

**FEATURES**

- IEC60601-1 Ed.3 medical
  - 2 x MOPP Pri-Sec
  - 1 x MOPP Pri-Chassis Ground
  - 1x MOPP (Main; V1) Output-Ground
- Applied part B & BF rating (voltage isolation and Patient Leakage Currents)
- 450W<sup>3</sup> natural convection at +50°C; (no derating with input line voltage)
- 650W with forced airflow at +50°C
- 800W 30s "power boost" (at start-up)
- Parallel/redundant capable; droop current share characteristic as standard.
- Output Voltage Adjustment +15%
- +5VAux and 12V fan outputs
- -30°C to +70°C operation
- Typical medical applications:
  - Ultrasound
  - Analytical equipment
  - Blood analysis
  - X-Ray, CT, and MRI machines
  - Medical beds



**DESCRIPTION**

The PQU650M-xxP Series products are rated at 650W employing a "U" channel construction that operates with natural or forced convection airflow.

The PQU650M series is a 6"x 4" format capable of providing a continuous 650W<sup>1</sup> output, with a constant current overload characteristic, and 800W "power boost" at output start<sup>4</sup> to support transient system loads.

The compact form factor offers an impressive 450W of natural convection cooled power at +50°C, whilst 650W is available using either external (system) airflow or via the optional cover assembly with integrated 80mm low profile fan.

Provision of an adjustable Main output, in addition to Auxiliary/Standby and fan outputs, will enable this technically superior solution to be deployed in the medical market sector, where applied part Type B or BF<sup>6</sup> deployment is required, complemented by medical standard safety certification.

All variants are provided with header style connectors, for AC source, DC output and signal/fan interfaces, and incorporate a droop current sharing characteristic for parallel/redundant operation.

<sup>6</sup>Applies to the Main V1 output only.

ORDERING GUIDE (MODEL NUMBER)						
Model (Order) Number	Main output (V1)		Aux Output (V2)		Fan Output (V3) <sup>5</sup>	
	Voltage Vdc	Current Adc; @ 50°C; 650W <sup>1</sup>	Vdc	Current Adc @ 50°C	Vdc	Current Adc @ 50°C
PQU650M-12P <sup>3</sup>	12	54.2	5	0.5	12	0.6
PQU650M-24P	24	27.1				
PQU650M-28P	28	23.2				
PQU650M-48P <sup>2</sup>	48	13.6				
PQU650M-54P <sup>2</sup>	54	12.1				
PQU650M-COVER <sup>3</sup>	Optional cover kit; End User assembly required					
PQU650M-F-COVER	Optional cover kit with top mounted cooling fan; End User assembly required.					

<sup>1</sup> Forced convection airflow required.

<sup>2</sup> PoE Isolation compliant.

<sup>3</sup> Derating for convection cooling required.

<sup>4</sup> Any condition resulting in the Main V1 output restarting. For example, recycling of PS\_ON or recovery from OCP/OTP protection.

<sup>5</sup> Only available for forced air-cooled deployments (not available for convection cooled deployments).

INPUT CHARACTERISTICS					
Parameter	Conditions	Min	Nom	Max	Units
Input Voltage AC Operating Range	Single Phase	90	100-240	264	Vac
Input Frequency		47	50/60	63	Hz
Turn-on input voltage	Input rising	75		90	Vac
Turn-off input voltage	Input falling	65		80	Vac
Maximum input current	Vin = 90VAC; Full Load <sup>1</sup> (650W FL)			9.0	Arms
Inrush Current	230Vac, Cold start, 25°C		30		Apk
Power Factor	At 230VAC, full load	0.95			W/VA
Hold-up Time	90Vac; 650W	10			msec
Efficiency @ 230VAC; 25°C	20% Full Load		92		%
	50% Full Load		95		
	100% Full Load		94		
No Load Input Power Consumption	(PS_ON = OFF; Aux (V2) = 0A)			<0.5	W

<sup>1</sup> Input current will increase to ~10Arms under 800W peak power

MAIN OUTPUT CHARACTERISTICS (ALL MODELS)					
Parameter	Conditions	Min	Nom	Max	Units
Line, Load Regulation	Main (V1) Output <sup>1</sup>			±5	%
Minimum Load Capability	Stable Operation	0			A
Output Ripple	Zero to Full Load <sup>2</sup>			1%	mVPP

<sup>1</sup> Zero load output voltage may exceed the regulation window however will not cause OVP to engage or PWOK to change to low state.

<sup>2</sup> Ripple and noise are measured with 0.1uF ceramic capacitor and 10uF tantalum capacitor. A short coaxial cable with 50 ohm termination is used. Min 120uF cap required at the output to keep ripple within 1% for 54V output. Min 10% load current required, to maintain ripple within 1% for the 12V output model.  
1A min load for all other models.

AUXILIARY OUTPUT CHARACTERISTICS					
Auxiliary Output	Aux Output Voltage	Load Current	Load Capacitance	Line, Load, Cross Regulation	Ripple Voltage & Noise
Aux (V2)	5V	0 to 0.5A	0 to 220µF	4.75 to 5.25Vdc	100mVPP

FAN OUTPUT CHARACTERISTICS (ALL MODELS)					
Auxiliary Output <sup>1,2</sup>	Aux Output Voltage	Load Current	Load Capacitance	Line, Load, Cross Regulation	Ripple Voltage & Noise
Aux (V3)	12V	0 to 0.6A	0 to 220µF	10.8 to 13.2Vdc	120mVPP

<sup>1</sup> Not recommended for "general use" due to its semi regulated characteristic. The output is for use with a fan intended to cool the PQU650M; therefore, if the PQU650M is convection cooled only then this output should not be used.

A 1.5A non-replaceable fuse is provided in this output for overload protection.

<sup>2</sup> Only available for forced convection cooled deployments (not available for natural convection cooled deployments).

