POWERBOX Industrial Line
PQB50U-72S Series
30-50W 12:1 Single Output
DC/DC Converter
Manual V11

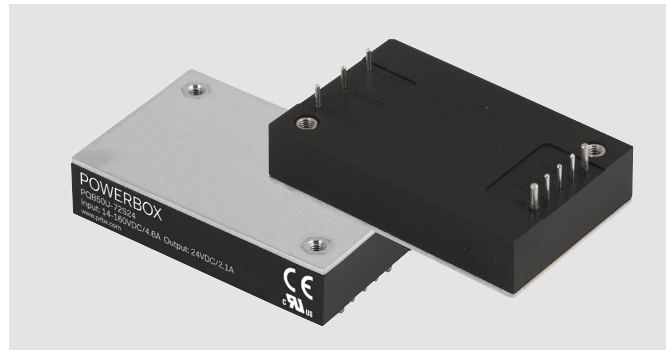



**Table of Contents**



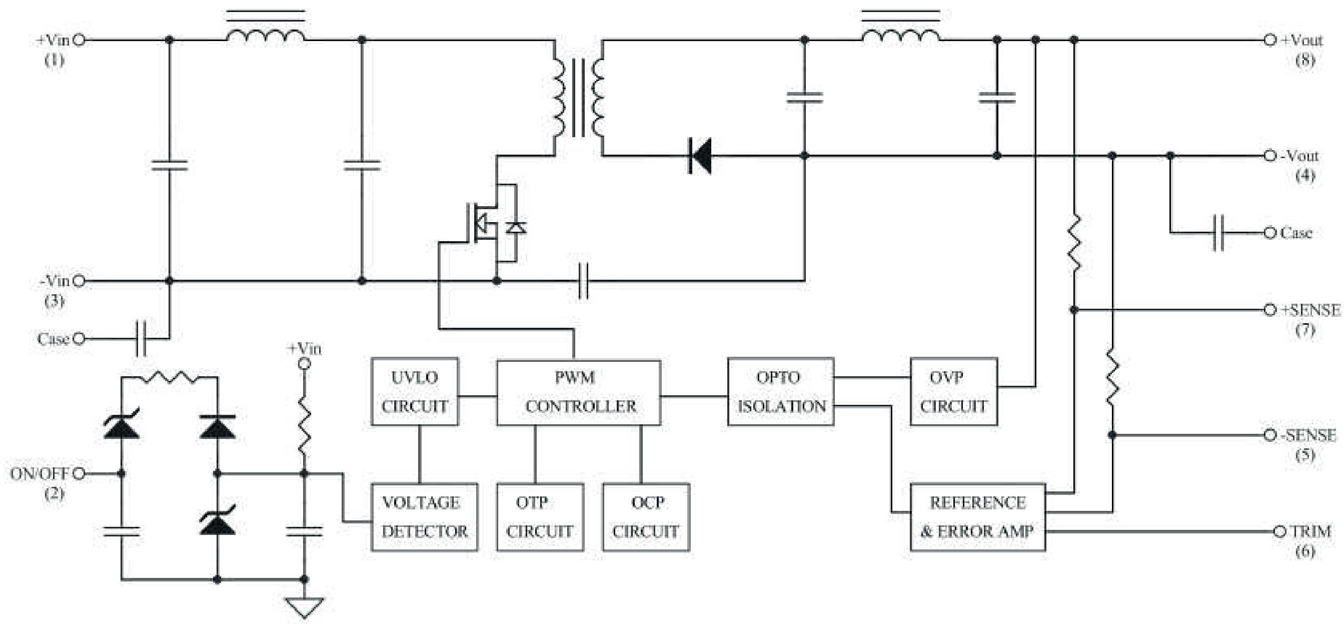
## 1. Introduction

The PQB50U-72S series of DC-DC converters offers 30- 50 watts of output power @ single output voltages of 5, 12, 24, 48VDC with industry standard quarter-brick. It has a wide (12:1) input voltage range of 14 to 160VDC (72VDC nominal) and 3000VDC basic isolation. Compliant with EN50155, EN45545, EN50121-3-2. High efficiency up to 89%, allowing case operating temperature range of –40°C to 100°C. An optional heat sink is available to extend the full power range of the unit. Very low no load power consumption (5mA), an ideal solution for energy critical systems. The standard control functions include remote on/off (positive or negative) and +10%, -20% adjustable output voltage. Fully protected against input UVLO (under voltage lock out), output over-current, output over-voltage and over- temperature and continuous short circuit conditions. PQB50U-72S series is designed primarily for common railway applications of 24V, 36V, 48V, 72V, 96V, 110V nominal voltage and also suitable for distributed power architectures, telecommunications, battery operated equipment and industrial applications.

## 2. DC/DC Converter Features

- 30-50W isolated output
- Efficiency to 89%
- Fixed switching frequency
- 12:1 input range
- Regulated outputs
- Remote On/Off
- Low no load power consumption
- Over temperature protection
- Over voltage/current protection
- Continuous short circuit protection
- Quarter brick size meet industrial standard
- UL60950-1 2nd (Basic Insulation) approval
- CB Test Certificate IEC60950-1
- Meet EN50155 with external circuits
- Shock & vibration meet EN 50155 (EN 61373)
- Fire & smoke meet EN45545-2
- 5000m operating altitude

## 3. Electrical Block Diagram




Electrical Block Diagram

## 4. Technical Specifications

(All specifications are typical at nominal input, full load at 25°C unless otherwise noted.)

**Absolute Maximum Ratings**

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| *Input voltage* | | | | | | |
| Continuous | | All | 0.3 | | 160 | VDC |
| Transient | 100ms | All | | | 200 | VDC |
| Operating case temperature | | All | -40 | | +100 | °C |
| Storage temperature | | All | -55 | | +125 | °C |
| Isolation voltage, 1 minute | Input/output | All | | | 3000 | VDC |
| | Input/case | All | | | 2500 | VDC |
| | Output/case | All | | | 500 | VAC |

**Input Characteristics**

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| Operating input voltage | | All | 14 | 72 | 160 | VDC |
| *Input Under Voltage Lockout* | | | | | | |
| Turn-on voltage threshold | | All | 14.2 | 14.6 | 15 | VDC |
| Turn-off voltage threshold | | All | 11.6 | 12.0 | 12.4 | VDC |
| Lockout hysteresis voltage | | All | | 2.6 | | VDC |
| Maximum input current | 100% Load, Vin=14V | All | | 4.6 | | A |
| No-load input current | | 72S05 | | 5 | | mA |
| | | 72S12 | | 5 | | mA |
| | | 72S24 | | 5 | | mA |
| | | 72S48 | | 8 | | mA |
| Input filter | Pi filter | All | | | | |
| Inrush current ($I^2t$) | As per ETS300 132-2 | All | | | 0.1 | $A^2s$ |
| Input reflected ripple current | P-P thru 12uH inductor, 5Hz to 20Mhz, see 6.3 | All | | 30 | | mA |

**Output Characteristics**

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| Output voltage set point | Vin=Nominal Vin, Io = Io_max, Tc=25°C | Vo=5.0 VDC | 4.95 | 5 | 5.05 | VDC |
| | | Vo=12 VDC | 11.88 | 12 | 12.12 | VDC |
| | | Vo=24 VDC | 23.76 | 24 | 24.24 | VDC |
| | | Vo=48 VDC | 47.52 | 48 | 48.48 | VDC |
| *Output voltage regulation* | | | | | | |
| Load regulation | Io=Io_min to Io_max | All | | | ±0.2 | % |
| Line regulation | Vin=low line to high line | All | | | ±0.2 | % |
| Temperature coefficient | TC=-40°C to +100°C | All | | | ±0.02 | %/°C |
| *Output voltage ripple and noise 5Hz to 20Mhz bandwidth* | | | | | | |
| Peak-to-Peak | Full load, 22uF aluminum solid capacitor and 1.0uF ceramic capacitors, see 6.13 | All | | | 100 | mV |
| RMS | Full load, 22uF aluminum solid capacitor and 1.0uF ceramic capacitors, see 6.13 | All | | | 40 | mV |
| Operating output current range | | Vo=5.0 V | 0 | | 6 | A |
| | | Vo=12 V | 0 | | 4.2 | A |
| | | Vo=24 V | 0 | | 2.1 | A |
| | | Vo=48 V | 0 | | 1.05 | A |
| Output DC current limit inception | Hiccup mode, auto recovery, see 5.3 | All | 110 | 180 | 220 | % |
| Maximum output capacitance | Full load (resistive) | Vo=5.0 V | 0 | | 10000 | µF |
| | | Vo=12 V | 0 | | 6800 | µF |
| | | Vo=24 V | 0 | | 3300 | µF |
| | | Vo=48 V | 0 | | 680 | µF |
| Output voltage trim range | Pout=max rated power, see 6.11 | All | -20 | | +10 | % |
| Output over voltage protection | Limited voltage, see 5.4 | All | 115 | 125 | 140 | % |

