EXCELSYS TECHNOLOGIES LTD
27 EASTGATE BUSINESS PARK
LITTLE ISLAND, CORK, T45 W950
IRELAND
www.advancedenergy.com

Installation Manual

For

FC15M SERIES

CAP CHARGER POWER SUPPLY

Contents

1. INTRODUCTION

This document provides the information required to operate the **FC15M** series of power supplies safely and within the limits of the specification. It shall be read in full before any attempt is made to operate the supply.

1.1. General Description

The FC15M capacitor charger power supply has been developed for general capacitor charging applications and use in non-contact medical environments. The design incorporates innovative digital control techniques to reduce switching losses and increase power density. In addition to the 1500W, 6A capacitor charging, earth referenced output programmable from 0-1kV, 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 isolation and <300uA leakage current. Other features include 4KV input surge immunity and the ability to withstand input voltages of up to 300Vac making it ideal for use in locations subject to input voltage disturbances. With analogue and digital communications (PMBus™), the FC15M provides the only combined Cap charging and modular power supply in the market.

A complete capacitor charging power supply is configured by selecting and inserting up to 5 output modules called CoolMods. This offers the advantages of a custom supply built into the Cap Charger but is assembled from standard modular building blocks. If output requirements change, i.e., more power or a different output voltage is needed, upgrading is easy, by replacing the module with an alternative 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).

1.2. Remote Control

A user-friendly interface on the high voltage Cap Charger output (via a 15 way D-type connector) 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.

1.3. Protection

The PSU is protected against damage from over current, output short circuit, output over voltage, output open circuit and over temperature.
A user accessible interlock signal pin is provided to enable/inhibit the HV output.

1.4. Safety

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.

2. SAFETY INFORMATION

2.1. Safety Symbols

Caution: Refer to equipment handbook

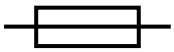
Danger: Risk of electric shock.
High voltage at power supply output

~ **Single phase alternating current**

Protective Earth Terminal

I **ON**

O **OFF**



Neutral line fusing

Caution hot surface

Figure 1 Safety Symbols

2.2. General

This power supply is intended for indoor professional use only in a nonexplosive, non-corrosive and mainly non-conductive environment. It can produce hazardous voltages and so must be treated with respect.

The product has been manufactured in an ISO9001 Quality Management approved facility to ensure continuity of the safety build standard. It leaves the factory in a safe condition.

It meets the requirements of the low voltage directive (LVD), 2014/35/EU by complying with IEC 60601-1 :2005+A1:2012 (E230761) and is CE marked accordingly. To ensure safety in its final application the power supply must be professionally installed into a final product and used in accordance with IEC 60601-1.

To maintain continued safety of the product and to the operator it is important that the entire handbook is read carefully, paying attention to the safety guidelines presented in this section. The handbook should be read before attempting installation or operation of the power supply.

If you do not fully understand the information given in the handbook do not use the power supply. Contact Excelsys Technologies or an authorised agent for advice.

The basic block and insulation diagram of the FC15M is presented in Figure 2. The FC15M unit is comprised of a main board for the AC Input to BULK (400Vdc) section, a non-removable, isolated output Cap Charger section (400Vdc-to-1kVdc) and a removable factory configurable modular section for the 5 slots of auxiliary, isolated converter CoolMod modules *(Note: this must be present to offer full functionality of the FC15M i.e. PMBUS™ communication)*. 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, barrier D represents the separation between the high voltage nodes and earth. The Cap Charger analogue I/O user interface is galvanically connected to the HV output negative. The galvanic isolation barriers of a configured FC15M are presented in Table 1 (MOOP: Means Of Operator Protection).

