EGSTON

Product Specification

SWITCHMODE BATTERY CHARGER

C2xFMW1 12/24W

FOR LITHIUM BATTERIES

Document prepared by	Distributed to
Markus Mauritz	
Responsible for technical data	**Approved**
Stefan Trethan	

1. Revision History

Edition	Date	Responsible	Reason for change
0A	25-01-2013	Trethan	Initial Draft of separate Li Specification
0B	23-04-2013	Mauritz	LED signals changed
0C	26-11-2020	Mauritz	Household and Information Technology removed
0D	28-03-2022	Mauritz	UKCA mark added, Test Standards changed

2. Sign off

Date	Company	Name	Signature

Signoff indicates that the design and function of the charger are approved. Egston is responsible for maintaining the construction of the charger so that it continues to comply with regulatory agency requirements.

3. Scope

This document describes a switch mode power supply unit (AC/DC converter) with a sub board for charging lithium batteries.

4. Electrical Specification

4.1. Input Specification

Parameter	Min	Typ.	Max	Unit	Test Cond.
Input Voltage	90		264	V	AC
Input Current	9		620	mA	
Input Frequency	47		63	Hz	
Efficiency	73		83	%	At full load
Switching Frequency		40		kHz	
Stand-by power		850		mW	Without load

Input Voltage
If the input voltage is outside the operating range, the power supply does not meet the full specification. Above the specified upper limit of the input voltage the unit may be damaged. Below the specified lower limit of the input voltage the charger does not meet the specification.

4.2. Output Specification

Parameter	Min	Typ.	Max	Unit	Test Cond.
Output Voltage	3		25.5	V	
Output Voltage Tolerance			1	%	at PCB
Output Current			2.5	A	

Parameter	Min	Typ.	Max	Unit	Test Cond.
Output Current Tolerance			10	%	CC mode
Ripple Voltage			80 100	mV_{rms}	U_{IN} = 264V U_{IN} = 90V Battery Load
Reverse Current		0.5		mA	25V battery connected, no mains input, steady-state current
Reverse Current		0.2		mA	10V battery connected, no mains input, steady-state current

The unit is long time short circuit proof.

5. Safety and Environmental Specification

Parameter	Min	Typ.	Max	Unit	Test Cond.
Dielectric Strength	3			KV_{AC}	
Operating Temperature	-5		40	°C	
	23		104	°F	
Storage Temperature	-30	25	80	°C	
	-22	77	176	°F	
Humidity			95	%	

6. Charging Profile

To achieve optimum battery performance as well as end user satisfaction it is necessary to match the charger exactly to the application. Universal chargers made for a range of different applications force the customer to accept a compromise and cut back on safety features to the lowest common denominator. Since this is not in line with EGSTON quality and performance standards we provide every application with it's own software and program each charger during final assembly.

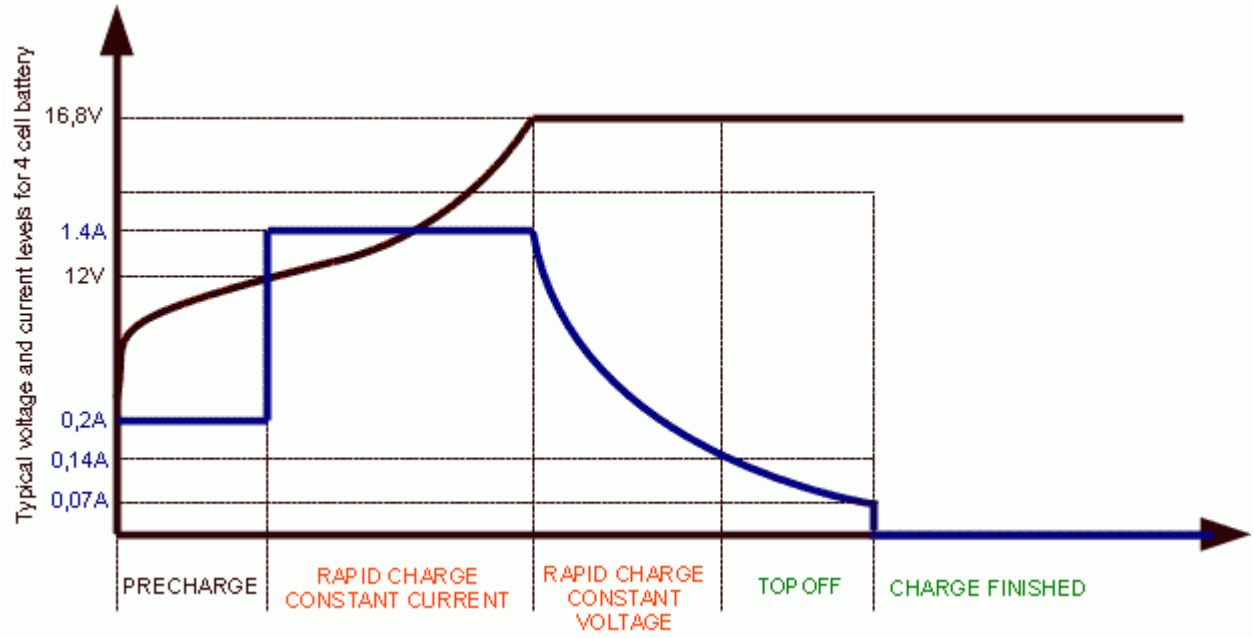
6.1. Standard Software vs. Custom Software

What we consider standard software is a charging algorithm suitable for most applications, which is configured by 29 parameters. The parameters include voltages, currents, timeouts, temperature values and LED indicator signals for the different stages in the charging process.

For some applications it is not enough to configure only the parameters of the charging algorithm. In such cases we can provide custom software which allows us to meet almost any requirement by changing the microprocessor code itself.

