Features

- Very low profile
- Very high efficiency (typically 90%)
- Single and dual output versions
- Input voltages from 24V to 110VDC nominal
- Output voltages from 5V to 48VDC
- -40°C to +71°C operation without de-rating
- 3U euro cassette suitable for rack or chassis mounting
- Active current sharing for parallel operation
- EN50155 and EN50121-3-2 compliant

Description

The SRE series is a very low profile and rugged converter designed specifically for use on railway rolling stock. Rated at 120W, units are available in single or dual output configurations with input ranges to cover all those typically found in rail applications. The unit is suitable for either rack or bulkhead mounting. The range is fully compliant with current international railway standards and norms.

Table of Contents

Model selection - quick guide

The following tables list the input and output configurations that are available as standard for the SRE series. Other versions may be available on request; please consult with the factory.

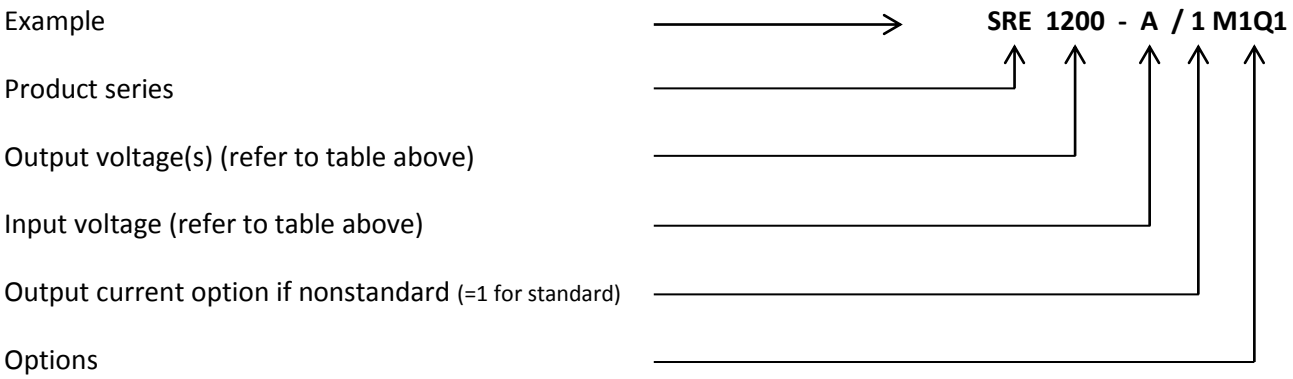
Part Number	Output 1 Single		Output 2 Dual	
	$V_{o\ nom}$ [V]	$I_{o\ nom}$ [A]	$V_{o\ nom}$ [V]	$I_{o\ nom}$ [A]
SRE 0500	5	16[1]	-	-
SRE 1200	12	10	-	-
SRE 1500	15	8	-	-
SRE 2400	24	5	-	-
SRE 3600	36	3.3	-	-
SRE 4800	48	2.5	-	-
SRE 1212	12	5	12	5
SRE 1515	15	4	15	4
SRE 2424	24	2.5	24	2.5

Notes:
1. 20A peak for 5 seconds.

Suffix	Input Nominal	Input Range
	$V_{i\ nom}$ [V]	$V_{i\ op}$ [V]
A	110	77.0 - 137.5
D	72	50.0 - 90.0
C	52	36.0 - 65.0
F	36	25.0[1] - 45.0
B	24	16.0 - 30.0

Notes:
1. Operation at 23.0V input is possible at maximum ambient (71°C) and 100W output load continuously, or at maximum ambient and 120W load for 10 minutes.

Part numbering and ordering information



M1 = Additional mounting plate
Q1 = Additional heatsink
Q4 = Additional front panel & handle for rack mounting
Please refer to Mechanical options for further information.

Input Parameters

The SRE series caters for all nominal voltages of equipment, including supply voltage variations, as defined in EN50155.

Standard Input *(consult factory for custom inputs)*			Suffix B			Suffix F			Suffix C			Suffix D			Suffix A			Unit
Parameter		Condition	min	nom	max	min	nom	max	min	nom	max	min	nom	max	min	nom	max	
$V_{i\,op}$	Input voltage Range		16	24	30	25[1]	36	45	36	52	65	50	72	90	77	110	138	V
$V_{i\,min}$	Input voltage Minimum	100ms	14.4			21.6			31.2			43.2			66.0			V
$V_{i\,abs}$	Input voltage Abs Max	1s			34			51			73			101			154	V
$V_{i\,off}$	Turn on Voltage		12.5		16	21.5		25	31		36	43		50	66		77	V
$V_{i\,on}$	Turn Off Voltage				14.4			21.6			31.2			43.2			66	V

Notes:
1. Operation at 23.0V input is possible at maximum ambient (70°C) and 100W output load continuously, or at maximum ambient and 120W load for 10 minutes.

No load power consumption

		Suffix A 110V	Suffix D 72V	Suffix C 52V	Suffix F 36V	Suffix B 24V	Unit
Output model	Condition	Typical	Typical	Typical	Typical	Typical	
SRE Single	I_o =0 $V_{i\,nom}$ Tc_{room}	2	1.5	1.3	1.0	0.8	W
SRE Dual	$I_{o\,max}$ $V_{i\,nom}$ Tc_{room}	2.3	1.8	1.5	1.2	1.0	W

