COMPACT, EFFICIENT 400 W AC-DC POWER SUPPLY
ITE AND MEDICAL RATED DDP/MDP400 SERIES

DS1_DDP-MDP400 SERIES REV07 _ SEPTEMBER 2013

DESCRIPTION

The DDP400 and MDP400 series of industrial and medical grade AC-DC power supplies are distinguished by their extremely compact form factor and high conversion efficiency.

3 YEAR WARRANTY

The series provide a steady 400 W of regulated DC power through the full 90 to 264 V_{AC} input voltage range. Based on an open frame, 3.00" x 6.50" x 1.46" form factor, the series is available in four different packages to enable designers to integrate more advanced features into a system without compromising on its size.

By converting energy at 94% typical efficiency, the DDP400 and MDP400 series generate less heat facilitating thermal management in space constrained system and offering high reliability.

Both the DDP and MDP series are available in four standard output voltages: 12, 24, 36, 48 V_{DC}, offer an auxiliary 12 V_{DC} and 5 V_{DC} stand-by outputs. Available control signals include Power Good (P_OK) and Remote On/Off (PS_ON).

Open frame and boxed units can deliver full output power up to 50 °C, can operate up to 70 °C with de-rating and are capable to start up from –30 °C.

A built in fan speed control circuit assure proper forced air cooling minimizing operation noise and enhancing useful life.

The MDP400 range comply with the 2nd and 3rd edition of the IEC 60601-1 safety standards for medical equipments and, the DDP400 range, comply with the 2nd edition of the IEC 60950-1 safety standards for IT equipments. Both the series meets the EN 55022 EMC limits of Class B for conducted and radiated emissions as well as the IEC/EN 61000-3 and IEC/EN 61000-4 EMC standards.

KEY FEATURES

- Universal input voltage range
- 400 W rated power (440 W peak)
- Extremely high efficiency (94% typical)
- Low stand-by consumption (<0.5 W)
- 12, 24, 36 and 48V standard output variants
- Active PFC, EN61000-3-2 compliant (Class C)
- Low earth leakage current
- Fan speed control circuit (off at <50 W load)
- Over temperature protection
- OV, OC, and short circuit protections
- +5 V Stand-by, 2 A Output
- 12 V Auxiliary, 1 A output
- Remote On/off and power good signals
- U-chassis and boxed packages fit 1U applications.
- ANSI/AAMI ES60601-1 3rd ed. compliant IEC/EN/UL 60601-1 2nd/3rd ed. compliant.
- RoHS-6 compliant (EU directive 2011/65/EU)
- 4000 m altitude operation.

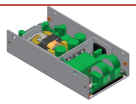
MARKET SEGMENT AND APPLICATIONS

- Video Wall Display & Entertainment
- Industrial and Process Control
- Telecommunications
- Laboratory Equipment
- Test and Measurement Equipment
- Medical applications

Model Coding and Output Ratings

Model Grade and Output Power		Output Nominal Voltage	Package / Fan Options
ITE:	**DDP400-**	*12 V_{DC}:* **US12-**	*Open Frame:* **OF**
Medical:	**MDP400-**	*24 V_{DC}:* **US24-**	*U-Chassis:* **UC**
		36 V_{DC}: **US36-**	*Punched Cover:* **PC**
		48 V_{DC}: **US48-**	*Vented Cover:* **VC**
			Front Fan: **FF**

D M	DP400	-	US	12 24 36 48


OF

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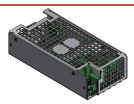
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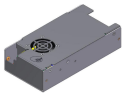
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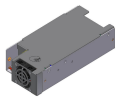

FF

Model Number	V1 (V)	I1[1] Convection (A)	I1[2] Forced air (A)	V1[3] Ripple (mV)	V2 (V)	I2[1] Rated (A)	V2[3] Ripple (mV)	$5V_{SB}$ (V)	$I5V_{SB}$[1] Convection (A)	$I5V_{SB}$[2] Forced air (A)	$5V_{SB}$[3] Ripple (mV)
DDP / MDP400-US12-OF / UC	12	20.8	33.3	120	12	1	240	5	1.5	2	50
DDP / MDP400-US24-OF / UC	24	10.4	16.7	240	12	1	240	5	1.5	2	50
DDP / MDP400-US36-OF / UC	36	6.9	13.9	360	12	1	240	5	1.5	2	50
DDP / MDP400-US48-OF / UC	48	5.2	8.3	480	12	1	240	5	1.5	2	50
DDP / MDP400-US12-VC / FF	12	-	33.3	120	12	1	240	5	-	2	50
DDP / MDP400-US24-VC / FF	24	-	16.7	240	12	1	240	5	-	2	50
DDP / MDP400-US36-VC / FF	36	-	13.9	360	12	1	240	5	-	2	50
DDP / MDP400-US48-VC / FF	48	-	8.3	480	12	1	240	5	-	2	50

[1] The combined output power of V1, V2 and $5V_{SB}$ for "-OF" and "-UC" packages, must not exceed 400 W when cooled by 400 LFM air flow, and 250 W when convection cooled, up to 50 °C. Above 50 °C output de-rating applies. See de-rating curves below.
In any case, the heat sink maximum temperature should not exceed +110 °C at 50 °C ambient temperature.

[2] The combined output power of V1, V2 and 5 V_{SB} for "-VC" and "-FF" packages, must not exceed 400 W up to 50 °C, and 280 W at 70 °C ambient temperature. See de-rating curves below.

[3] Peak-to-Peak measured at 20 MHz Bandwidth.

Input Specifications

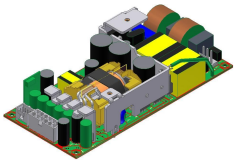
Specification	Test Conditions / Notes	Min.	Nominal	Max.	Units
AC Input Voltage	PS starts and operates at 90 V_{AC} at all load conditions	90	100-240	264	V_{AC}
DC Input Voltage		170	-	270	V_{DC}
Input Frequency		47	50/60	440	Hz
Input Current	RMS at 180 V_{AC}, maximum load RMS at 90 V_{AC}, maximum load	-	-	2.5 5	A
Inrush Current	265 V_{AC}, 25 °C ambient, cold start. 24, 36, 48 V, no damage 12 V	- -	- -	- 20	A
Fusing	2X Time Lag 6.3 A, 250 V on both L and N	-	-	6.3	A
Efficiency	At 230 V_{AC}, 20% rated load 50 – 100 % rated load At 115 V_{AC}, 20% rated load 50 – 100 % rated load	- - - -	90 94 90 92	- - - -	%
Input Power Consumption	Power on, 115-230 V_{RMS}, no load Stand by, 115-230 V_{RMS}, no load	- -	1 0.5	1.5 -	W
Power Factor	At full rated load, 115 V_{AC}, 60 Hz and 230 V_{AC}, 50 Hz input voltages	0.95	-	-	-
Harmonic Current Fluctuations and Flicker	Complies with EN-61000-3-2 Class C at 230 V_{AC} 50 Hz, load >50 W. Complies with EN-61000-3-3 at nominal voltages and full load.				
Leakage Current	Normal conditions, 240 V_{RMS}, 60 Hz.	-	-	300	µA