6.2. Standard Charge Profile

The lithium charger uses a constant current / constant voltage charging profile.
Primary charge termination is via taper current threshold.
There are precharge, wakeup, fault, and other modes to safely deal with abnormal conditions.



6.3. Charge voltages and currents

Any charge voltage between 3 and 25.5V and any charge current up to 2.5A can be configured with the standard software.

The following table gives some examples for typical lithium ion charge voltages of 4.2V per cell, however in some applications it is preferred to use 4.1V per cell to extend cycle life, or one may require a charge voltage of 3.6V per cell for lithium iron phosphate batteries.

Number of Li-ion cells	Nominal Battery Voltage	Max. Output Voltage	Max. Output Current
	V	V	A
1	3,7	4,2	2,5
2	7,4	8,4	2,5
3	11,1	12,6	1,9
4	14,8	16,8	1,4
5	18,5	21,0	1,1
6	22,2	25,2	0,9

6.4. Modes of Operation

6.4.1. RESET – CONNECTION TO MAINS

The LED indicator will briefly flash during power-up. This flash contains an encoded software ID which is detected by a light sensor during final testing to make sure your charger was programmed with the correct software.

6.4.2. STANDBY – BATTERY DETECTION

Charger waits for connection of battery.
The primary means to detect a battery is via the NTC (temperature sensor) input.
If no temperature sensor is configured the battery is detected via periodic polling.

6.4.3. POLLING

Detection of batteries without temperature sensor via very short (ms) pulse activation of the output.
As soon as current flow is detected the charger continues to precharge.
This mode also wakes up typical protection circuits if they have disabled the battery due to deep discharge.

6.4.4. PRECHARGE I

Battery voltage is below 3V.
The charger applies current pulses to the battery with an average current of 12mA until the voltage rises.

6.4.5. PRECHARGE II

Battery voltage is between 3V and a programmable rapid charge minimum voltage (typically 3V times the number of cells). Freely programmable output precharge current is applied to the battery. Should the voltage not rise within a programmable time the charger will enter fault mode.

6.4.6. CHARGE PENDING

Battery temperature is either very low (typically below 0°C) or very high (typically over 40°C), programmable temperature limits, timeout and LED signal, charge current switched off.

6.4.7. RAPID CHARGE CONSTANT CURRENT / CONSTANT VOLTAGE

Programmable output current and voltage are applied to the battery, the charger works as a CC/CV source.
Rapid charge is terminated once the current has tapered to a programmable limit, typically C/10.
The battery temperature is monitored for abnormal conditions (if sensor is present).
Maximum charge timeout can also be configured, after which a fault is indicated.

6.4.8. TOPOFF

Some applications demand "battery full" indication to the user before the state of charge has reached 100% to avoid long waiting times for just the last few percent of capacity. Topoff mode allows for a higher rapid charge termination current to be programmed, while the charge is finished during topoff mode to either the topoff taper current or unti the timeout has elapsed.

6.4.9. CHARGE FINISHED

The battery is full and the charger output switched off.
Once the battery voltage drops below a prgrammable limit the charge cycle is started again.

6.4.10. FAULT I

Charger is switched off because of high battery temperature, or expired timeout.
Unplug the battery to restart.

6.4.11. FAULT II

Charger is switched off because of excessive battery voltage.
Unplug from mains to restart.

6.5. Battery types

The charger is suitable to charge any rechargeable lithium battery or any other battery that can be charged with a CC/CV taper current cutoff algorithm. There are separate charge algorithms for Ni based batteries, and lead acid batteries.

6.6. Thermistor

A thermistor inside the battery pack can be used to measure battery temperature as a safety feature and to avoid charge during unacceptable conditions. It is connected between the thermistor output of the charger and battery negative.

Typically a NTC resistor of 10k and beta value of 3380 is used, but both values are programmable to match the temperature sensor already present in the battery pack.

6.7. Voltage drop compensation

The voltage drop on the output leads of the charger is compensated during rapid charge. This ensures that charge time is minimised, especially for batteries with low impedance.

For temperature measurement the voltage drop in the negative lead, which is used as a return for the NTC resistor connection, is also compensated for in software to minimise measurement errors.

6.8. LED signals

There is a single LED indicator with red/green LED in the charger. The two colours can be mixed to produce amber light, and various flashing light patterns are also available.

6.8.1. Examples of typical patterns used

Standard

Condition	LED Color
Rapid Charge	AMBER
Charge Complete	GREEN
Precharge	FLASHING AMBER
Charge Pending	FLASHING RED
Charge Failure	RED
No AC/Standby	OFF

Medical

Condition	LED Color
Rapid Charge	GREEN 50/50
Charge Complete	GREEN
Precharge	GREEN 10/90
Charge Pending	GREEN 10/90
Charge Failure	RED
No AC/Standby	OFF