MAIN OUTPUT CHARACTERISTICS (ALL MODELS EXCEPT UNLESS NOTED)					
Parameter	Conditions	Typ.	Max.	Units	
Transient Response <sup>1</sup>	50% load step, 1A/µsec slew rate and min 10% load i.e. 10% to 60%; 100% to 50%		± 5	%	
Settling Time to 1% of Nominal			500	µsec	
Turn On Delay	After application of input power		3	sec	
Output Voltage Rise		200		msec	
Remote Sense <sup>2</sup>	Compensates for up to 120mV of total lead drop (output and return connections) with remote sense connected. Protected against short circuit and reverse connection.		1	%	

<sup>1</sup> Minimum of 1 second time between consecutive transients; requires 10% minimum load.

<sup>2</sup> Remote sense is not offered as a standard feature due to droop current share characteristic offered on the standard models; consult the sales channel for availability of remote sense option.

ENVIRONMENTAL CHARACTERISTICS					
Parameter	Conditions	Min.	Typ.	Max.	Units
Storage Temperature Range		-40		85	°C
Operating Temperature Range <sup>2</sup>	See power derating curves	-30		70	
Operating Humidity	Non-condensing	10		95	%
Operating Altitude		-200		5000 <sup>1</sup>	m
MTBF	Telcordia SR-332 Issue 3; M1C3 @ 25°C Telcordia SR-332 Issue 3; M1C3 @ 40°C		1810K 797K		Hours
Shock	30G, non-operating				Complies
Operational Vibration	Sine Sweep; 5-150Hz, 2G				Complies
	Random Vibration, 5-500Hz, 1.11G				
Safety – Medical Standards 2 x MOPP (Primary-Secondary)	IEC 60601-1:2005; IEC60601-1:2005/AMD1:2012 CAN/CSA-C22.2 No. 60601-1:2008/A1:2014 ANSI/AAMI ES 60601-1:2005/A1:2012-08 EN 60601-1:2006/A1:2013				
Fuses	Dual Fuses; Line and Neutral; 12.5A Fast Acting; 250V				
"U" Channel Outer Dimensions	4.0" x 6.0" x 1.69" (101.6mm x 152.4mm x 42.8mm) nominal				
Weight (typ.); "U" Channel	0.692/1.526				kg/lbs.

<sup>1</sup> Meets 5000 M max. altitude for Medical certification requirements.

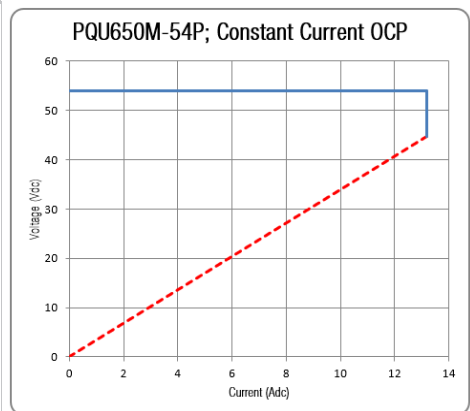
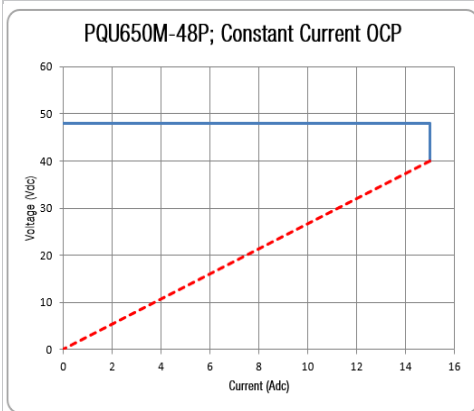
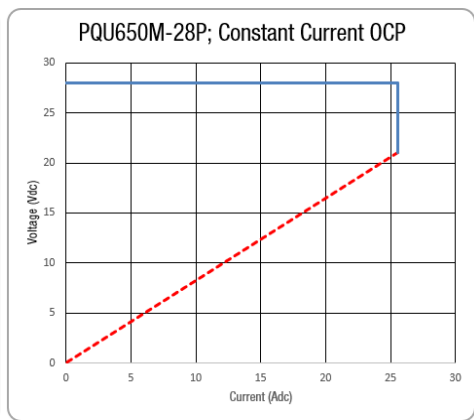
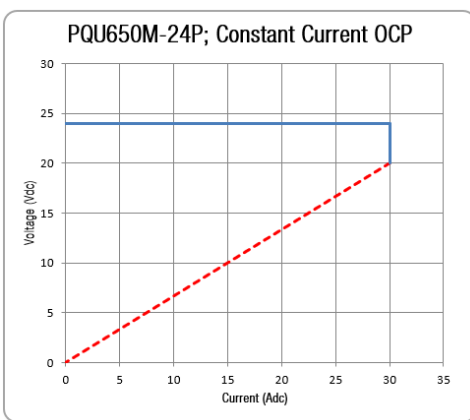
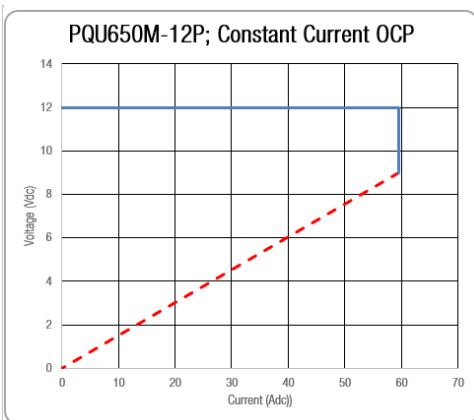
<sup>2</sup> Starts at -30°C at 100Vac minimum input; however full specification guaranteed at -20°C; \*contact Murata for lower operating temperature range operation.

**PROTECTION CHARACTERISTICS**

Parameter	Conditions	Min.	Typ.	Max.	Units
Over Current Protection	V2, auto-recovery	110		150	%
	V3; non-resettable fuse <sup>1</sup>			1.5	Adc
Over Voltage Protection <sup>2</sup>	Latching	110		140	%Vdc
Over Temperature Protection	Auto-recovery				
Primary Heatsink Temperature				130	°C
Secondary Temperature				130	
Remote Sense Short Circuit Protection			Complies		--
Remote Sense Reverse Connection Protection			Complies		--

<sup>1</sup>OCP of the 12V Fan (V3) output is provided by an SMD fuse (accessible from top) rated at 1.5A; therefore if ruptured the 12V Fan output will not be available and the fuse shall require to be replaced.