OUTPUT SPECIFICATIONS

Specification	Test Conditions / Notes	Min.	Nom.	Max.	Units
V1 Output Voltage	12V	-	12	-	V
	24V (0.5% set point accuracy)	-	24	-	
	36V (0.5% set point accuracy)	-	36	-	
	48V (0.5% set point accuracy)	-	48	-	
V1 Output Power Rating	All voltages, OF/UC, convection cooling	-	-	250	W
	All voltages, VC/FF, and OF/UC forced air cooling (> 400 LFM)	-	-	400	
	All models , peak power (≤ 10 s)	-	-	440	
V2 Output Voltage	All models. Load on V2: from 5 to 1000 mA Load on V1: from 0.1 to I1 rated	11.25	12.5	13.75	V
V2 Output Current	All models, convection/forced air cooling	-	-	1	A
$5V_{SB}$ Output Voltage	All models (3% set point accuracy)	-	5	-	V
$5V_{SB}$ Output Current	All voltages, OF/UC, convection cooling	-	-	1.5	A
	All voltages, VC/FF, and OF/UC forced air cooling (> 400 LFM)	-	-	2	
V1 Voltage Adjustment Range		±5	-	-	%V1
V1 Load-Line-Cross Regulation	V_{AC}: 90 – 264 V_{RMS} V1 Load: 0 – 33.3 A (12V) 0 – 16.7 A (24V) 0 – 13.9 A (36V) 0 – 8.3 A (48V) V2 Load: 0 – 1 A $5V_{SB}$ Load: 0 – 2 A	-	-	±2	%V1
$5V_{SB}$ Load-Line-Cross regulation	V_{AC}: 90 – 264 V_{RMS} V1 Load: 0 – 33.3 A (12V) 0 – 16.7 A (24V) 0 – 13.9 A (36V) 0 – 8.3 A (48V) V2 Load: 0 – 1 A $5V_{SB}$ Load: 0 – 2 A	-	-	±5	%$5V_{SB}$
V1 Line Regulation	V_{AC}: 90 – 264 V_{RMS}	-	-	±0.1	%V1
Transient Response (Voltage Deviation) V1, $5V_{SB}$	25% load changes at 1 A/µs 12V at 2200 µF Load / I_{OUT}> 0.5 A 24 V at 1000 µF Load / I_{OUT}> 0.5 A 36 V at 820 µF Load / I_{OUT}> 0.5 A 48V at 560 µF Load / I_{OUT}> 0.5 A $5V_{SB}$ at 560 µF Load / I_{OUT}> 0.1 A	-	-	±5	%V1 %$5V_{SB}$
V1 Ripple and Noise	All models, Peak-to-peak, 20 MHz BW. 100 nF ceramic and 10 µF tantalum caps at the load.	-	-	1	%V1
Start-up Rise Time	90<V_{IN}<264, any load conditions.	5	-	85	ms
Start-up Delay	V1 in regulation after PS_ON is asserted	-	-	200	ms
	V1 in regulation after AC is applied			750	
	$5V_{SB}$ in regulation after AC is applied			500	
Turn-on Overshoot	At 500 mA output current, V1 in regulation within 50 ms.	-	10 10 10	-	%V1 %V2 %V_{SB}
Hold-up Time	At nominal V_{IN}, 400 W, for all outputs	-	16	-	ms
	At nominal V_{IN}, 365 W, for all outputs	-	20	-	
	At nominal V_{IN}, 200 W, for all outputs	-	35	-	
Minimum Load *	All models; V1, V2 and $5V_{SB}$	0	-	-	A
Maximum Load Capacitance	At nominal V_{IN}, 25 °C ambient				µF
	12 V	-	-	33000	
	24 V	-	-	16000	
	36 V	-	-	10000	
	48 V	-	-	7000	
Temperature Drift		-1.2	-	+1.2	mV/°C

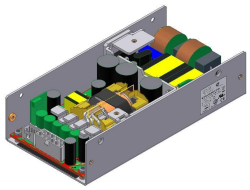
*- When the load on the main output is less than 100 mA, V2 output voltage might regulate below its minimum value. Contact ROAL Electronics for details.