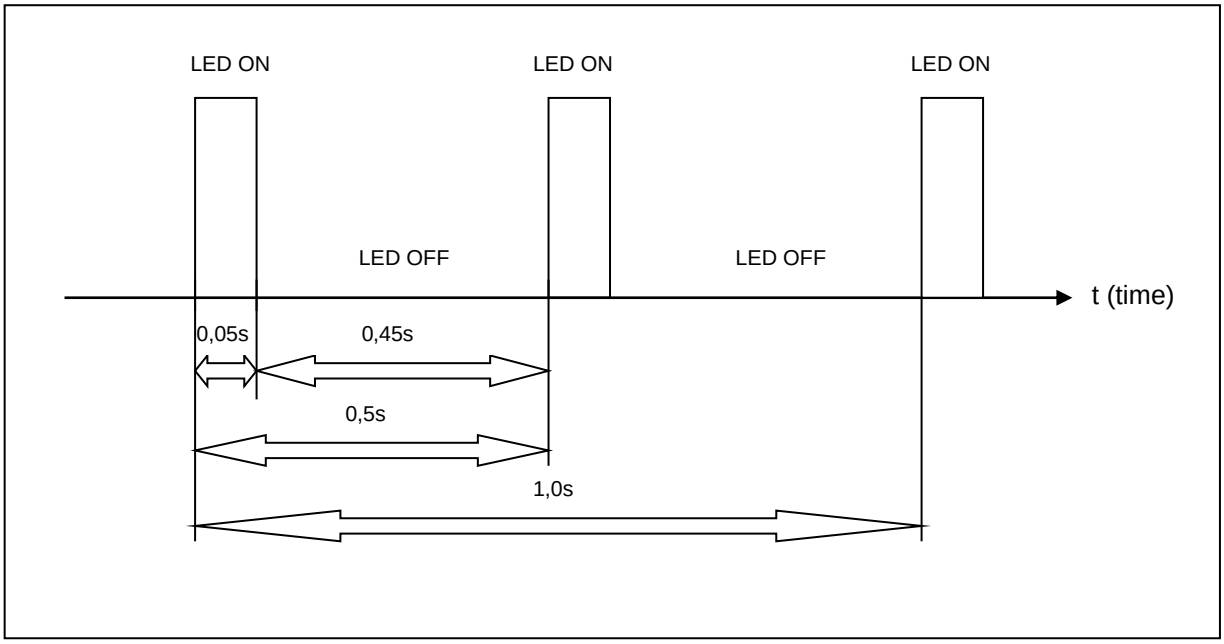
6.8.2. Selection of standard LED patterns

Visible Colour	Green LED	Red LED
Dark	OFF	OFF
Green	ON	OFF
Red	OFF	ON
Amber	ON	ON
Flashing Red	OFF	0,5 sec ON / 1 sec (50/50)
Flashing Amber	0,25 sec ON / 1 sec (25/75)	0,25 sec ON / 1 sec (25/75)
Flashing Green	0,5 sec ON / 1 sec (50/50)	OFF
Fast Flashing Green	0,05 sec ON / 0,5 sec (5/45)	OFF
Flashing Green, low duty cycle	0,1 sec ON / 1 sec (10/90)	OFF

It is possible to create other patterns as required.

Schematical Example for cycle time:

Example for: 0,05 sec ON / 0,5 sec (5/45)



There are two types of LED lens available, the standard lens and the high diffusion lens. It is recommended to order the high diffusion lens for products using amber light to optimise light mixing and achieve a pleasing appearance.

6.9. Remote LED

Many applications benefit from mounting a state of charge indicator LED directly inside the battery pack, powered device, or charge cradle because it is more easily visible to the user. The remote LED can be connected to a dedicated output on the charger which powers it from 3V via a 330 Ohm resistor. The use of a low current/high brightness LED is recommended.

6.10. Auxiliary Power

It is possible to supply a a load directly from the charger with a separate wire, to avoid draining the battery while mains power is available. There are some limitations on the voltage that can be supplied since this output must be tapped from the same source as the charge current.

