OPERATING MANUAL
RADIAN TPCMQ48 SERIES
48VDC INPUT DC/DC CONVERTERS

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OPERATING MANUAL
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1.0 INTRODUCTION

This Operating Manual should be read through carefully before installing and operating the Radian TPCMQ48 Series DC/DC converters.

Radian TPCMQ48 is a family of high density hot-swappable, modular DC/DC converters producing up to 1000 watts output power from a nominal 48VDC source. There are 6 standard models with different output voltages and power levels. The modules are ultra-compact with power density up to 12.5 watts per cubic inch. The modules have automatic load sharing and active output ORing circuit so they can be hot-swapped while the system is operating. When using the optional I^2C serial communications interface, status and control data can be passed between the module and a host system or power management unit.

Front panel mounted LEDs indicate input and output condition and a +5Vstandby output is also included. Operating temperature range is -20°C to +70°C.

TPCMQ48 modules can be fully integrated into an OEM host system or alternatively installed into a matching 1U high 19" rack-mount power shelf. Multiple power shelves may be connected in parallel for increased system capacity.

Figure 1 below shows a TPCMQ48 module and three modules installed into a power shelves.

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Figure 1 - Module & Power Shelf

2.0 STANDARD FEATURES

- ◆ Isolated 5V, ¼ A Standby Output
- ◆ Hot-Swap Operation
- ◆ 12, 24 or 48 VDC Output
- ◆ Up to 3000 Watts Shelf Output
- ◆ Remote Output Adjustment
- ◆ Wide Range 40 to 60VDC Input
- ◆ Integral LED Status Indicators
- ◆ -20°C to +70°C Operating
- ◆ I²C Serial Data Bus Option
- ◆ Up to 12.5 Watts/Cubic Inch Power Density
- ◆ Low Profile: 1.6 Inches High
- ◆ Single Hot-Swappable Connector
- ◆ Reverse Air Flow Option
- ◆ Staged Pin Engagement
- ◆ ORing Diode on Output
- ◆ 1U, 19" Rack/Shelf Holds 3 Units
- ◆ 19- or 23-Inch Rack Mounting
- ◆ Active Current Sharing
- ◆ Optimized Thermal Management
- ◆ No Minimum Load
- ◆ Control & Monitoring Features

3.0 SUMMARY OF PRODUCT LINE

3.1 Standard Modules & Shelves

STANDARD MODULES

OUTPUT POWER	OUTPUT VOLTAGE	OUTPUT CURRENT	INPUT CURRENT	MODULE NUMBER	RACK/SHELF NUMBER
650W	12VDC	54.2A	16.5A @ 48VDC	TPCMQ48-12/54	TPCMQR1U3-48
700W	24VDC 27.2VDC	29.2A 25.7A	16.6A @ 48VDC 19.9A @ 40VDC	TPCMQ48-24/29 TPCMQ48-27/26	
1000W	48VDC 54.4VDC	20.8A 18.4A	20.8A @ 48VDC 25.0A @ 40VDC	TPCMQ48-48/21 TPCMQ48-54/18	TPCMQR1U3-48H

3.2 Options

OPTIONS

CODE	DESCRIPTION	OUTPUT DERATING	APPLICABILITY
R	Reverse Air Flow (Back to Front)	20%	All modules
Z	I²C Serial Data Bus	N/A	All modules TPCMQR1U-48

NOTE: TPCMQR1U3-48H will accept modules both with and without the I²C option, but modules should not be mixed.

4.0 SAFETY WARNINGS

4.1 These power supplies have hazardous external and internal voltages. They should be handled, tested and installed only by qualified technical persons who are trained in the use of power systems and are well aware of the hazards involved.

4.2 The input terminals are at hazardous voltage potentials. Do not touch this area when power is applied.

4.3 When operating this power supply, the chassis ground terminal must be connected to safety ground by means of a three-wire AC power line to minimize electrical shock hazard and to ensure low EMI (electromagnetic interference).

4.4 The internal voltages are at hazardous potentials. The power supply cover should not be removed. There are no user-serviceable components in these units. Removing the cover of the power supply will void the warranty.

5.0 WARRANTY (summary)

TPCMQ48 Series DC/DC Converters are warranted for two (2) years from date of shipment against defects in material and workmanship. This warranty does not extend to products which have been opened, altered or repaired by persons other than persons authorized by the manufacturer or to products which become defective due to acts of God, negligence or the failure of customer to fully follow instructions with respect to installation, application or maintenance.

For a complete text of UNIPOWER's warranty conditions please request a copy from your local Sales Office.

6.0 UNPACKING AND INSPECTION

6.1 This unit was carefully tested, inspected and packaged for shipment from our factory. Upon receipt the unit should be carefully unpacked and inspected for any damage in shipment.

6.2 If there is evidence of damage, **do not attempt to install the unit**. The freight carrier should be notified immediately and a claim for the cost of the unit should be filed with the carrier for direct reimbursement. Be sure to include the model and serial number of the damaged unit in all correspondence with the freight carrier. Also save the shipping carton and packing material as evidence of damage for the freight carrier's inspection.

6.3 UNIPOWER LLC will cooperate fully in case of any shipping damage investigation.

6.4 Always save the packing materials for later use in shipping the unit. Never ship this unit without proper packing.

7.0 MODULE SPECIFICATIONS

The following specifications are typical at 25°C unless otherwise noted.

OUTPUT SPECIFICATIONS

Total Output Power, Continuous, Max. .....see table page 1
Voltage Adjustment Range, Min. ..... -25% to +10%
Total Regulation[1].....2.0%
Total Regulation, Standby Supply 5.0%
Ripple & Noise, Pk-Pk[2].....200mV
Voice Band Noise .....<32dBrnC
Dynamic Response[3].....300µS
Temperature Coefficient .....±0.02%/°C
Minimum Load.....0A
Current Limit..... 105% Rated Current
Overload Protection.....Auto Recovery
Overvoltage Protection..... Latched Shutdown
Remote Sense..... Up to 0.25V Per Wire
Current Share.....±10% Full Load Rating
Standby Output.....+5V, 250mA
Output Power Good Signal.....Logic Low
Input Power Fail Signal..... Logic High
Inhibit.....Logic Low
Enable .....Logic Low
Thermal Warning ..... Logic High