<sup>2</sup>Refers to percentage of nominal voltage



- Curves generated for the PQU650M variants by subjecting output to an incremental (constant resistance load, equivalent to 1Adc increments (above full load)).
- The resultant curve shows the current limited to a constant "brick wall" shown by the blue portion of curve.
- If the load current is further incremented the output will enter "hiccup" (recycling on/off; shown by the red dashed curve) commencing when the output voltage falls to ~75% of the nominal set point.
- If the overload current is maintained above maximum load for an extended period the "hiccup" operation will continue indefinitely while the overload persists. In the event that the overload is maintained just below that where "hiccup" operation is initiated then, dependent on the prevailing operating conditions, the power module may enter thermal protection.
- Each time the output recovers from hiccup the output power will be capable of 800W peak to provide additional power to ensure that the transient load is delivered.

**ISOLATION CHARACTERISTICS**

Parameter	Conditions	Min.	Typ.	Max.	Units
Isolation	Primary to Chassis	1500			Vac <sup>2</sup>
	Primary to Secondary (2xMOPP)	4000			
	Secondary to Chassis <sup>1</sup>	1500			
	Output to Output <sup>1</sup>	1500			
Earth Leakage Current (under normal conditions)	264Vac, 60Hz, 25°C			400	µAac

<sup>1</sup> Also meets IEEE802.at PoE isolation limits for V1 Output.

<sup>2</sup> Isolation is verified during safety compliance testing by the use of an equivalent DC voltage as defined by IEC60601-1 3<sup>rd</sup> Edition; Section 8.8.3 using values as per Table 6, based upon the relevant peak working voltage.

CURRENT SHARING OPTION	
Model Number	Description
All PQU650M; Refer to ACAN-107 for additional details	Main output current share is achieved using the "droop" method. Nominal output voltage is achieved at 50% load; the output voltage increases/decreases (approximately ±3% of nominal voltage) with decreasing/increasing (respectively) load current. This regulation window does not include the additional tolerance due to line, and temperature, long term stability. Startup of parallel power supplies is not internally synchronized. No more than 800W combined power is allowed at start-up. To account for ±10% full load current sharing accuracy, and the reduction in full load output voltage due to droop, available output power must be derated by 15% when units are operated in parallel. Current sharing can be achieved with or without remote sense connected to the common load. External ORing protection is recommended (see Application notes, ACAN-105 for additional details); Aux (V2) outputs can be tied together for redundancy but total combined output power must not exceed 2.5W; external ORing devices are recommended to preserve redundancy. It is not recommended that the 12V Fan (V3) outputs are connected in parallel since these outputs are only semi regulated.

EMISSIONS AND IMMUNITY <sup>1</sup>		
Characteristic	Standard	Compliance
Input Current Harmonics	IEC/EN 61000-3-2	Class A
Voltage Fluctuation and Flicker	IEC/EN 61000-3-3	Complies
Conducted Emissions	CISPR 32/EN 55032	Class B
	FCC Part 15	Class B
Radiated Emissions	CISPR 32/EN 55032	Class B
	FCC 15.109 - 3 meter	Class B
ESD Immunity	IEC/EN 61000-4-2	Level 4, Criterion 2
Radiated Field Immunity	IEC/EN 61000-4-3	Level 3, Criterion A
Electrical Fast Transient Immunity	IEC/EN 61000-4-4	Level 4, Criterion A
Surge Immunity	IEC/EN 61000-4-5	Level 3, Criterion A (Com. Mode: 2kV 12 OHM, Diff. Mode: 1kV, 2ohm)
Radiated Field Conducted Immunity	IEC/EN 61000-4-6	Level 3, 10V/m, Criterion A
Magnetic Field Immunity	IEC/EN 61000-4-8	Level 3, Criterion A
Voltage dips, interruptions	IEC/EN 61000-4-11	Level 3, Criterion B

<sup>1</sup> Designed to comply with the relevant sections of IEC60601-2-4<sup>th</sup> Edition

**EMI CONSIDERATIONS**  
For optimum EMI performance, the power supply should be mounted to a metal plate grounded to all 4 mounting holes of the power supply. To comply with safety standards, this plate must be properly grounded to protective earth (see mechanical dimension notes). Pre-compliance testing has shown the stand-alone power supply to comply with EN55032 class B radiated emissions with a metal enclosure with grounded base plate. See PQU-COVER for details - testing was based on adding a toroid (4 turns of both main output wires wound as common mode choke on FAIR-RITE#5961002701 torroid. Radiated emission results vary with system enclosure and cable routing paths.  
A minimum 10% load current is required, on the main output.

STATUS AND CONTROL SIGNALS		
Parameter	Models	Conditions
PS_ON Connector J3 Pin 3	All Models (Except if separately noted)	This pin can be left unterminated (or alternatively pulled high to +5V_AUX; Connector J3 Pin 1) to (enable) turn on the main output. The +5V_AUX output is independent of the PS_ON signal, and comes up automatically when the input AC or input DC voltage is applied (within their respective specified operating ranges). If it is desired to turn off the Main Output (during normal operation) then this pin can be pulled "low" (sink current ≥2mA) to +5V_AUX_RTN.
PWOK Connector J3 Pin 2	All Models	The PWOK is a combined digital signal that signifies the status of the Main V1 output. It changes state due to loss of the incoming AC source and any condition that causes the Main V1 DC output shutdown (UVP, OCP, OTP protection). The output is via an open drain CMOS buffer (that has a 10K pull up resistor to an internal +5Vdc rail) that transitions high 15-25ms after the main output is within regulation; it transitions low at least 1msec before loss of regulation.