6.11. Configuration File Example

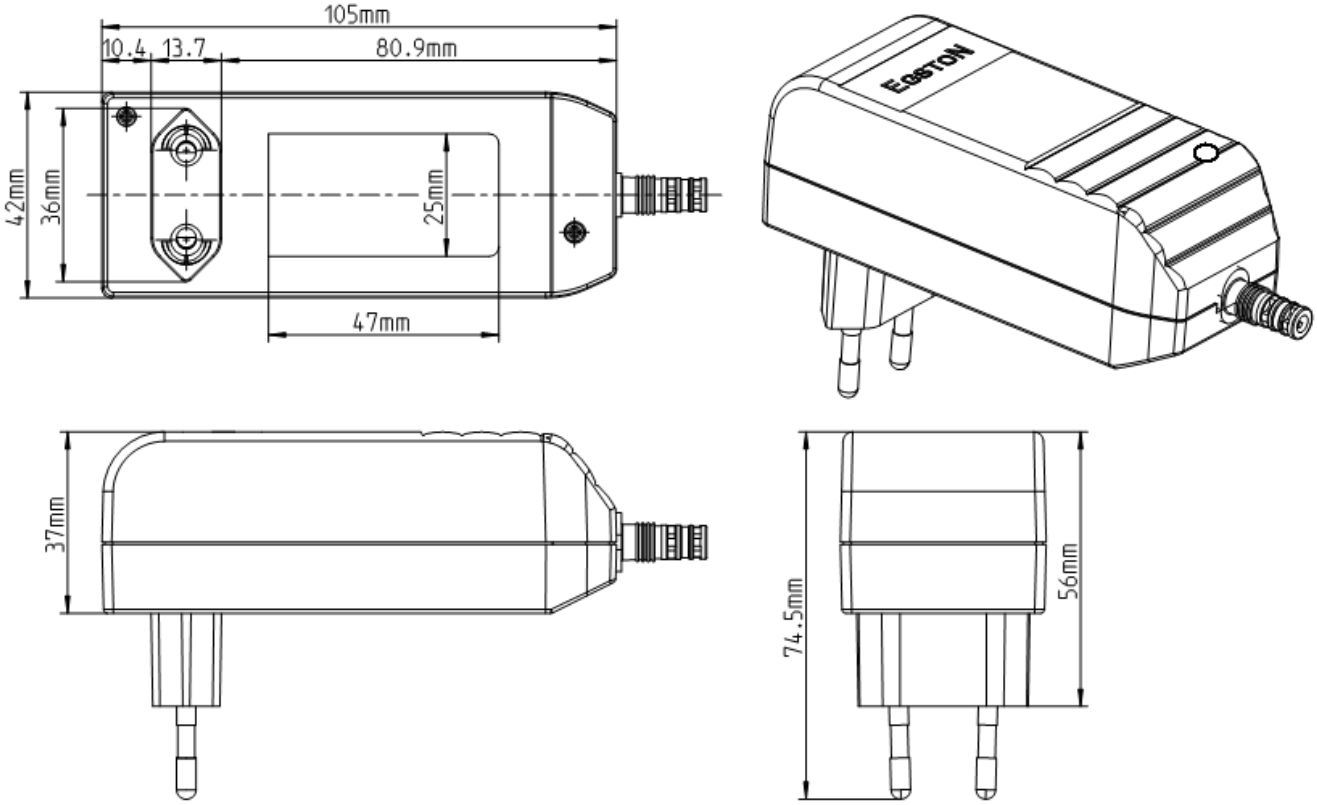
A configuration file is used to enter the parameters for standard software.
EGSTON will set up the configuration according to your specification.

```
; configuration for Li charger

; software ID (16 Bit)
.equ charger_ID         = 164   ; unique software identification number

; currents (mA)
.equ c_rapid            = 1500  ; rapid charge current
.equ c_precharge_2      = 150   ; precharge 2 current
.equ c_rapid_term       = 100   ; terminate rapid charge below this current
.equ c_topoff_term      = 50    ; terminate topoff charge below this current

; voltages (V)
#define v_nominal      14.4     ; nominal voltage (CV output)
#define v_precharge_2  2.9      ; precharge 2 above this voltage
#define v_rapid_charge 8        ; rapid charge above this voltage
#define v_restart      14       ; restart below this voltage
#define v_max          15       ; overvoltage fault above this voltage (at charger, allow for cable compensation)
.equ r_cable            = 110   ; cable resistance (mOhm) for voltage drop compensation

; times (minutes)
.equ t_precharge_1      = 60    ; precharge 1 timeout (--> fault)
.equ t_precharge_2      = 60    ; precharge 2 timeout (--> fault)
.equ t_pending          = 60    ; charge pending (temperature) timeout (--> fault)
.equ t_rapid            = 160   ; rapid charge timeout (--> fault)
.equ t_topoff           = 0     ; topoff timeout (--> charge done)

; temperatures (°C)
.equ n_NTC              = no            ; NTC temperature sensor present (yes/no)
.equ tp_beta            = 4300          ; beta of NTC
.equ tp_r_spec          = 10000         ; nominal NTC resistance
.equ tp_t_spec          = 25            ; temperature at which NTC is specified
.equ tp_pre_min         = 0             ; no charge below this temperature
.equ tp_rapid_min       = 10            ; precharge below this temperature
.equ tp_rapid_max       = 30            ; rapid charge does not start above this temperature
.equ tp_max             = 50            ; max. temperature (--> fault)

; LED signals
.equ s_precharge        = green01       ; precharge signaling
.equ s_pending          = green01       ; charge pending signaling
.equ s_rapid            = green05       ; rapid charge signaling
.equ s_topoff_done      = green         ; topoff, maintainance, charge complete signaling
.equ s_fault            = green005      ; fault signaling

; off
; red ; green ; amber = continuous light
; green05       = 0,5/1s,
; green005      = 0,05/0,5s,
; green01       = 0,1/1s,
; red05         = 0,5/1s,
; amber025      = 0,25/1s
```

