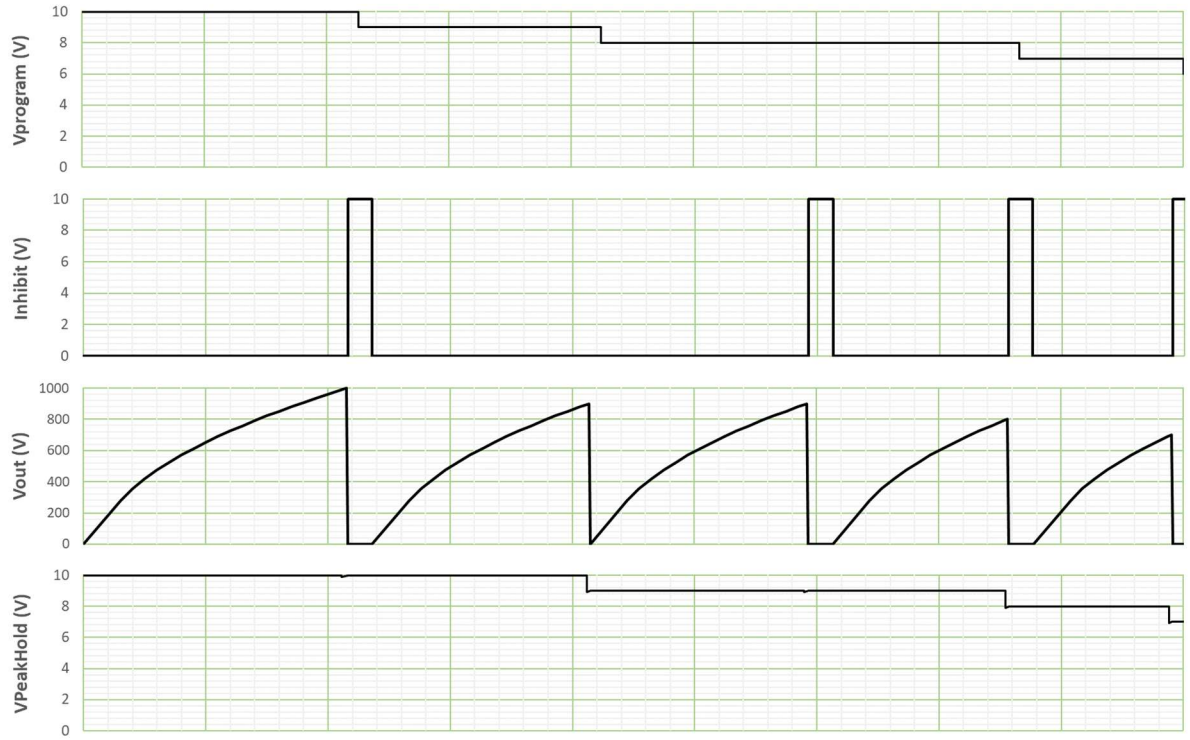
The HV Output peak voltage can be adjusted with an analog signal voltage applied to the Vprogram pin of the HV Output Signal Connector (Pin 5) which is referred to Pin 14 (Earth).

A user applied 0-10 V voltage signal sets the output voltage with a gain of 100 (0-1000 V). Vprogram is internally pulled to 0V by a 100 kohm resistor so that the HV Output voltage is set to 0V when the pin is left floating.

Note that the peak voltage of the HV Output setting is held at the level set by Vprogram when Inhibit is pulled low. When Inhibit is high, changing Vprogram will have no effect on the HV Output.

To adjust the voltage setting with Vprogram during the operation of the Flexicharge, Inhibit must be toggled.





SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

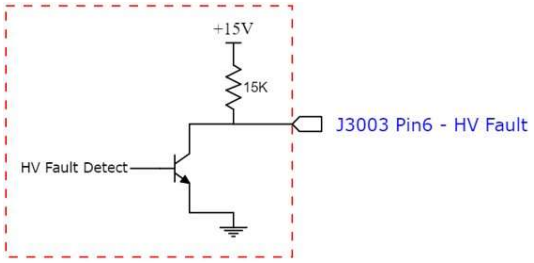
HV Fault - High Voltage Output Fault Detect - (Pin 6 of J3003)

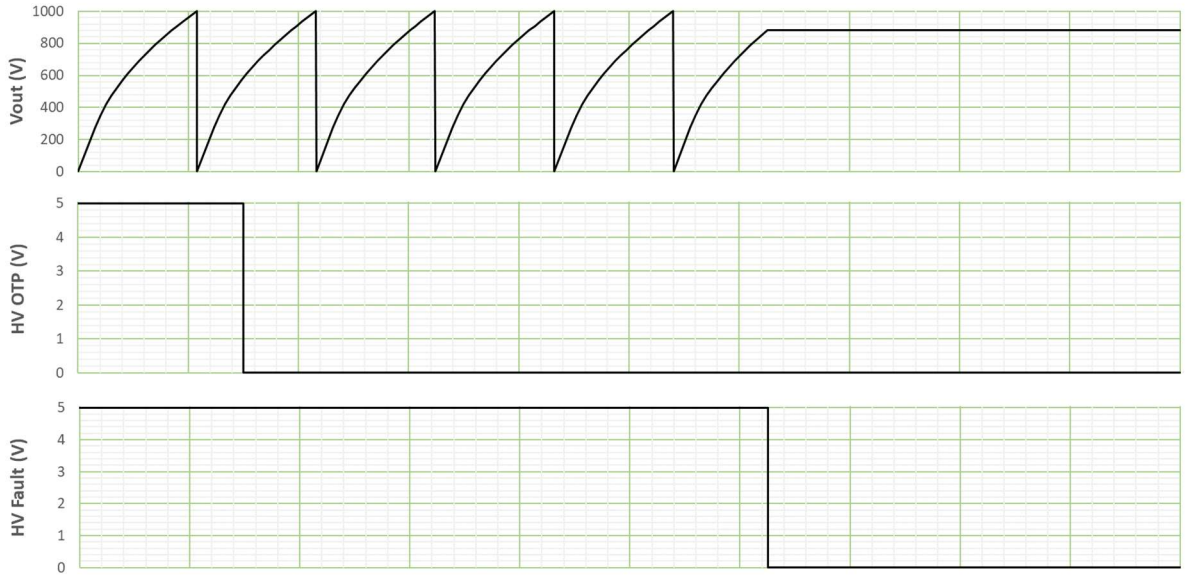
HV Fault (Pin 6) is an open collector signal that is referred to Pin 14 (Earth) and informs the user that the HV Output has been disabled due to a fault condition, or that the HV Output Enable signal is low.

Fault conditions that can disable the HV Output and activate HV Fault include:

- Enable Pin (J3003, Pin 15) is low
- An Over-Voltage condition has been detected on the HV Output
- An Over-Temperature condition has been detected in the HV Output circuitry
- An Over-Current condition has been detected on the HV Output
- An Open-Load (or load capacitance < 50uF) has been detected on the HV Output
- The lid of the Flexicharge has been removed

HV Fault is normally pulled to 15V, and is pulled to < 1V on activation with a response time of < 1ms.





SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

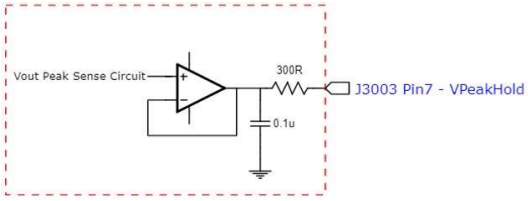
VPeakHold - Output Voltage Peak Level - (Pin 7 of J3003)

VPeakHold (Pin 7) provides a 0-10 V analog signal voltage referred to Earth (Pin 14) that represents the peak voltage of the HV Output with a gain of 100 (10V = 1000V).

VPeakHold acts as a Peak Detector of the Vmonitor signal that is reset each time the End of Charge signal activates.

For best accuracy, it is recommended to sink as little current as possible from the VPeakHold pin by using a high impedance sensing circuit.