**PART NUMBER STRUCTURE**

PQU

650M

-

XXP

yyy

Options: None

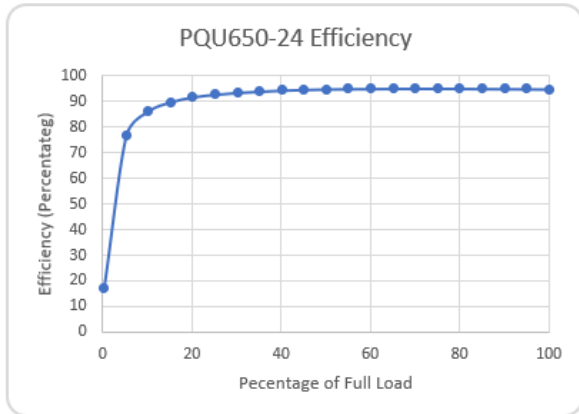
PQU = Power, Quality, "U" Channel

Main Output Voltage  
(12, 24, 28, 48, 54)  
P = Plugs/Receptacles for all input, output and signals  
Output Power (Watts); M = Medical Variant

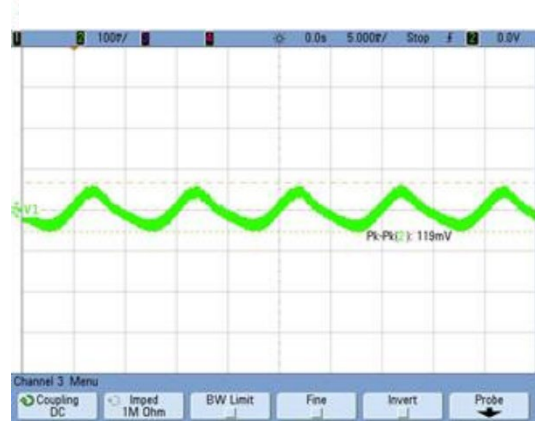
Examples: PQU650M-24P = Medical Variant, Plug/Receptacles for all input, output and signal connections, droop current share

PERFORMANCE TYPICAL DATA EXAMPLES (BASED ON 24V VARIANT)

Efficiency 24V Model



Typical Ripple & Noise (24V Model)



Transient Performance, 24V Model Half to Full Load

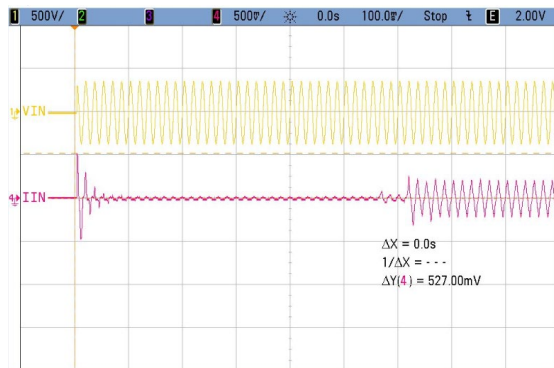


Transient Performance, 24V Model Full to Half Load



NB: Waveforms as shown include the effects of 3% droop regulation.

Inrush Current; 264Vac input, Cold Start, 10.5A<sub>pk</sub>



Hold Up Time; 90Vac; 650W



EMI; Conducted CISPR 22; Peak vs. Average Limit; L1; 100Vac 24Vdc @ 25Aac

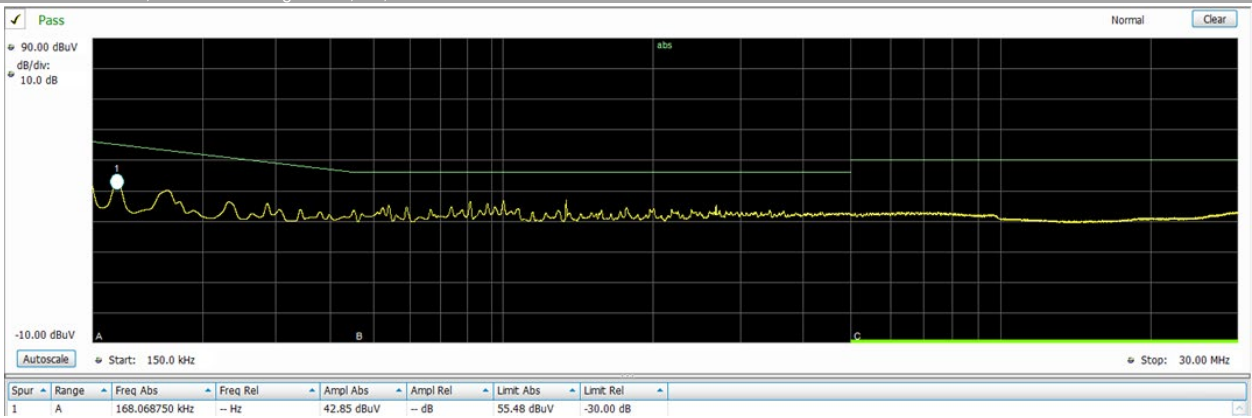


EMI; Conducted CISPR 22; Peak vs. Average Limit; L2/Neutral; 100Vac 24Vdc @ 25Aac



**PERFORMANCE TYPICAL DATA EXAMPLES**

EMI; Conducted CISPR 22; Peak vs. Average Limit; L1; 208Vac 24Vdc @ 25Aac



EMI; Conducted CISPR 22; Peak vs. Average Limit; L2/Neutral; 208Vac 24Vdc @ 25Aac



**THERMAL CONSIDERATIONS**

System thermal management is critical to the performance and reliability of the PQU650M series power supplies.

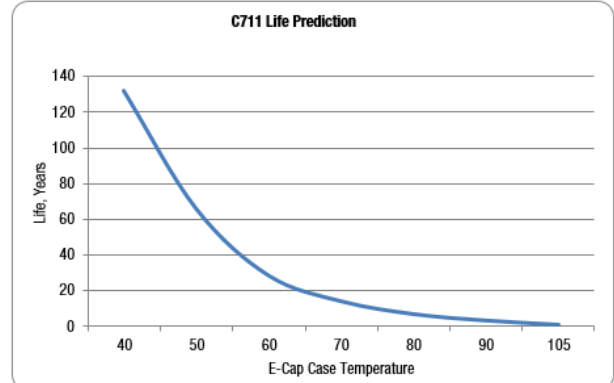
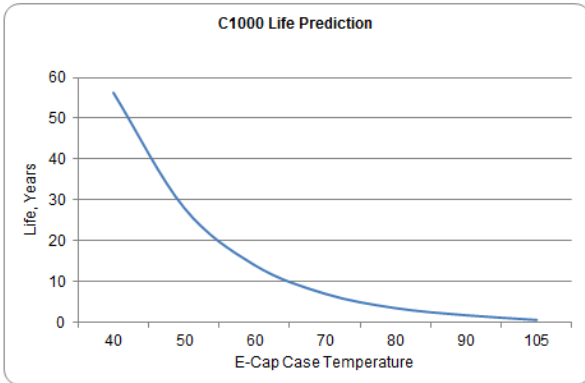
The product is designed to provide 450W using natural convection cooling when mounted with un-obstructed convection current airflow flow at up to +50°C local ambient temperature. At elevated temperatures the power supply data is taken while it is surrounded by a large vented enclosure to minimize forced cross flows inherent in the elevated temperature test.