### Dynamic Characteristics

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| *Output voltage current transient* | | | | | | |
| Error band | 75% to 100% of Io_max step load change | All | | | ±5 | % |
| Recovery time | di/dt=0.1A/us (within 1% Vout nominal) | All | | | 250 | us |
| *Turn-on delay and rise time* | *Full load (constant resistive load)* | | | | | |
| Turn-on delay time, from on/off control | Von/off to 10%Vo_set | All | | 15 | | ms |
| Turn-on delay time, from input | Vin_min to 10%Vo_set | All | | 15 | | ms |
| Output voltage rise time | 10%Vo_set to 90%Vo_set | All | | 10 | | ms |

### Efficiency

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| 100% load | Vin=72V, see 6.8 | Vo=5.0 V | | 83 | | % |
| | | Vo=12 V | | 87 | | % |
| | | Vo=24 V | | 89 | | % |
| | | Vo=48 V | | 88 | | % |
| | Vin=110V, see 6.8 | Vo=5.0 V | | 81 | | % |
| | | Vo=12 V | | 86 | | % |
| | | Vo=24 V | | 87 | | % |
| | | Vo=48 V | | 85 | | % |

### Isolation Characteristics

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| Isolation voltage, 1 minute | Input/output | All | | | 3000 | VDC |
| | Input/case | All | | | 2500 | VDC |
| | Output/case | All | | | 500 | VAC |
| Isolation resistance | Input/output | All | 100 | | | MΩ |
| Isolation capacitance | Input/output | All | | 1000 | | pF |
| | Input/case | All | | 1500 | | pF |
| | Output/case | All | | 10000 | | pF |

**Feature Characteristics**

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| Switching frequency | Pulse wide modulation (PWM), fixed | All | 215 | 240 | 265 | KHz |
| *ON/OFF control, positive remote On/Off logic Refer to -Vin pin* | | | | | | |
| Logic low (module off) | Von/off at Ion/off=1.0mA | All | 0 | | 1.2 | V |
| Logic high (module on) | Von/off at Ion/off=0.0uA | All | 3.5 or open circuit | | 160 | V |
| *ON/OFF control, negative remote On/Off logic Refer to -Vin pin* | | | | | | |
| Logic low (module off) | Von/off at Ion/off=0.0uA | All | 4.0 or open circuit | | 160 | V |
| Logic high (module on) | Von/off at Ion/off=1.0mA | All | 0 | | 1.2 | V |
| ON/OFF current (for both remote on/off logic) | Ion/off at Von/off=0.0V | All | | 0.4 | 1 | mA |
| Leakage current (for both remote on/off logic) | Logic high, Von/off=15V | All | | | 30 | uA |
| Off converter input current | Shutdown input idle current | All | | 3 | 5 | mA |
| Over temperature shutdown | Aluminum baseplate temperature | All | | 110 | | °C |
| Over temperature recover | Aluminum baseplate temperature | All | | 100 | | °C |

**General Specifications**

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| MTBF | Io=100% of Io, max: Ta=25°C per MIL-HDBK-217F | All | | 780 | | Khours |
| Weight | | All | | 61.5 | | grams |
| Case material | Plastic, DAP | | | | | |
| Baseplate material | Aluminum | | | | | |
| Potting material | UL 94V-0 | | | | | |
| Pin material | Base: Copper<br>Plating: nickel with matte tin | | | | | |
| Shock/Vibration | MIL-STD-810F, EN61373 | | | | | |
| Humidity | 95% RH max. Non condensing | | | | | |
| Altitude | 5000m operating altitude, 12000m transport altitude | | | | | |
| Thermal shock | MIL-STD-810F | | | | | |
| EMI | Meets EN55011, EN55022 & EN50155 with external input filter, see 7.2 EN55032 | | | | Class A | |
| ESD | EN61000-4-2 | Level 3: Air ±8kV, Contact ±6kV | | | Perf. Criteria A | |
| Radiated immunity | EN61000-4-3 | Level 3: 80~1000MHz, 20V/m | | | Perf. Criteria A | |
| Fast Transient | EN61000-4-4 | Level 3: On power input port, ±2kV, external input capacitor required, see 7.1 | | | Perf. Criteria A | |
| Surge | EN61000-4-5 | Level 4: Line to earth, ±4kV, Line to line, ±2kV | | | Perf. Criteria A | |
| Conducted immunity | EN61000-4-6 | Level 3: 0.15~80MHz, 10V | | | Perf. Criteria A | |
| Interruptions of voltage supply | EN50155 | Class S2: 10ms Interruptions | | | Perf. Criteria B | |
| Supply change over | EN50155 | Class C2: During a supply break of 30 ms | | | Perf. Criteria B | |

## 5. Main Features and Functions

### 5.1 Operating Temperature Range

The PQB50U-72S series converters can be operated within a wide case temperature range of -40°C to 100°C. Consideration must be given to the derating curves when ascertaining maximum power that can be drawn from the converter. The maximum power drawn from open quarter brick models is influenced by usual factors, such as:

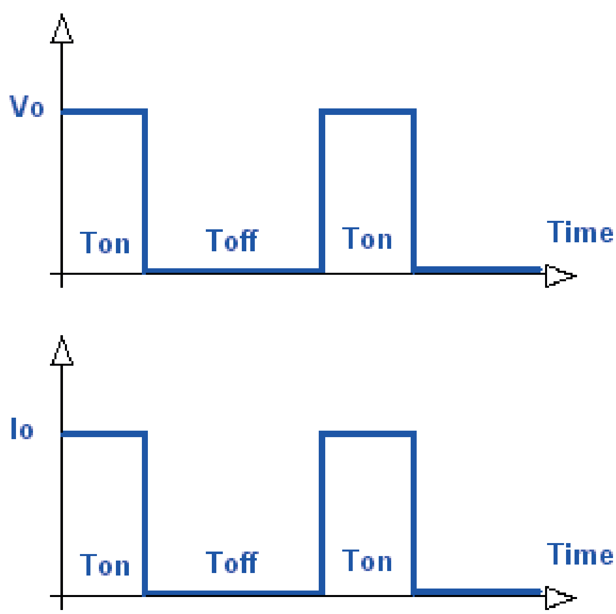
- Input voltage range
- Output load current
- Forced air or natural convection
- Heat sink optional

### 5.2 Output Voltage Adjustment

Section 6.11 describes in detail how to trim the output voltage with respect to its set point. The output voltage on all models is adjustable within the range of +10% to –20%.

### 5.3 Over Current Protection

All models have internal over current and continuous short circuit protection. The unit operates normally once the fault condition is removed. At the point of current limit inception, the converter will go into hiccup mode protection.




### 5.4 Output Over Voltage Protection

The output over voltage protection consists of circuitry that internally limits the output voltage. If more accurate output over voltage protection is required then an external circuit can be used via the remote on/off pin. Note: Please note that device inside the power supply might fail when voltage more than rate output voltage is applied to output pin. This could happen when the customer tests the over voltage protection of unit.

### 5.5 Remote On/Off

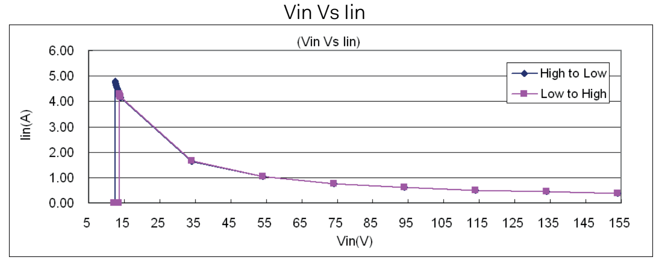
The PQB50U-72S series allows the user to switch the module on and off electronically with the remote on/off feature. All models are available in “positive logic” and “negative logic” (optional) versions. The converter turns on if the remote on/off pin is high (>3.5Vdc to 160Vdc or open circuit). Setting the pin low (0 to <1.2Vdc) will turn the converter off. The signal level of the remote on/off input is defined with respect to ground. If not using the remote on/off pin, leave the pin open (converter will be on). Models with part number suffix “N” are the “negative logic” remote on/off version. The unit turns off if the remote on/off pin is high (>4.0Vdc to 160Vdc or open circuit). The converter turns on if the on/off pin input is low (0 to<1.2Vdc). Note that the converter is off by default. See 6.15.

| **Logic State ( Pin 2 )** | **Negative Logic** | **Positive Logic** |
|---|---|---|
| Logic Low – Switch Closed | Module on | Module off |
| Logic High – Switch Open | Module off | Module on |

### 5.6 UVLO (Unde Voltage Lock Out)

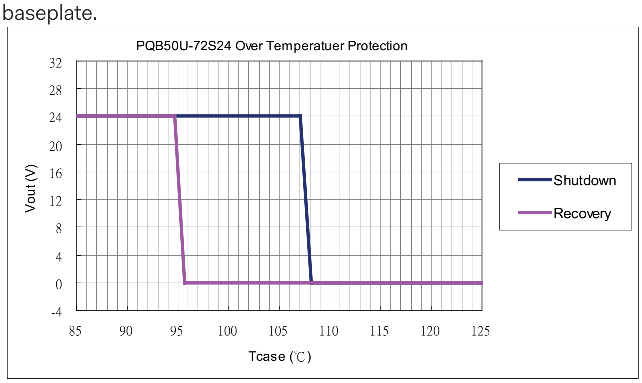
Input under voltage lockout is standard on the PQB50U-72S series unit. The unit will shut down when the input voltage drops below a threshold, and the unit will operate when the input voltage goes above the upper threshold.