INPUT SPECIFICATIONS

Input Voltage Range..... 40-60VDC
Inrush Current Limiting .....10A Peak
Input EMI Filter .....Standard
Analog Voltage Adjust.....0 to +5V
Input Immunity, Conducted
Fast Transients, Line-Line .....±500V (EN61000-4-4)
Surges, Line-Line .....±500V (EN61000-4-5)
Surges, Input Ground .....±500V (EN61000-4-5)
Input Protection 12/24Vout .....Internal Fuse, 30A
48Vout ..... requires external protection

GENERAL SPECIFICATIONS

Efficiency [4]
12/24Vout .....82-88% at Full Load
48Vout ..... up to 90% at Full Load
Switching Frequency .....210kHz Nominal
Isolation, Class I, min.[5]
Input-Output.....2121VDC
Input-Ground 1000VDC
Output-Ground.....
100VDC..... MTBF
(Bellcore) .....200,000 Hours
Safety Standards..... UL60950-1, CSA22.2 No.60950-1
EN60950-1

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature.....-20°C to 70°C Ambient
Derating.....2.5%/°C, 50°C to 70°C
Storage Temperature.....-40°C to +85°C
Cooling .....Integral Ball Bearing Fans

PHYSICAL SPECIFICATIONS

Case Material, Module & Rack/Shelf..... Aluminum
Dimensions, Inches(mm)
Module.....1.6 H x 5.0 W x 10.0 D
(40.6 x 127 x 254)
Rack/Shelf ..... 1.72H x 19.00 W x 11.56 D
(44 x 483 x 294)
Weight
Module..... 3.15 lbs. (1.43 kg.)
Rack/Shelf ..... 4.15 lbs. (1.88 kg.)

NOTES:
1. No load to full load, including line regulation and load regulation.
2. Whichever is greater. 20MHz bandwidth. Measure with 0.1µF ceramic and 10µF tantalum capacitors in parallel across the output.
3. <4% deviation recovering to within 1% for 25% load change.
4. Typical efficiency is at low end of range for 12V output and at high end of range for 24V output.
5. Input-output isolation figure is for isolation components only. 100% production Hipot tested input to ground.

8.0 FRONT PANEL DESCRIPTION

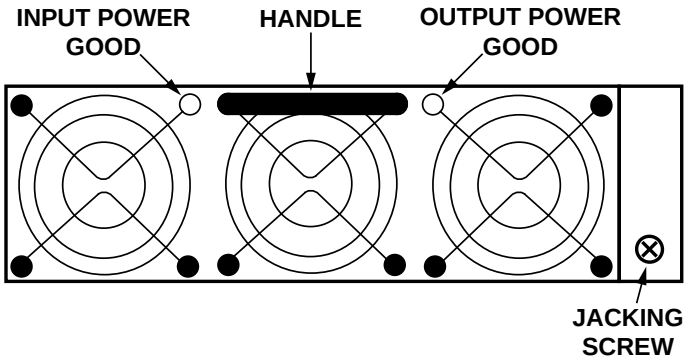


Figure 2 - Front Panel View

8.1 FRONT PANEL INDICATORS

The two green front panel indicators together indicate the status of the power module.

LED	Status	Condition
INPUT POWER GOOD	ON	DC input within limits
	OFF	DC input outside limits
OUTPUT POWER GOOD	ON	DC Output is on and within limits
	OFF	DC Output is off

9.0 DESCRIPTION OF OPERATION

9.1 Power Outputs

The power output terminals provide the main output power of the unit. The output voltage is adjustable by means of a potentiometer accessible through the top cover of by using the analogue remote adjust pin. Note that all of the power pins must be used for correct operation and to avoid overheating of the connector. The power output terminals are isolated from chassis ground to a maximum voltage of 100VDC.

9.2 I/O Signals

The # symbol in the following text is used to denote an active low signal.

9.2.1 Sense +Ve, Sense –Ve

The sense signals are intended to be connected to the point of load so that voltage drop in the load cables can be compensated for. The amount of compensation is limited to 0.25V per wire. Care must be taken when using the sense signals as if the power connections to the load are interrupted by disconnection or circuit breaker with the senses still connected then damage may occur to the power supply and sense wiring. Sense +Ve and Sense -Ve are internally connected to the module output power terminals using 10 Ohm resistors so that if the senses are not connected the output will still be regulated.

Sense -Ve is also used as the return path for the other I/O signals.

9.2.2 Current Share

This signal is connected between all modules required to share a load. This signal is capable of driving up to 16 modules. The return path for this signal is Sense -Ve and that signal should also be connected between all modules for correct sharing operation.

9.2.3 Current Monitor

This analogue signal provides a voltage proportional to the output load current of the module. The full scale voltage for nominal full load current is 3.0V.

9.2.4 Standby Return

This is the return path for the +5V standby supply.

9.2.5 Remote Adjust

An analogue voltage from 0 to +5V controls approximately -25 to +10% output range. This input can be controlled externally by a power control system. Multiple inputs can also be connected together so that the external control voltage adjusts multiple module outputs simultaneously.

9.2.6 +5V Standby

The 5V supply is always present when the DC input is within the operating range of the module. The maximum current available from 5VSB pin is 25mA The return for this power rails is standby return. The standby supply has an internal ORing diode so that it can be connected to the same outputs of additional units directly on the backplane.

9.2.7 Input Power Fail

This signal provides an open drain output that indicates the status of the DC input. The signal is low for the OK state. The output is capable of supporting voltages of up to 30V and will sink current up to 30mA.

9.2.8 Output Power Good

This signal provides an open drain output that indicates that the DC output voltage outside the -25 to +10% output range for the converter, the unit has failed or is in current limit. The signal is low for the OK state. The output is capable of supporting voltages of up to 30V and will sink current up to 30mA.

On the 12/24V model this pin is used for I²C address GA1 when the I²C option is fitted.

9.2.9 Overtemp. Warning

This signal provides an open drain output that indicates that the power supply internal temperature is within a safe operating range. The signal is low for the OK state and goes high a few milliseconds before the unit shuts down. The output is capable of supporting voltages of up to 30V and will sink current up to 30mA.

On the 12/24V model this pin is used for I²C address GA0 when the I²C option is fitted.

9.2.10 Module Present (48V/54V output units only)

This signal can be used to detect if a module is present. It is connected to standby return when the module is present. This signal should be driven from a source impedance of less than 100 Ohms.

9.2.11 Enable

This signal is used to enable the unit. This pin engages after the power terminals when plugging in the module and disengages before the power terminals when unplugging the module. It is intended to control hot-plugging to avoid burning connector pins caused by arcing of high currents. This pin should be connected to Sense -Ve on the backplane for correct operation.