Package	Model Number	Output Power De-rating Curves



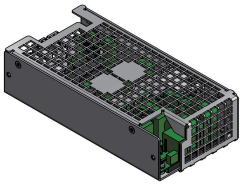
Open Frame

DDP/MDP400 - US12/24/36/48–OF



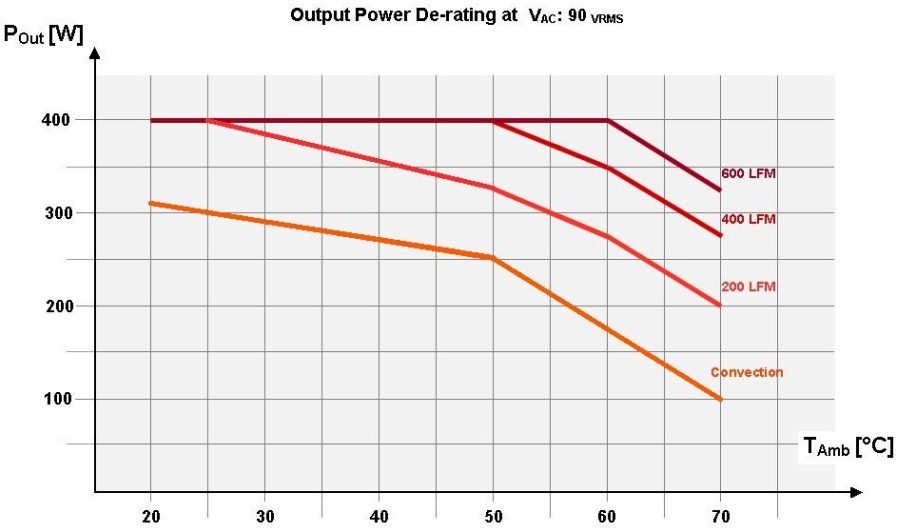
U-Chassis

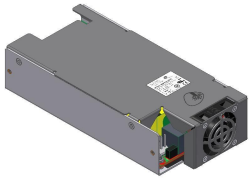
DDP/MDP400 - US12/24/36/48–UC



Punched Cover

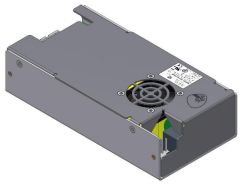
DDP/MDP400–US12/24/36/48-PC





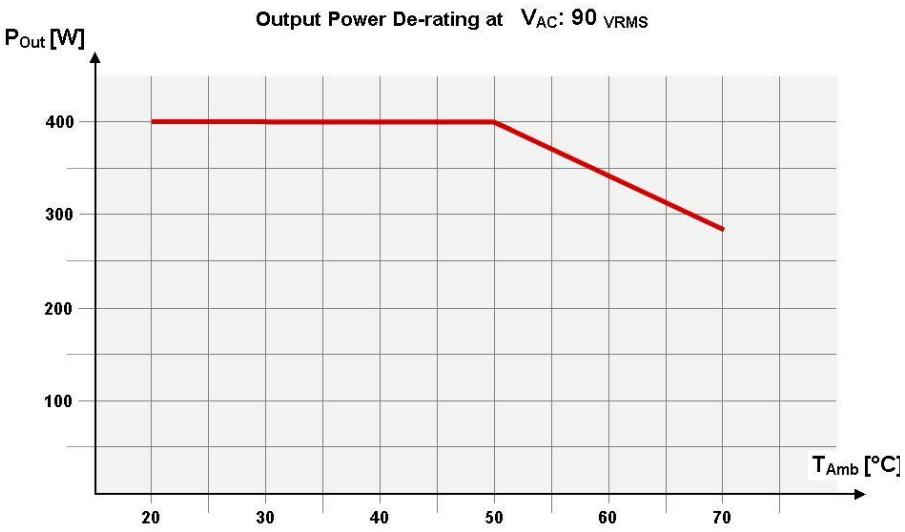
Front Fan

DDP/MDP400 - US12/24/36/48–FF



Vented Cover

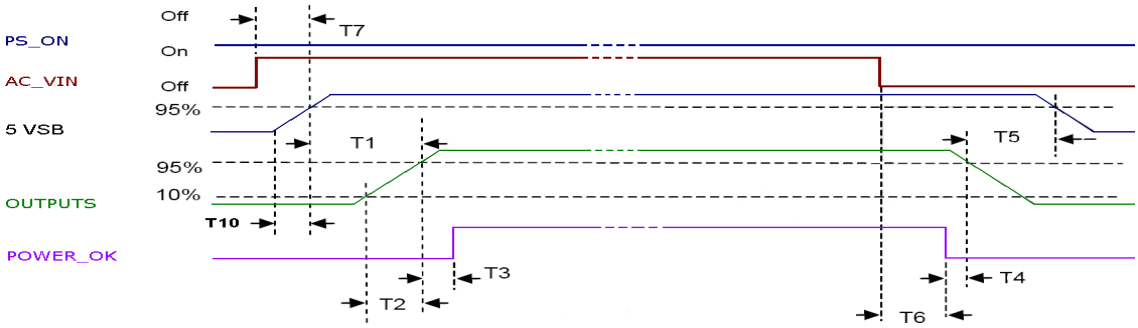
DDP/MDP400 - US12/24/36/48–VC



SIGNALS/CONTROLS

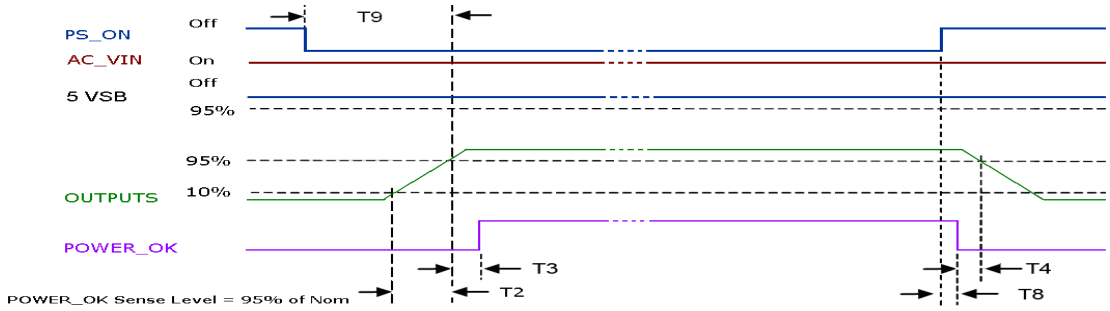
Signal	Notes	Min	Typ	Max	Unit
PS_ON	Active low, +5 V TTL signal compatible. Input low voltage	0	-	2.0	V
	Input high voltage (I_{IN}= 200 µA)	3.0	-	-	V
	V1 and V2 disabled when PS_ON is open				
	$5V_{SB}$ not affected by PS_ON				
	V1 and V2 enabled with PS_ON connected to RTN				
P_OK	+5 V TTL compatible				
	Logic level low (<10 mA sinking)	-	-	0.7	V
	Logic level high (100µA sourcing)	2.4	-	5	V
	Low to high time after V1 in regulation	0.05	-	0.1	s
	Power down warning time	1	-	-	ms
$5V_{SB}$ output	Active and in regulation after a 90<V_{AC}<264 is applied	-	-	200	ms
	$5V_{SB}$ not affected by PS_ON				

SIGNAL TIMINGS



Above waveforms are expected with AC Input ON/OFF:

Standby on - Main outputs on	50 ms ≤ T1 ≤ 250 ms
Main output Rise Time	5 ms ≤ T2 ≤ 85 ms
5 VSB Rise Time	4 ms ≤ T10 ≤ 20 ms
Main outputs On – P_OK delay	40 ms ≤ T3 ≤ 100 ms
Power down warning[1]	T4 ≥ 1 ms
Main Output off – Standby off[2]	T5 ≥ 1.2 s
Hold-up time (AC off – P_OK low)	T6 ≥ 15 ms (115/ 230 VAC)
AC_ON - Standby turn on time	T7 ≤ 500 ms



Above waveforms are expected with PS_ON Signal ON/OFF state change:

Main Output Rise Time	5 ms ≤ T2 ≤ 85 ms
Main Outputs on – P_OK delay	50 ms ≤ T3 ≤ 100 ms
Power down warning[1]	1 ms ≤ T4 ≤ 5 ms
PS_ON - Main Output (off) Timing	T8 ≤ 1 ms
PS_ON - Main Output (on) Timing	T9 ≤ 200 ms

[1] T4 parameter measurement setup will assume at least 10% of the maximum load on each output.
[2] T5 parameter measurement setup will assume at least 50% of the maximum load on main output.