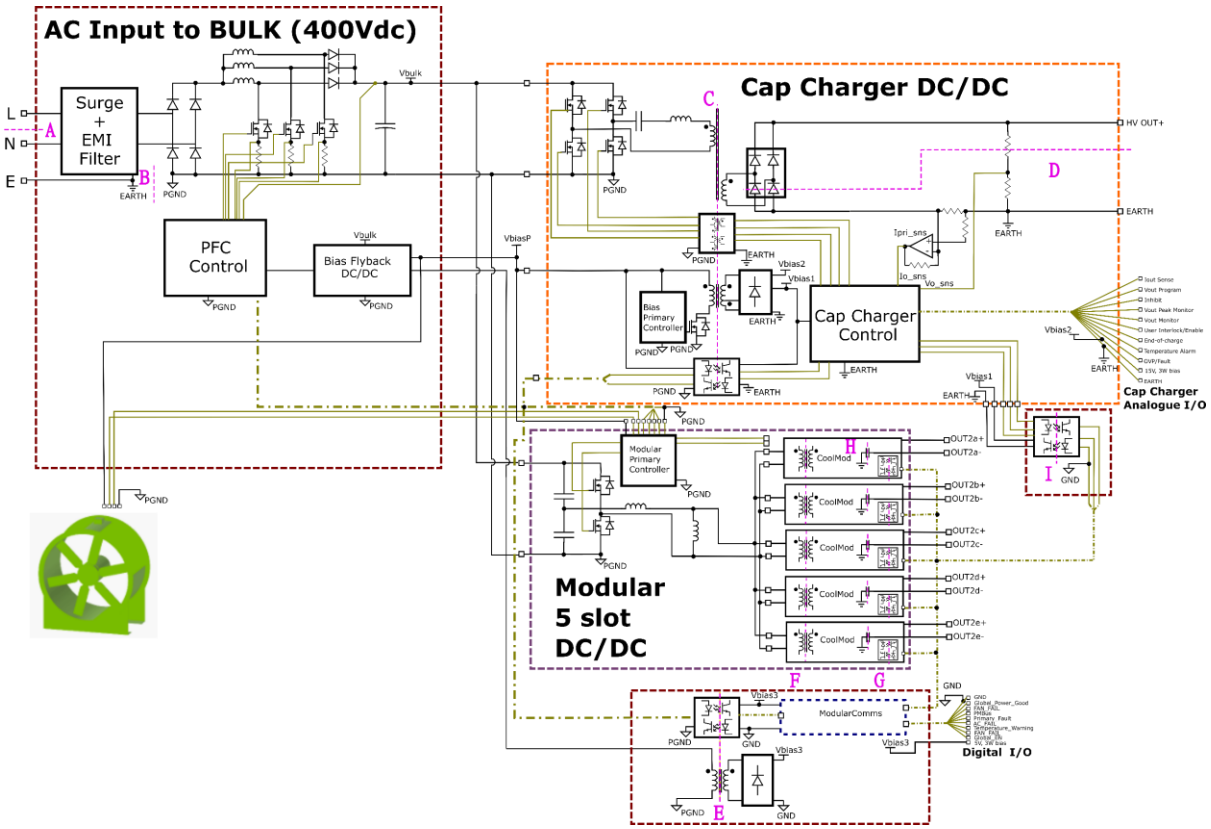


Figure 2 High level schematic showing isolation barriers

Table 1 Isolation barriers

Isolation barrier	Type	Withstand voltage
Input-to-Case (earth) (B)	Basic (1 x MOPP)	2100Vac
Input-to-HV Output (C)	Basic (1 x MOOP/1 x MOPP)	3000Vac
Input-to-Digital I/O (E)	Reinforced (2 x MOPP)	4200Vac
Input-to-Modular Output (F)	Reinforced (2 x MOPP)	4600Vac
Modular Output-to-Digital I/O (G)	Basic (1 x MOPP)	1000Vac
Modular Output-to-Case (earth) (H)	Basic (1 x MOPP)	1000Vac
Digital I/O-to-Case (earth) (I)	Basic (1 x MOPP)	1500Vac

2.3 Safety Guidelines

1) This power supply can produce hazardous voltages, which under some circumstances may be fatal.

2) 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.