9.2.12 Inhibit

This signal can be used to control the main output of the unit in order to turn it on and off. A low signal on this pin will turn the main output off. This behavior can allow a system to be setup so that the main output will not come on until commanded by a supervisory circuit. The driving circuit should be capable of sinking and sourcing at least 0.5mA.

9.2.13 SCL, SDA

These are the I²C serial data bus signals used for digital communication. They require pull-up resistors or active pull-up circuits to 3.3V or 5V.

9.2.14 GA0, GA1, GA2

These are the I²C interface address lines. They are used to set the hardware address of each module on the backplane. Each module should have a unique address when connected using the same serial bus.

The address lines should either be tied high (to 5VSB) for '1' or low (standby return) for '0'.

10.0 MECHANICAL SPECIFICATIONS

The mechanical dimensions of the TPCMQ48 Series module are shown.

Note that while TPCMQ48 Series modules are designed for hot-swap applications, fixing points are provided for applications not requiring this capability.

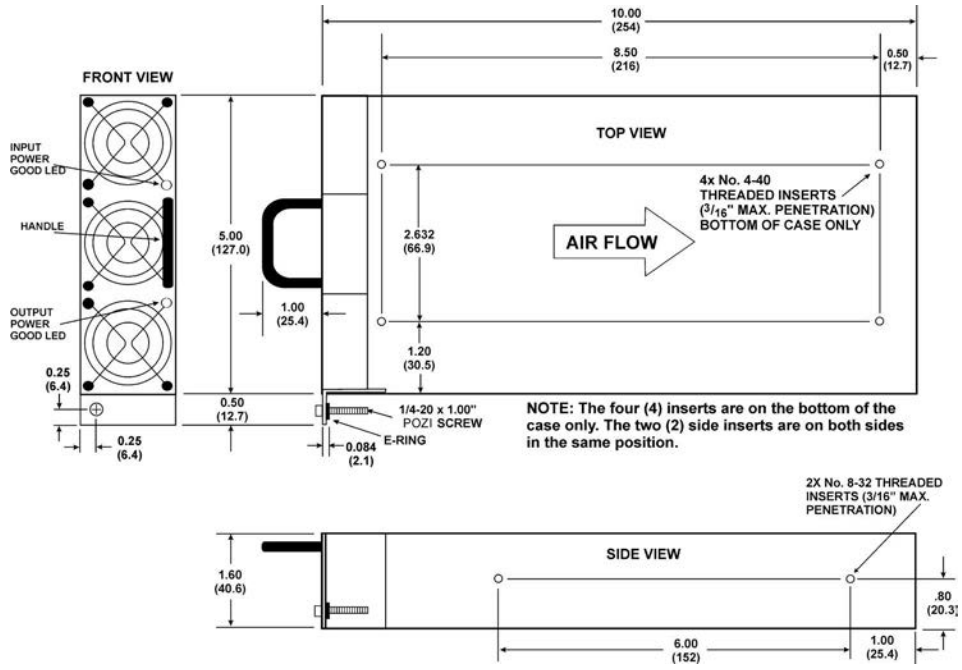


Figure 3 - Module Dimensions

11.0 SAFETY AND INDUSTRY STANDARDS

11.1 TPCMQ48 modules and power shelves meet the following safety standards:

UL60950-1
CSA22.2 No. 60950-1
EN60950-1

11.2 TPCMQ48 modules and power shelves are CE Marked to indicate conformance with the European Union's Low Voltage Directive.

11.3 Input conducted EMI meets FCC20780 part 15J Curve A and EN55022 Curve A.

11.4 Immunity, meets the following:

Input fast transients, line to line – EN61000-4-4, level 3, criteria A
Input surges, line to line – EN61000-4-5, level 3, criteria A
Input surges, line to ground – EN61000-4-5, level 4, criteria A
ESD – EN61000-4-2, level 4, criteria A
Radiated – EN61000-4-3, criteria A (10V/m)

12.0 OPERATING INFORMATION

12.1 **Input Voltage and Connection** - The TPCMQ48 Series operates from a DC input voltage in the range of 40 to 60 VDC. The +Ve DC connection is made to +DC Input pins and the –Ve DC connection is made to the –DC Input pins on the rear mounted connector.

The +DC Input and –DC Input pins are isolated from Chassis Ground, allowing TPCMQ48 Series dc/dc converters to be connected to DC sources with either a positive of a negative ground configuration.

12.2 **Output Connections** - The main output is provided on pins 1 to 6 on the connector. Three pins (1 to 3) are connected together internally for the +V Out; three other pins (4 to 6) are connected together internally for the V Return. The output is fully floating and may be configured for positive or negative operation.

12, 24 & 27.2V models **48 & 54.4V models**

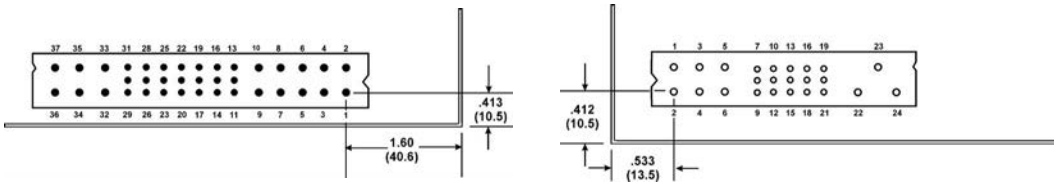


Figure 4 - Module Rear Views showing connection details

PIN	FUNCTION	PIN	FUNCTION
1	+V Out	13	Output Power Good / ADD GA1
2	+V Out	14	Input Power Fail
3	+V Out	15	Remote Adjust
4	-V Out	16	Overtemp. Warning / ADD GA0
5	-V Out	17	Current Share
6	-V Out	18	Current Monitor / ADD GA2
7	Enable	19	+5V Standby
8	+Sense	20	Standby Return
9	-Sense	21	Chassis Ground
10	Inhibit	22	Chassis Ground
11	Spare / SDA	23	-DC Input
12	Spare / SCL	24	-DC Input
13	-Sense	26	-DC Input

Figure 5a – Signal Connections – 12, 24 & 27.2V Models

PIN	FUNCTION	PIN	FUNCTION
1	-DC Input	20	Module Present
2	-DC Input	21	N.C.
3	-DC Input	22	Input Power Fail
4	-DC Input	23	N.C.
5	+DC Input	24	GA2
6	+DC Input	25	GA1
7	+DC Input	26	SCL
8	+DC Input	27	SDA
9	Chassis Ground	28	GA0
10	Chassis Ground	29	Remote Adjust
11	N.C.	30	-Sense
12	Standby Return	31	+Sense
13	+5V Standby	32	-V Out
14	Output Power Good	33	-V Out
15	Overtemp. Warning	34	-V Out
16	Inhibit	35	+V Out
17	Enable	36	+V Out
18	Current Share	37	+V Out
19	Current Monitor		

Figure 5b – Signal Connections – 48 & 54.4V Models

12.3 **Module Evaluation Board** - A mating interface board which is available for simplifying the testing of a TPCMQ48 module.