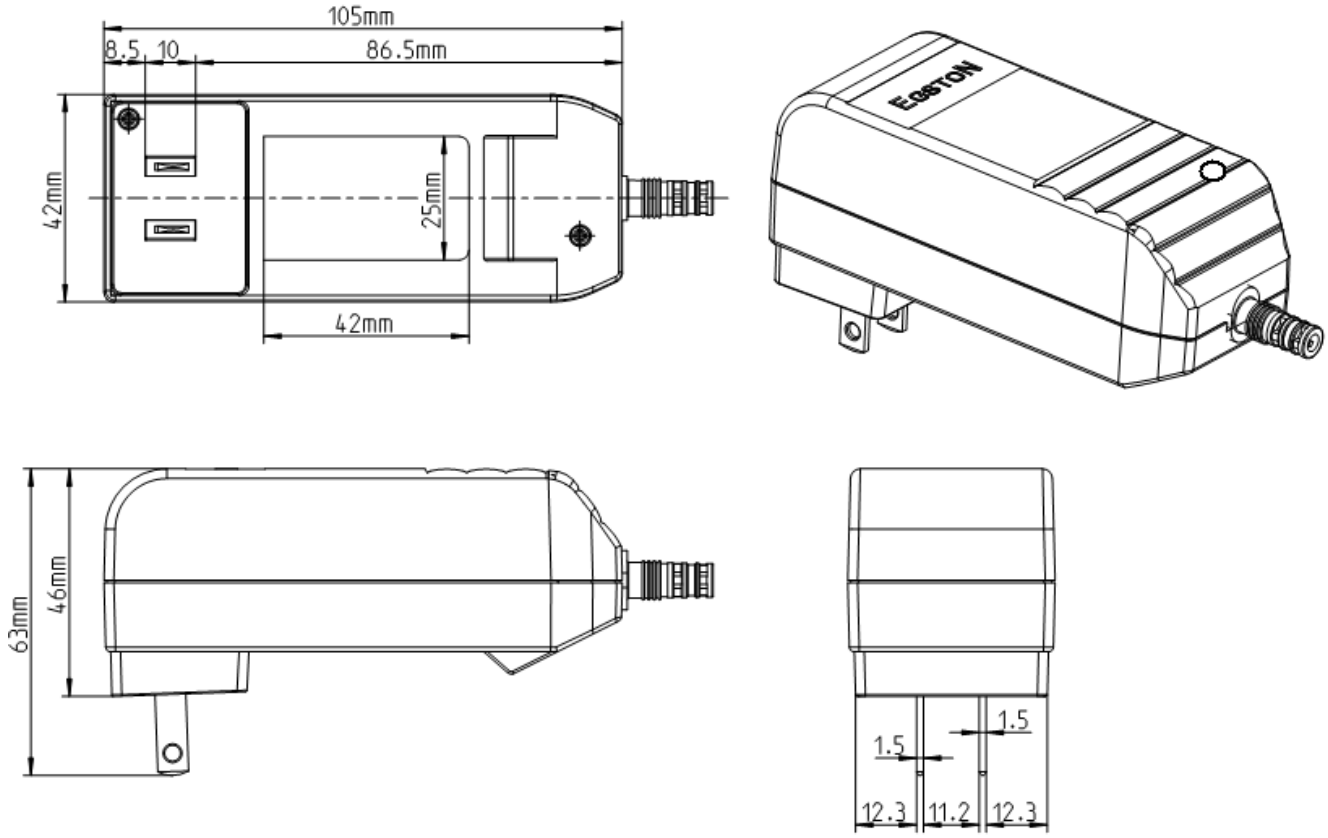
7. Mechanical Specification

7.1. Housing dimensions

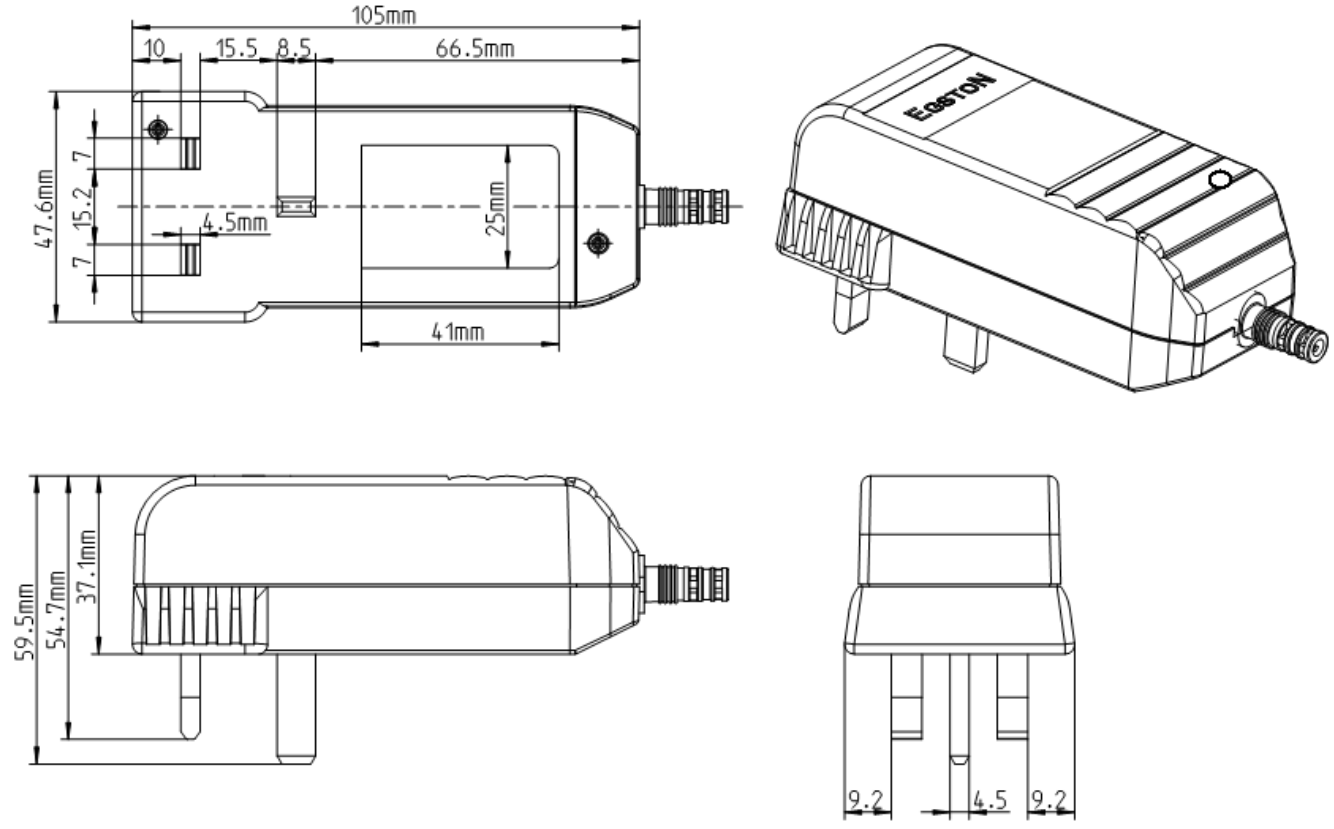
7.1.1. Euro plug-in enclosure



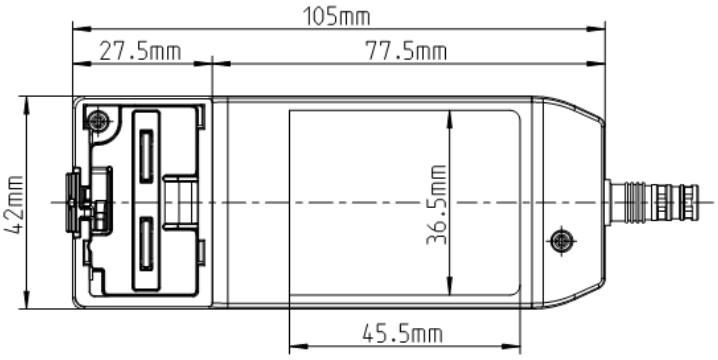
7.1.2. US plug-in enclosure

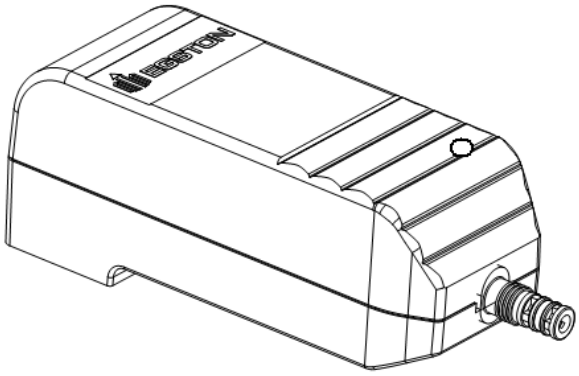


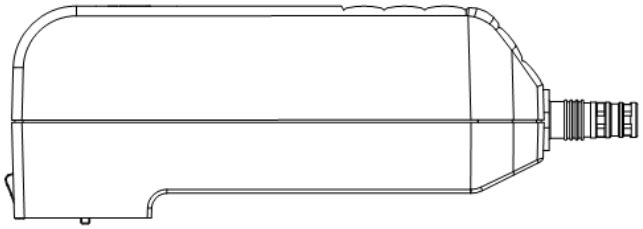
7.1.3. UK plug-in enclosure

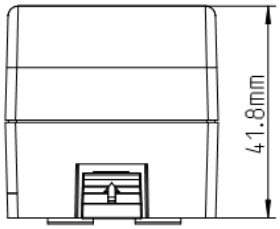


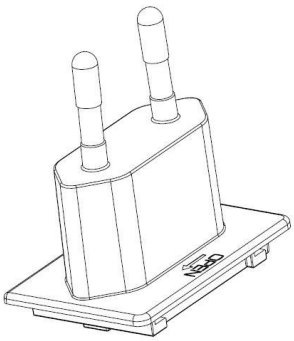
7.1.4. Changeable Plug enclosure



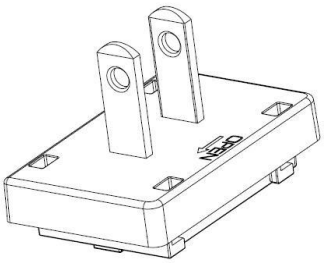




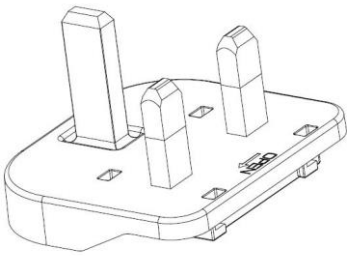




EU Plug according: EN50075

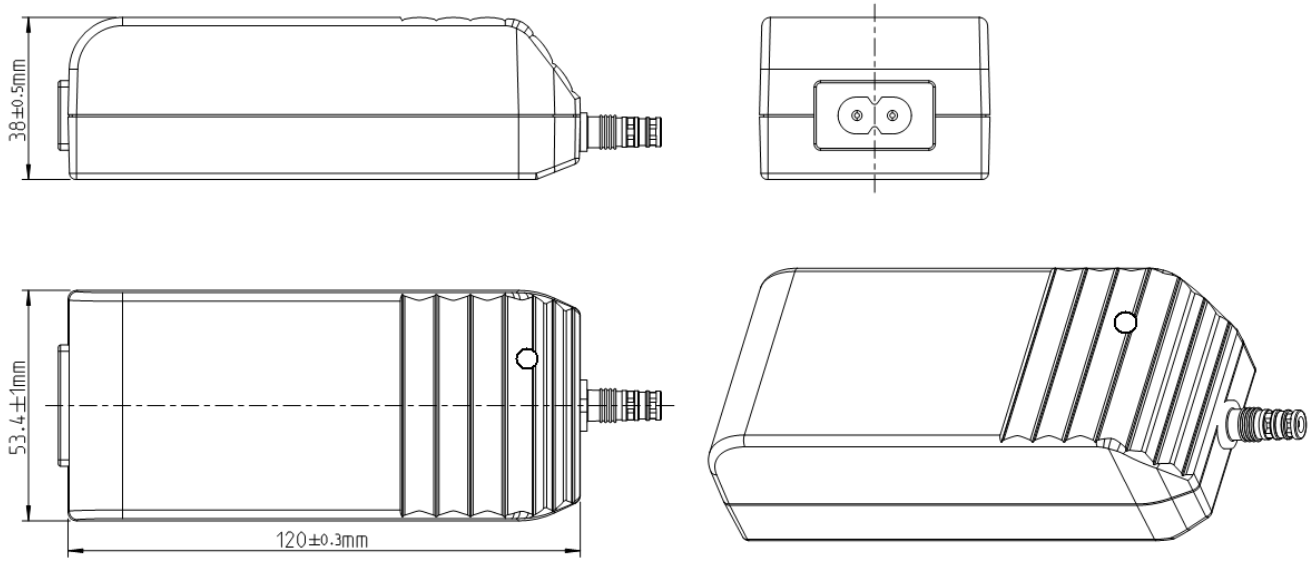


US Plug according: UL1310

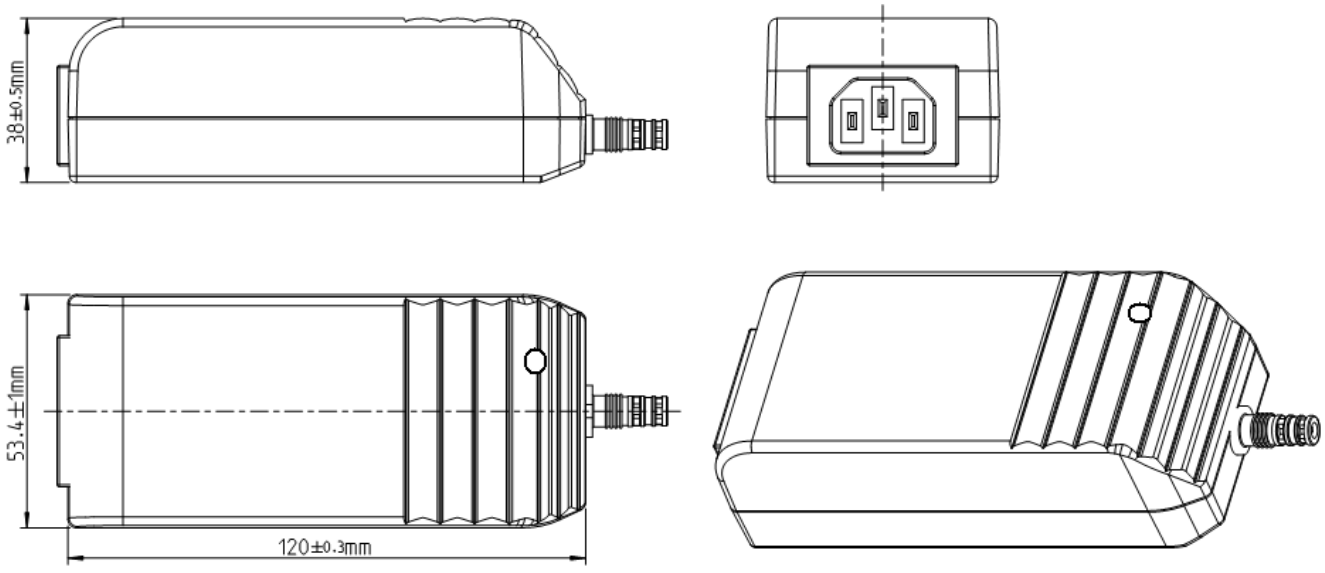


UK Plug according: BS1363

7.1.5. Desktop enclosure IEC 320 C8 primary plug



7.1.6. Desktop enclosure IEC 320 C14 primary plug



7.1.7. Open Frame Module

The charger PCB can also be supplied as an open frame module.

7.2. Housing Material

PA or PBT, black.

7.3. Laser marking on the housing

Product name
Input parameters
Output parameters
Safety instructions
Date code of production
CE marking
Approval marks

7.4. Cable and connector

There is a selection of EGSTON standard cables with different connectors to choose from, or any customer specific connector can be fitted on request.

8. Production Testing

The charger is equipped with a one-time-only testmode to allow accurate testing of all functions. Automated equipment verifies the current and voltage parameters to ensure they meet specification. In addition the software ID encoded in the power-up LED flash is read electro-optically to make sure the correct software is programmed into the unit and the LEDs are operational. The testing is done with automated equipment and the results are recorded in a protocol file. After one execution the testmode is disabled and the charger is ready for normal use.

EMC – Special requirements according medical standard	
Intended use and intended environment	Home healthcare and/or Professional environment