PROTECTION FEATURES

Specification	Test Conditions / Notes	Min.	Nominal	Max.	Units
Input Under Voltage Lockout	Auto Recovery, Hiccup Mode	60	75	-	V_{AC}
Input Fuse	2X Time Lag 6.3 A, 250 V on L and N	-	-	6.3	A
Over Current	At nominal input voltages. V1: Hiccup mode, auto-recovery V2: PTC limiting, auto-recovering 5 VSB: Hiccup mode, auto-recovering.	110	-	150	$\%I1_{MAX}$
Short Circuit	At nominal input voltages. V1: Hiccup mode, auto-recovery V2: PTC limiting, auto-recovering 5 VSB: Hiccup mode, auto-recovering.	-	-	-	
Over Voltage	12 V 24 V 36 V 48 V 5 V_{SB} Unit shut down and latch off	110	-	136	$\%V_{NOM}$
Over Temperature (on primary stage)	Shut down, latch off.	-	-	-	
Over Temperature (on secondary side)	Hiccup mode with auto recovery	-	-	-	
Isolation Primary to Secondary	Reinforced	4000	-	-	V_{AC}
Isolation Input to Earth	Basic	1500			V_{AC}
Isolation V1 / V2		100	-	-	V_{DC}
Isolation Output to Earth		500	-	-	V_{DC}

ENVIRONMENTAL SPECIFICATIONS

Specification	Test Conditions / Notes	Min	Nominal	Max	Units
Operating Temperature Range	No de-rating up to 50°C PS starts up at -30 °C	-20	-	50	°C
De-rated Operating Temperature Range	Convection cooling: Linearly de-rate from 250 W at 50 °C, to 100 W at 70 °C Forced air cooling: Linearly de-rate from 400 W at 50 °C, to 280 W at 70 °C. See graphs above for fan boxed versions.	-	-	70	°C
Storage Temperature Range		-40	-	85	°C
Humidity	RH, Non-condensing Operating Non-operating	-	-	90 95	% %
Operating Altitude		-	-	4000	m
Shock	**EN 60068-2-27** Operating: Half sine, 30 g, 18 ms, 3 axes, 6x each (3 positive and 3 negative). Non-Operating: Half sine, 50 g, 11 ms, 3 axes, 6x each (3 positive and 3 negative).				
Vibration	**EN 60068-2-64** Operating: Sine,10 – 500 Hz, 1 g, 3 axes, 1 oct/min., 60 min. Random, 5 – 500 Hz, 0.02 g^2/Hz, 1 g_{RMS}, 3 axes, 30 min. Non-Operating: 5 – 500 Hz, 2.46 g_{RMS} (0.0122 g^2/Hz), 3 axes, 30 min.				
MTBF	Full Load, 120 V_{AC}, 50 °C ambient 70% Duty cycle, Telcordia Issue 1	400000	-	-	Hours
Useful Life	Low line range, 200 W, 40 °C ambient, natural convention.	-	4	-	Years
Thermal Considerations	The output power de-rating curves are herein provided. These curves can be used as a guideline to assess the limit in performance of a power supply once installed in a system providing controlled air flow at a certain input voltage and ambient temperature.				

Electromagnetic Compatibility (EMC) - Emissions

Phenomenon	Conditions / Notes	Standard	Equipment / Performance Class
Conducted	115 V_{RMS}, 230 V_{RMS}. Maximum load. 4 dB minimum margin	EN 55022 (ITE) EN 55011 (ISM) EN 60601-1-2 (Medical)	B
Radiated	At 10 m distance	EN 55022 (ITE) EN 55011 (ISM) EN 60601-1-2 (Medical)	B
Line Voltage Fluctuation and Flicker	At 20%, 50% and 100% maximum load. Nominal input voltages.	EN 61000-3-3	
Harmonic Current Emission	Nominal input voltages. All load conditions > 50 W.	EN 61000-3-2	C

Electromagnetic Compatibility (EMC) - Immunity

Phenomenon	Conditions / Notes	Standard	Test Level	Performance criteria
	Reference standard for the medical version	**EN 60601-1-2**		
ESD	15 kV air discharge, 8 kV contact, at any point of the system.	EN 61000-4-2	4	A
Radiated Field	3 V/m, 80-1000 MHz, 1 KHz/2 Hz 80% AM. Dwell time is 3 sec for 2 Hz modulation Dwell time is 1 sec for 1KHz modulation	EN 61000-4-3	3	A
Electric Fast Transient	±2 kV on AC power port for 1 minute; ±1 kV on signal/control lines	EN 61000-4-4	3	A
Surge	± 2kV line to line; ± 4 KV line to earth; on AC power port; ±0.5 kV for outdoor cables	EN 61000-4-5	3	A B
Conducted RF Immunity	3 V_{RMS}, 0,15-80 MHz, 1 KHz/2 Hz 80% AM	EN 61000-4-6	3	A
Dips and Interruptions	Dip to 30% for 0.5 cycle (10 ms) Dip to 40% for 5 cycles (100 ms) Dip to 70% for 25 cycles (500 ms) Drop-out to 5% for 10 ms Interrupts > 95% for 5 s	EN61000-4-11 EN61000-4-11 EN61000-4-11 EN61000-4-11 EN61000-4-11		A B B B B