VPeakHold has a typical accuracy of ±1% of max voltage over the voltage range of 100-1000 V.



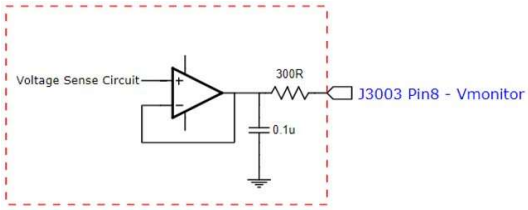
Vmonitor - Output Voltage Sense - (Pin 8 of J3003)

Vmonitor (Pin 8) provides a 0-10 V analog signal voltage referred to Earth (Pin 14) that represents the output voltage of the HV Output with a gain of 100 (10V = 1000V).

For best accuracy, it is recommended to sink as little current as possible from the Vmonitor pin by using a high impedance sensing circuit.

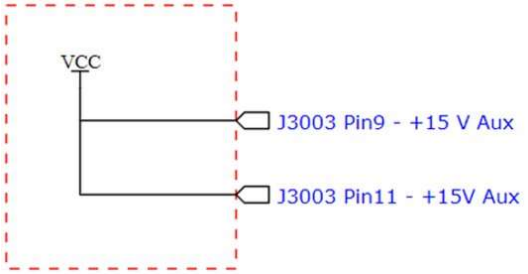
Vmonitor has a typical accuracy of ±1% of max voltage over the voltage range of 100-1000 V.

Vmonitor has no software dependency and is suitable for use in system protective functions.



+15V Aux - 15V 3W User Bias Supply - (Pin 9 and Pin 11 of J3003)

15 V DC Source with a maximum rated current of 200 mA.



SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

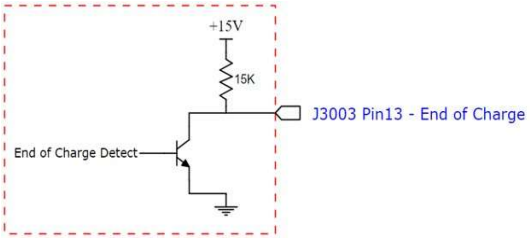
End of Charge - End-of-Charge Indicator - (Pin 13 of J3003)

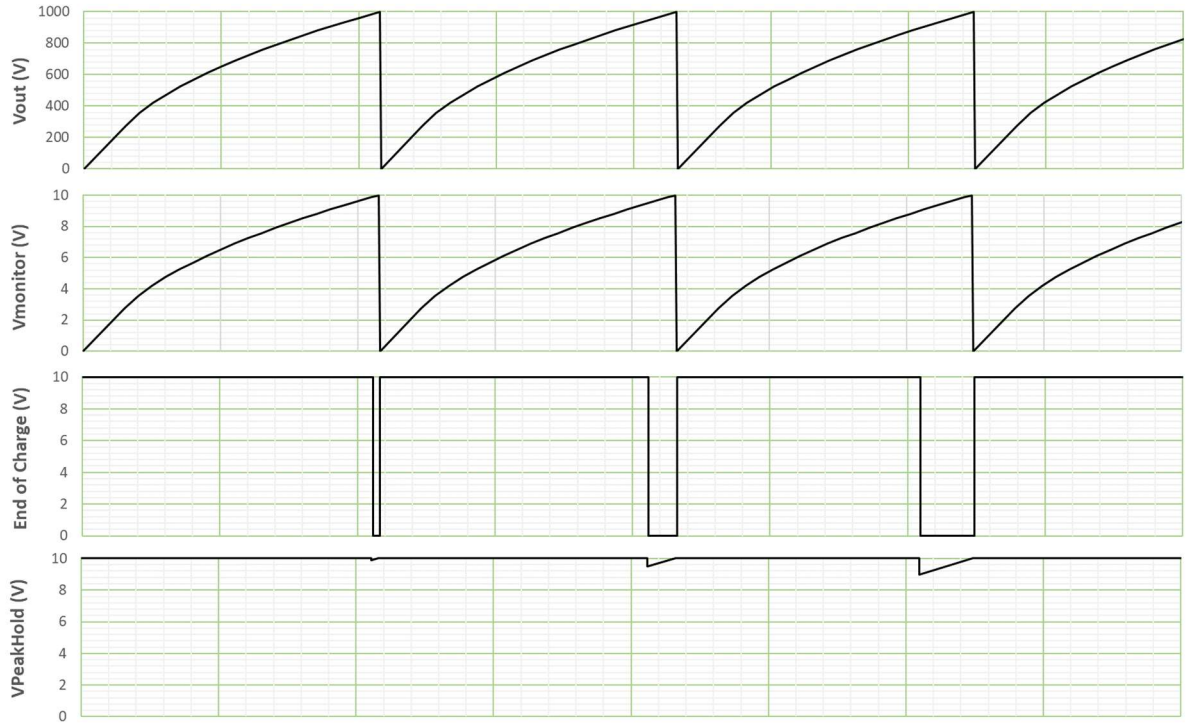
End of Charge (Pin 13) is an open collector signal referred to Pin 14 (Earth) that informs the user that HV Output voltage is within 1% of the voltage set by Vprogram.