Basic safety and essential performance of the EUT	The power supply unit is not a medical end product, therefore no essential performance is defined by the manufacturer.
Basic safety regarding EMC	The power supply has to ensure proper output voltage according to its characteristics, without service within expected service life.
WARNINGS	Medical electrical equipment needs special precautions regarding EMC and needs to be installed according to EMC information.
	PE of power supply shall be connected to PE of end medical product. User shall not modify power supply.
	The switch mode power supply is designed to achieve the EMI behavior of the specified environment, it includes specific EMI filter to reduce the emissions which are specified in the IEC60601-1-2 standard.
	Please read the complete technical documentation to avoid adverse events to the patient and operator. Read also instructions for use.

EMC - Environment

The power supply is intended for use in the electromagnetic environment specified below. The customer or the user of the power supply should assure that it is used in such an environment.

Emissions test	Compliance	Electromagnetic environment - guidance
RF emissions CISPR 11	Group 1	The power supply uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
RF emissions CISPR 11	Class B	The power supply is suitable for use in all establishments, including domestic establishments and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Harmonic emissions IEC 61000-3-2	Complies	
Voltage fluctuations / flicker emissions IEC 61000-3-3	Complies	

Immunity test	EN 60601-1-2:2015 test level	Achieved levels according EN 60601-1-2:2015 and achieved levels from additional standards.	Electromagnetic environment - guidance
Electrostatic discharge (ESD) IEC 61000-4-2	± 8 kV contact ±2 kV, ± 4 kV, ± 8 kV, ± 15 kVair	± 8 kV contact ±2 kV, ± 4 kV, ± 8 kV, ± 15 kVair	Floors should be wood, concrete or ceramic tile. If floors are covered with synthetic material, the relative humidity should be at least 30%.