12.4 **Output Voltage** - The output voltage is factory set to its nominal value to an accuracy of ±1%. The voltage can be adjusted to any value within the range given in the table below using the remote adjust input.

Model	Adjustment Range
TPCMQ48-12/54	9.0-13.2V
TPCMQ48-24/29	18.0-26.4V
TPCMQ48-27/26	20.4-29.9V
TPCMQ48-48/21	36.0-52.8V
TPCMQ48-54/18	40.8-59.8V

12.5 **Output Power & Current** - The following table shows the maximum output power and current ratings for the various models:

Model	Output Voltage	Maximum Power	Maximum Current
TPCMQ48-12/54	12.0VDC	650W	54.2A
TPCMQ48-24/29	24.0VDC	700W	29.2A
TPCMQ48-27/26	27.2VDC		25.7A
TPCMQ48-48/21	48.0VDC	1000W	20.8A
TPCMQ48-54/18	54.4VDC		18.4A

When the output voltage is adjusted below the nominal voltage shown in the table the maximum current indicated will apply. Conversely, when the output voltage is adjusted above the nominal voltage shown the maximum power indicated will apply.

The maximum output power may be drawn up to +50°C air inlet temperature. Above +50°C the total output power must be derated by 2.5%/°C, up to an absolute maximum air inlet temperature of +70°C. Note that dependent on actual airflow through the unit output power may be further limited or a temperature alarm indicated at lower temperatures.

12.6 Overvoltage Protection - The power supply has two internal O.V.P. protection circuits. One operates at a fixed voltage level and the other is programmable by the PMBus. The fixed O.V.P. levels are defined below:

Model	Fixed OVP Point (nominal)
TPCMQ48-12/54	21.1V
TPCMQ48-24/29	31.9V
TPCMQ48-27/26	
TPCMQ48-48/21	59.4V
TPCMQ48-54/18	

The O.V.P. circuit has a latching function and will not allow the unit to automatically restart. In order to reset the O.V.P. latch, the DC input must be cycled off for at least 5 seconds before turning back on.

12.7 Overcurrent and short circuit protection - The power supply will provide a constant current limit in the event of an overload on the output. If the output voltage of the power supply falls below a certain level, the power supply will enter a 'hiccup' mode of operation. Removing the overload or short circuit will allow normal operation to resume. The voltage at which the 'hiccup' mode of operation occurs is programmable down to the minimum default setting.

12.8 Remote Sensing - Remote sensing connections are made to the +Sense and-Sense pins on the connector. Remote sensing is not available on the +5V Standby output. Remote sensing is used to regulate the output voltage at the point of load by compensating for the voltage drop in the wires to the load. The +Sense lead must be connected to the +Ve side of the load and the -Sense lead to the -Ve side of the load. The sense leads should be a color-coded, twisted pair of AWG no. 22 or 24 copper wire.

Remote sensing can compensate for a total voltage drop of 0.5V, or 0.25V per load wire. The sense leads should not exceed 10 feet (3 meters) in length. If remote sensing is not required, the sense leads may be left open for local sensing at the output terminals. **Be careful not to reverse the sense lead connections, as this could damage the unit.**

12.9 Alarm, Control & Supervisory Signals - All alarm, control and supervisory signals are available on the connector at the rear of the unit. See section 9.2 for a complete description.

All logic signals are TTL level compatible and are referenced to -Sense.

12.10 I²C Option – The I²C serial bus is available on the connector at the rear of the unit.

13.0 PARALLEL OPERATION

13.1 Parallel Connection - Two or more TPCMQ48 modules can be operated in parallel by connecting their outputs in parallel and connecting their current sense terminals together. The TPCMQ48 19-inch rack power shelves permit conveniently operating two or three units in parallel in either redundant mode or non-redundant mode.

13.2 Redundant Operation - Connecting two TPCMQ48 modules in parallel, with or without the compatible 19-inch rack, so that the full output load current can be carried by one unit results in 1+1 redundant operation. While operating normally, the load current is shared approximately equally between the two units. Should one TPCMQ48 module fail, the full load is then maintained by the other unit. The failed unit can then be replaced (hot-swap) without affecting the load current. This operation is facilitated by an active ORing circuit built into the module. 1+1 redundancy with quick replacement of a failed unit results in virtually infinite MTBF. 2+1 redundancy works the same way except that the full load is carried by two out of three units respectively.

13.3 Non-Redundant Operation - Higher output load currents can be realized by operating two or three modules in the non-redundant mode to achieve up to 2000 watts for two modules, 3000 watts for three modules. The units are connected in parallel the same as before. In this case if one unit fails, the load will lose power since only part of the load current can now be supplied by the remaining module(s), which will go into current limit. The failed unit can be quickly replaced, however, without turning the power off (hot-swap) to restore load current.

The number of TPCMQ48 modules that can be operated in parallel is 16. The most convenient way to parallel large numbers of units is to connect multiple TPCMQ48 19-inch rack power shelves in parallel.

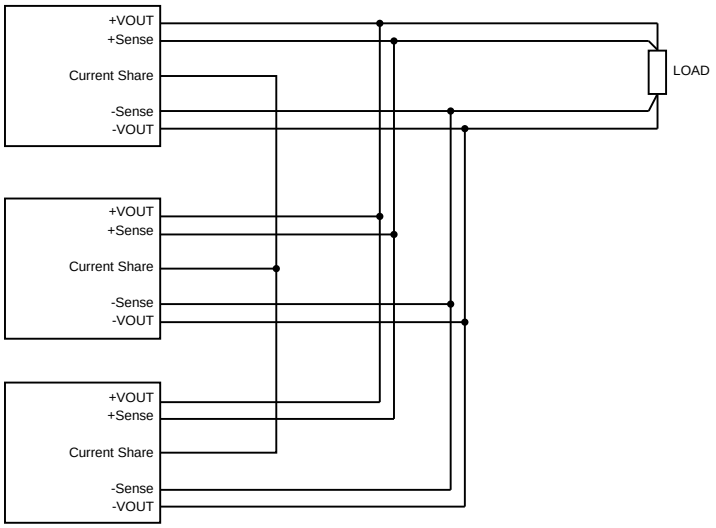


Figure 6 – Connection Diagram for Parallel Operation

14.0 MODULE INSTALLATION

TPCMQ48 Series modules are designed for mounting into the TPCMQ48 Series power shelves or similar OEM housing. Fixing in place is achieved by means of a jacking screw that is also used to push the module home into the mating connector.