End of Charge is normally pulled to a 15V reference, and is pulled down to < 1V when the HV Output is > 99% of the Output Voltage setting, and returns to 15V when the voltage is < 94% of the set level.

The percentage threshold of the End of Charge signal can be adjusted with a PMBus command. The example below has a 99% threshold for the first charge, followed by a 95%, and finally a 90%.

End of Charge has a response time of < 1ms.





SECTION 7 OPERATION - POWER, CONTROL AND COMMUNICATION CON'T

Earth - (Pin 14 J3003)

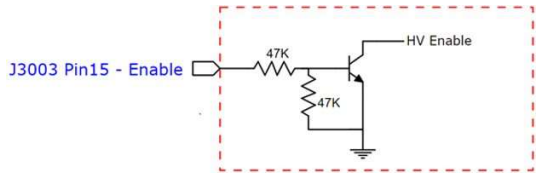
Return for all the pins of the connector and is also tied to both chassis Earth, and the AC Mains Earth line.

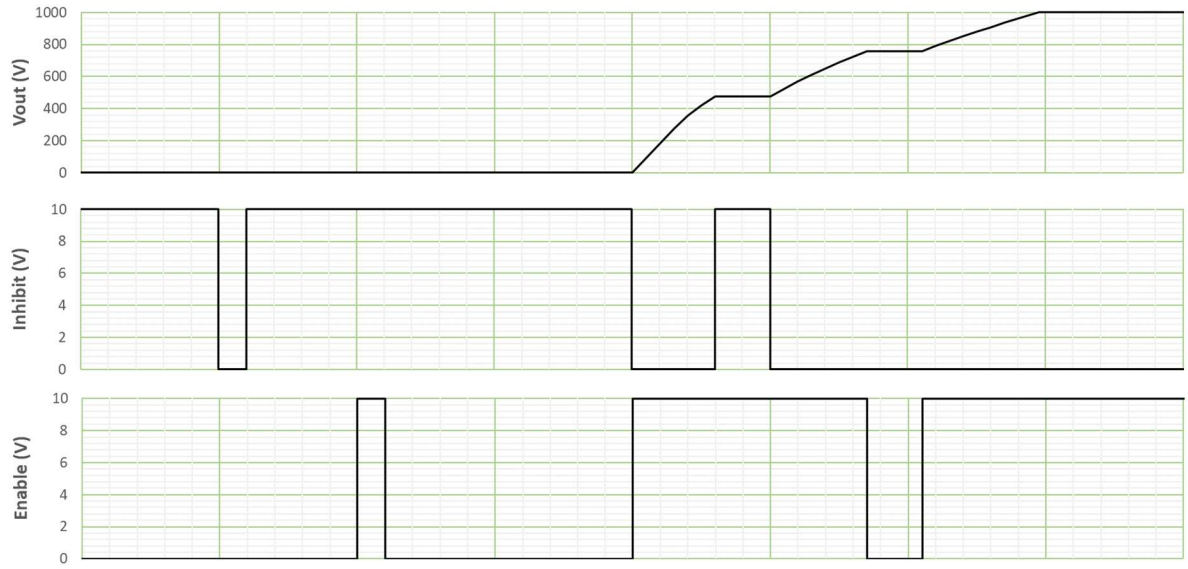
Enable - (Pin 15 J3003)

The HV Output of the FLEXICHARGE can be enabled / inhibited with a signal applied to the Enable pin of the HV Output Signal Connector (Pin 15), which is referred to Pin 14 (Earth).