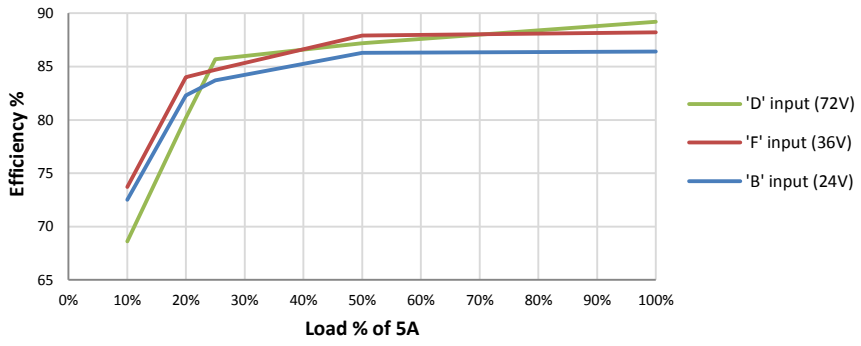
Notes:
Tc_{room} = 15 to 25°C

Efficiency data

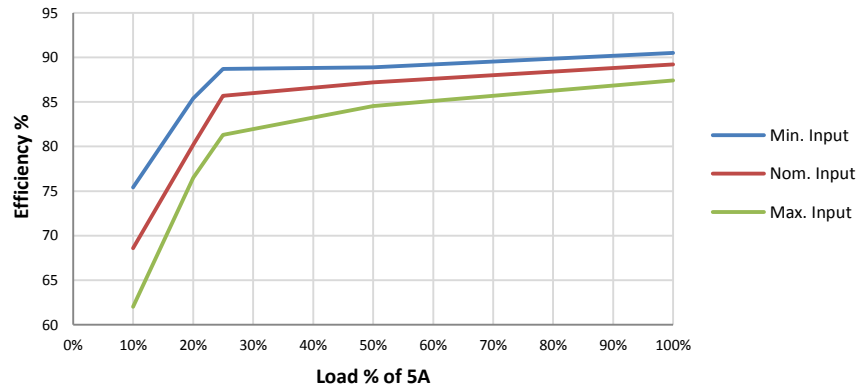
		Suffix A 110V	Suffix D 72V	Suffix C 52V	Suffix F 36V	Suffix B 24V	Unit
Output model	Condition	Typical	Typical	Typical	Typical	Typical	
SRE 0500	$I_{o\,max}$ $V_{i\,nom}$ Tc_{room}	82	83	82	81	80	%
SRE 1200	$I_{o\,max}$ $V_{i\,nom}$ Tc_{room}	88	89	88	87	86	%
SRE 1500	$I_{o\,max}$ $V_{i\,nom}$ Tc_{room}	88	89	88	87	86	%
SRE 2400	$I_{o\,max}$ $V_{i\,nom}$ Tc_{room}	88	90	90	89	87	%
SRE 3600	$I_{o\,max}$ $V_{i\,nom}$ Tc_{room}	88	90	90	89	87	%
SRE 4800	$I_{o\,max}$ $V_{i\,nom}$ Tc_{room}	89	91	91	90	88	%
SRE 1212	$I_{o\,max}$ $V_{i\,nom}$ Tc_{room}	87	87	87	86	86	%
SRE 1515	$I_{o\,max}$ $V_{i\,nom}$ Tc_{room}	88	89	88	87	85	%
SRE 2424	$I_{o\,max}$ $V_{i\,nom}$ Tc_{room}	90	91	90	88	87	%

Typical performance figures for the SRE series efficiency vs. operating points are shown below.

Efficiency vs. Load at nominal input voltages (Data for 24V output models)



Efficiency vs. input voltage (Data for 72V input, 24V output model)



Inrush current

The high frequency electronics allow the use of relatively low capacity bulk storage capacitors in the converter's input circuitry in order to minimise inrush current. This allows the use of fast acting input protection fuses or circuit breakers (see table on page 8). The absolute level of inrush current is determined by the source impedance. As a guide to the duration of the inrush surge, if the total impedance limits the current to 25 times the full load input current at $V_{i\ nom}$, the duration will be <0.5ms if maximum input voltage is applied.

Supply interruptions (hold-up time)

The SRE series is designed to operate down to $0.6V_{i\ nom.}$ for 100ms as defined by EN50155 Class C1 and will operate at this voltage indefinitely but with correspondingly higher input current. However, if operation at this voltage lasts for longer than 1s, full regulation is not guaranteed.

All versions are suitable for use with an additional HM100 hold-up module if 10ms hold-up time is required to meet EN50155 Class S2.

Input under voltage shutdown

The input is provided with under voltage lockout protection. This shuts down the electronics, and limits the power drawn from the input supply to significantly less than the no load power consumption figures quoted on page 3, when the input drops below $0.6V_{i\ nom}$. When the supply recovers to typically $0.65V_{i\ nom}$, the output will be restored. Sufficient hysteresis is provided between the stop and start thresholds in order to prevent on/off oscillation in most applications. However, low input versions with long supply leads may need careful attention to cabling design to prevent any occurrence.

Input ripple

Input ripple voltage of ±15% of mean input voltage can be accommodated, subject to the peaks or dips not exceeding the input range, with no loss of output performance.

Output Parameters: SRE Single

Standard Output - Single *(consult factory for custom outputs)*			SRE 0500			SRE 1200			SRE 1500			Unit
Parameter		Condition	min	nom	max	min	nom	max	min	nom	max	
$V_{o\ nom}$	Output voltage set point	$V_{i\ nom}$ $I_{o\ 50\%}$ Tc_{room}	5.02	5.05	5.08	11.93	12.0	12.07	14.90	15.0	15.10	V
$V_{o\ op}$	Regulation across full operation	$V_{i\ op}$ I_o = 0% - $I_{o\ max}$ Tc_{min} - Tc_{max}	4.95		5.15	11.76		12.24	14.70		15.30	V
$V_{o\ ovp}$	Over voltage		5.5		6.5	12.6		14.7	15.7		18.2	V
$V_{o\ rip}$	Output ripple	$I_{o\ max}$ $V_{i\ nom}$ Tc_{min} - Tc_{max}			50			120			150	mV
$V_{o\ no}$	Output HF noise	$I_{o\ max}$ $V_{i\ nom}$ Tc_{min} - Tc_{max} *0.5 - 20MHz*			50			100			120	mV
$I_{o\ nom}$	Output current	$V_{i\ nom}$ Tc_{min} - Tc_{max}		16	20[1]		10			8		A
$I_{o\ lim}$	Output Current Limit	$V_{i\ min}$ Tc_{min} - Tc_{max}	20.5		22.0	10.2		11.2	8.2		9.1	A

Notes:
1. 20A peak for 5 seconds.
2. Tc_{room} = 15 to 25°C

Standard Output - Single *(consult factory for custom outputs)*			SRE 2400			SRE 3600			SRE 4800			Unit
Parameter		Condition	min	nom	max	min	nom	max	min	nom	max	
$V_{o\ nom}$	Output voltage set point	$V_{i\ nom}$ $I_{o\ 50\%}$ Tc_{room}	23.86	24.0	24.14	35.79	36.0	36.21	47.71	48.0	48.29	V
$V_{o\ op}$	Regulation across full operation	$V_{i\ op}$ I_o = 0% - $I_{o\ max}$ Tc_{min} - Tc_{max}	23.52		24.48	35.28		36.72	47.04		48.96	V
$V_{o\ ovp}$	Over voltage		24.5		28.0	38.0		43.0	49.0		56.5	V
$V_{o\ rip}$	Output ripple	$I_{o\ max}$ $V_{i\ nom}$ Tc_{min} - Tc_{max}			240			360			480	mV
$V_{o\ no}$	Output HF noise	$I_{o\ max}$ $V_{i\ nom}$ Tc_{min} - Tc_{max} *0.5 - 20MHz*			200			300			400	mV
$I_{o\ nom}$	Output current	$V_{i\ nom}$ Tc_{min} - Tc_{max}		5.0			3.3			2.5		A
$I_{o\ lim}$	Output Current Limit	$V_{i\ min}$ Tc_{min} - Tc_{max}	5.2		5.8	3.4		3.9	2.6		2.9	A