For OEMs wishing to install the TPCMQ48 modules in their own system enclosure detailed dimension information is available as a 3D CAD model. Please consult your nearest sales office.

A mating interface board is available for module evaluation or testing, see section 12.3 on page 13 of this manual.

15.0 COMPATIBLE 19-INCH POWER SHELVES

There are three 19-inch compatible power shelves. Two is for use with the 12, 24 and 27.2V output modules, with and without the I²C option respectively while the third is for the 48 & 54.4V output modules. The latter will accept modules with or without the I²C option. These power shelves have the following features:

- Standard 19-Inch Rack-Mounting
- Only 1U High
- Hot-Swap Operation
- Holds up to three TPCMQ48 Modules

Ordering Guide

MAXIMUM POWER	DESCRIPTION	MAXIMUM CURRENT	MODEL NUMBER	I²C
2100W	12, 24 & 27.2V operation	162.6A	TPCMQR1U3-48	No
2100W	12, 24 & 27.2V operation	162.6A	TPCMQR1U3-48-Z	Yes
3000W	48 & 54.4V operation	62.4A	TPCMQR1U3-48H	Yes

15.1 Power Shelf Front & Rear Views - Front and rear views of the both types are shown in figure 7 below.

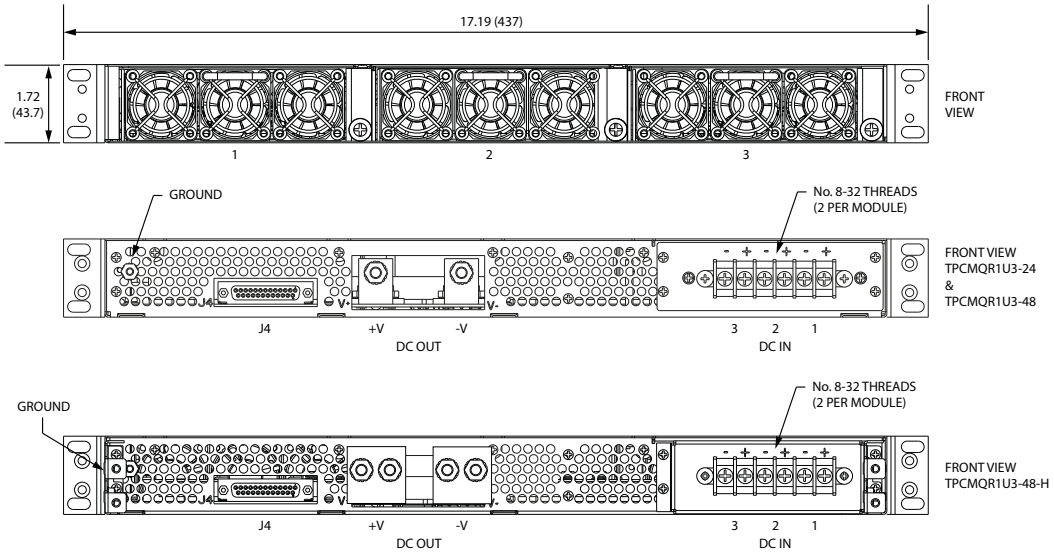


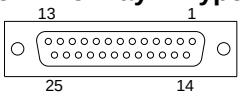
Figure 7 - Power Self Front & Rear Views

DC inputs are supplied separately to each module either via 8-32 threaded screw terminal block connections. The DC output is supplied on two pairs of bus bars which are internally connected inside the unit.

J4 is a 25-way D-type socket providing the alarm, control and supervisory signals. The following tables and figures show the pin-out for this connector. Details of each pin function can be found in section 9.2.

PIN	FUNCTION	PIN	FUNCTION
1	Inhibit	14	Input Power Fail - 1
2	Overtemp. Warning - 1	15	Output Power Good - 1
3	Current Monitor - 1	16	Input Power Fail - 2
4	Overtemp. Warning - 2	17	Output Power Good - 2
5	Current Monitor - 2	18	Input Power Fail - 3
6	Overtemp. Warning - 3	19	Output Power Good - 3
7	Current Monitor - 3	20	Module Present - 1
8	+5V Standby	21	Module Present - 2
9	Current Share	22	Module Present - 3
10	SDA	23	-Sense
11	+Sense	24	Remote Adjust - 1
12	Remote Adjust - 2	25	Remote Adjust - 3
13	SCL		

J1 – 25-Way D-Type



Standby return is connected to -Sense. Current rating of +5V Standby is 250mA.

16.0 MECHANICAL DIMENSIONS

Figures 8a and 8b below show the outline dimensions for the TPCMQR1U3-48 and TPCMQR1U3-48H power shelves respectively.