Enable is internally pulled down to 0V to inhibit the HV Output when the pin is floating. Application of > 2V enables the HV Output (provided that the Inhibit pin has been pulled low).

The Enable pin has no software dependency, and so is suitable for use in system protective functions.





Note that the HV Output of the Flexicharge can only be enabled by pulling Inhibit (Pin 1) below 1V, and driving Enable (Pin 15) higher than 2V.

At any point during the operation of the Flexicharge, the HV Output can be disabled by driving Inhibit high, or by pulling Enable low.

SECTION 8 INSTALLATION

8.1 Unpacking and Inspection

This product has been carefully packed to prevent damage during transit. When removing the product from the packing, ensure that the PSU shows no evidence of rough handling and/or damage.

If evidence of damage is visible do not operate the power supply.

Notify the carrier and keep all packaging/PSU for warranty claims.

8.2 Mechanical Installation

The PSU is designed to be mounted inside the earthed enclosure using M4 screws (or equivalent) fitted through the fixing holes. When securing the product, do not use screws which infringe the maximum penetration depth of 4.5mm. Customer fixings are provided on the base of the unit in addition to the side mounting which allows the unit to be mounted on either side of the chassis.

The weight of the PSU is approximately 3.75kg.

Cooling of the PSU is by forced air cooling using the integral fan. Air is channelled in through the fan (ac input end) and exhausts via the rear panel (HV end). To ensure adequate air flow through the PSU, a minimum of 15cm air space is recommended around the rear panel and 7cm air space where the fan fits.

8.3 Electrical Installation

This power supply can produce hazardous voltages, which under some circumstances may be fatal. It is recommended that the power supply is only operated by personnel who are familiar with high voltage and recognise the dangers it can pose, and the following precautions should be taken:

Connection of the power supply input, Capacitance Charging output and remote interface cables must be made in the following order:

1. Ensure the power supply is disconnected from the mains AC supply.

2. Before touching the high voltage cable, ensure that the high voltage circuit and load are discharged.

3. Connect the earth terminal to a protective earth.

4. Connect the user interface cable, ensuring the INHIBIT and ENABLE are open circuit or driven to their default levels (pulled up to +15V and down to 0V respectively).

5. Connect the high voltage cable to the load circuit. The cable supplied with the unit should be connected directly to a load capacitor (total load capacitance > 50uF). If the cable is extended then open load protection may be triggered preventing the high output voltage being delivered.

6. Connect to the mains AC supply using the input power cable, ensuring that the earth terminal is securely connected to a protective earth.

7. Energise the AC supply and pull INHIBIT down to 0V and ENABLE to >2V and set demand signals as required.

Before removing or touching the high voltage output ensure that the AC supply is de-energised and all high voltage parts are fully discharged.

SECTION 8 INSTALLATION

The mains input cable must be disconnected before disconnection of the earth terminal.

The only Cap Charger analogue interface pins without software dependency are ENABLE, VO (output voltage monitor) and +15V so only these may be used for system safety protective functions (such as interlock). These signals are only functional when the input ac supply is present.

The output high voltage cable and load must not be accessible to the user. Ensure the equipment enclosure housing of the power supply has suitable interlocks to prevent contact with the high voltage. Ensure that the creepage and clearance distances between the high voltage output and the enclosure meet the requirements of IEC 60601-1.

The power supply should only be operated with the HV output cable connected.

Ensure adequate ventilation of the power supply to ensure that possible ozone build up will be kept to a safe level.

Operation with the cover removed exposes hazardous voltages. This should only be attempted by qualified service personnel authorized by Advanced Energy. 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.