Notes:
Tc_{room} = 15 to 25°C

Output Parameters: SRE Dual

Standard Output - SRE Dual *(consult factory for custom combinations)*			SRE 1212						SRE 1515						Unit
Parameter		Condition	Output1			Output2			Output1			Output2			
			min	nom	max	min	nom	max	min	nom	max	min	nom	max	
$V_{o\ nom}$	Output voltage set point	$V_{i\ nom}$ $I_{o\ 50\%\ /\ 50\%}$ Tc_{room}	11.93	12.0	12.07	11.88	12.0	12.12	14.90	15.0	15.10	14.85	15.0	15.15	V
$V_{o\ op}$	Regulation across full operation range	$V_{i\ op}$ I_o = 10% - $I_{o\ max}$ on either U1 or U2 Tc_{min} - Tc_{max}	11.76		12.24	11.50		12.50	14.70		15.30	14.38		15.62	V
$V_{o\ ovp}$	Over voltage	Applied to U2, also fault protects U1		≈15V		13.5		16.5		≈19V		18.5		21.5	V
$V_{o\ rip}$	Output ripple	$I_{o\ max}$ $V_{i\ nom}$ Tc_{min} - Tc_{max}			120			120			150			150	mV
$V_{o\ noi}$	Output HF noise	$I_{o\ max}$ $V_{i\ nom}$ Tc_{min} - Tc_{max} *0.5 - 20MHz*			100			100			120			120	mV
$I_{o\ nom}$	Output current Nominal	$V_{i\ nom}$ Tc_{min} - Tc_{max}			5.0			5.0			4.0			4.0	A
$I_{o\ lim}$	Output Current Limit	$V_{i\ min-max}$ outputs in series	5.2		5.8	5.2		5.8	4.2		4.6	4.2		4.6	A

Notes:
Tc_{room} = 15 to 25°C

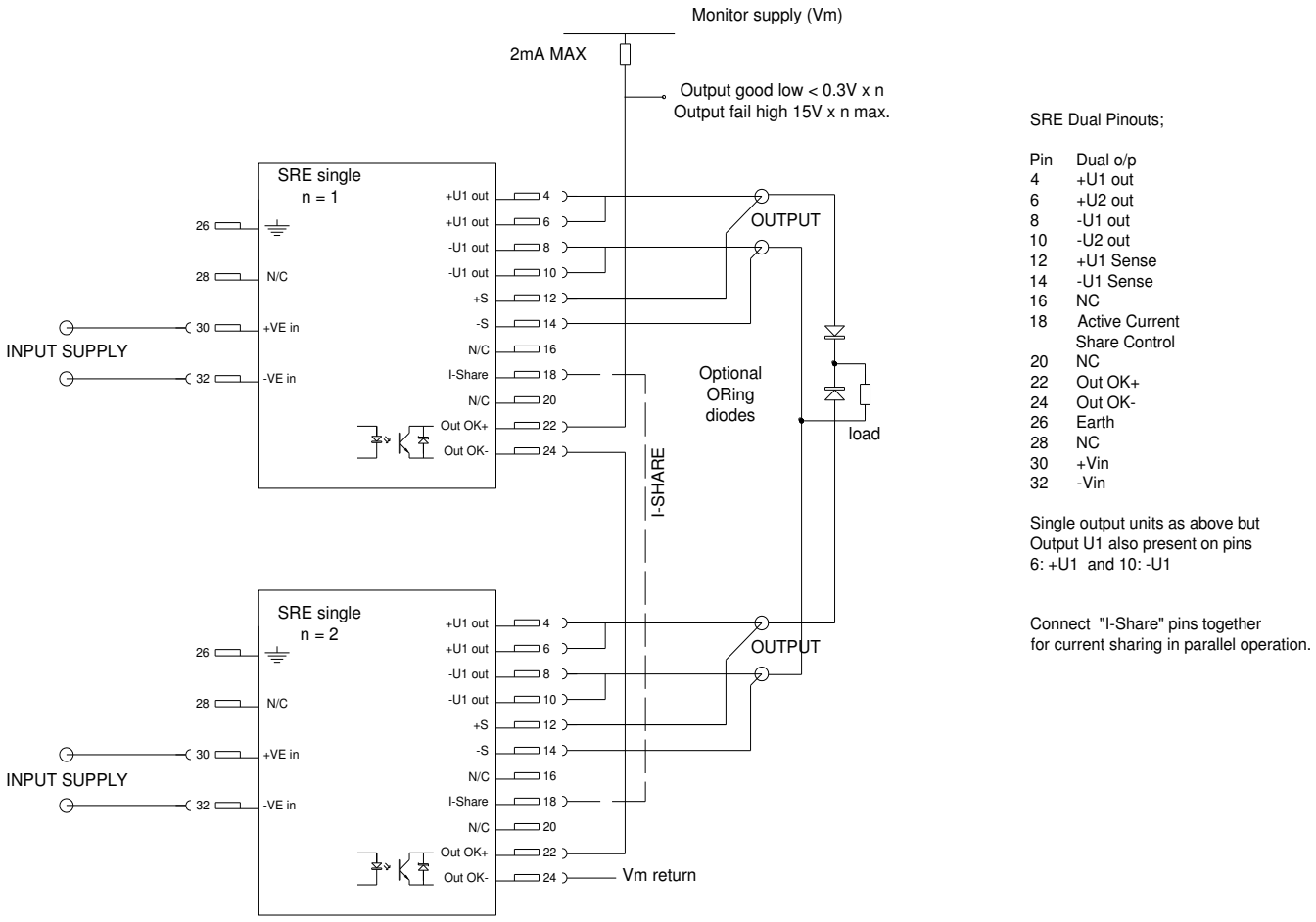
Standard Output - SRE Dual *(consult factory for custom combinations)*			SRE 2424												Unit
Parameter		Condition	Output1			Output2			Output1			Output2			
			min	nom	max	min	nom	max	min	nom	max	min	nom	max	
$V_{o\ nom}$	Output voltage set point	$V_{i\ nom}$ $I_{o\ 50\%\ /\ 50\%}$ Tc_{room}	23.86	24	24.14	23.76	24	24.24							V
$V_{o\ op}$	Regulation across full operation range	$V_{i\ op}$ I_o = 10% - $I_{o\ max}$ on either U1 or U2 Tc_{min} - Tc_{max}	23.52		24.48	23.00		25.00							V
$V_{o\ ov}$	Over voltage	Applied to U2, also fault protects U1		≈28V		24.5		28.0							V
$V_{o\ rip}$	Output ripple	$I_{o\ max}$ $V_{i\ nom}$ Tc_{min} - Tc_{max}			240			240							mV
$V_{o\ noi}$	Output HF noise	$I_{o\ max}$ $V_{i\ nom}$ Tc_{min} - Tc_{max} *0.5 - 20MHz*			200			200							mV
$I_{o\ nom}$	Output current Nominal	$V_{i\ nom}$ Tc_{min} - Tc_{max}		2.5			2.5								A
$I_{o\ lim}$	Output Current Limit	$V_{i\ min-max}$ outputs in series	2.6		2.9	2.6		2.9							A