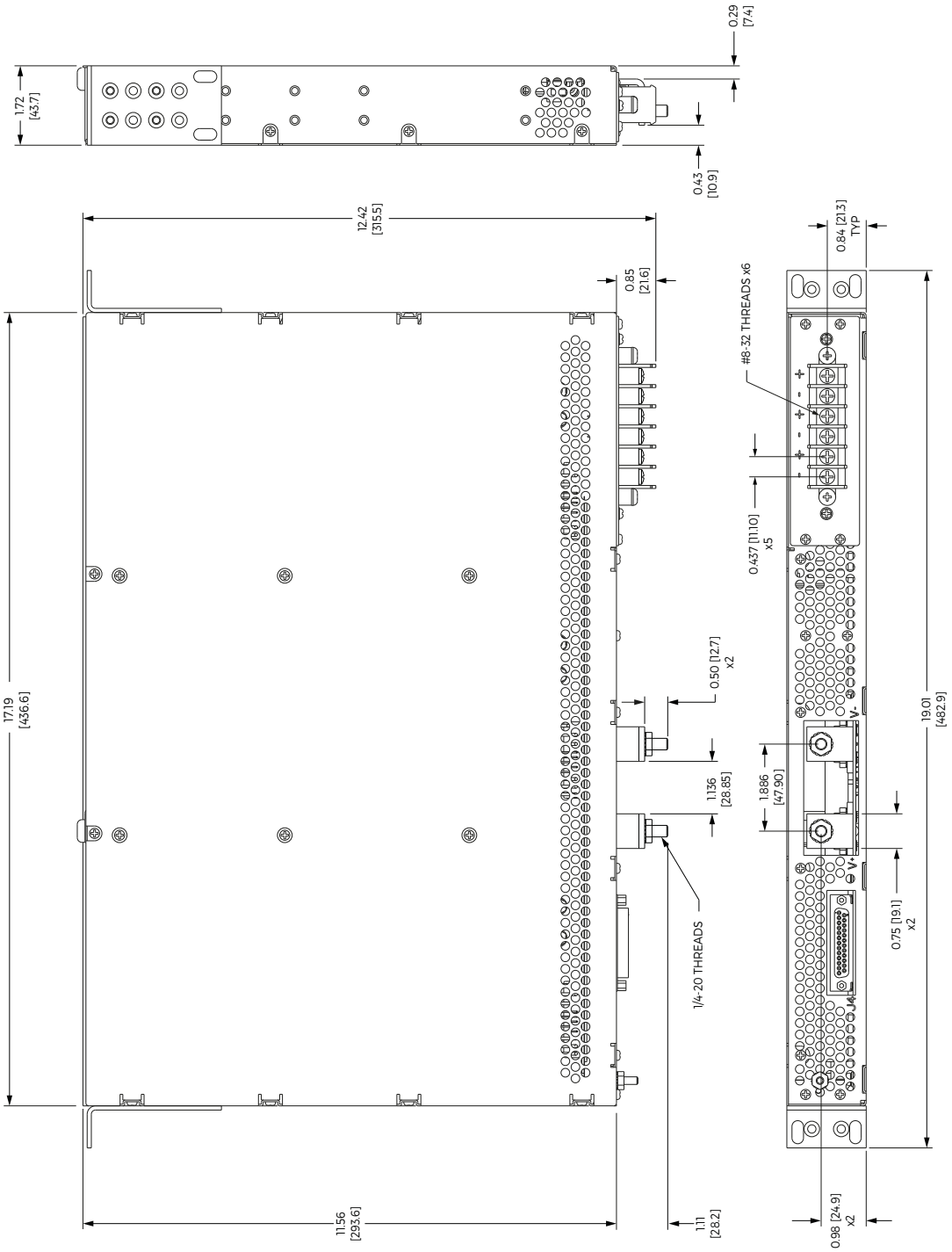


Figure 8a – TPCMQR1U3-48 Power Shelf Outline

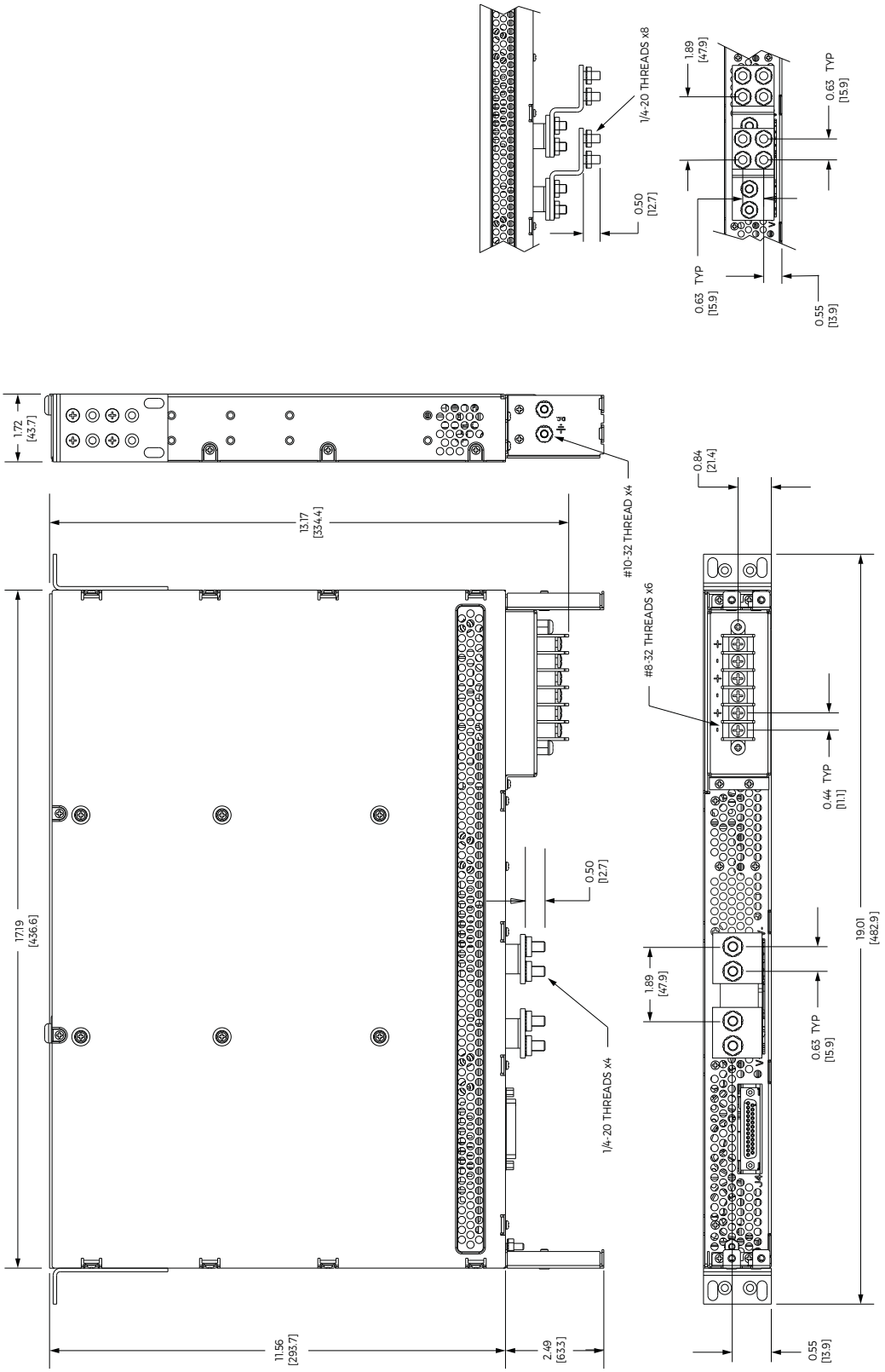


Figure 8b - TPCMQR1U3-48H Power Shelf Outline

17.0 SHELF INSTALLATION

17.1 Mounting - TPCMQ48 Series 19-inch rack-mount power shelves are provided with universal rack- brackets that allows them to be mounted into a 1U high space in both 19-inch and 23-inch racks. The brackets can be located at various positions in the side of the shelf to allow for offset mounting in the rack.