3) To avoid this risk of electric shock, this equipment must only be connected to a supply mains with protective earth.

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

    a) Ensure the power supply is disconnected from the mains AC supply.
    b) Before touching the high voltage cable, ensure that the high voltage circuit and load are discharged.
    c) Connect the earth terminal to a protective earth.
    d) 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).
    e) Connect the high voltage cable to the load circuit.
    f) Connect to the mains AC supply using the input power cable, ensuring that the earth terminal is securely connected to a protective earth.
    g) Energise the AC supply and pull INHIBIT down to 0V and ENABLE to >2V and set demand signals as required.

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

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

7) The only Cap Charger analogue interface pins without software dependency are ENABLE, Vmonitor (output voltage monitor) and +15V (see 4.3.5.1) 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.

8) 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.

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

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

11) The HV output cable carries high frequency current so should be routed away from sensitive circuitry.

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

13) Operation with the cover removed exposes hazardous voltages. This should only be attempted by qualified service personnel authorised by Excelsys Technologies. 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.

14) 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 has blown.

15) There are no user serviceable parts in the power supply. If the power supply fails to operate, it must be returned to Excelsys Technologies or to an Excelsys Technologies authorised service centre for repair.

16) Do not use the power supply if it is damaged. Return to Excelsys Technologies, or to an Excelsys Technologies authorised service centre for repair.

17) 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.

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

3. ENVIRONMENTAL PARAMETERS

The unit is designed for the following parameters:

- Material Group IIIb, pollution degree 2
- Installation category 2
- Class 1
- For use as part of another piece of equipment such that unit is accessible to service engineers only.
- Altitude: < 3000m above sea level
- Humidity: up to 90% non-condensing
- Operating temperature: 0ºC to 40ºC

3.1. Guidelines for Optimal EMC Performance

FC15M series products are designed to comply with European Normative limits (EN) for conducted and radiated emissions and immunity when correctly installed in a system. However, power supply compliance with these limits is not a guarantee of system compliance. System performance can be impacted by a number and combination of items. Design consideration such as PCB layout and tracking, cabling arrangements and orientation of the power supply amongst others, can all directly contribute to the EMC performance of a system.

3.2. Storage

The unit should be stored at:

- Temperature between -40ºC and 85ºC.
- Maximum relative humidity of 90%.
- Maximum altitude of 3,000m

4. OPERATION OF THE POWER SUPPLY

4.1. 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.

4.2. Mechanical Installation

The PSU is designed to be mounted inside the earthed enclosure using M4 screws (or equivalent) fitted through the fixing holes. Figure 3 details the dimensions of the fixing holes relative to the PSU size. 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 required around the rear panel and 7cm air space where the fan fits.
When securing the product, do not use screws which infringe the maximum penetration depth of 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.