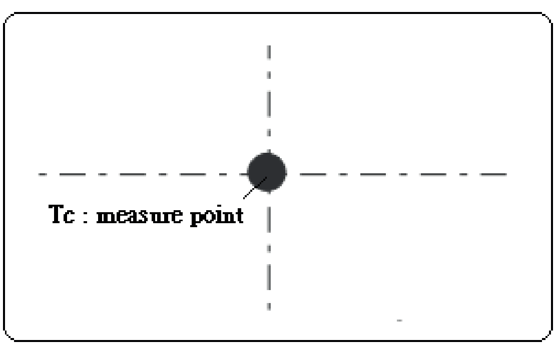
Vin Vs Iin



## 5.7 Over Temperature Protection

These modules have an over temperature protection circuit to safeguard against thermal damage. Shutdown occurs with the maximum case reference temperature is exceeded. The module will restart when the case temperature falls below over temperature recovery threshold. Please measure case temperature of the center part of aluminum baseplate.

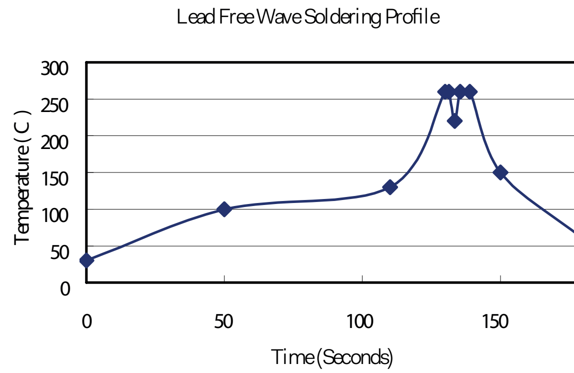


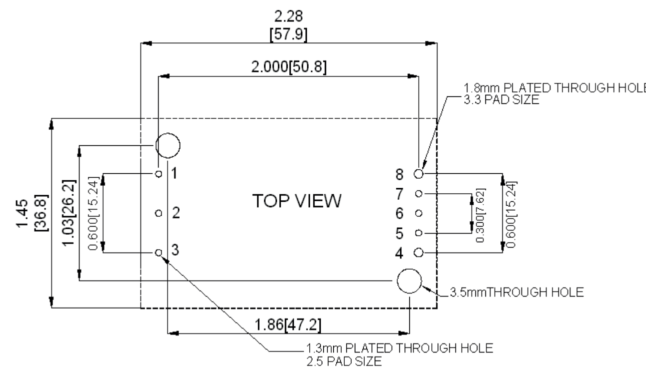



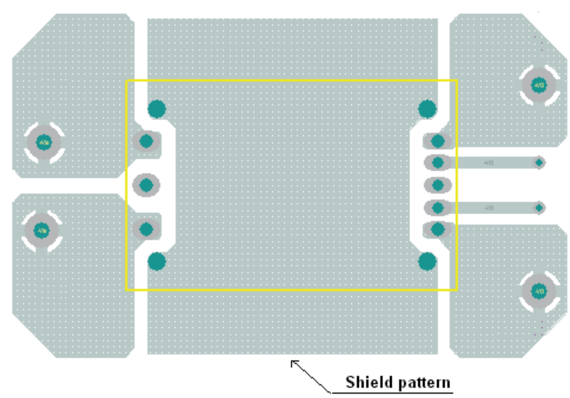

## 6. Applications

### 6.1 Recommended Layout, PCB Footprint and Soldering Information

The system designer or end user must ensure that metal and other components in the vicinity of the converter meet the spacing requirements for which the system is approved. Low resistance and inductance PCB layout traces are the norm and should be used where possible. Due consideration must also be given to proper low impedance tracks between power module, input and output grounds. The recommended soldering profile and PCB layout are shown below.

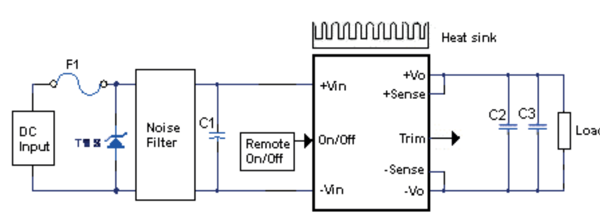



### 6.2 Connection for Standard Use

The connection for standard use is shown below. An external input capacitor (C1) 68uF for all models is recommended to reduce input ripple voltage. External output capacitors (C2, C3) are recommended to reduce output ripple and noise, 22uF aluminum solid and 1uF ceramic capacitor for all models.

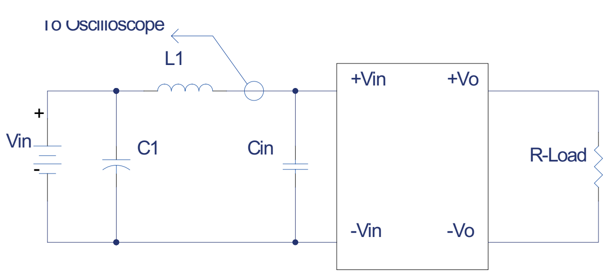


| **Symbol** | **Component** | **Reference** |
|---|---|---|
| F1 | Input fuse, TVS | Section 7.1 |
| C1 | External capacitore on input side | Note |
| C2,C3 | External capacitor on the output side | Section 6.13/6.14 |
| Noise Filter | External input noise filter | Section 7.2 |
| Remote On/Off | External Remote On/Off control | Section 6.15 |
| Trim | External output voltage adjustment | Section 6.11 |
| Heat sink | External heat sink | Section 6.4/6.5/6.6/6.7 |
| +Sense/-Sense | -- | Section 6.11 |

Note: If the impedance of input line is high, C1 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20°C.

## 6.3 Input Capacitance at the Power Module

The converters must be connected to low AC source impedance. To avoid problems with loop stability source inductance should be low. Also, the input capacitors (Cin) should be placed close to the converter input pins to de- couple distribution inductance. However, the external input capacitors are chosen for suitable ripple handling capability. Low ESR capacitors are good choice. Circuit as shown as below represents typical measurement methods for reflected ripple current. C1 and L1 simulate a typical DC source impedance. The input reflected-ripple current is measured by current probe to oscilloscope with a simulated source Inductance (L1).




L1: 12uH
C1: 68uF ESR<0.7ohm @100KHz
Cin: 68uF ESR<0.7ohm @100KHz

## 6.4. Convection Requirements for Cooling

To predict the approximate cooling needed for the quarter brick module, refer to the power derating curves in section 6.6. These derating curves are approximations of the ambient temperatures and airflows required to keep the power module temperature below its maximum rating. Once the module is assembled in the actual system, the module's temperature should be monitored to ensure it does not exceed 100°C as measured at the center of the top of the case (thus verifying proper cooling).

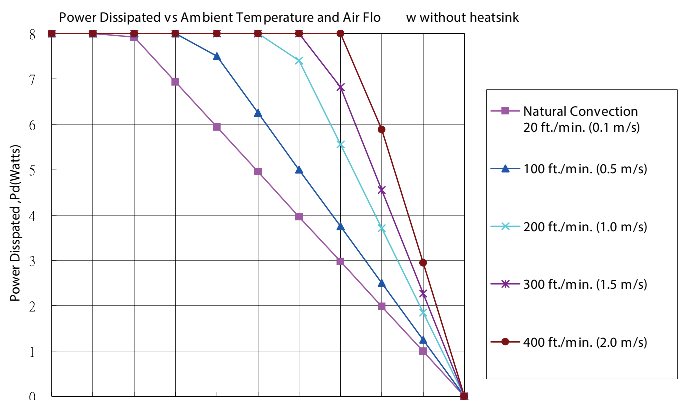
## 6.5 Thermal Considerations

The power module operates in a variety of thermal environments; however, sufficient cooling should be provided to help ensure reliable operation of the unit. Heat is removed by conduction, convection, and radiation to the surrounding environment. The example is presented in section 6.6. The power output of the module should not be allowed to exceed rated power (Vo_set x Io_max).

## 6.6 Power Derating

The operating case temperature range of PQB50U-72S series is -40°C to +100°C. When operating the PQB50U-72S series, proper derating or cooling is needed. The maximum case temperature under any operating condition should not exceed 100°C.