Double pole / neutral fusing is used. If the installation is not completely disconnected from power, parts may remain live even if one of the two mains fuses have blown.

There are no user serviceable parts in the power supply. If the power supply fails to operate, it must be returned to Advanced Energy or to an Advanced Energy authorized service center for repair.

The power supply should only be used for the purpose for which it is designed and manufactured. Failure to do this may impair the protection provided by the power supply.

When adding or removing FC25M modules from the unit, care must be taken to handle the modules by the output terminals ONLY, ensuring that all other surface mount components are not unduly damaged.

Avoid excessive bending of output power cables after they are connected to the FC25M. For high current outputs, use cable-ties to support heavy cables and minimize mechanical stress on output terminals. Be careful not to short-out to neighbouring output terminals. The maximum torque allowed on output connectors is 0.74Nm.

The FC25M should be supplied by a power source of the type indicated on its label, and only used with a suitably rated mains cord.

SECTION 8 INSTALLATION

Best Practice Earthing of Secondary

The unit must be protectively grounded, which is considered as 1 x MOPP (Means Of Patient Protection). The HV output negative is connected to the case and functionally isolated from the HV positive (D, Figure 1). The Cap Charger analogue I/O user interface is galvanically connected to the HV output negative. A configured FC25M has the following galvanic isolation barriers (MOOP: Means Of Operator Protection):

Isolation Barrier	Type	Withstand Voltage
Input to Case (earth) (B)	Basic (1 x MOPP)	1650Vac
Input to HV Output (C)	Basic (1 x MOOP)	4000Vac
Input to Digital I/O (E)	Reinforced (2 x MOPP)	4000Vac
Input to Modular Output (F)	Reinforced (2 x MOPP)	4000Vac
Modular Output to Digital I/O (G)	Basic (1 x MOPP)	1850Vac
Modular Output to Case (earth) (H)	Basic (1 x MOPP)	1850Vac
Digital I/O to Case (earth) (I)	Basic (1 x MOPP)	1850Vac

SECTION 8 INSTALLATION CON'T

8.4 Configuration Considerations

- Do not unplug FC25M modules while input power is applied to the FC25M. The modules are not designed for hot-plug insertion.
- Always ensure that input and output screw terminals are properly torqued before applying power to the FC25M.
- Wait 4 minutes after shutting off power before inserting or removing FC25M Modules.
- FC25M 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 FC25M modules as described in this Designers' Manual.
- Use proper size wires to avoid overheating and excessive voltage drop.
- Take appropriate precautions when touching the FC25M after it has been operating for a period of time.

Choice of capacitive loading

1. The minimum load capacitance is 50uF, for lower levels of capacitance, open load protection may be triggered shutting down the high voltage output.

2. For complete discharge applications of a film capacitor, it is recommended that a load capacitor with rms current rating ≥ 50A at 55^{O}C ambient be used, eg EPCOS / TDK: B25631A1506K200 or Cornell Dubilier Electronics (CDE): 944U101K122ACI or KYOCERA AVX: FFVS6U0656K or Kemet: C4DENPQ5680A8TK.

Cabling options / make up / recommendations

1. The output high voltage cable and load must not be accessible to the user.

2. Ensure the equipment enclosure housing of the power supply has suitable interlocks to prevent contact with the high voltage.

3. Ensure that the creepage and clearance distances between the high voltage output and the enclosure meet the requirements of IEC 60601-1.

4. The power supply should only be operated with the HV output cable connected.

5. The cable supplied with the unit should be connected directly to a load capacitor (total load capacitance > 50uF). If the cable is extended, then open load protection may be triggered preventing the high output voltage being delivered.

SECTION 9 APPLICATION NOTES

9.1 Series Connection of FC25M outputs (Standard, Wide-Trim Modules and High Voltage Modules)

It is possible to connect modules in series to increase output voltage. Standard, Wide-Trim 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 links can be fitted to FC25M modules to reduce wiring complexity.

A maximum of three CmK modules can be connected in series.

CmG and CmH 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.

Special parallel connection links can be fitted to CoolMod modules to reduce wiring complexity.