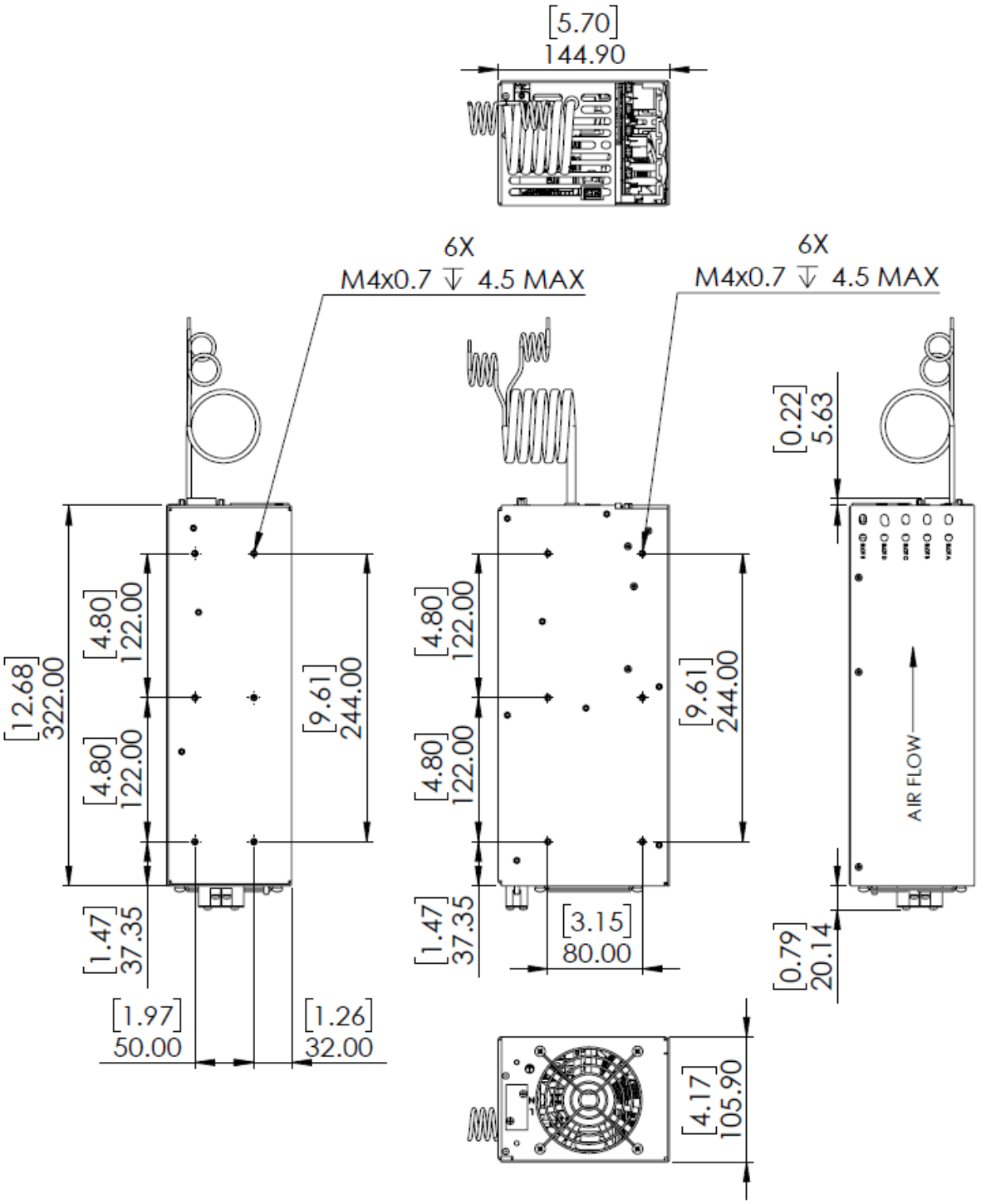


Figure 3 Basic Outline Dimensions

4.3. Electrical Installation

4.3.1. Mains Input

The power supply requires an ac input of 90V rms - 255V rms (maximum 16A rms - 10A rms), 50 - 60Hz. The ac power should be connected as indicated to the mains input terminal block. When this product is used on 180 to 253 Volts AC mains with no neutral, connect one live wire to L (live) terminal and the other live wire to N (neutral) terminal on the input connector.

DANGER: Ensure the ac power source is off before connecting the ac mains to the input terminal block.

4.3.2. Protective Earth Terminal

An M4 earth terminal is provided on the front panel. This shall be connected to mains earth or other good earth. Furthermore, connection should be made to the earth terminal before connection to the mains input terminal block.

4.3.3. HV Output

Connect the high voltage twin-core cable to the load ensuring that it is routed away from low voltage and mains wiring.

DANGER: Ensure that the ac mains is not present at the mains input terminal block before connecting/removing the HV or return leads.

4.3.4. Modular Outputs

Up to 800W of auxiliary isolated configurable power is available from 5 slots which accommodate standard CoolMod modules which 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).