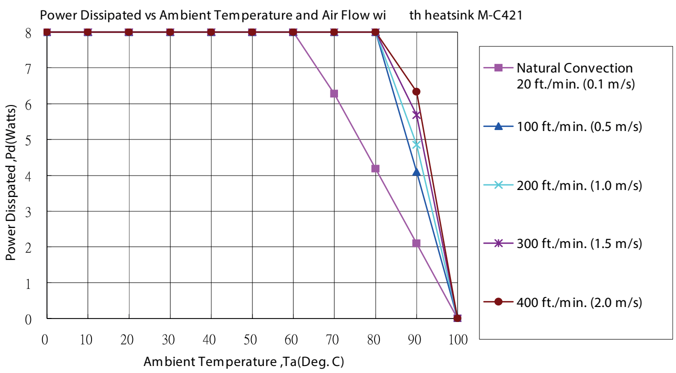
The following curve is the derating curve of PQB50U-72S series without heat sink.




| **Air Flow Rate** | **Typical Rca** |
|---|---|
| Natural Convection 20ft./min. (0.1m/s) | 10.1°C/W |
| 100 ft./min. (0.5m/s) | 8.0°C/W |
| 200 ft./min. (1.0m/s) | 5.4°C/W |
| 300 ft./min. (1.5m/s) | 4.4°C/W |
| 400 ft./min. (2.0m/s) | 3.4°C/W |

*Example:*
What is the minimum airflow necessary for a PQB50U-72S12 operating at nominal line voltage, an output current of 4.2A, and a maximum ambient temperature of 40°C?

Solution: Given: $V_{in}$=72$V_{dc}$ Vo=12$V_{dc}$ Io=4.2A
Determine power dissipation ($P_d$): Pd =Pi-Po=Po(1-η)/η
Pd =12V×4.2A×(1-0.87)/0.87=7.53Watts
Determine airflow: Given: $P_d$ =7.53W and Ta=40°C
Check above power de-rating curve: Airflow ≤200ft./min
Verify: The maximum temperature rise:
ΔT = Pd × Rca=7.53×5.4=40.67°C
The maximum case temperature: Tc=Ta+ΔT=80.67°C <100°C
Where:
The $R_{ca}$ is thermal resistance from case to ambient environment.
The $T_a$ is ambient temperature and the Tc is case temperature.

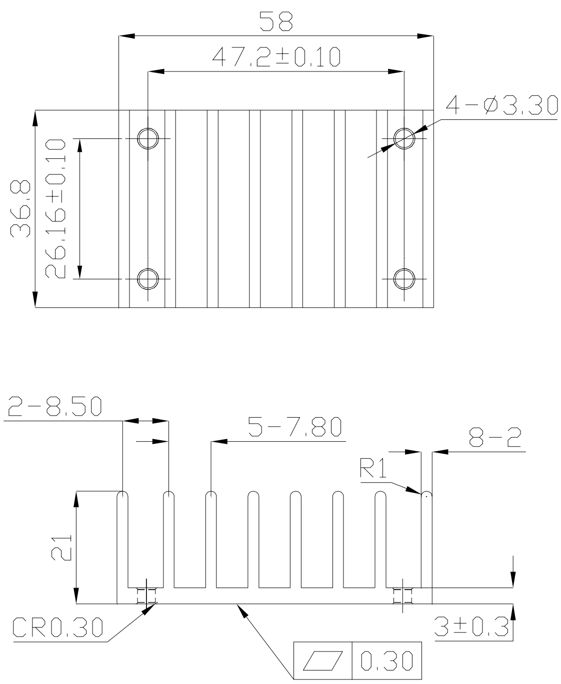


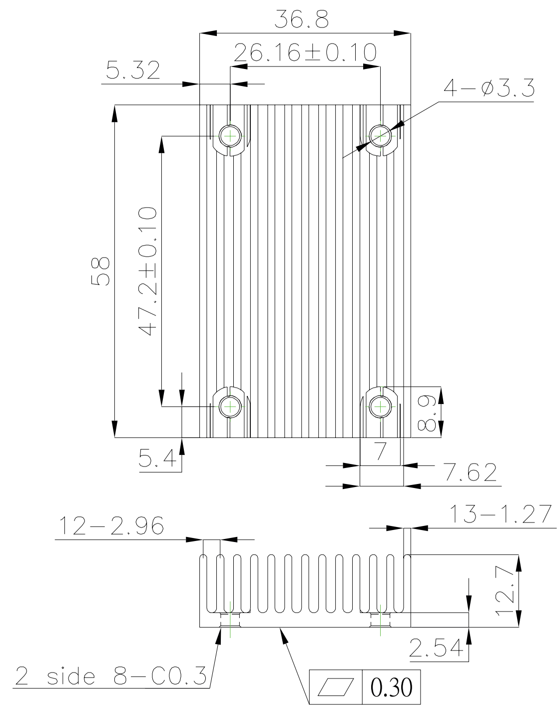

| Air Flow Rate | Typical Rca |
|---|---|
| Natural Convection 20ft./min. (0.1m/s) | 4.78°C/W |
| 100 ft./min. (0.5m/s) | 2.44°C/W |
| 200 ft./min. (1.0m/s) | 2.06°C/W |
| 300 ft./min. (1.5m/s) | 1.76°C/W |
| 400 ft./min. (2.0m/s) | 1.58°C/W |

*Example (with heatsink M-C421):*
What is the minimum airflow necessary for a PQB50U-24S12 operating at nominal line voltage, an output current of 6A, and a maximum ambient temperature of 80°C.

Solution: Given: $V_{in}$=72$V_{dc}$ Vo=12$V_{dc}$ Io=4.2A
Determine power dissipation ($P_d$): Pd =Pi-Po=Po(1-η)/η
Pd =12×4.2×(1-0.87)/0.87=7.53Watts
Determine airflow: Given: $P_d$ =7.53W and Ta=80°C
Check above power de-rating curve: Miminum airflow=100ft/min
Verify: The maximum temperature rise:
ΔT = Pd × Rca=7.53×2.44=18.37°C
The maximum case temperature: Tc=Ta+ΔT=98.37°C <100°C
Where:
The $R_{ca}$ is thermal resistance from case to ambient environment.
The $T_a$ is ambient temperature and the Tc is case temperature.

## 6.7 Quarter Brick Heat Sinks




All Dimensions in mm

**M-C421 (G6620510201)**

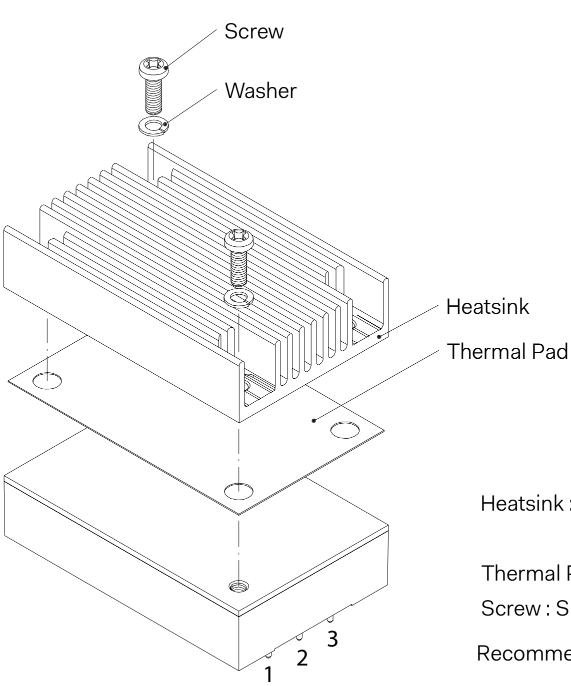
**Transverse Heat Sink**

Rca: 4.78°C/W (typ.), At natural convection
2.44°C/W (typ.), At 100LFM
2.06°C/W (typ.), At 200LFM
1.76°C/W (typ.), At 300LFM
1.58°C/W (typ.), At 400LFM

**M-C448 (G6620570202)**

**Longitudinal Heat Sink**

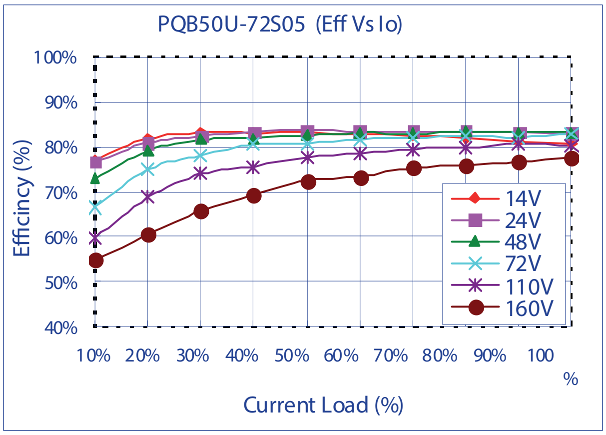
Rca: 5.61°C/W (typ.), At natural convection
4.01°C/W (typ.), At 100LFM
3.39°C/W (typ.), At 200LFM
2.86°C/W (typ.), At 300LFM
2.49°C/W (typ.), At 400LFM