9.2 Parallel Connection of FC25M outputs (Standard, Wide-Trim Modules and High Voltage Modules)

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

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

A maximum of three CmK modules may be connected in parallel.

SECTION 9 APPLICATION NOTES

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

Since all FC25M signals are isolated from the Module 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.

9.3 Module Start-Up and Shutdown

FC25M Modules 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)	30ms max
From CoolMod Enable	30ms max

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

9.4 Over Voltage Protection (OVP)

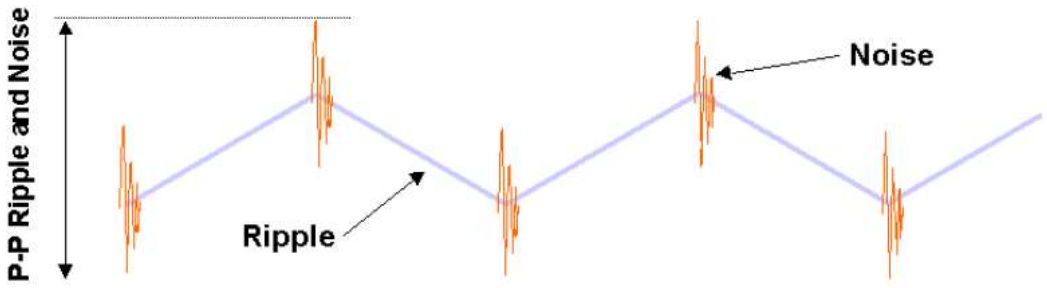
Standard and Wide-Trim modules have two levels of over-voltage protection (tracking and fixed), while the CmG-CmH have fixed over-voltage protection only.

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 125%-160% of the maximum output voltage. The fixed OVP will turn off all outputs of the FC25M and, like the tracking OVP, will hiccup all outputs until the fault condition is removed.

SECTION 9 APPLICATION NOTES

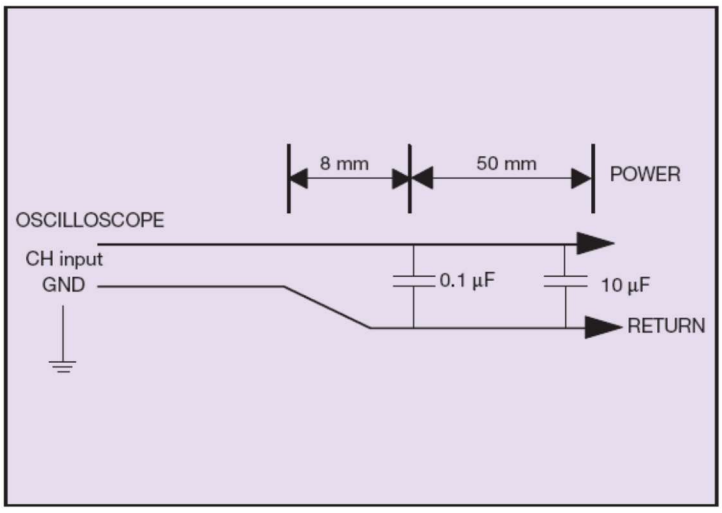
9.5 Ripple and Noise Measurement



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. Advanced Energy 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, We 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.

The setup outlined in the diagram below has been used for output voltage ripple and noise measurements on FC25M Modules. When measuring output ripple and noise, a scope jack in parallel with a 0.1uF ceramic chip capacitor, and a 10uF tantalum capacitor will be used. Oscilloscope can be set to 20MHz bandwidth for this measurement.



SECTION 10 RECORDS OF REVISION AND CHANGES

Issue	Date	Description	Originators
1.0	06.17.2024	First Issue	J. Zhang

ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

Our products enable customer innovation in complex applications for a wide range of industries including semiconductor equipment, industrial, manufacturing, telecommunications, data center computing, and medical. With deep applications know-how and responsive service and support across the globe, we build collaborative partnerships to meet rapid technological developments, propel growth for our customers, and innovate the future of power.

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FC25M - Rev.06.17.24_#1.0