4.3.5. User Interface

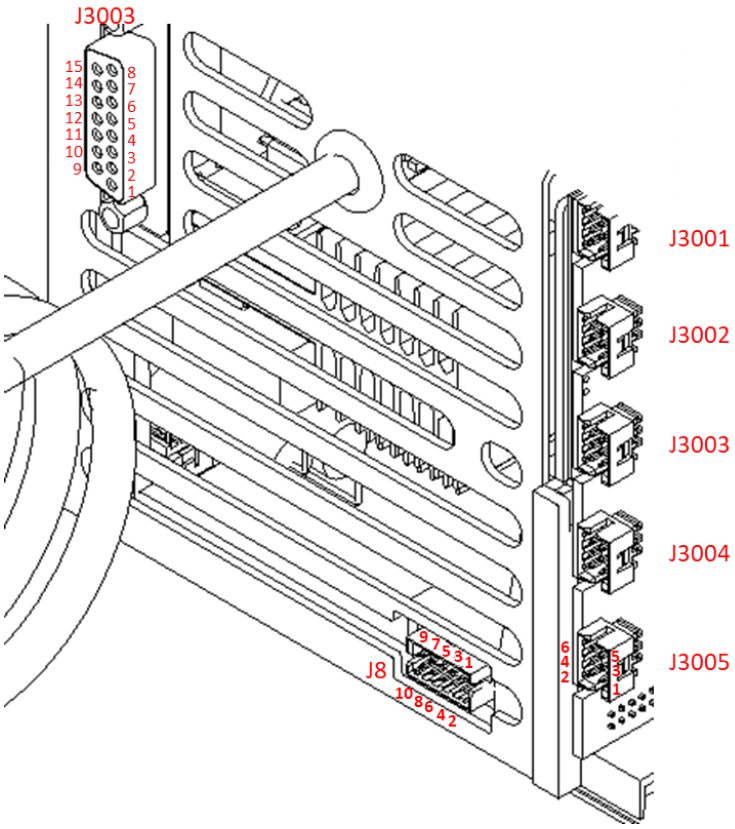


Figure 4 User interface connectors

4.3.5.1. Cap Charger Analogue Interface

The high output voltage Cap Charger user interface cable should be connected to the front panel via the 15 way female D-type connector fitted J3003 (Figure 4).

The connection details are as follows:

1	-	Inhibit
2	-	Ptrim (User power limit)
3	-	HV OTP (Over-Temperature Protection warning)
4	-	Imonitor(User output current sense)
5	-	Vprogram (Output voltage setting, 0 - 10V)
6	-	HV FAULT
7	-	VPeakHold (Peak output voltage)
8	-	Vmonitor (Voltage monitor)
9	-	+15V Aux
10	-	Not Used
11	-	+15V Aux
12	-	Not Used
13	-	End of Charge (End of charge indication)
14	-	Earth
15	-	Enable

A detailed description of the user interface functions is shown in Table 2, with a schematic shown in Figure 5.