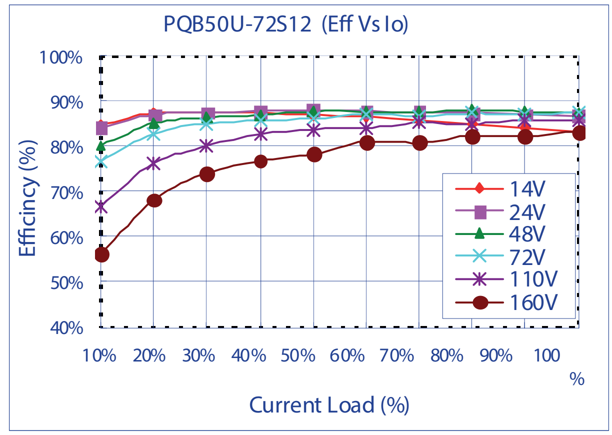


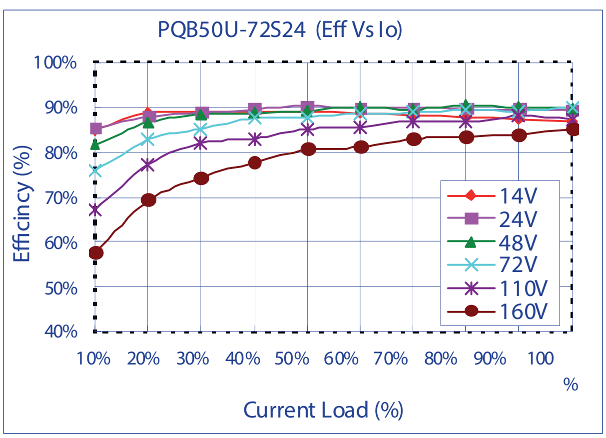

Heatsink : M-C448
M-C421
Thermal Pad : SZ35.8x56.9x0.25mm
Screw : SMP+SW M3x8L

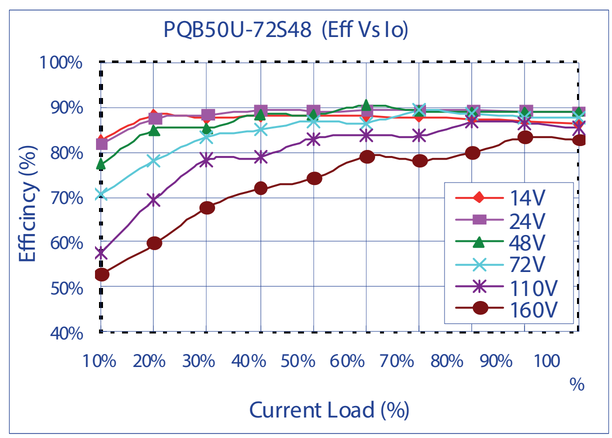
Recommended torque 3 Kgf-cm

## 6.8 Efficiency VS. Load

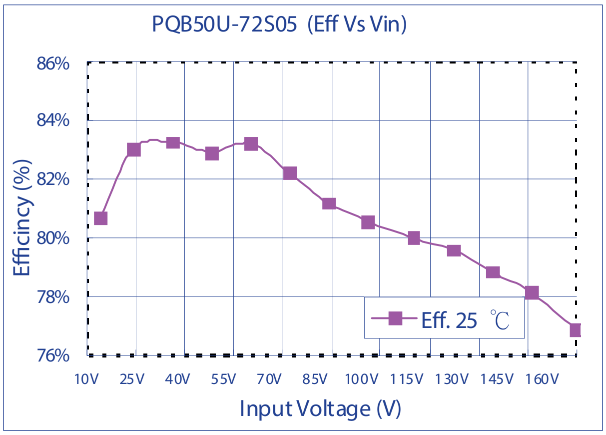


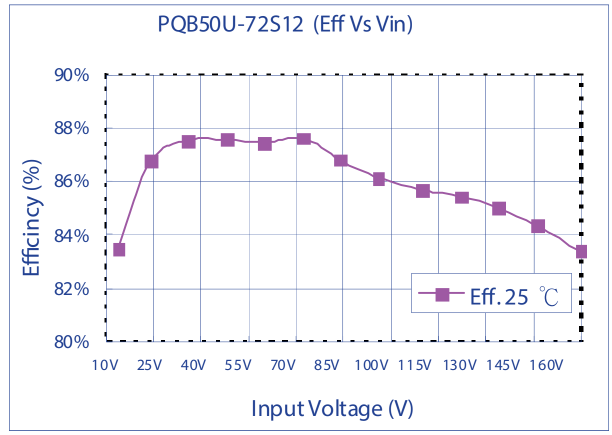



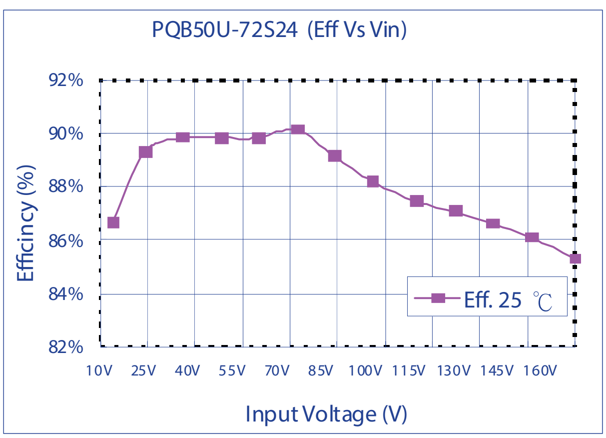



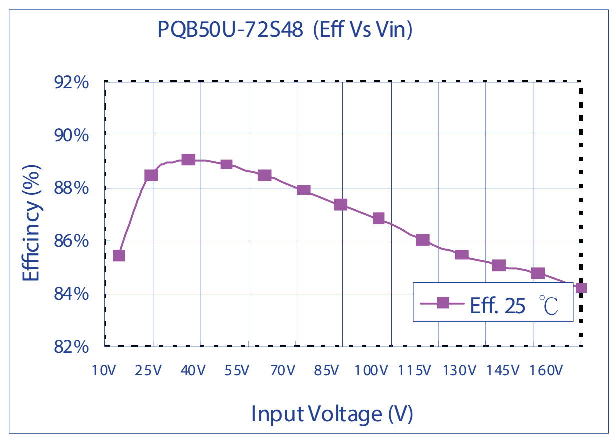



6.8 Efficiency VS. Vin



## 6.10 Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown as below. When testing the modules under any transient conditions please ensure that the transient response of the source is sufficient to power the equipment under test. We can calculate the

· Efficiency
· Load regulation and line regulation.

The value of efficiency is defined as:

$$\eta = \frac{Vo \times Io}{Vin \times Iin} \times 100\%$$

Where:
$V_o$ is output voltage,
$I_o$ is output current,
$V_{in}$ is input voltage,
$I_{in}$ is input current.

The value of load regulation is defined as:

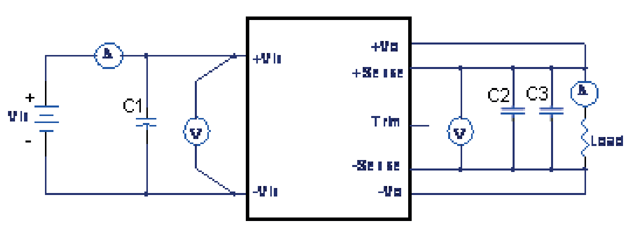
$$Load.reg = \frac{V_{FL} - V_{NL}}{V_{NL}} \times 100\%$$

Where:
$V_{FL}$ is the output voltage at full load
$V_{NL}$ is the output voltage at no load

The value of line regulation is defined as:

$$Line.reg = \frac{V_{HL} - V_{LL}}{V_{LL}} \times 100\%$$

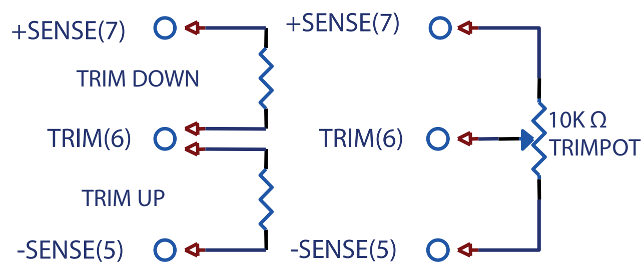
Where: $V_{HL}$ is the output voltage of maximum input voltage at full load.
$V_{LL}$ is the output voltage of minimum input voltage at full load.



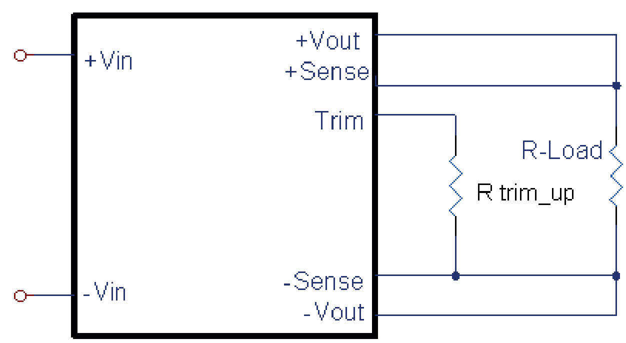

PQB50U-72S Series Test Setup
C1: 68uF/200V ESR<0.7Ω
C2: 1uF/ 1206 ceramic capacitor
C3: 22uF aluminum solid capacitor.