To minimize obstruction to ventilation UNIPOWER advises that any equipment mounted directly above the TPCMQ48 power shelf should be shorter in overall depth.

17.2 Input Power Connections - DC input power connections are made to the Terminal Blocks mounted at the rear of the power shelf. Each module position has its own input terminals. A 3-wire connection is required for each module position that is to be used. The minimum suitable cable size for these connections is 14AWG or equivalent. It is recommended that each input feed is protected by its own circuit breaker. After installation it is important to ensure that the supplied safety covers are fitted.

17.5 DC Output Connections - DC output connections are provided at the rear of the power shelf on two of bus bars. Shelf model TPCMQR1U3-48 has a single 10-32 threaded post on each bus bar while model TPCMQR1U3-48H has two posts. There is also an adapter kit available to convert from 2 post to 4 post. The output polarity can be configured either positive or negative as desired. UNIPOWER can supply various pre-made DC load cables; see the current data sheet for available options. Users wishing to fabricate their own DC cables should note that such cables should be rated to handle at least 200A.

17.5.1 Connecting Multiple Shelves in Parallel - Multiple power shelves can be connected together to create higher capacity power systems than can be achieved with a single shelf. UNIPOWER can assist customer with the design of link bars to parallel the DC output connections.

17.6 Signal Connections - These connections are made to the D-type connector described in section 15. Wire size for all signal connections should be 22-24AWG.

17.6.1 Connecting Multiple Shelves in Parallel - To ensure proper power sharing between parallel connected power shelves it is important to make sure that current share and signal returns are connected between each shelf. See sections 15 for details.

17.7 Cooling - The TPCMQ48 series modules incorporate three DC ball bearing fans. Standard airflow is from the front to rear with exhaust ventilation holes at the rear of the power shelf. To minimize obstruction to ventilation there should be a minimum of 3 inches (76mm) free space behind and in front of the power shelf when it is installed in the rack. UNIPOWER also recommends that any equipment mounted directly above the TPCMQ48 series power shelf should be shorter in overall depth so as to not obstruct any ventilation holes in the top surface.

18.0 MAINTENANCE

No routine maintenance is required on the TPCMQ48 series except for periodic cleaning of dust and dirt around the front ventilation grill. A small vacuum nozzle should be used for this purpose.

19.0 SETUP AND TESTING

19.1 The TPCMQ48 can be initially tested mounted in a rack or on a test bench. If two or more units are to be tested in a rack, they should first be individually tested in Position 1 (left side) of the rack.

19.2 With the input power source turned off, connect input power wires to the DC input terminals of the mating interface board, the TPCMQ48 mating connector or in the case of a power shelf the input terminal block. Make sure that the safety ground wire is connected. Do not touch the output terminals when DC input power is present.

19.3 Connect a resistive power load across the proper output pins, terminals or bus bars. The load should be 20% to 50% of the full load value and can be either a power resistor or electronic load set to the resistive mode. Make sure that the power resistor has adequate heat sinking and cooling.

19.4 Connect a color-coded, twisted pair (22 or 24AWG) from the remote sense pins to the load. The +Ve Sense must go to the positive side of the load and the –Ve Sense to the negative side of the load. Also connect the Enable pin to the -Ve Sense. This must be done for the unit to operate. When using the mating interface board or a power shelf, the Enable pin is automatically connected to -Ve Sense. The units are then controlled by the Inhibit inputs.

19.5 **Checking Front Panel LEDs** - With the TPCMQ48 module on the bench or in Position A of the power shelf, turn on (or plug in) the power source. The two LEDs should be on. If either is not the case see section 8.2 on page 8 of this manual to determine a possible cause.

19.6 **Checking the Output Voltage** - Measure the output voltage at its load with a digital voltmeter. The voltage should be within ±1% of its nominal value.

19.7 **Checking the Inhibit Input** - Unplug the input power source. Connect a wire from the Inhibit input to Standby Return. Turn the input power source back on. The Output power Good LED should be off and the Input Power Fail LED should be on. Check the output voltage with a digital voltmeter. It should read zero volts.

19.8 **Checking the Input Power Fail and Output Power Good Signals** - Next check the voltage on the Input Power Fail pin with respect to Standby Return. The voltage should be a logic LO, +0.5V or less. Finally, check the voltage on the Output Power Good pin with respect to Standby Return. The voltage should be a logic HI, approximately +5V. These signals need pull-up resistors to 5VStandby using 10K Ohm resistors.

Disconnect the wire from the Inhibit & Standby return. The Output Power Good LED should turn on. Check the voltage on the Output Power Good pin as described above. The voltage should be a logic LO, +0.5V or less. Check that the DC output with a digital voltmeter.

19.9 **Testing other TPCMQ48 modules** - For a power shelf with two or three TPCMQ48 modules, the other modules should be plugged into Position 1 in the rack and tested in the same manner as above in Sections 19.2 to 19.8.

19.10 **Testing the Complete Power System** - With the input power source off or disconnected, insert all TPCMQ48 modules into the power shelf. Connect a resistive power load of approximately 80% of full load value for a single TPCMQ48 across the output. Connect a color-coded, twisted pair of remote sense leads to the load, being careful to connect the correct polarity.

Note the comments in section 9.2.1 regarding circuit breakers or fuses in the output power feed.

19.11 Turn on or plug in the input power source. Check the voltage across the load with a digital voltmeter. The voltage should be within about ± 1% of its nominal value. All LEDs should be on.

19.12 While the rack is operating, disengage module 1 (left one) and check the output voltage. It should be very close to the previous value and the Output Power Good LED should remain on for module 2 (and 3) which are now carrying the load. Re-insert module 1 and repeat the procedure by disengaging and re-engaging modules 2 and 3in turn. The complete power shelf has now been shown to operate properly in the redundant mode with hot swapping.

Disconnect the input power source.

20.0 OPTIONAL I²C SERIAL BUS INTERFACE

The I²C interface that is incorporated into the TPCMQ48 Series includes facilities to monitor various operating parameters within the unit and transmit these to a host computer on demand over an industry standard I²C Serial bus.