Notes:
Tc_{room} = 15 to 25°C

Output voltage and cross regulation

Dual output models have full output regulation on output 1 only. Output 2 tracks output 1 as long as there is a minimum of 10% load on each output, but will have more variation with unbalanced load currents. The worst case regulation of output 2 with 10% load on one of the outputs and 100% load on the other is shown in the output data tables. At some point below 10% load on either output, dependant on factors such as input voltage and temperature, regulation of output 2 will be lost but full regulation of output 1 will continue. Load current exceeding 100% on one output with reduced load on the other is possible (see current limit section), but the cross regulation limits shown may be exceeded.

Parallel current sharing or redundant connection



SRE Dual Pinouts;

Pin	Dual o/p
4	+U1 out
6	+U2 out
8	-U1 out
10	-U2 out
12	+U1 Sense
14	-U1 Sense
16	NC
18	Active Current Share Control
20	NC
22	Out OK+
24	Out OK-
26	Earth
28	NC
30	+Vin
32	-Vin

Single output units as above but Output U1 also present on pins 6: +U1 and 10: -U1

Connect "I-Share" pins together for current sharing in parallel operation.

Parallel operation and current sharing

By connecting the I-share pins on two paralleled units with similar –ve return connections from the load they will be forced to share current to a ratio better than 40:60 assuming that their outputs are set within the standard ±0.5% accuracy. This applies when the individual loads are within the range 40% to 100% of I_o rated.

Dual output configurations

Dual output units may have their two outputs connected in series to give $2V_o$, with a centre connection to give $+V_o$ 0 $-V_o$ or in parallel to give $2I_o$. U1 output may be paralleled with U1 of a second unit to share as detailed above. This also applies if U1 & U2 of each unit are also connected in parallel.

Redundant operation

For parallel redundant or n+1 operation ORing diodes may be added in series with the +ve output connections. This is necessary if independent monitoring of each converter via its output good optocoupler is required. Low V_f schottky diodes with suitable current ratings and adequate heat-sinking are ideal for this.

Protection Features

Current protection

All versions have output current limit protection that operates at approximately 110% of I_o rated. On dual output versions this is the total current of both outputs. As the load is increased (load resistance reduced), the output voltage will reduce to maintain approximately constant current. Further increase towards short circuit will result in the converter entering a stop and retry mode of operation in order to protect itself, but will recover as the current is reduced to I_o rated.

Dual output units are able to deliver an output current greater than the rated current on one output if the current on the other output is reduced accordingly. The absolute limit for this is I_o +20% to avoid reduced life and the possibility of thermal protection being activated.

Output over voltage protection (OVP)

Over voltage protection is incorporated on all models and limits the output voltage(s) in the unlikely event of single fault loss of output feedback control. Output voltages are limited to the values defined in the Output Parameters tables.

Dual output versions have OVP on Output 2. This gives fault protection on both outputs as a loss of control of Output 1 will also cause output 2 to rise. Under certain conditions of output 2 being on low load, the OVP may be invoked. If Output 2 is not used it should be connected in parallel with output 1 power terminals to avoid this. If output 2 is only used at < ≈ 5% load, or intermittently, it may need a passive or active bleed circuit added to control regulation.

The built in OVP will not give protection against externally applied output over-voltage events.

Input fuse and reverse polarity protection

The SRE inputs have a shunt (parallel) diode to protect against reverse polarity installation. A factory replaceable internal fuse link gives protection against catastrophic failure, but it is important that the input supply is externally protected by a lower rated circuit breaker or fuse. The recommended ratings are as below:

	Suffix A 110V	Suffix D 72V	Suffix C 52V	Suffix F 36V	Suffix B 24V
Fuse or circuit breaker (fast acting)	2.5AF	3.5AF	5AF	8AF	12AF

Input transient protection

The SRE input is fully protected against direct (line to line) and indirect (line to chassis) transients and surges as defined by EN50121-3-2 (2006). The protection devices used are very conservatively rated in order to ensure long life.

Thermal Protection

Thermal protection operates when the mounting face of the converter reaches 100°C ±10°C and causes the output voltage to fall. Recovery is automatic when the temperature reduces.

Isolation and earth continuity

The SRE series meets the isolation voltages shown in the table below. All converters are 100% factory tested to the values shown.

Characteristic	Condition	Input to Output / Out-OK	Input to Case	Output / Out-OK to Case	Output / Out-OK to Output	Unit
Electric Strength	Factory tested > 60 seconds	2900	1500	1500	250	**VDC**
Electric Strength	AC equivalent voltage	2000	1000	1000	175	**VAC**
Insulation Resistance	500VDC	>20	>20	>20	>20	**MΩ**
Minimum creepage distances		4.0	2.5	1.5		**mm**

Earth continuity between the chassis and connector earth pin (pin 26) is also 100% factory tested to ensure resistance is <0.1Ω.

Safety

All models, when appropriately installed, are compliant with EN60950 and EN50153.

The converters correspond to class II equipment as defined by EN60950 and therefore do not require a safety earth connection. However for optimum EMC performance it is advised that there is a good earth connection to pin 26 and / or the converter enclosure.