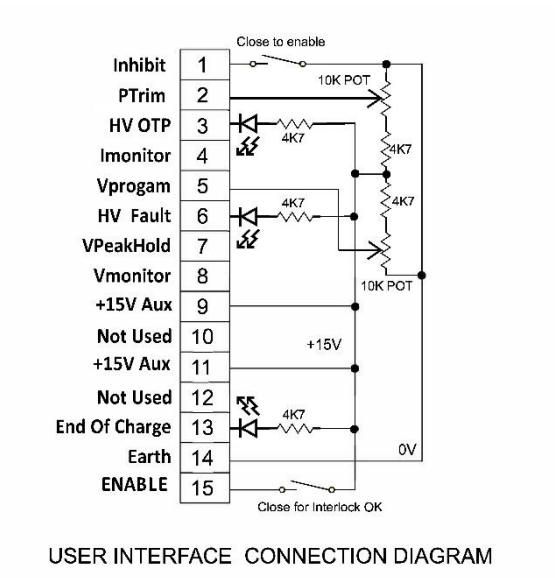


Figure 5 Cap Charger Analogue User Interface Connection Diagram

Table 2 Capacitor Charger Interface Connector

Pin no.	**Function**	**Description**
1	Inhibit	Pulled up to 15V so output disabled if open and enabled by pulling down to < 1V.
2	Ptrim	Power limit adjustment. Pulled up to 11V (43kΩ to +15V, 100kΩ to earth) if open, > 10V on this pin sets the peak charge power to 1650W, 0V decreases the peak power charge to 800W, adjustment is linear between 0V & 10V.
3	HV OTP	Over temperature protection warning. Normally 5V potentially divided from 15V with 7.5kΩ lower resistor, open-collector pulled down to < 0.1V at least 1 minute prior to over-temperature shut-down.
4	Imonitor	Output current sense signal. 0-10V signal representing average output current with gain of 1.67V/A.
5	Vprogram	Output voltage setting. User applied 0-10V signal setting the output voltage with gain of 100 (10V ≡ 1kV output). Internal input resistance of 100kΩ. The units maintains the output at the level set by 'V_PROG' when 'INHIBIT' goes low. In order to adjust the setting of the output voltage to a new level of 'Vprog_User', it is necessary to toggle 'INHIBIT'.
6	HV FAULT	Indicates that a fault has occurred: • ENABLE is low or • output over-voltage or • over-temperature or • over-current or • open load (load capacitance < 50µF). Open-collector, normally pulled up to 15V through 15kΩ internally and is pulled down to < 1V on activation.
7	VPeakHold	Peak Output Voltage. Represents the peak output voltage with gain of 0.01 (10V ≡ 1kV). A 0 to +10V ±1% signal, via < 300Ω source impedance, represents 0 to 100% of rated HV output.
8	Vmonitor	Voltage Monitor. This pin has no software dependency. Pin 8 provides a buffered signal proportional to the HV output. A 0 to +10V ±1% signal, via < 300Ω source impedance, represents 0 to 100% of rated HV output.
9, 11	+15V Aux	+15V DC source with maximum current capability of 200mA. These pins have no software dependency.
10, 12	Not Used	Not used
13	End Of Charge	End of Charge Indication. For the default settings, this open collector signal is pulled to < 1V when the HV output is > 99% of the output voltage setting. Pulled up internally to 15V via 15kΩ.
14	Earth	The return signal connection for the signals at pins 2, 4, 5, 7 and 8 should be made to pin 14. This pin connects the internal circuitry 0V to both chassis earth and the ac mains earth line.
15	Enable	This pin, having no software dependency is provided for use as part of a system interlock function. It is pulled down internally and needs to be driven high externally to > 2V for the output to be enabled. The internal resistance is 50kΩ.

4.3.5.2. Global System Signals

A global system signal connector is present on the main board, which allows the user to communicate with the PMBUS, as well as receive several warning and failure signals. This global system signal connector is J8 on the main board (Figure 4) , and the function of each pin is presented in Table 3.

Table 3 Global System Signal Connector (J8) Pinout

Pin	Name	Function	Note
1	Common	Common Ground	All signals on J8 to be referenced to this pin
2	SCL	Communications Port	
3	LV Global EN	External global enable and disable of modules	Only enables/disables modules. Does not enable/disable Capacitor Charger. Pull low to disable modules. Release/pull high to enable
4	SDA	Communications Port	
5	LV Global PG	Power Good signal for all modules	Signal to show output voltage of all modules are within desired levels. Requires external pullup resistor to 5V. Recommend 4.7kΩ. Pin is pulled low internally when power good.
6	LV AC Fail	Primary Fault status in which the modules must turn off.	Requires external pullup resistor to 5V. Recommend 4.7kΩ. Pin is pulled low internally when power good. Will give minimum 1ms warning before modules turn off if fault is loss of AC. Faults such as modular OVP and primary OCP will not give 1ms warning.
7	LV OTP	Warning that shutdown may occur due to over temperature	Requires external pullup resistor to 5V. Recommend 4.7kΩ. Pin is pulled low internally when power good. Will give minimum 1 s warning before modules turn off. However, outputs may not turn off if temperature does not rise any more.
8	HV AC Fail	Primary Fault status in which the Cap Charger output must turn off	Requires external pullup resistor to 5V. Recommend 4.7kΩ. Pin is pulled low internally when power good. No Prewarning available
9	Fan Fail	Primary Fault status in which the fan fault has occurred must turn off	Requires external pullup resistor to 5V. Recommend 4.7kΩ. Pin is pulled low internally when power good. No Prewarning available
10	+5V_Aux	Auxiliary Output_B	A 5V 3W Bias for external use by the user.