The product is capable of operation when mounted in diverse orientations; See ACAN-106 for additional details

**Capacitor Case Temperature and Mounting Orientation:**

The power supply can operate in any orientation; however, the power supply contains overtemperature protection that will shut off the output as the temperature of critical components exceed their safe and reliable thermal limits.

Additionally, life expectancy of the power supply is inversely proportional to the case temperature of electrolytic capacitors. The designer of the system in which this power module is deployed should consider this relationship to ensure optimum product life. The following charts are life predictions based on 80% of full load capability (and illustrate this relationship).



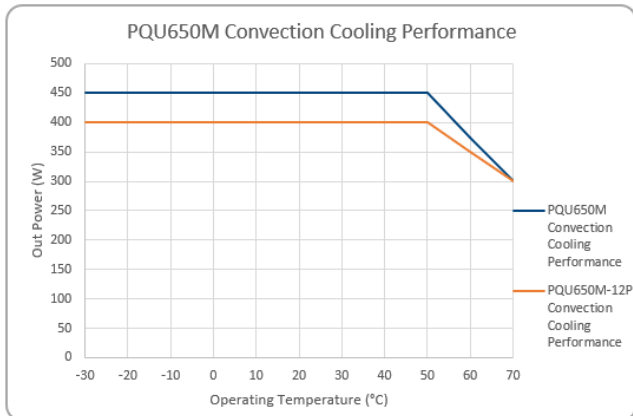
The PQU650M Series will also benefit from the provision of forced convection cooling airflow either generated by an external host system fan or from the integral fan provided in the optional PQU650M-F-COVER assembly.

A dedicated 12V Fan (V3) output is provided that can be used to power an external (system) fan. This shall enable operation to the full capability of 650W at +50°C local ambient (forced convection cooling air) temperature.

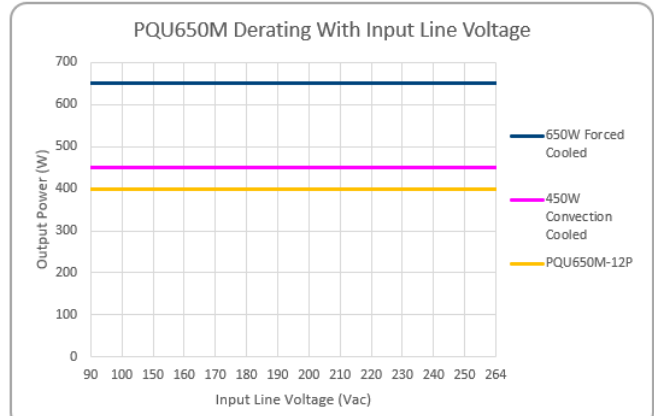
Please refer to ACAN-106 for additional details