Additional Functions

Remote sensing

Remote output sensing is provided on the single output model and on Output 1 of the dual version to improve the load regulation some distance from the output connector if required. The total load line drop voltage that can be compensated for varies depending on the model version, but it is generally at least 0.2V before loss of regulation will occur during the 0.6Vin 100ms dips.

Output status signal and LED

As shown on the connection drawing on page 7, a fully isolated open collector output status signal is provided. This is capable of sinking at least 2mA to a saturation voltage of less than 0.30V. To give protection against indirect transients, the output is clamped at nominally 16V. With a suitable pull up resistor to an input side or output side supply V_m, the following truth table will apply:

	Front Panel LED	V_{ok}	I_{ok}
V_o >0.98$V_{o\ nom}$	ON (Green)	<0.30V	>2mA
V_o <0.94$V_{o\ nom}$	OFF	Vm (<15V)	<100µA

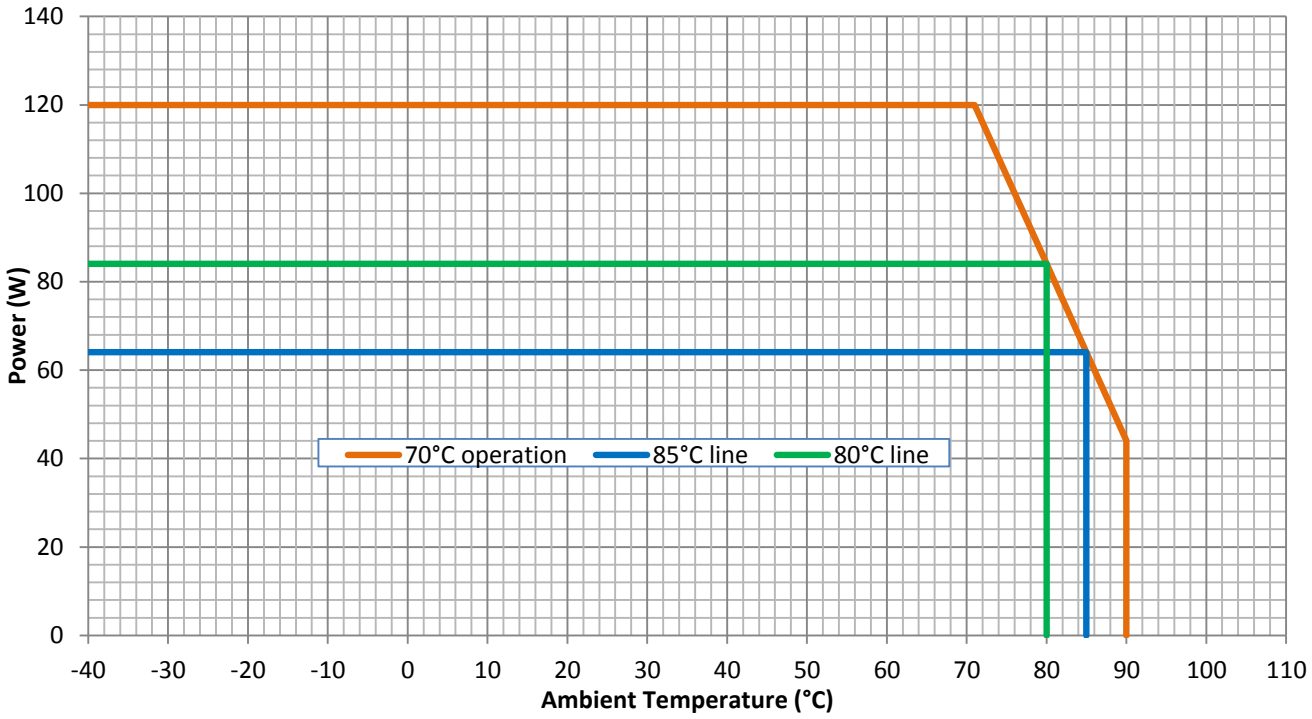
Environmental Parameters

Temperature performance

The SRE series meets the requirements of EN50155 category TX for ambient temperature rating, i.e. -40 to +71°C continuous, 85°C short term (15 minutes start-up). Converters may be operated at their full rated power (120W for most models) at the maximum temperature without the need for forced air cooling. However the installation should be such as to provide some element of natural convection airflow around the converter enclosure, and temperature at any point on the case should not exceed 90°C.

For chassis mount installations, mounting on a surface capable of some conduction cooling is desirable but not essential.

The SRE series may be operated at temperatures above 71°C at reduced power in accordance with the following de-rating curve.



Storage temperature rating is -55°C to +80°C.

Shock and vibration

The SRE series has been tested to, and is compliant with, EN61373 Category 1, Class B – body mounted; mounted in any orientation. A type test report is available on request.

Protection degree and humidity

The PCBs within the converter are conformal coated. With the female connector fitted the converters are rated to IP54. Maximum relative humidity is 95%, non-condensing.

Reliability & burn-in test

Theoretical MTBF calculations for the SRE series result in the figures shown in the table below. Calculations using in-service reliability data suggest a real-world MTBF of >3 million hours. Further details can be provided on request.

Characteristic	Condition	Model	Ground benign	Ground Fixed	Ground Mobile	Unit
MTBF according to MIL-HDBK- 217F	Full load, 40°C ambient temperature	SRE single output models	825,000	161,000	70,000	**hours**
		SRE dual output models				**hours**

Notes:
Calculations based on an ambient temperature local to the converter. Case temperature will be higher and this is accounted for in the calculations.

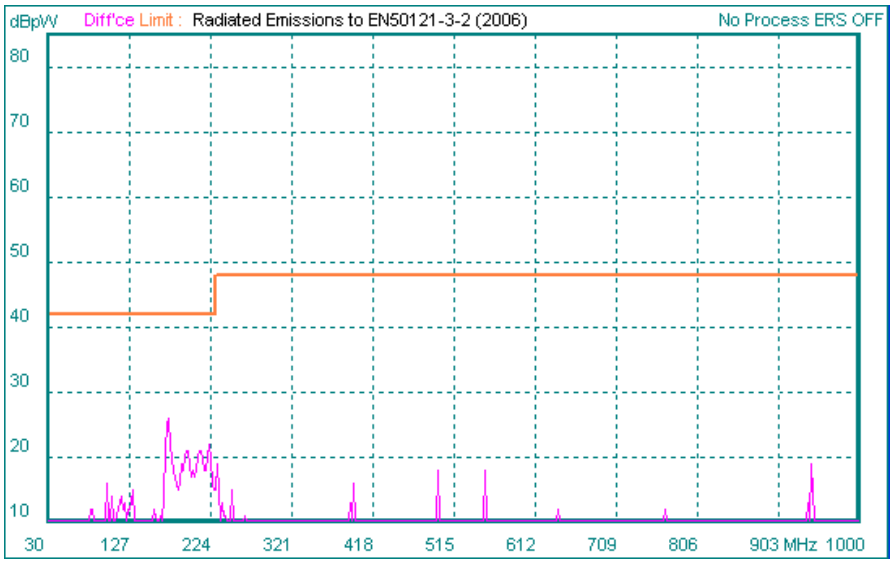
All products are subjected to a 100% burn-in test for 16 hours at full load and 55°C.