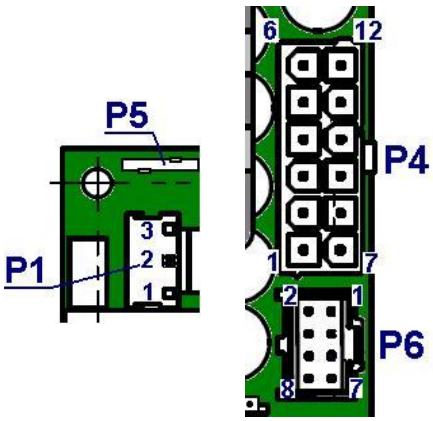
Safety Agencies Approval

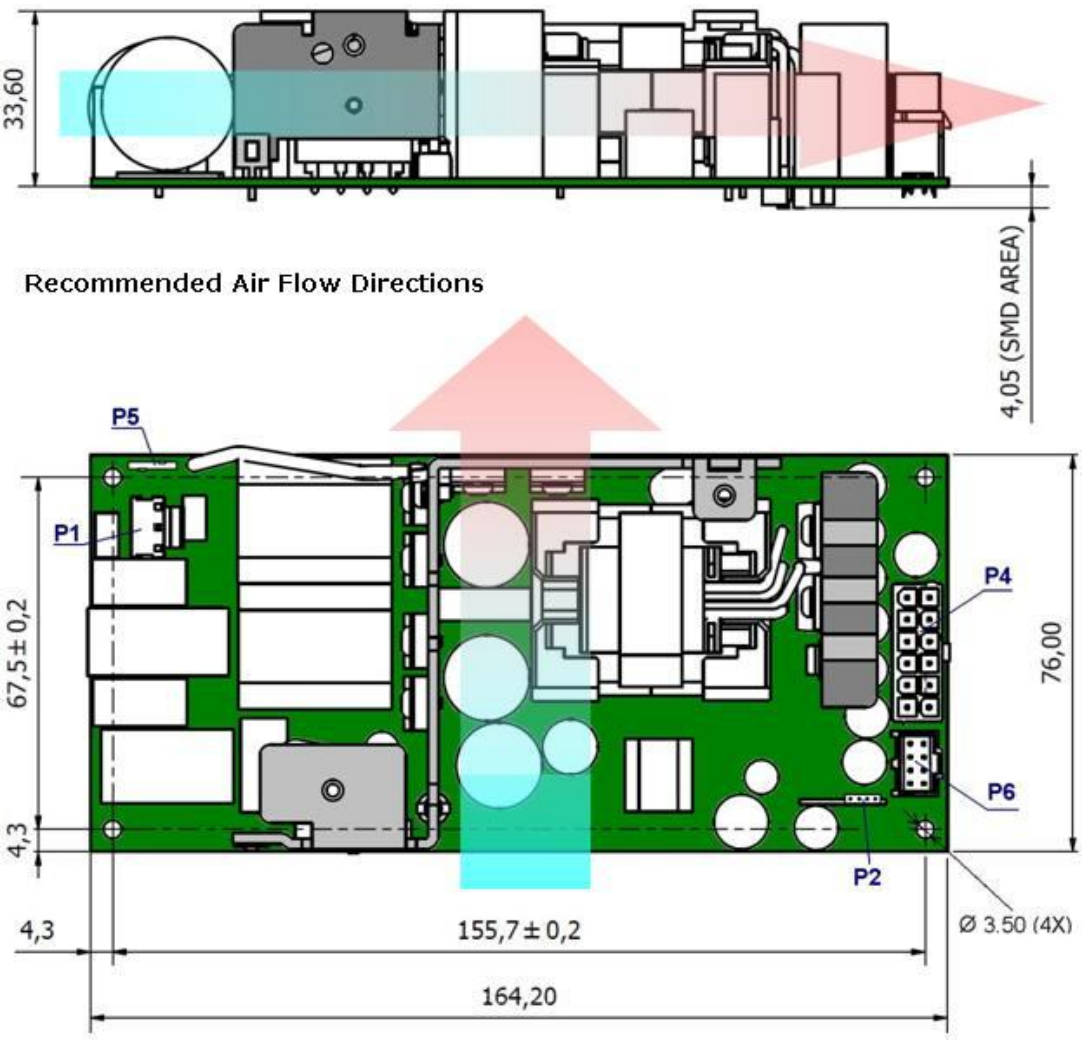
Certification Body	Safety Standards and file numbers	Category
CSA / UL	CSA C22.2 No. 60950-1, UL 60950-1; 2007, 2nd edition	Information Technology Eq.
	CSA C22.2 No.601.1, ANSI/AAMI ES60601-1 3rd edition	Medical
IEC IECEE CB Certification	IEC/EN 60950-1 2nd edition	Information Technology Eq.
	IEC/EN 60601-1 3rd edition	Medical
	IEC/EN 61558-2-16 (24 V_{DC} Open Frame version only)	SMPS
CE	Low Voltage Directive (LDV) 2006/95/EC	Information Technology Eq.
	Low Voltage Directive (LDV) 2007/47/EC MDD	Medical

Outline Drawing and Connections – Open Frame

Connector	Manufacturer and Part Number
AC Input Connector P1	Molex 26-60-4030 or equivalent
P1 Mating Connector	Molex 09-93-0300 (Crimp Terminal Housing) Molex 08-50-0105 (Crimp Terminal, 18-24 AWG)
Protection Earth Connector P5	Tyco 63849-1 equivalent
P5 Mating Connector	Any tin finished 6.35x0.81 mm receptacle
Output Connector P4	Molex 39-28-8120 or equivalent
P4 Mating Connector	Molex 39-01-2120 (Crimp Terminal Housing) Molex 39-00-0039 (Crimp Terminal, 18-24 AWG)
Signals Connector P6	Molex 90130-1108 or equivalent
P6 Mating Connector	Molex 90142-0008 (Crimp Terminal Housing) Molex 90119-0109 (Crimp Terminal, 22-24 AWG)

Note: PCB head connectors and their mating are the same for all the package options.





AC Input P1	
Pin	**Function**
1	AC Neutral
2	Not Present
3	AC Live

Protection Earth P5	
GND	AC Ground

Output Connector P4	
Pin	**Function**
1	V1
2	V1
3	V1
4	V1
5	V1
6	V1
7	DC Return
8	DC Return
9	DC Return
10	DC Return
11	DC Return
12	DC Return

Signal Connector P6	
Pin	**Function**
1	$+5V_{SB}$
2	P_OK
3	-V2
4	PS_ON
5	RS+
6	RTN
7	+V2
8	RTN