**DERATING CURVES**

**Output Thermal Derating**



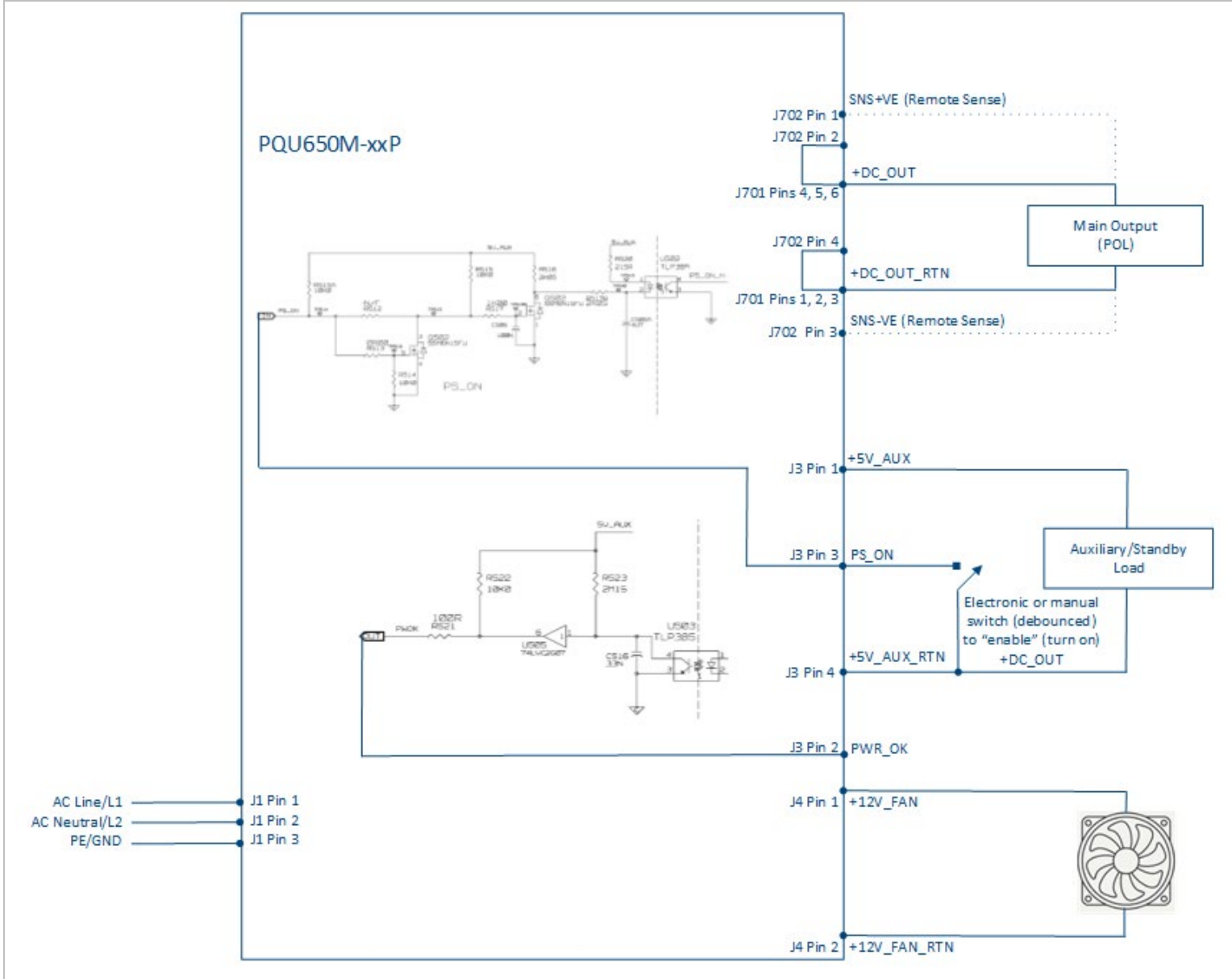
**Derating with Input Line**



- The PQU650M will reliably provide 450W cooled by natural convection with no derating for AC line at a local ambient temperature of +50°C; except for PQU650M-12P that is derated to 400W at +50°C.
- It is also capable of providing 300W at operation up to +70°C.
- The PQU650M shall provide 650W of power with a minimum recommended airflow of 300LFM/1.5m/s (for the opening area of the "U" channel i.e. 4.0" x 1.55" (101.6mm x 40mm); this equates to circa 13CFM/ 6.14 litre/s) via an external (system fan) or when provided with the PQU650M-F-COVER assembly with integral (top) mounted fan.

No derating with input line voltage for convection or forced cooling airflows for all series variants except for PQU650M-12P that derates to 400W when convection cooled.

WIRING DIAGRAM FOR OUTPUT CONNECTIONS

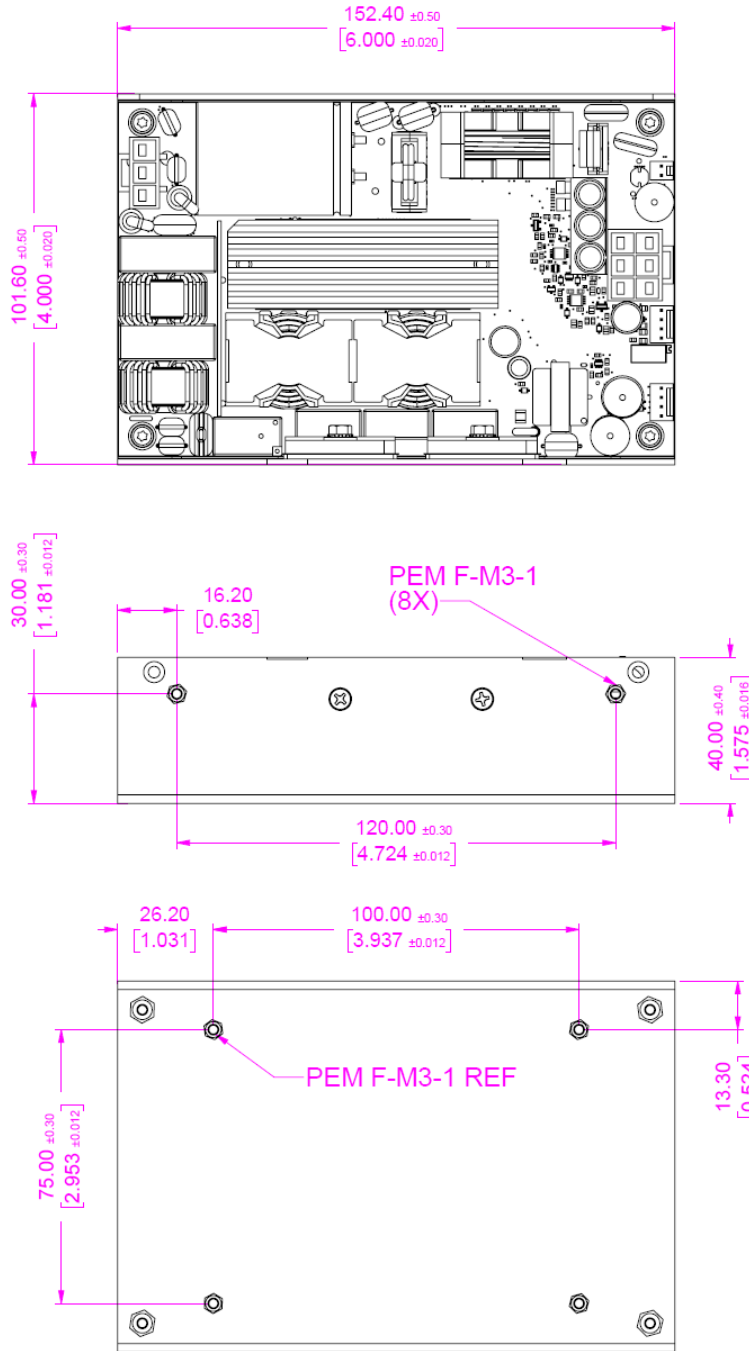


Note: For parallel (current share) operation it is required to connect the sharing power supplies in parallel (+DC\_OUT connected together and +DC\_OUT\_RTN connected together between sharing power supplies).  
 Since each output has an identical "droop" share characteristic then each output will intrinsically share the total load current. See ACAN-107 for more details.  
 It is recommended that for redundant (critical) applications that external isolation devices (diodes or MOSFETS) are employed. See ACAN-105 for more details