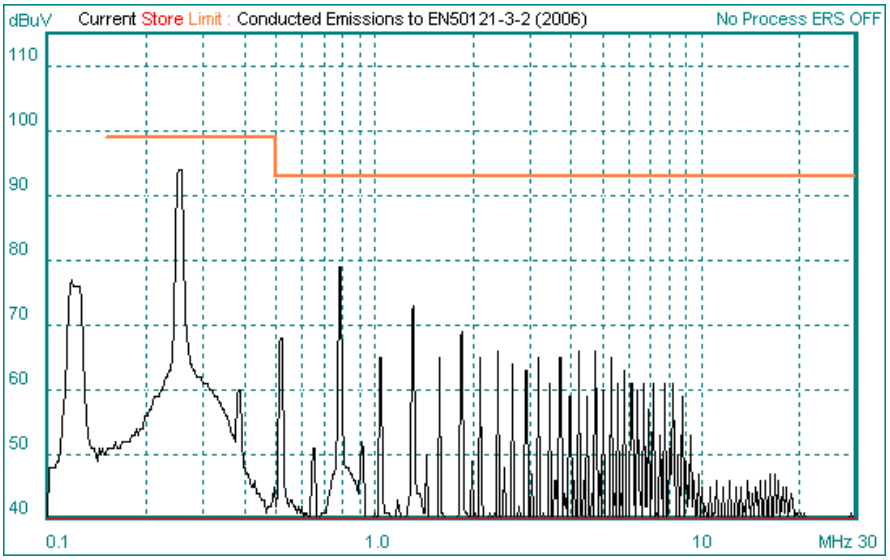
EMC

All models are fully tested for compliance with surges and transients and emissions and immunity in accordance with the requirements of EN 50155 (2007) and EN 50121.3.2 (2006), specifically:

- Supply related surge — EN 50155
- Direct & indirect transients — EN 50155
- Electrostatic discharge — EN 61000-4-2:1995 A1 & A2
- Radiated RF immunity — EN 61000-4-3:2002 A1 & A2
- Electrical fast transients — EN 61000-4-4: 2004
- Surges — EN 61000-4-5:1995 A1 & A2
- Conducted RF immunity — EN 61000-4-6:1996 A1 & A2+A2
- Conducted emissions — EN 55011 (1998) A1 & A2
- Radiated emissions — EN 55011 (1998) A1 & A2

Typical emissions are shown below. Full EMC test results for any model are available on request.



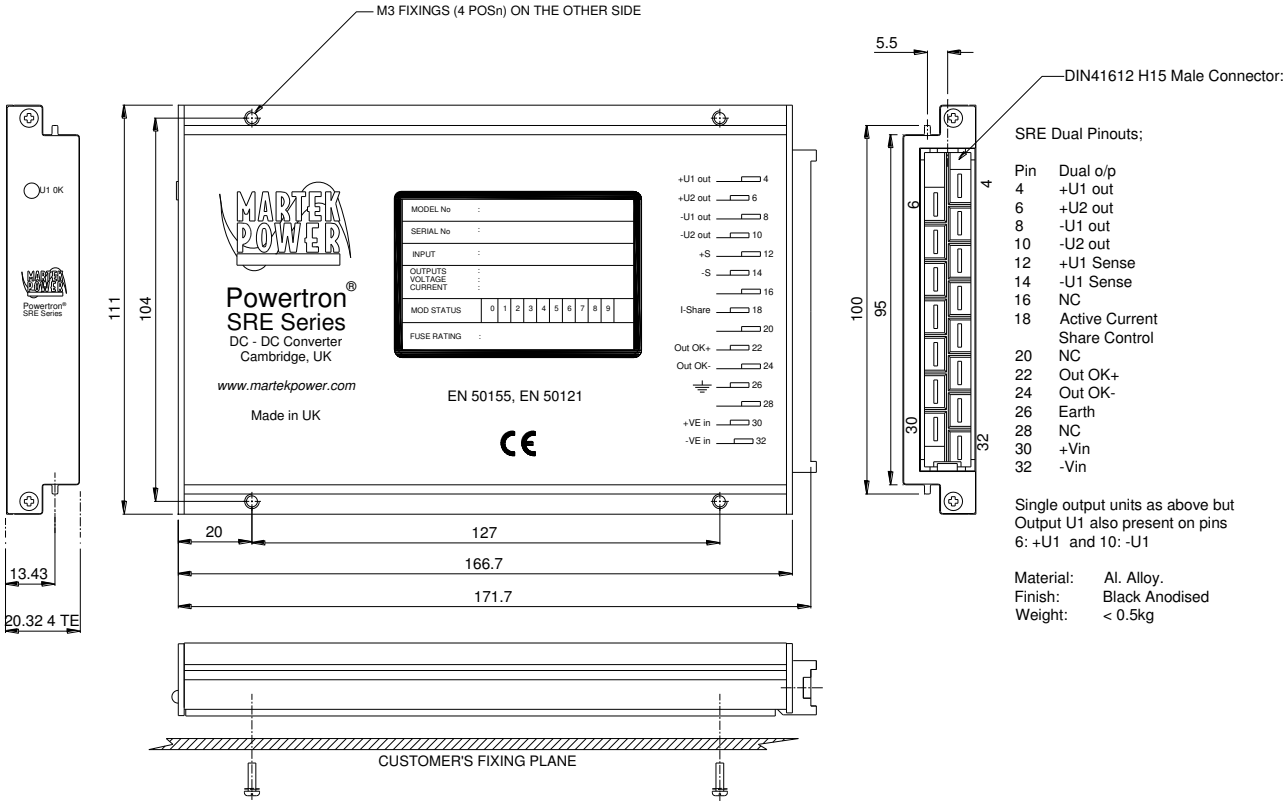


Mechanical Data

The SRE series is suitable for 19" rack installation or chassis mounting. Various mechanical options are available; please see below for further details.