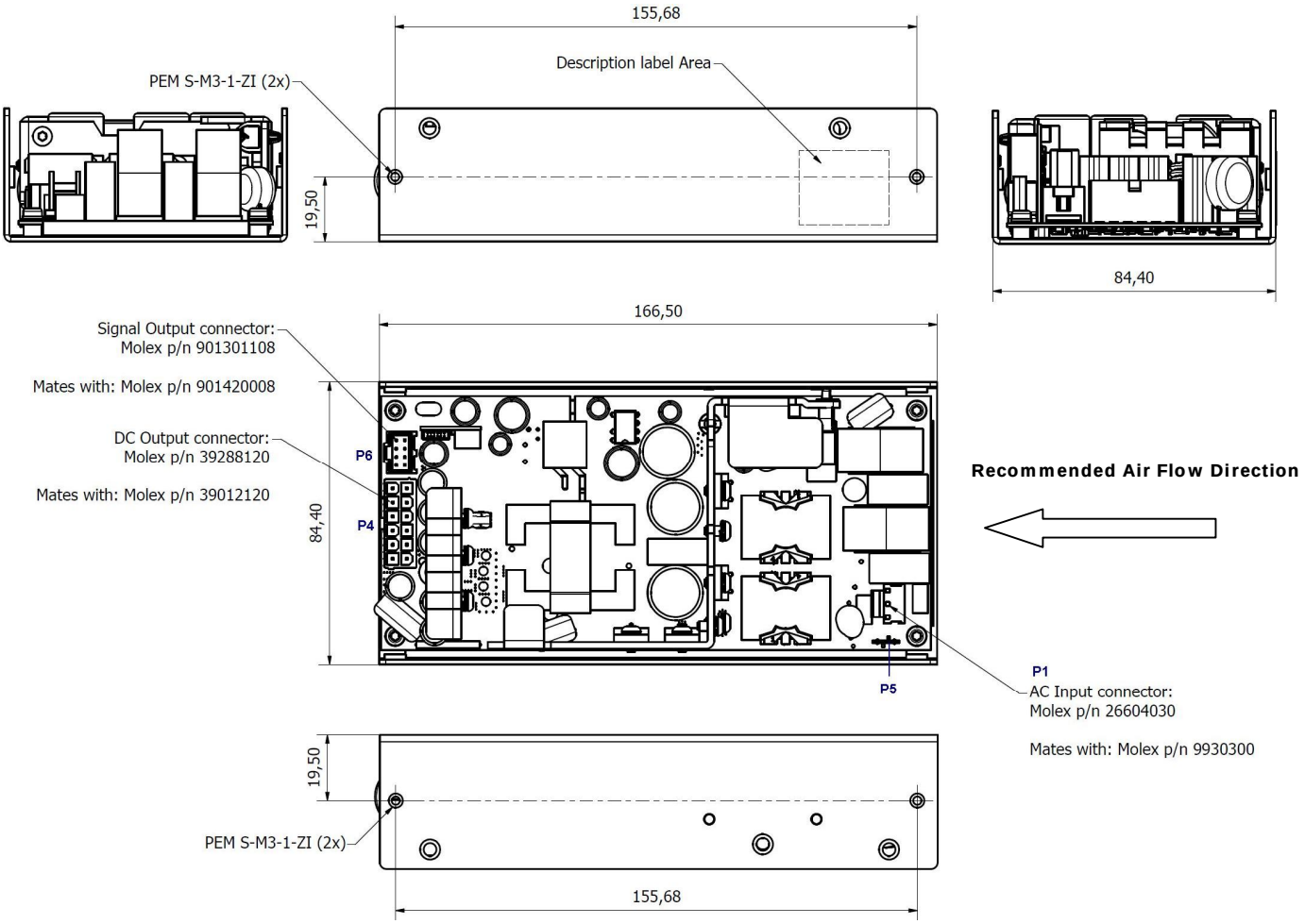
Overall dimensions: (76.0 X 164.2 X 37.7) mm; (2.99 X 6.46 X 1.48) in

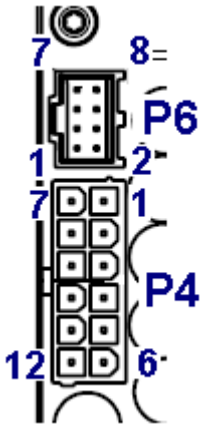
Weight: 410 g; 0.90 lb

Outline Drawing and Connections _ U-Chassis

Overall dimensions: (84.4 X 166.5 X 40) mm; (3.32 X 6.55 X 1.57) in

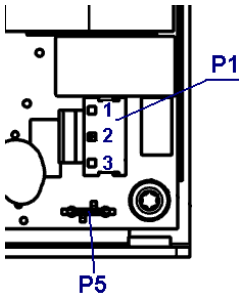
Weight: 525 g; 1.16 lb





Signals Connector P6	
Pin Ref.	Function
1	+5V$_{SB}$
2	P_OK
3	-V2
4	PS_ON
5	RS+
6	RTN
7	+V2
8	RTN

Output Connector P4	
Pin Ref.	Function
1 - 6	+V1
7 - 12	V1 RTN



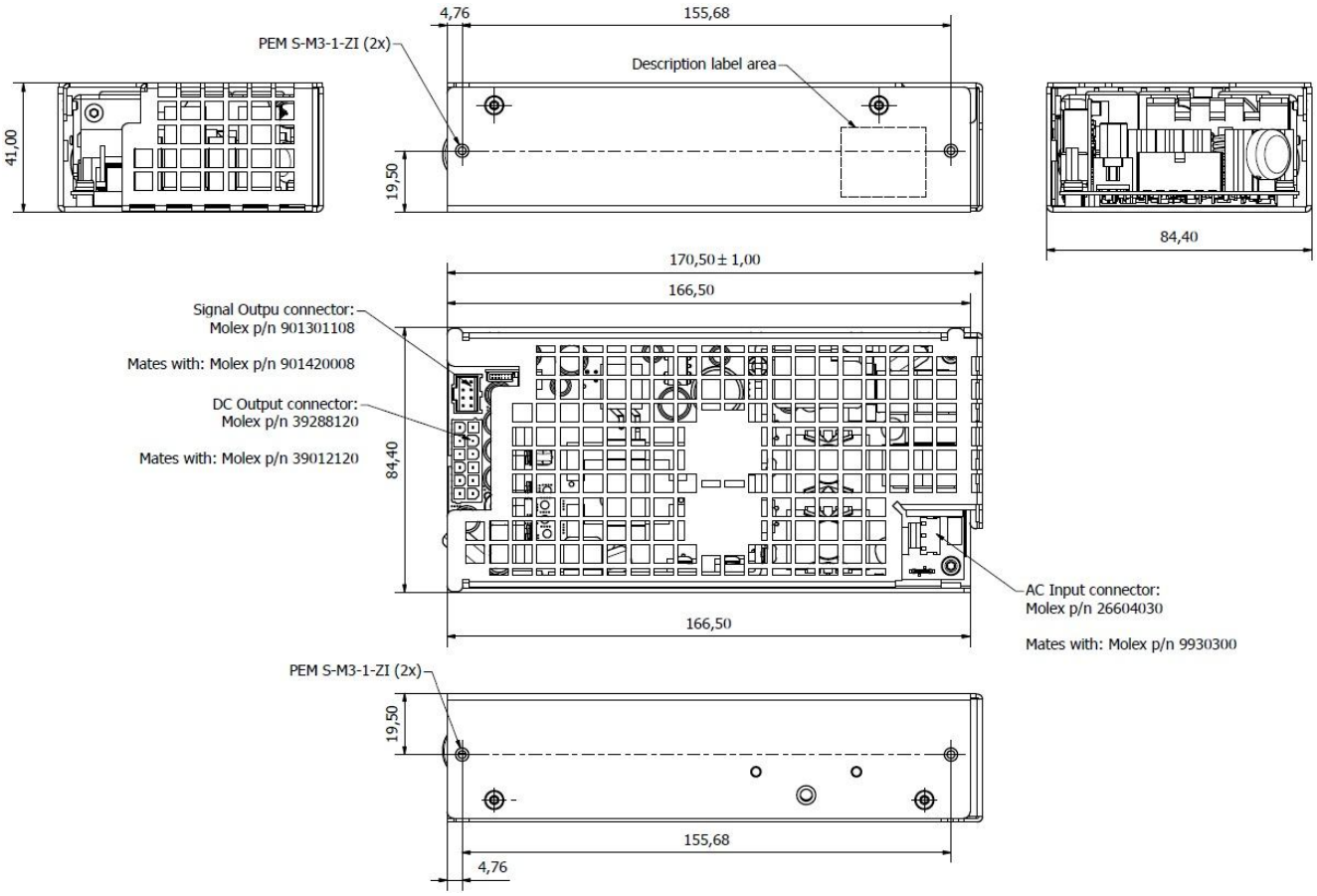
AC Input Connector P1	
Pin Ref.	Function
1	Neutral
2	Not Present
3	Live