## 6.11 Output Voltage Adjustment

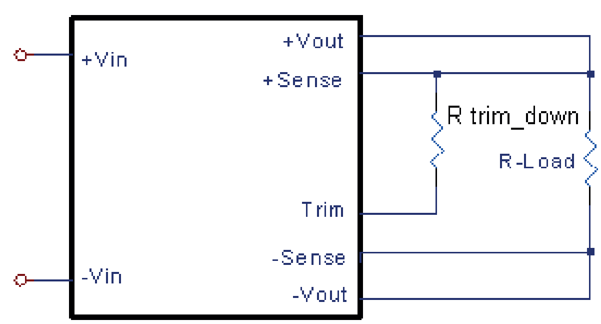
Output may be externally trimmed (-20% to +10%) with a fixed resistor or an external trim pot as shown (optional). Model specific formulas for calculating trim resistors are available upon request as a separate document.




In order to trim the voltage up or down, one needs to connect the trim resistor either between the trim pin and -Sense for trim-up or between trim pin and +Sense for trim-down. The output voltage trim range is -20% to +10%. This is shown:




Trim-up Voltage Setup




Trim-down Voltage Setup

| Vout (V) | R1 (KΩ) | R2 (KΩ) | R3 (KΩ) | Vr (V) | Vf (V) |
|---|---|---|---|---|---|
| 5V | 3 | 6.8 | 2.4 | 1.24 | 0.5 |
| 12V | 9.1 | 24 | 5.1 | 2.5 | 0.5 |
| 24V | 20 | 68 | 7.5 | 2.5 | 0.5 |
| 48V | 36 | 82 | 5.1 | 2.5 | 0.5 |

Trim Resistor Values

The value of Rtrim_up defined as:

$$R_{trim\_up} = \left(\frac{R_1\left(V_r - V_f\left(\frac{R_2}{R_2+R_3}\right)\right)}{Vo - V_{o\_nom}}\right) - \frac{R_2 R_3}{R_2+R_3} \quad (\mathrm{K\Omega})$$

Where: R trim_up is the external resistor in KΩ.
Vo_nom is the nominal output voltage.
Vo is the desired output voltage.
R1, R2, R3 and Vr are internal components.

For example, to trim-up the output voltage of 12V module (PQB50U-72S12) by 5% to 12.6V, R trim_up is calculated as follows:

Vo – Vo_nom = 12.6 – 12 = 0.6V
R1 = 9.1KΩ, R2 =24KΩ, R3 = 5.1KΩ, Vr= 2.5V, Vf=0.5

$$R_{trim\_up} = \frac{18.947}{0.6} - 4.206 = 27.45\ (\mathrm{K\Omega})$$

The value of R trim_down defined as:

$$R_{trim\_down} = \frac{R_1 \times (V_o - V_r)}{V_{o\_nom} - V_o} - R_2 \quad (\mathrm{K\Omega})$$

Where: R trim_down is the external resistor in Kohm.
Vo_nom is the nominal output voltage.
Vo is the desired output voltage.
R1, R2, R3 and Vr are internal components.

For example, to trim-down the output voltage of 12V module (PQB50U-48S12) by 5% to 11.4V, R trim-down is calculated as follows :
Vo_nom – Vo = 12 – 11.4 = 0.6V
R1 = 9.1KΩ, R2 = 51KΩ, Vr= 2.5V

$$R_{trim\_down} = \frac{9.1 \times (11.4 - 2.5)}{0.6} - 24 = 110.98\ \ (\mathrm{K\Omega})$$

The typical value of Rtrim_up

| | 5V | 12V | 24V | 48V |
|---|---|---|---|---|
| **Trim up %** | **Rtrim_up (KΩ)** | | | |
| 1% | 50.45 | 154.1 | 164.0 | 147.3 |
| 2% | 24.34 | 74.95 | 78.64 | 71.29 |
| 3% | 15.63 | 48.56 | 50.18 | 45.93 |
| 4% | 11.28 | 35.37 | 35.94 | 33.24 |
| 5% | 8.67 | 27.45 | 27.40 | 25.63 |
| 6% | 6.93 | 22.17 | 21.71 | 20.56 |
| 7% | 5.69 | 18.41 | 17.64 | 16.94 |
| 8% | 4.75 | 15.58 | 14.59 | 14.22 |
| 9% | 4.03 | 13.38 | 12.22 | 12.10 |
| 10% | 3.45 | 11.62 | 10.32 | 10.41 |

The typical value of Rtrim_down

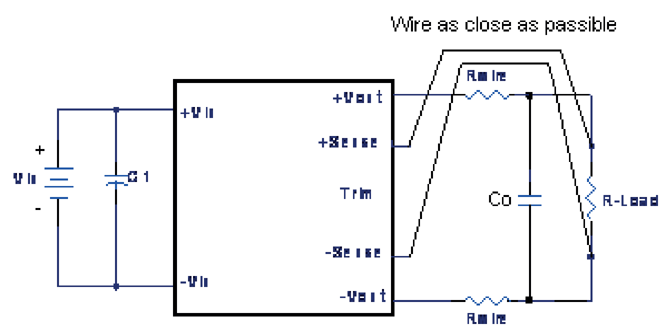
| | 5V | 12V | 24V | 48V |
|---|---|---|---|---|
| **Trim down %** | **Rtrim_down (KΩ)** | | | |
| 1% | 215.8 | 687.3 | 1703 | 3294 |
| 2% | 103.0 | 327.1 | 807.8 | 1588 |
| 3% | 65.40 | 207.0 | 509.2 | 1019 |
| 4% | 46.60 | 147.0 | 359.9 | 735.1 |
| 5% | 35.32 | 110.9 | 270.3 | 564.5 |
| 6% | 27.80 | 86.96 | 210.6 | 450.7 |
| 7% | 22.43 | 69.81 | 167.9 | 369.5 |
| 8% | 18.40 | 56.95 | 135.9 | 308.5 |
| 9% | 15.27 | 46.94 | 111.0 | 261.1 |
| 10% | 12.76 | 38.94 | 91.16 | 223.2 |
| 11% | 10.71 | 32.39 | 74.87 | 192.2 |
| 12% | 9.00 | 26.93 | 61.30 | 166.3 |
| 13% | 7.55 | 22.31 | 49.82 | 144.5 |
| 14% | 6.31 | 18.35 | 39.97 | 125.7 |
| 15% | 5.24 | 14.92 | 31.44 | 109.5 |
| 16% | 4.30 | 11.92 | 23.97 | 95.28 |
| 17% | 3.47 | 9.277 | 17.39 | 82.73 |
| 18% | 2.73 | 6.923 | 11.53 | 71.58 |
| 19% | 2.07 | 4.817 | 6.298 | 61.60 |
| 20% | 1.48 | 2.921 | 1.583 | 52.62 |

## 6.12 Output Remote Sensing

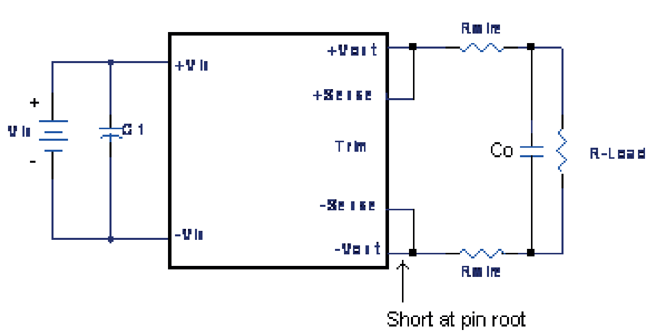
The PQB50U-72S series converter has the capability to remotely sense both lines of its output. This feature moves the effective output voltage regulation point from the output of the unit to the point of connection of the remote sense pins. This feature automatically adjusts the real output voltage of the PQB50U-72S series in order to compensate for voltage drops in distribution and maintain a regulated voltage at the point of load. The remote-sense voltage range is:

[(+Vout) - (-Vout)] – [(+Sense) – (-Sense)] ≤ 10% of Vo_nominal

When remote sense is in use, the sense should be connected by twisted-pair wire or shield wire. If the sensing patterns short, heave current flows and the pattern may be damaged. Output voltage might become unstable because of impedance of wiring and load condition when length of wire is exceeding 400mm. This is shown in the schematic below.

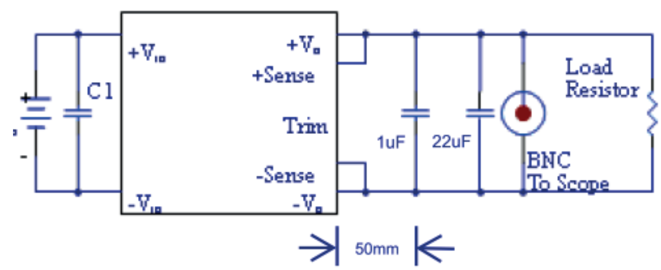



If the remote sense feature is not to be used, the sense pins should be connected locally. The +Sense pin should be connected to the +Vout pin at the module and the -Sense pin should be connected to the -Vout pin at the module. Wire between +Sense and +Vout and between -Sense and –Vout as short as possible. Loop wiring should be avoided. The converter might become unstable by noise coming from poor wiring. This is shown in the schematic below.