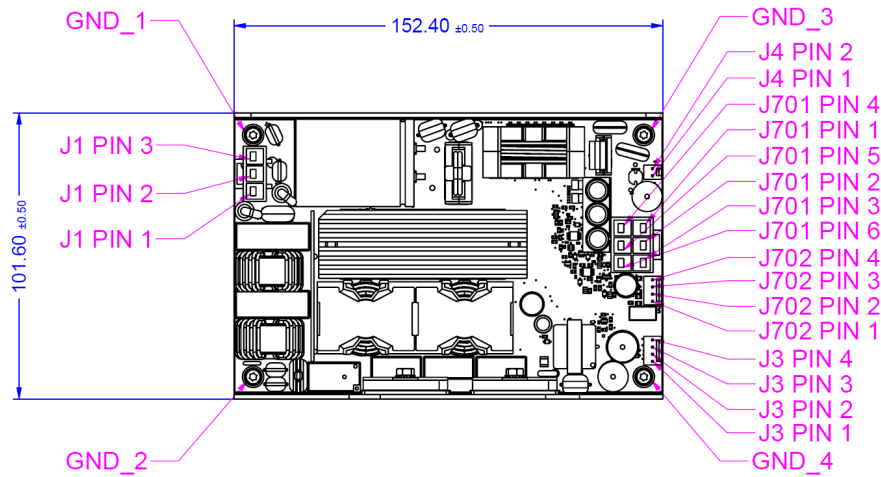
PQU650M-xxP Series

"U" Channel Mechanical Dimensions



PQU650M-xxP Series

CONNECTOR IDENTIFICATION



OUTPUT AND SIGNAL CONNECTIONS

Input Connector J1; AC Source

JST Connectors, B03P-VL (VL Series)  
Mating Half: JST Housing VLP-03V  
Crimps/Terminals:

- SVF-61T-P2.0
- 20-14AWG
- SVT-81T-P2.0 12AWG

Pin 1	AC Line/L1
Pin 2	AC Neutral/L2
Pin 3	PE/GND

Output Connector; J701

JST Connectors; B06P-VL (VL Series)  
Mating Half: JST Housing VLP-06V  
Crimps/Terminals:

- SVF-61T-P2.0
- 20-14AWG &
- SVT-81T-P2.0 12AWG

Pins 1, 2, 3	+DC_OUT_RTN
Pins 4, 5, 6	+DC_OUT

Remote Sense Connector; J702

TE Connectivity;  
640456-4  
4 pin Friction Lock Header  
Mating Receptacle Half:

- 3-640621-4
- 24AWG Cable

Pin 1	SNS+VE
Pin 2	+DC_OUT
Pin 3	SNS-VE
Pin 4	+DC_OUT_RTN

Signal Connector; J3

TE Connectivity; 640456-4  
4 pin Friction Lock Header  
Mating Receptacle Half:

- 3-640621-4
- 24AWG Cable

Pin 1	+5V_AUX
Pin 2	PWR_OK
Pin 3	PS_ON
Pin 4	+5V_AUX_RTN

External Fan Connector; J4

TE Connectivity; 640456-2  
2pin Friction Lock Header  
Mating Receptacle Half:

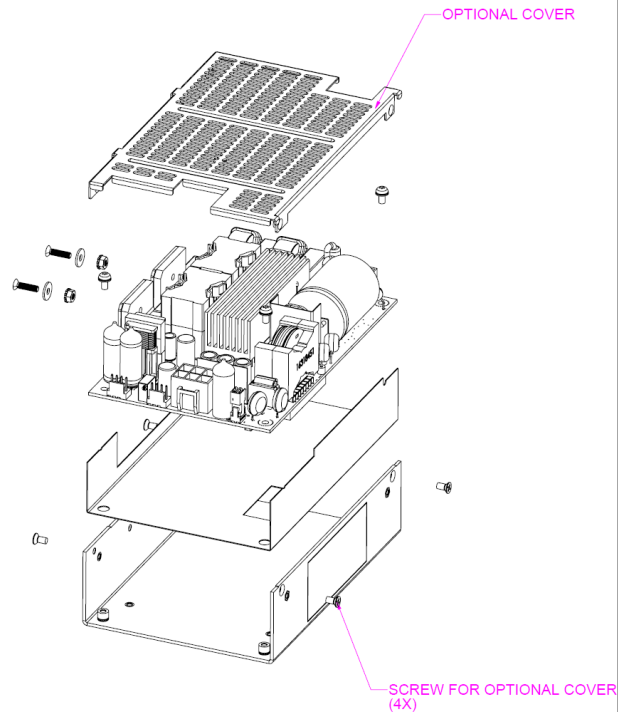
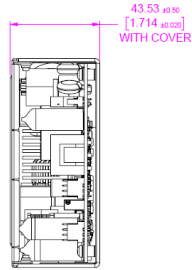
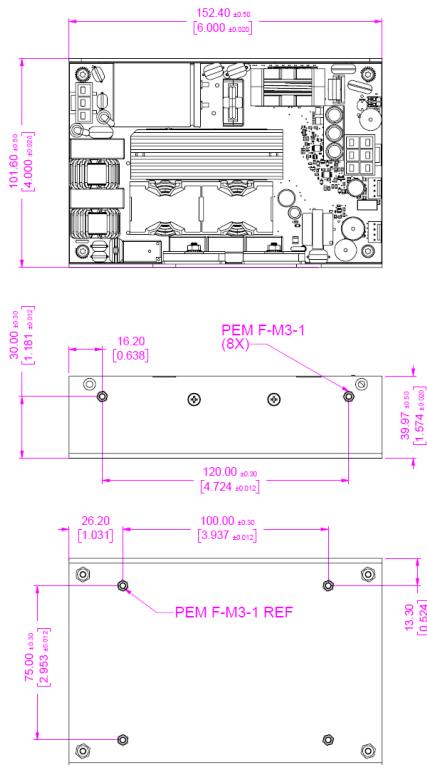
- 3-644795-2
- 24AWG Cable