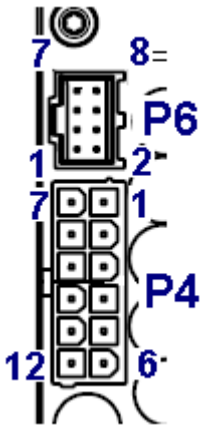
Protection earth P5
Protection Earth

OUTLINE DRAWING AND CONNECTIONS _ PUNCHED COVER

Overall dimensions: (84.4 X 170.5 X 41.0) mm; (3.32 X 6.71 X 1.61) in

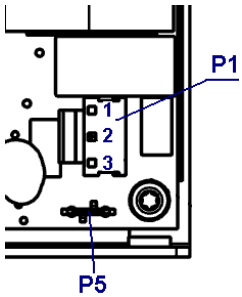
Weight: 575 g; 1.43 lb





Signals Connector P6	
Pin Ref.	Function
1	+5V$_{SB}$
2	P_OK
3	-V2
4	PS_ON
5	RS+
6	RTN
7	+V2
8	RTN

Output Connector P4	
Pin Ref.	Function
1 - 6	+V1
7 - 12	V1 RTN



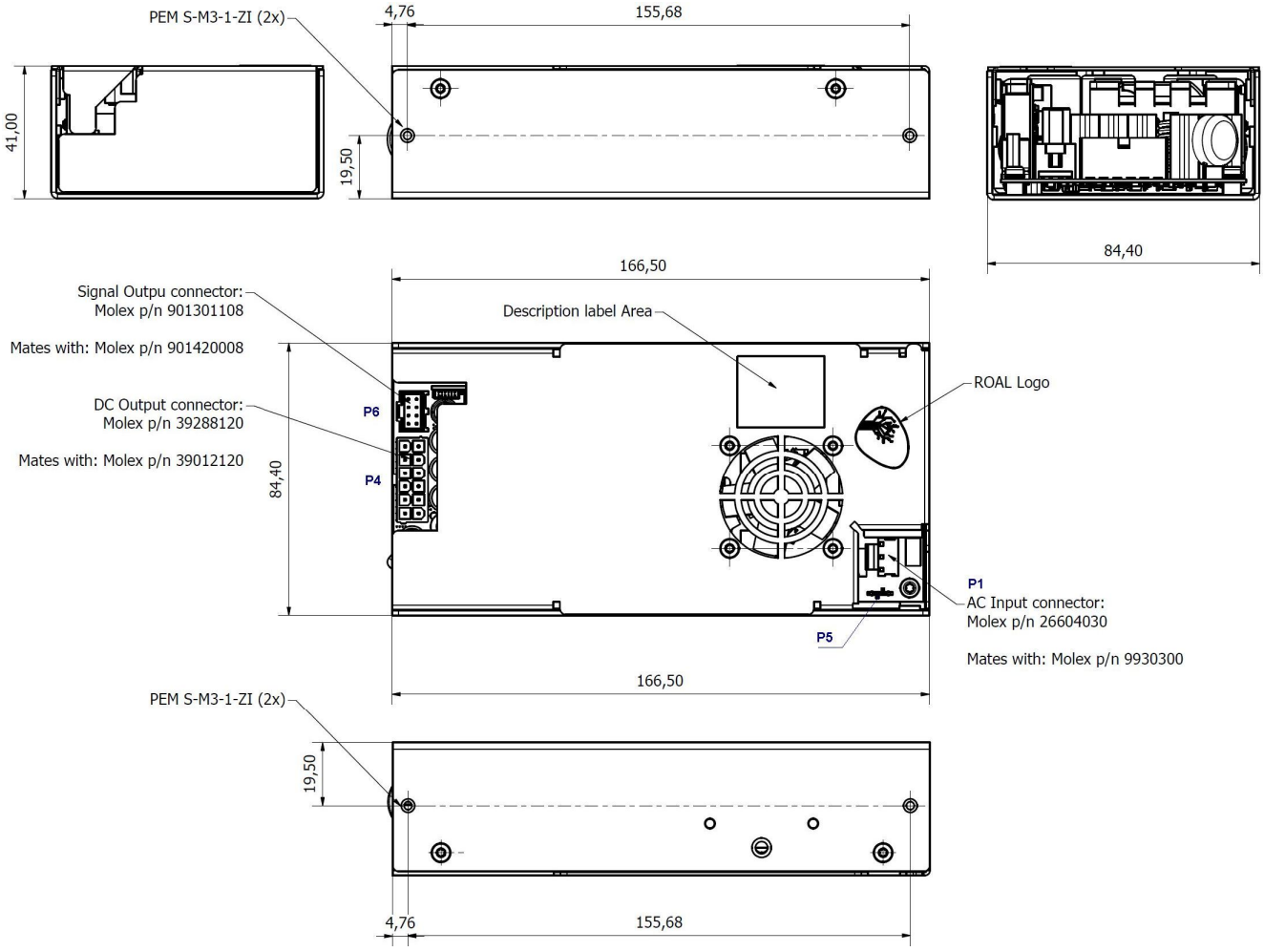
AC Input Connector P1	
Pin Ref.	Function
1	Neutral
2	Not Present
3	Live