Electrical fast transient/burst IEC 610004-4	± 2 kV 100 kHz repetition frequency	± 2 kV (mains input), 100 kHz ± 2 kV (DC output), 5 kHz	Mains power quality should be that of a typical commercial or hospital environment.
Surge IEC 61000-4-5	Line-Line:± 0,5 kV, ± 1 kV	Line-Line:± 0,5 kV, ± 1 kV	Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	0 % Ut; 0,5 cycle At 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315° 0 % Ut; 1 cycle and 70 % Ut; 25/30 cycles Single phase: at 0° 0 % Ut; 250/300 cycle	0 % Ut; 0,5 cycle At 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315° 0 % Ut; 1 cycle and 70 % Ut; 25/30 cycles Single phase: at 0° 0 % Ut; 250/300 cycle	Mains power quality should be that of a typical commercial or hospital environment. If the user of the power supply requires continued operation during power mains interruptions, it is recommended that the power supply is powered from an uninterruptible power supply or battery.
Power frequency (50/60 Hz) magnetic field IEC 61000-4-8	30 A/m	1, 3, 30 A/m	Power should be at levels characteristic of frequency magnetic fields a typical location in a typical commercial or hospital environment.

Conducted RF IEC 61000-4-6	6 Vrms 150 kHz to 80 MHz	6 Vrms	Portable and mobile RF communications equipment should not be used closer to any part of the power supply, including cables, than the recommended separation distance. Recommended separation distances see following table.
Radiated RF IEC 61000-4-3	10 V/m 80 MHz to 2.7 GHz	10 V/m	

Field strengths from fixed transmitters such as base stations for radio (cellular/cordless) telephones, land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast, cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters an electromagnetic site survey should be considered. If the measured field strength in the location in which the power supply is used, exceeds the applicable RF compliance level above, the power supply should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the power supply.

Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey should be less than the compliance level in each frequency range. Over the frequency range 150 kHz to 80 MHz, field strength should be less than 3 V/m.

Interference may occur in the vicinity of equipment marked with the following symbol:

Proximity fields from RF wireless communications equipment IEC 61000-4-3

Frequency range and Level: RF wireless communication equipment

Test Frequency (MHz)	Modulation	Immunity Level (V/m)
385	**Pulse Modulation: 18Hz	27
450	*FM ±5Hz deviation: 1kHz sine	28
710 745 780	**Pulse Modulation: 217Hz	9
810 870 930	**Pulse Modulation: 18Hz	28
1720 1845 1970	**Pulse Modulation: 217Hz	28
2450	**Pulse Modulation: 217Hz	28
5240 5500 5785	**Pulse Modulation: 217Hz	9

Supplementary information:

EUT powered at one of the nominal input voltages and frequencies.

Dwell time minimum 1s. Actual dwell time noted in results table.

Note * - As an alternative to FM modulation, 50% pulse modulation at 18Hz may be used because while it does not represent actual modulation, it would be worst case.

Note ** - The carrier shall be modulated using 50% duty cycle square wave signal.

Recommended separation distances between portable and mobile RF communications equipment and the power supply			
The power supply is intended for use in the electromagnetic environment in which radiated RF disturbances are controlled. The customer or the user of the power supply can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the power supply as recommended below, according to the maximum output power of the communication equipment.			
Rated maximum output power of transmitter (W)	Separation distance according to frequency of transmitter (m)		
	150 kHz to 80 MHz $d = 1.2\sqrt{P}$	80 MHz to 800 MHz $d = 1.2\sqrt{P}$	800 MHz to 2.5 GHz $d = 2.3\sqrt{P}$
0.01	0.12	0.12	0.23
0.1	0.38	0.38	0.73
1	1.2	1.2	2.3
10	3.8	3.8	7.3
100	12	12	23
For transmitters rated at a maximum output power not listed above, the recommended separation distance d in metres (m) can be determined using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer. NOTE 1 At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies. NOTE 4 These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.			

9. Reliability

MTBF can be calculated on request.

10. Maintainability

The power supply is not to be repaired.

11. Temperature cycle test

During quality approval the unit passed the EGSTON standard temperature cycle test.

12. Dielectric Strength

The input isolation test voltage is
3kV 50/60 Hz for standard and household applications / 4KV 50/60Hz for medical application, sinusoidal waveform.
Test duration is 2 seconds for 100% test, 1minute for lot-test.

13. Single Component Failure

A single component failure does not cause any damage to persons or ambient (fire, explosions, etc).

14. Approvals and test standards

14.1. General

The device is galvanically isolated with safety extra low voltage (SELV) output.

14.2. Test Standards

EN 55032 EN 55035 EN 60601-1-2	**General EMC standards**
EN 60601-1* UL 60601-1	**Medical electrical equipment**

* IEC 60601-1 2nd edition fulfills all parameters within this specification.
IEC 60601-1 3rd edition max 30°C ambient or full ambient temperature with max output power 15W.

14.3. Approvals

Housing	Medical electrical equipment
EU, UK:	CE UKCA
US, Canada:	 CE
Desktop	 CE UKCA
Changeable plug:	 CE UKCA

 C/US NRTL recognized approval issued by UL

CE Conformity with the EU low voltage directive and EMC directive

UKCA Conformity with the relevant UK regulations.

15. Ordering Information

C 2 _ F _ W _ _ _ _ _

Options:
- F Functional Earth
- W Waterproof

Voltage Tolerance:
- 3 3% on PCB
- 1 1% on PCB

Application Area:
- M Medical electrical device

Housing:
- E Euro Plug-In
- U US, Canada Plug-In
- G United Kingdom Plug-In
- A Australia Plug-In
- C Changeable Plug
- D Desktop
- O Open Frame

16. Packaging and weight

C2EFMW3 30W	pcs	kg	size
Single Carton	1	0,2	135x74x44
Power Supply per Packaging Case	50	10	406x286x247
Power Supply per Layer (EU- Pallet) 8 Packaging cases	400	80	1200x800x247
1 Full Pallet (6 Layer)	2400	500	1200x800x1500

C2GFMW3 30W	pcs	kg	size
Single Carton	1	0,22	135x74x49
Power Supply per Packaging Case	50	11	406x286x272
Power Supply per Layer (EU- Pallet) 8 Packaging cases	400	88	1200x800x272
1 Full Pallet (5 Layer)	2000	460	1200x800x1500

C2UFMW3 30W	pcs	kg	size
Single Carton	1	0,2	135x74x44
Power Supply per Packaging Case	50	10	406x286x247
Power Supply per Layer (EU- Pallet) 8 Packaging cases	400	80	1200x800x247
1 Full Pallet (6 Layer)	2400	500	1200x800x1500

C2CFMW3 30W	pcs	kg	size
Single Carton (including Power Supply and 4 Adapters)	1	0,3	210x74x50
Power Supply per Packaging Case	25	7,5	406x286x272
Power Supply per Layer (EU- Pallet) 8 Packaging cases	200	60	1200x800x272
1 Full Pallet (5 Layer)	1000	300	1200x800x1500

C2DFMW3 30W	pcs	kg	size
Single Carton	1	0,22	150x74x49
Power Supply per Packaging Case	50	11	460x366x255
Power Supply per Layer (EU- Pallet) 9 Packaging cases	450	120	1200x800x460
1 Full Pallet (3 Layer)	1350	318	1200x800x1500