4.3.5.3. Module System Signals

As well as the global system signal connector, each module has a dedicated module signal connector used to communicate solely with that module. These connectors are present on the Communications board and are designated J1001 to J1005 (corresponding sequentially from Slot A to Slot E of the modules as shown in Figure 4). The function of each pin on a module signal connector is presented in

Table 4.

Table 4 Individual Module Signal Connectors (J100n) Pinout

Pin	Name	Function	Note
1	Common	Common Ground	All signals on connector to be referenced to this pin
2	PG	Power Good signal for module *n*	Signal to show output voltage of module *n* is within desired levels. Requires external pullup resistor to 5V. Recommend 4.7kΩ. Pin is pulled low internally when power good.
3	Common	Common Ground	All signals on connector to be referenced to this pin
4	EN	External global enable and disable module *n*	Only enables/disables module *n*. Does not enable/disable Capacitor Charger or other modules. Pull low to disable module. Release/pull high to enable.
5	Itrim	Connect voltage source to control level of current limit of module *n*	Control voltage ranges from 0V to 2.5V
6	Vtrim	Connect voltage source to control the output voltage level	Control voltage ranges from 0V to 2.5V. Output voltage will be limited to trim value set by potentiometer on module.

5 CONFIGURATION OF THE POWER SUPPLY

5.1 Input Specification

Table 5 Input Specification

Input voltage range	100 to 240Vac
Input frequency	50/60Hz
Earth leakage current	< 300µA

5.2 Modular Output Specifications

The CoolX series comprises 13 types of CoolMods. The CoolMods are output PCB based converters, with the output voltages separated from the input by Reinforced Isolation. CoolMods are available with the ratings provided in Table 6 below.

Table 6 COOLX COOLMOD VARIANTS AND SPECIFICATIONS

CoolMod variant	Vnom [V]	Vmin to Vmax [V]	OVP tracking [%] of Vset	OVP [%] Note 5	Imax [A]	Ilim [%]	Max Power [W]	
CmA	5	2.5 to 6	105 to 125	110 to 150	21.0	130 to 160	105	
CmB	12	6 to 15	105 to 125	110 to 140	15.0	120 to 140	180	
CmC	24	15 to 28	105 to 125	110 to 135	8.33	110 to 130	200	
CmD	48	28 to 58	105 to 125	103 to 115	4.17	110 to 130	200	
CmE Note 1	24	22.8 to 25.2	N/A	115 to 125	25	104 to 115	600	
CmF Note 1	48	45.6 to 50.4	N/A	115 to 125	12.5	104 to 115	600	
CmG Note 2	24	3 to 30	N/A	103 to 130	3.0	100 to 260	90	120
	24	3 to 30	N/A	103 to 130	3.0	100 to 260	90	120
CmH Note 3	5	3 to 6	N/A	130 to 170	6.0	100 to 180	36	100
	24	3 to 30	N/A	103 to 130	3.0	100 to 260	90	100
CmA-W01	5	1 to 6	105 to 125	110 to 150	21.0	130 to 160	105	
CmB-W01	12	1 to 15	105 to 125	110 to 140	15.0	120 to 140	180	
CmC-W01	24	1 to 28	105 to 125	105 to 135	8.33	110 to 130	200	
CmD-W01	48	3 to 58	105 to 125	103 to 115	4.17	110 to 130	200	
CmK Note 4	200	175 to 205	105 to 125	112 to 122	0.66	105 to 130	132	