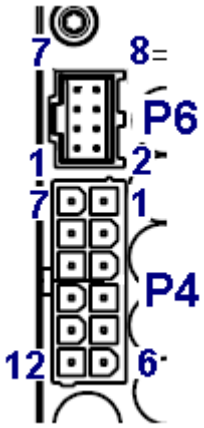
Protection earth P5
Protection Earth

Outline Drawing and Connections _ Vented Cover

Overall dimensions: (84.4 X 166.5 X 41.0) mm; (3.32 X 6.55 X 1.61) in

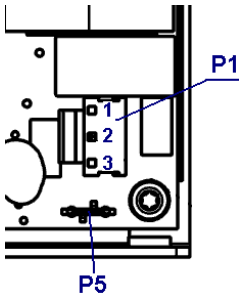
Weight: 670 g; 1.48 lb





Signals Connector P6	
Pin Ref.	Function
1	+5V$_{SB}$
2	P_OK
3	-V2
4	PS_ON
5	RS+
6	RTN
7	+V2
8	RTN

Output Connector P4	
Pin Ref.	Function
1 - 6	+V1
7 - 12	V1 RTN



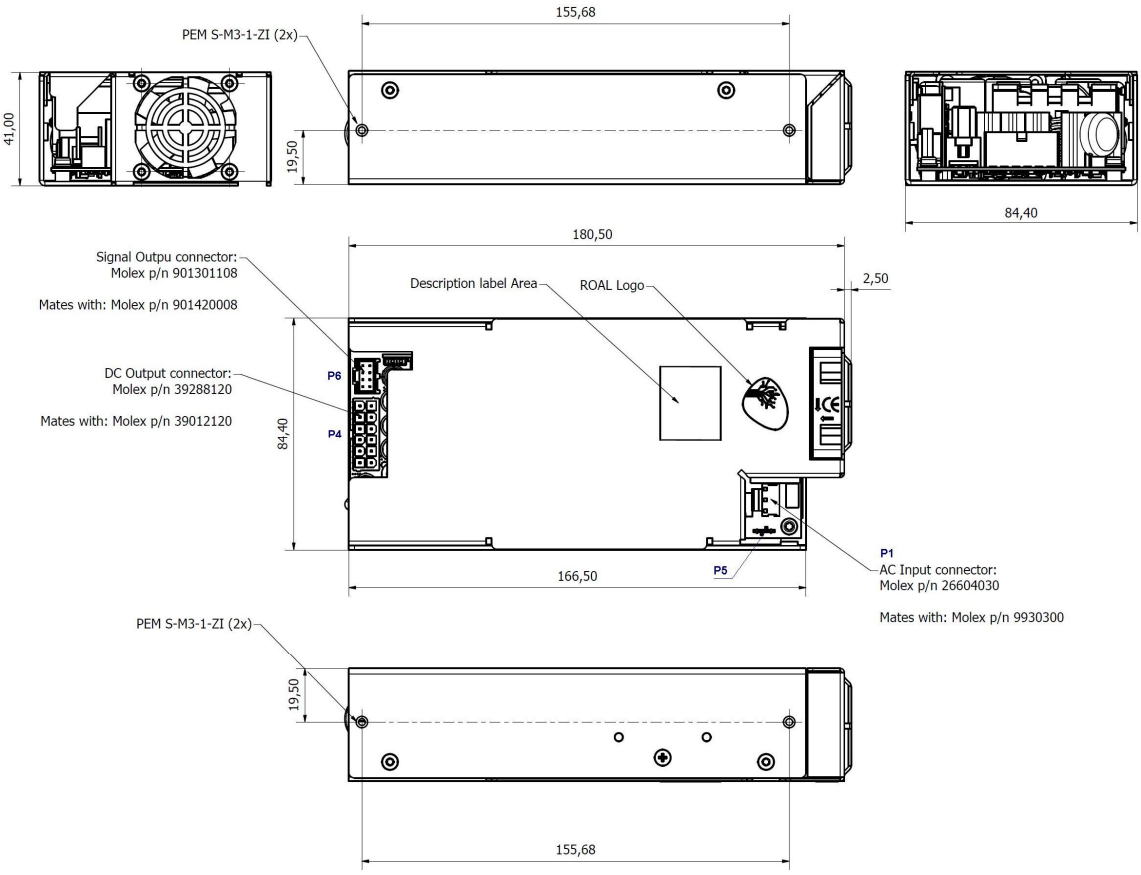
AC Input Connector P1	
Pin Ref.	Function
1	Neutral
2	Not Present
3	Live

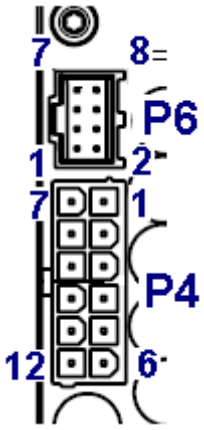
Protection earth P5
Protection Earth

OUTLINE DRAWING AND CONNECTIONS _ FRONT FAN

Overall dimensions: (84.4 X 183.0 X 41.0) mm; (3.32 X 7.20 X 1.61) in

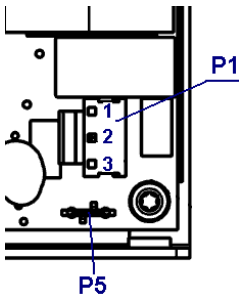
Weight: 685 g; 1.51 lb





Signals Connector P6	
Pin Ref.	Function
1	+5V$_{SB}$
2	P_OK
3	-V2
4	PS_ON
5	RS+
6	RTN
7	+V2
8	RTN

Output Connector P4	
Pin Ref.	Function
1 - 6	+V1
7 - 12	V1 RTN



AC Input Connector P1	
Pin Ref.	Function
1	Neutral
2	Not Present
3	Live

Protection earth P5
Protection Earth

Europe, Middle East and Africa

ROAL Electronics S.p.A
Via Jesina 56/A
60022 – Castelfidardo (AN) - Italy
Tel: +39 071 721461
Fax: + 39 071 72146 480

www.roallivingenergy.com

North America

ROAL Electronics USA, Inc.
701, Main St. Suite 405
Stroudsburg, PA18360
Phone: + 1 570 421 5750
Fax: +1 570 421 5687

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