Three forms of data are available. These allow the user to monitor the actual status of an individual unit, manage system loading through measurement of the actual load on the output and also control inventory through an inbuilt EEPROM containing specific data about each individual unit.

The implementation of I²C that has been utilized is a subset of more complete implementations such as IPMI. The following provides information for the system designer to make decisions on how to utilize the available information within his overall system philosophy.

20.1 I²C devices employed

PCF8574 - This device is an 8-bit digital register manufactured by Philips.
PCF8591 - This device is a Quad A/D converter manufactured by Philips.
24C02 - This device is a 256 byte EEPROM manufactured by ST
MAX6633 - This is a 12-bit temperature measurement device manufactured by Maxim.

For detailed information about the operation of these devices please consult the original manufacturers' data-sheets.

20.2 Electrical Interface

20.2.1 Addressing (GA0, GA1 and GA2)
Three external address lines are employed allowing up to eight TPCMQ48 modules to be addressed on a single I²C bus.

Module addressing is achieved through hard-wiring the address lines to -Sense or the +5V standby supply via a 100-ohm resistor on the system back-plane. In this way it is the location or position of the module rather than any particular module that is identified by an individual address.

20.2.2 Serial Clock (SCLK)
This line is clocked by the processor which controls the I²C serial bus. It should be tied to +5V via a pull-up resistor in the range 3k to 10k.

20.2.3 Serial Data (SDA)
This line is a bidirectional data line. It should be tied to +5V via a pull-up resistor in the range 3k to 10k.

20.2.4 BUS speed

The I²C interface as used in TPCMQ48 is designed to run with a serial clock speed 100kHz.

20.3 Operation and Functions

20.3.1 Digital Functions

Digital status functions are provided by a PCF8574 8-bit I/O port device. When this device is read by the I²C bus controller a single 8-bit word provides the information given in the following table.

BIT	FUNCTION	GOOD STATE	MEANING
0	Input Power Fail	0	A “1” provides warning of input supply failure.
1	Output Power Good	0	Output voltage is within specified limits.
2	Temperature Warning	0	Temperature exceeds normal operating limit.
3	Fan #1 Good	1	Fan running at >80% nominal speed.
4	Fan #2 Good	1	Fan running at >80% nominal speed.
5	Fan #3 Good	1	Fan running at >80% nominal speed.
6	-	1	Not used
7	Temperature Alarm	1	Ambient temperature exceeds 70°C, unit switched off. Also indicates OVP and Inhibit activated.

PCF8574 slave address

BIT	7	6	5	4	3	2	1	0
VALUE	0	1	0	0	GA2	GA1	GA0	R/W

HEX ADDRESS RANGE
0x40 – 0x4E

Note that if a zero is written to bit 7 in a data byte, the unit will be inhibited. The default state is enabled.

20.3.3 Analogue Functions

Analogue status functions are provided by two PCF8591 4-channel 8-bit A/D converter devices. When these devices are read by the I²C bus controller a single 8-bit word provides the information given in the following table.

Device U1			
A/D	FUNCTION	A/D	FUNCTION
1	Output voltage	3	Not used
2	Output current	4	Not used

PCF8591 slave address – device U1

BIT	7	6	5	4	3	2	1	0
VALUE	1	0	0	1	GA2	GA1	GA0	R/W

HEX ADDRESS RANGE 0x90 – 0x9E

The PCF8591 devices initially require a control byte (04 Hex) to be written to the configuration register. This control byte sets the device so that on each successive read the data from the next A/D is read.

Note that on each read a conversion is started for a particular channel and the result will be read from the previous channel, thus the first result from a sequence of reads should always be discarded.

A/D Converter scaling

To obtain a correct voltage or current measurement it is necessary to employ a scaling factor in the controlling software. Note that all voltage measurements are made inside the PSU module, before the 'ORing' devices, and are typically 0.5V higher than the actual module output voltage. The calculation given in the following table should be employed.

Value = (byte read x scaling factor)

Output Voltage	Scaling	Tolerance	
12V	0.0625	±2%	V Measure (U1 A/D Chan. 1)
24V	0.1225	±2%	
48V	0.24	±2%	
12V	0.27	±10%*	I Measure (U1 A/D Chan. 2)
24V	0.145	±10%*	
48V	0.084	±10%*	

*of full scale

20.3.4 EEPROM Functions

The EEPROM is a 2048 bit (256 byte) device which is pre-programmed at the factory with the data given in the following table.

Note that other data may be specified to special order. Please consult sales.

Address Range	Data
0-15	Model Number
16-31	Manufacturing Part Number
32-47	Serial Number
48-63	Modification Level
64-79	Manufacturer
80-95	Country of Manufacture
96-255	Not used

Note: Data is organized such that each field of data can be accessed by a page read (16 bytes).

24C02 slave address

BIT	7	6	5	4	3	2	1	0
VALUE	1	0	1	0	GA2	GA1	GA0	R/W

HEX ADDRESS RANGE
0xA0 – 0xAE

20.3.5 Temperature Measurement Functions

The internal temperature of the unit is measured using a MAX6633. This device provides

a 12-bit measurement at a resolution of 0.0625°C.

MAX6633 slave address

BIT	7	6	5	4	3	2	1	0
VALUE	1	0	1	0	GA2	GA1	GA0	0

HEX ADDRESS RANGE
0x80 – 0x8E

For further information or support in using the I²C serial bus features incorporated into the TPCMQ48 series please contact applications support.

21.0 TROUBLESHOOTING GUIDE

21.1 If you encounter difficulties in getting a TPCMQ48 module or complete power system to operate properly please check all connections carefully and use the following as a troubleshooting guide.

a) If the INPUT GOOD LED is ON, the OUTPUT GOOD LED is OFF and there is no voltage on the output then the unit will be inhibited. To enable the unit make sure that the Inhibit input is connected to the +5V Standby supply.

b) If the INPUT GOOD LED is ON, the OUTPUT GOOD LED is OFF and the voltage on the output is low then the output has been set below the DCOK detection point. If the remote adjust feature is being used ensure that the control voltage is set at a level sufficient to bring the output voltage within limits.

c) If both LEDs are OFF and the +5V standby supply is present then there is a fault with the unit and it should be returned for repair.

d) If both LEDs are OFF and the +5V standby supply is present then the input supply is not reaching the unit. Check that any breakers in the supply side have not tripped.

Please note that there are no user serviceable parts inside either the modules or the shelves and that opening either will void the warranty.

If you are still unable to resolve any problem call your nearest UNIPOWER sales office for support:

US +1 954 346 2442

UK +44 (0)1903 768200