All dimensions are in mm.

Dimensions and pin assignments of standard model



SRE Dual Pinouts;

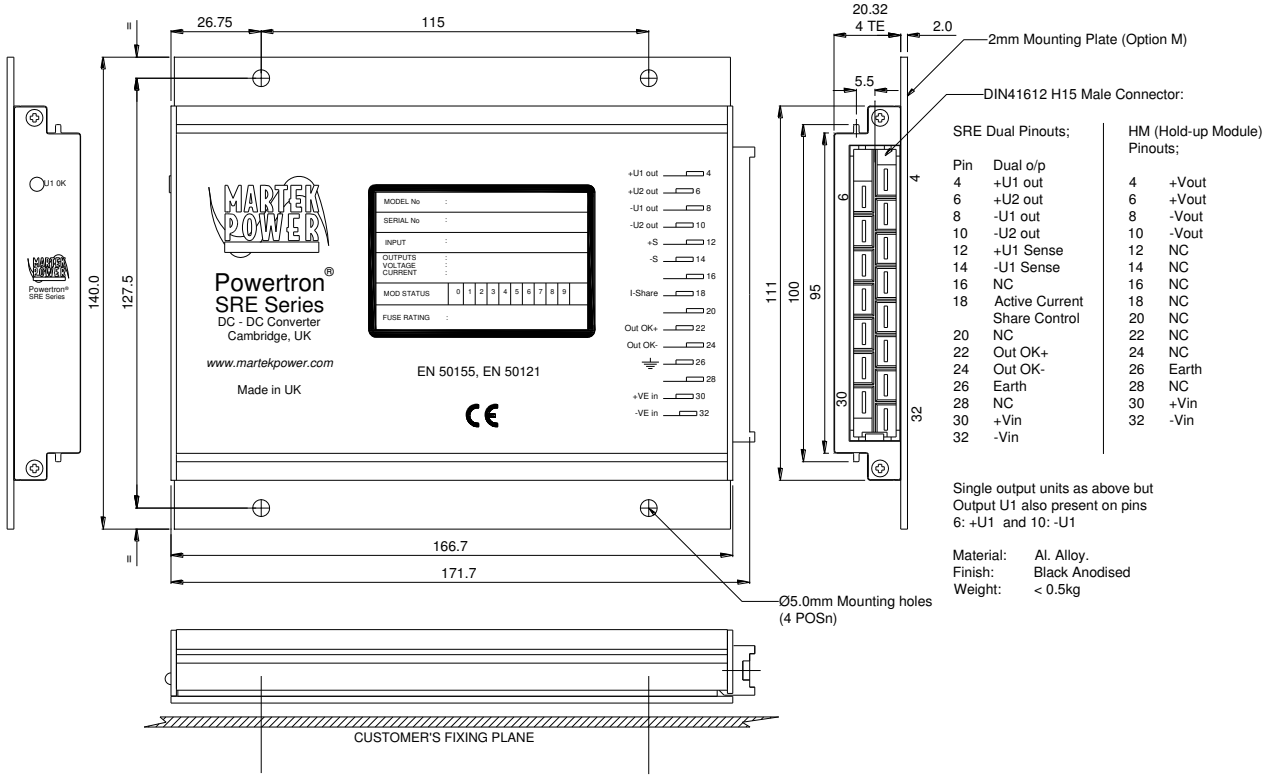
Pin	Dual o/p
4	+U1 out
6	+U2 out
8	-U1 out
10	-U2 out
12	+U1 Sense
14	-U1 Sense
16	NC
18	Active Current Share Control
20	NC
22	Out OK+
24	Out OK-
26	Earth
28	NC
30	+Vin
32	-Vin

Single output units as above but Output U1 also present on pins 6: +U1 and 10: -U1

Material: Al. Alloy.
Finish: Black Anodised
Weight: < 0.5kg

Mechanical options

Option 'M' additional mounting plate



SRE Dual Pinouts;

Pin	Dual o/p
4	+U1 out
6	+U2 out
8	-U1 out
10	-U2 out
12	+U1 Sense
14	-U1 Sense
16	NC
18	Active Current Share Control
20	NC
22	Out OK+
24	Out OK-
26	Earth
28	NC
30	+Vin
32	-Vin

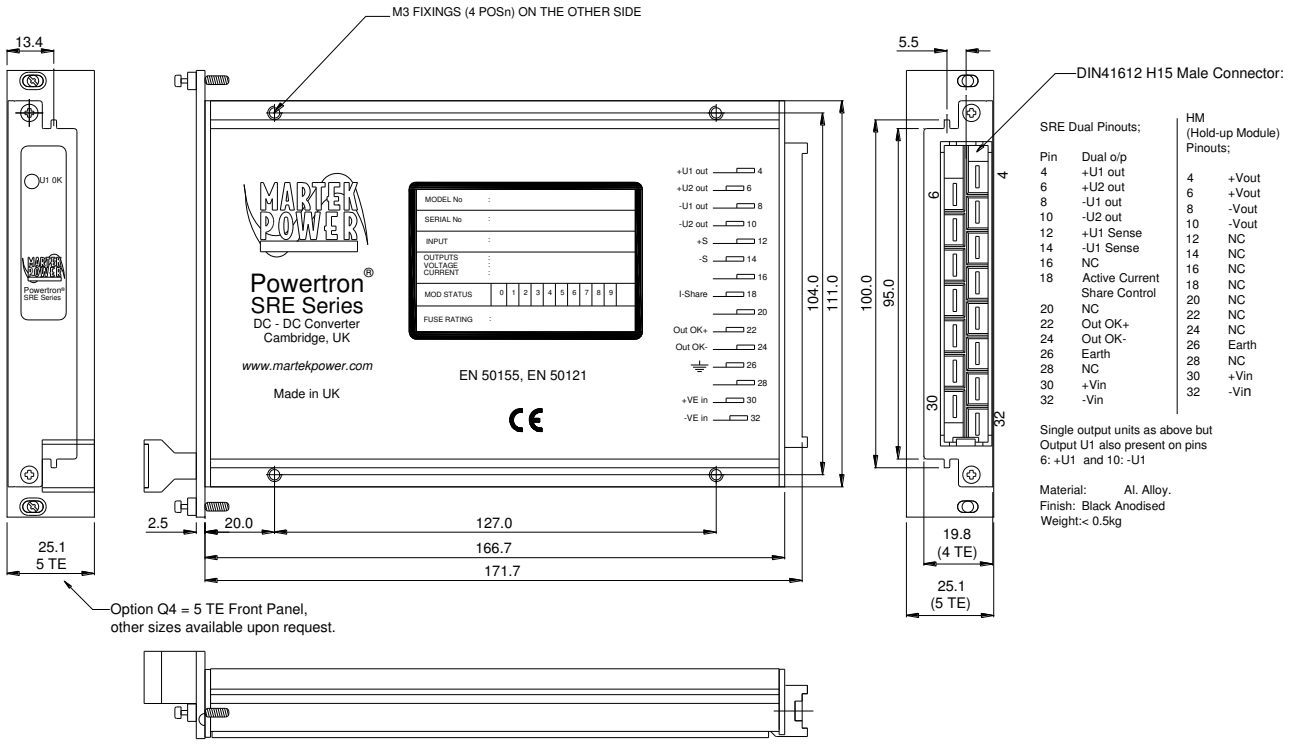
HM (Hold-up Module) Pinouts;