Note 1 - CoolMod variants CmE/CmF are 3 slot wide modules which plug into slot E of the FC15M only. When a FC15M is populated with a CmE or CmF CoolMod the power supply part number will show the CmE/CmF in slot E and have slots C and D marked as unavailable by using the # symbol.
Note 2 - For CoolMod variant CmG the maximum output power of each channel is 90W, while the total combined output power of both channels must not exceed 120W.
Note 3 - For CoolMod variant CmH the maximum output power is 36W (V1 channel) and 90W (V2 channel), while the total combined output power of both channels must not exceed 100W.
Note 4 – When a CmK module is used in the same pack as a CmE or CmF module, one module slot must remain unpopulated
Note 5 – Specified as a percentage of maximum voltage

5.3 Capacitor Charger Output Specifications

The output specifications of the capacitor charger section of the FC15M are presented in Table 7 below.

Table 7 Cap Charger Output Specification

Parameter	Symbol	Min	Max	Unit
Output Voltage[Note 1]	V_{oHV}	0	1000	Vdc
Output Power	P_{oHV}	0	1650	W
Output Current [Note 2]	I_{oHV}	0	6	Adc
Capacitive loading	C_{extHV}	50	□	µF
Pulse-to-pulse repeatability		-2	2	Vdc
Output voltage adjustment accuracy[Note 3]			1	%
Output voltage drift with temperature			0.02	%/ºC
Output Power Limit Adjustment[Note 4]	P_{oHV_Max}	800	1650	W
Output Power Limit Adjustment accuracy			3	%
Turn-On Delay[Note 5]			2,000	mS
Enable Delay[Note 6]			2	mS
Disable Delay[Note 7]			1	mS

Note 1 – The output voltage is adjustable (analogue or digital), negative connected to earth/chassis
Note 2 – The power limits the maximum output current to < 6A 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 'PLim_User' according to: $P_{oHV_Max} = 800 + $ 'PLim_User' x 85 [W]
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

6 MAINTENANCE OF THE POWER SUPPLY

6.1 Replacement of components (including fuses)

Any components that are believed to be faulty must be replaced by Excelsys Technologies Ltd (see Repairs Section).

There are no operator accessible fuses to replace.

It is not permissible for the operator to replace any components (including fuses) within the power supply. Instead, the power supply must be returned for investigation, following the procedure given in the Repairs Section.

6.2 Replacement of consumables, routine maintenance of parts

There are no consumables to replace, neither are there parts that require routine maintenance, except the fans. If required, the power supply may be returned to Excelsys Technologies Ltd for recalibration (see repairs section).

It is recommended that the internal fans are replaced at periodic intervals based upon power supply usage. The fans should only be replaced by Excelsys Technologies Ltd. Follow the procedure provided in section 6.0 for the return of the unit.

6.3 Cleaning

It is recommended that should the power supply require internal cleaning it should be returned to Excelsys Technologies Ltd. The exterior of the power supply must only be cleaned with a dry lint free cloth.

6.4 Modification

No modification of this equipment is allowed.

7 REPAIR PROCESS

During the warranty periods, Excelsys Technologies Ltd will repair all PSUs free of charge, providing the PSU has not been serviced/repaired by anyone other than Excelsys Technologies Ltd personnel.
For repair it is recommended that the complete power supply/instrument be returned to:

Advanced Energy,
27 Eastgate Drive,
Little Island,
Cork,
Ireland,
T45 W950

Contact our service dept who will issue you with a “returns material authorisation” (RMA) number and advise shipping instructions.
Please ensure adequate care is taken with packing and arrange insurance cover against transit damage or loss.
NB: failure to adhere to this procedure may cause unnecessary delays or incur extra cost.

8 DOCUMENT HISTORY

ISSUE	DATE	ECO	DESIGN	SALES
Aa	20 Sept.,2022			
	Provisional release.			