Pin 1	+12V_FAN
Pin 2	+12V_FAN_RTN

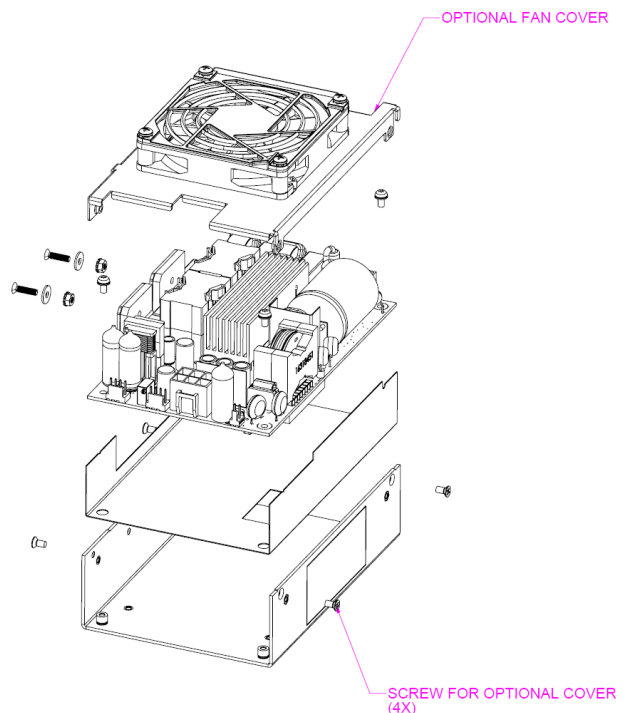
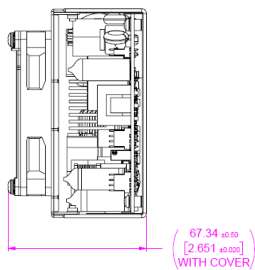
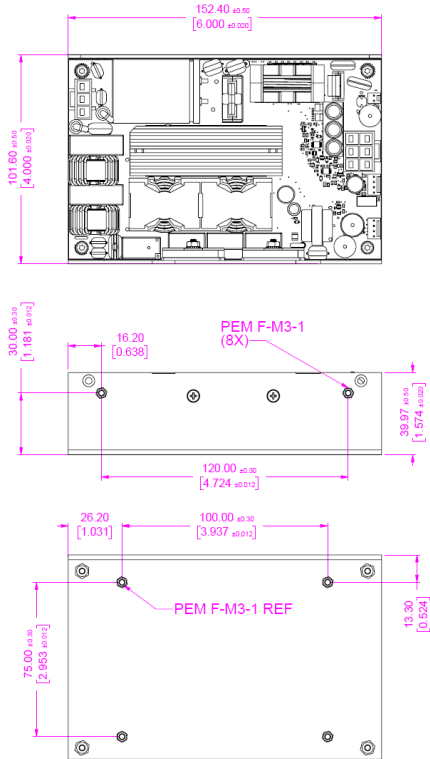
OUTPUT AND SIGNAL CONNECTIONS; TECHNICAL DETAILS

Connector	Technical Data	Manufacturer
Input Connector J1	250V, 7.5A, 3 positions. Flame Rated: UL94V-0; 5.08mm Pitch	JST Connectors, B03P-VL (VL Series) Mating Half: JST Housing VLP-03V Crimps/Terminals: SVF-61T-P2.0; 20-14AWG & SVT-81T-P2.0 12AWG
Output Connector; J701	600V, 15A, Flame Rated at 94V-0; 90°C temperature rated	JST Connectors; B06P-VL (VL Series) Mating Half: JST Housing VLP-06V Crimps/Terminals: SVF-61T-P2.0; 20-14AWG & SVT-81T-P2.0 12AWG
Remote Sense Connector; J702	250VAC; 5A max, -55° to 105°C operating UL94V-0 rated (black)	TE Connectivity; 640456-4 Friction Lock Header
Signal Connectors J3 & J4		Mating Receptacle Half: 3-640621-4; IDC 22-28AWG Cable

PQU650M-xxP Series  
PQU650M-COVER Assembly



PQU650M-F-COVER Assembly



**SAFETY CONSIDERATIONS**



1. This power supply is a component level power supply intended for use in Class I applications.
2. A protective bonding conductor from the end product protective earthing terminal must be tied to connector J1 (relevant pin dependent on connector type).
3. The primary heatsink is considered a live primary circuit and should not be touched. It is recommended that the primary heatsink be kept at least 4mm from chassis/ground and 8mm from secondary (SELV) circuitry. In all cases, the applicable safety standards must be applied to ensure proper creepage and clearance requirements are met.
4. This product is subject to the following operating requirements and the Life and Safety Critical Application Sales Policy: <https://www.murata.com/products/power/requirements/>
5. The power supply has been evaluated for 5000m altitude and tropical climatic conditions for China.
6. Double pole/neutral fusing is used; the product label is annotated accordingly.
7. If the product is used with the PQU650M-COVER or PQU650M-F-COVER assemblies, the relevant safety creepage and clearance requirements are preserved when the PQU650M is correctly installed.
8. For all deployment installed chassis mounting screws, the End User should ensure that the screw does not protrude by more than two (2) threads through the captive PEM mounted in the "U" channel.

**APPLICATION NOTES**

Document Number	Description	Link to Document
ACAN-105	PQU650M External ORing deployment notes	<a href="#">ACAN-105</a>
ACAN-106	PQU650M Installation/Thermal deployment notes	<a href="#">ACAN-106</a>
ACAN-107	PQU650M Current Sharing deployment notes	<a href="#">ACAN-107</a>

Murata Power Solutions, Inc.  
129 Flanders Road  
Westborough, MA 01581  
ISO 9001 an 14001 REGISTERED



**This product is subject to the following operating requirements and the Life and Safety Critical Application Sales Policy. Refer to: <https://www.murata.com/products/power/requirements/>**

Murata Power Solutions, Inc. ("Murata") makes no representation that the use of its products in the circuits described herein, or the use of other technical information contained herein, will not infringe upon existing or future patent rights. The descriptions contained herein do not imply the granting of licenses to make, use, or sell equipment constructed in accordance therewith. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards that anticipate dangerous consequences of failures, monitor failures and their consequences to lessen the likelihood of failures that might cause harm, and take appropriate remedial actions. Buyer will fully indemnify Murata, its affiliated companies, and its representatives against any damages arising out of the use of any Murata products in safety-critical applications. Specifications are subject to change without notice. Customer hereby acknowledges and agrees that Murata has not made, and will not make, any representations, warranties, covenants or other statements that would in any way indicate that the Products are suitable for use in connection with medical devices, medical equipment or for any other medical purposes, whether as a stand-alone product, or combined in any way with another good, product, part, hardware or otherwise, and, to the extent permitted by applicable law, Customer hereby expressly assumes any and all liability for any and all such use of the Products.

2021 Murata Power Solutions, Inc.