4	+Vout
6	+Vout
8	-Vout
10	-Vout
12	NC
14	NC
16	NC
18	NC
20	NC
22	NC
24	NC
26	Earth
28	NC
30	+Vin
32	-Vin

Single output units as above but Output U1 also present on pins 6: +U1 and 10: -U1

Material: Al. Alloy.
Finish: Black Anodised
Weight: < 0.5kg

Option 'Q4' additional front panel



SRE Dual Pinouts;

Pin	Dual o/p
4	+U1 out
6	+U2 out
8	-U1 out
10	-U2 out
12	+U1 Sense
14	-U1 Sense
16	NC
18	Active Current Share Control
20	NC
22	Out OK+
24	Out OK-
26	Earth
28	NC
30	+Vin
32	-Vin

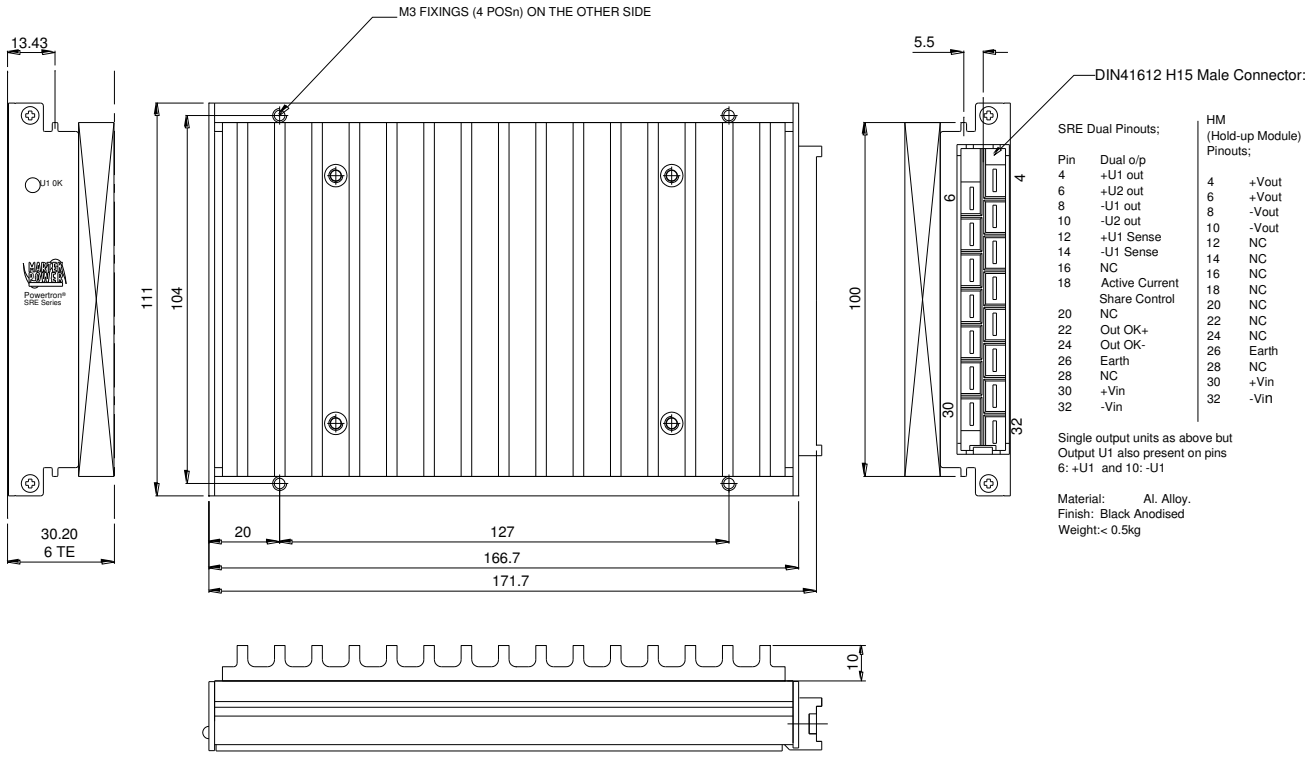
HM (Hold-up Module) Pinouts;

4	+Vout
6	+Vout
8	-Vout
10	-Vout
12	NC
14	NC
16	NC
18	NC
20	NC
22	NC
24	NC
26	Earth
28	NC
30	+Vin
32	-Vin

Single output units as above but Output U1 also present on pins 6: +U1 and 10: -U1

Material: Al. Alloy.
Finish: Black Anodised
Weight:< 0.5kg

Option 'Q1' additional heatsink



SRE Dual Pinouts;

Pin	Dual o/p
4	+U1 out
6	+U2 out
8	-U1 out
10	-U2 out
12	+U1 Sense
14	-U1 Sense
16	NC
18	Active Current Share Control
20	NC
22	Out OK+
24	Out OK-
26	Earth
28	NC
30	+Vin
32	-Vin

HM (Hold-up Module) Pinouts;

4	+Vout
6	+Vout
8	-Vout
10	-Vout
12	NC
14	NC
16	NC
18	NC
20	NC
22	NC
24	NC
26	Earth
28	NC
30	+Vin
32	-Vin

Single output units as above but Output U1 also present on pins 6: +U1 and 10: -U1

Material: Al. Alloy.
Finish: Black Anodised
Weight:< 0.5kg