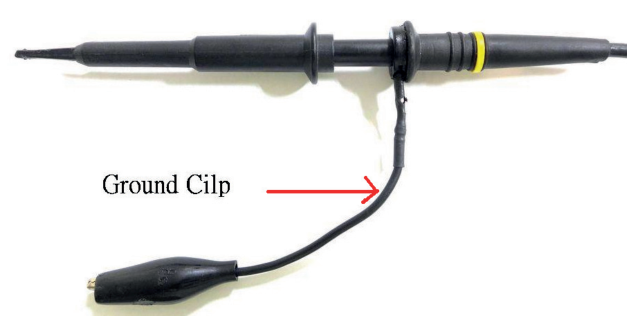

Note: Although the output voltage can be varied (increased or decreased) by both remote sense and trim, the maximum variation for the output voltage is the larger of the two values not the sum of the values. The output power delivered by the module is defined as the voltage at the output terminals multiplied by the output current. Using remote sense and trim can cause the output voltage to increase and consequently increase the power output of the module if output current remains unchanged. Always ensure that the output power of the module remains at or below the maximum rated power. Also be aware that if $V_{o.set}$ is below nominal value, $P_{out.max}$ will also decrease accordingly because $I_{o.max}$ is an absolute limit. Thus, $P_{out.max} = V_{o.set} \times I_{o.max}$ is also an absolute limit.

## 6.13 Output Ripple and Noise

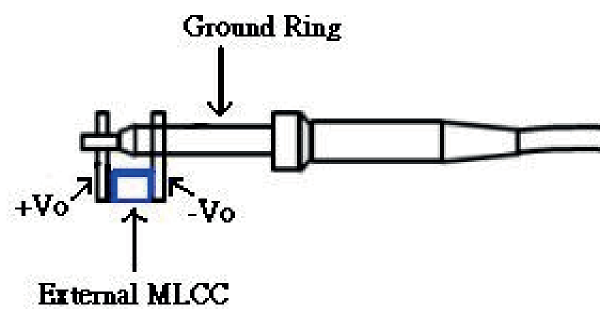



Output ripple and noise measured with 22uF aluminum solid and 1uF ceramic capacitor across output, A 20 MHz bandwidth oscilloscope is normally used for the measurement.

The conventional ground clip on an oscilloscope probe should never be used in this kind of measurement. This clip, when placed in a field of radiated high frequency energy, acts as an antenna or inductive pickup loop, creating an extraneous voltage that is not part of the output noise of the converter.



Another method is shown in below, in case of coaxial- cable/BNC is not available. The noise pickup is eliminated by pressing scope probe ground ring directly against the -Vout terminal while the tip contacts the +Vout terminal. This makes the shortest possible connection across the output terminals.

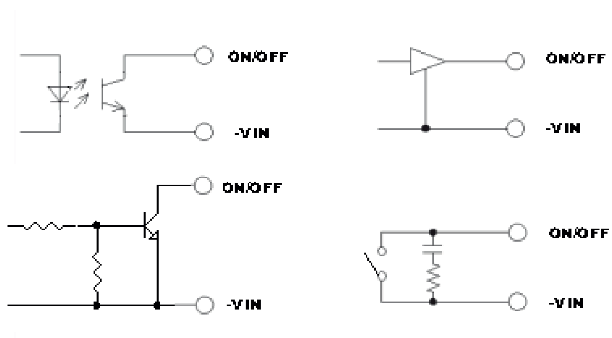



## 6.14 Output Capacitance

The PQB50U-72S series converters provide unconditional stability with or without external capacitors. For good transient response, low ESR output capacitors should be located close to the point of load (<100mm). PCB design emphasizes low resistance and inductance tracks in consideration of high current applications. Output capacitors with their associated ESR values have an impact on loop stability and bandwidth. Powerbox converters are designed to work with load capacitance to see technical specifications.

## 6.15 Remote On/Off Circuit

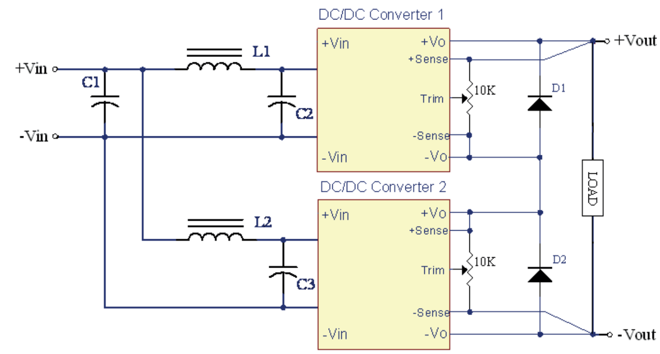
The converter remote On/Off circuit built-in on input side. The ground pin of input side Remote On/Off circuit is –Vin pin. Refer to 5.5 for more details. Connection examples see below.




Remote On/Off Connection Example

## 6.16 Series Operation

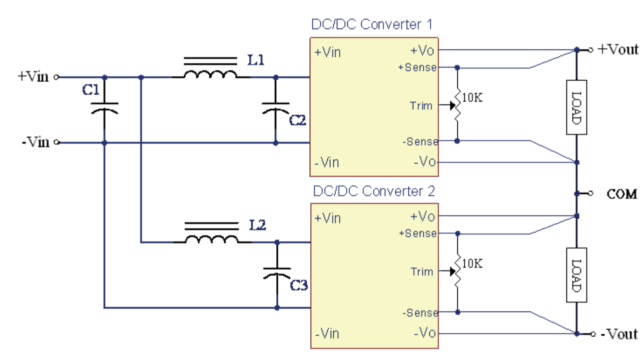
Series operation is possible by connecting the outputs two or more units. Connection is shown in below. The output current in series connection should be lower than the lowest rate current in each power module.




Simple Series Operation Connect Circuit

L1, L2: 1.0uH
C1, C2, C3: 68uF/200V ESR<0.7Ω

Note:
1. If the impedance of input line is high, C1, C2, C3 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20°C.
2. Recommend Schottky diode (D1, D2) be connected across the output of each series connected converter, so that if one converter shuts down for any reason, then the output stage won't be thermally overstressed. Without this external diode, the output stage of the shut-down converter could carry the load current provided by the other series converters, with its MOSFETs conducting through the body diodes. The MOSFETs could then be overstressed and fail. The external diode should be capable of handling the full load current for as long as the application is expected to run with any unit shut down. Series for ±output operation is possible by connecting the outputs two units, as shown in the schematic below.



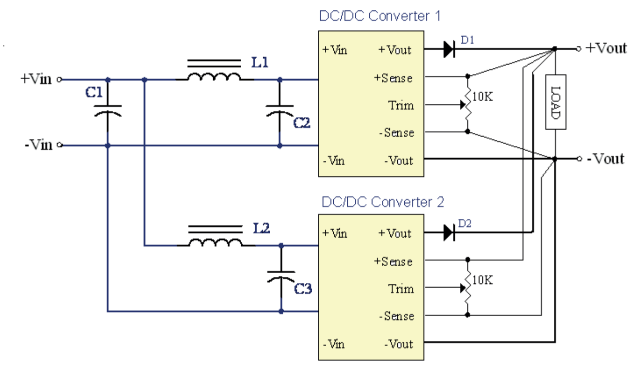

Simple ±Output Operation Connect Circuit

L1, L2: 1.0uH
C1, C2, C3: 68uF/200V ESR<0.7Ω

Note:
If the impedance of input line is high, C1, C2, C3 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20°C.

## 6.17 Parallel/Redundant Operation

The PQB50U-72S series parallel operation is not possible. Parallel for redundancy operation is possible by connecting the units as shown in the schematic below. The current of each converter become unbalance by a slight difference of the output voltage. Make sure that the output voltage of units of equal value and the output current from each power supply does not exceed the rate current. Suggest use an external potentiometer to adjust output voltage from each power supply.




Simple Redundant Operation Connect Circuit

L1, L2: 1.0uH

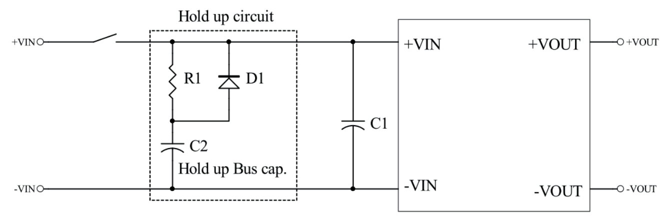
C1, C2, C3: 68uF/200V ESR<0.7Ω

Note:

If the impedance of input line is high, C1, C2, C3 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20°C.

## 6.18 Hold Up Time

Hold up time is defined as the duration of time that DC/DC converter output will remain active following a loss of input power. To meet power supply interruptions, an external circuit is required, shown below.




D1:200V/10A

R1:100Ω/10W

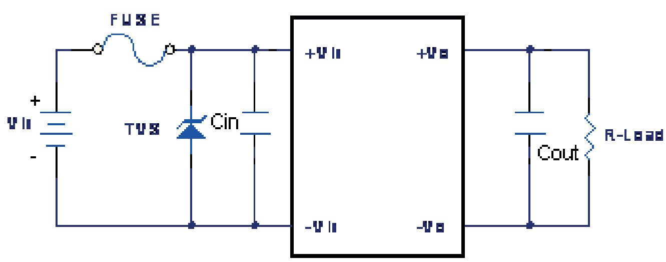
C1: 68uF/200V ESR<0.7Ω

| **C2** | **24Vin** | **36Vin** | **48Vin** |
|---|---|---|---|
| Hold up time for 10ms | 3300uF | 1100uF | 600uF |
| Hold up time for 30ms | 9400uF | 3300uF | 1700uF |
| **C2** | **72Vin** | **96Vin** | **110Vin** |
| Hold up time for 10ms | 250uF | 150uF | 120uF |
| Hold up time for 30ms | 730uF | 410uF | 330uF |

## 7. Safety & EMC

### 7.1 Input Fusing and Safety Considerations

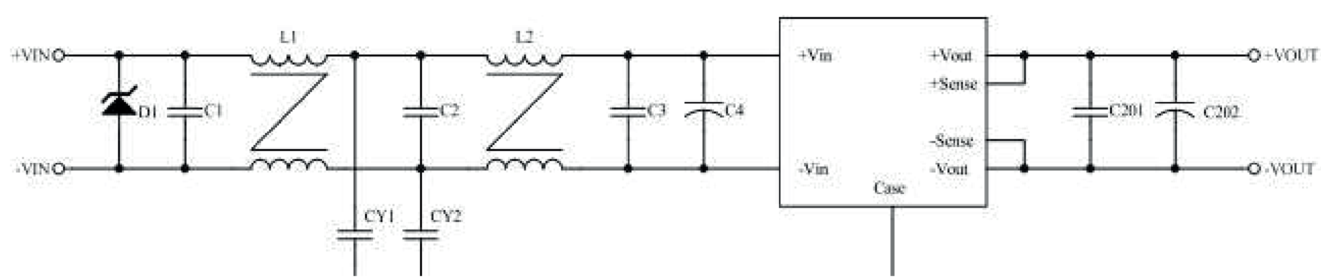
The PQB50U-72S series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a 6A fast acting fuse for all models. It is recommended that the circuit have a transient voltage suppressor diode (TVS) across the input terminal to protect the unit against surge or spike voltage and input reverse voltage (as shown).




The external TVS is required if CQB50W12 series has to meet EN61000-4-4, EN61000-4-5. The PB50U-72S series recommended a TVS (Littelfuse 1.5KE180A) to connect parallel.

### 7.2 EMC Considerations

EMI Test standard: EN50121-3-2 Conducted & Radiated Emission Test
Condition: Input Voltage: 110Vdc, Output Load: Full Load
(1) EMI meet EN55011 / EN55022 / EN50121-3-2:2006

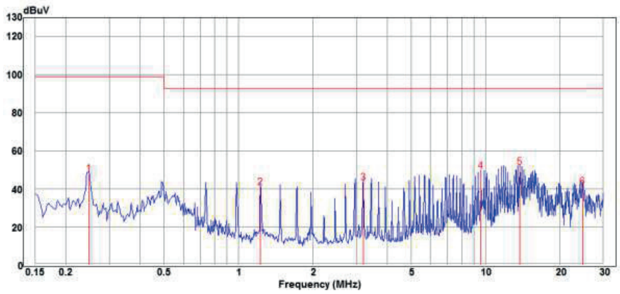



| C1,C2,C3 | C4 | C201 | C202 | CY1,CY2 | D1 | L1,L2 |
|---|---|---|---|---|---|---|
| 1uF/250V 1812 Ceramic Cap. | 82uF/250V KXJ Series Aluminum Cap. | 1uF/100V 1206 Ceramic Cap. | 22uF/100V Solid Aluminum Cap. | 1500pF | 1.5KE180A 5.5mH | URT24-050055H |

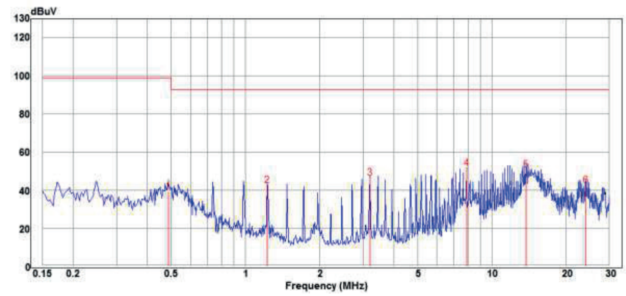
Note: C4 UNITED CHEMI-CON KXJ series or equivalent, CY1, CY2 MURATA Y1 capacitors or equivalent, L1, L2 BULL WILL URT24-05055H or equivalent

Conducted Emission:

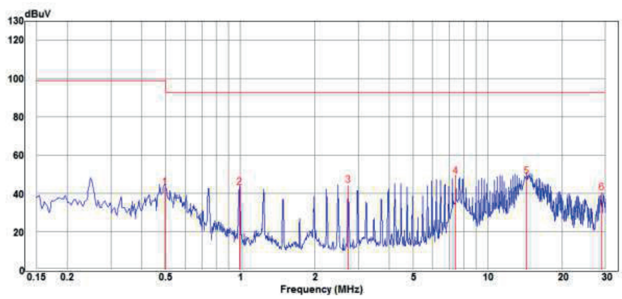
PQB50U-72S05
Line



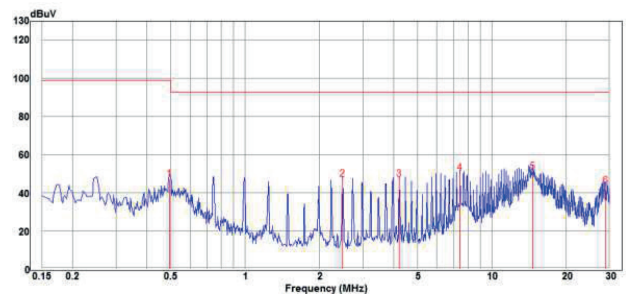

PQB50U-72S05
Neutral



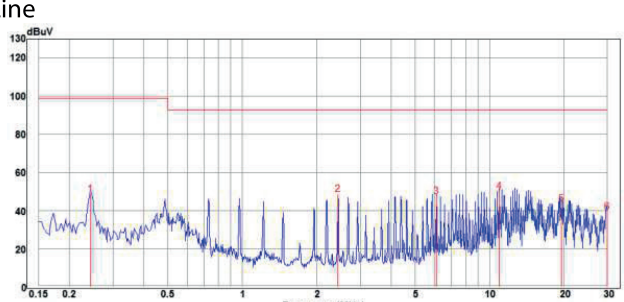

PQB50U-72S12
Line



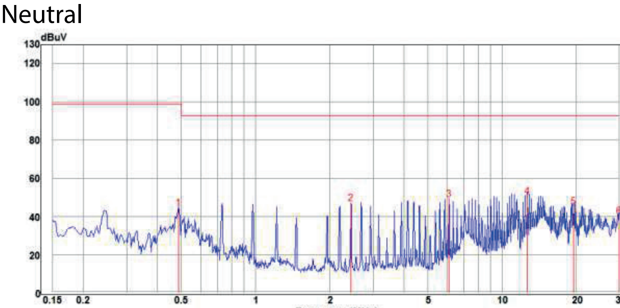

PQB50U-72S12
Neutral



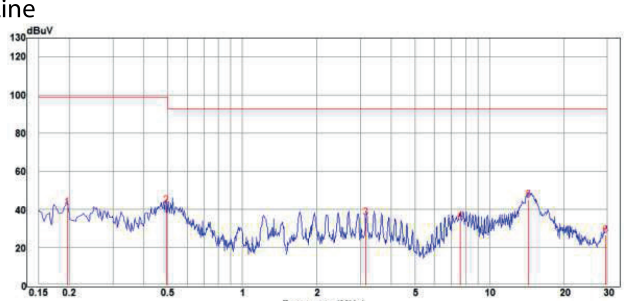

PQB50U-72S24
Line



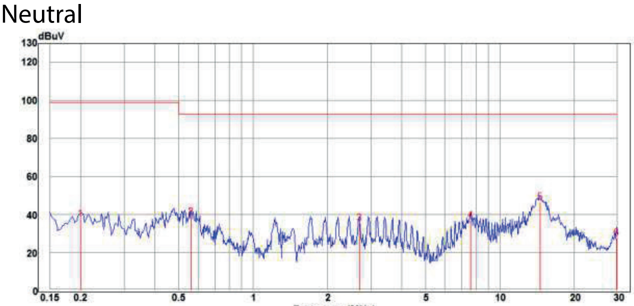

PQB50U-72S24
Neutral




PQB50U-72S48
Line

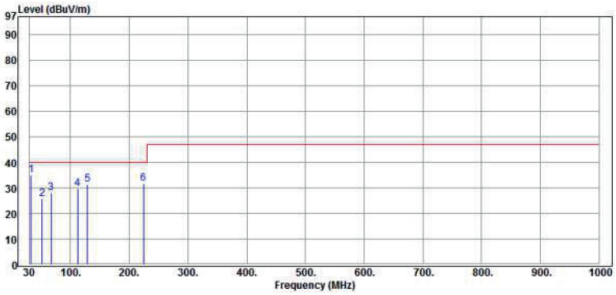



PQB50U-72S48
Neutral

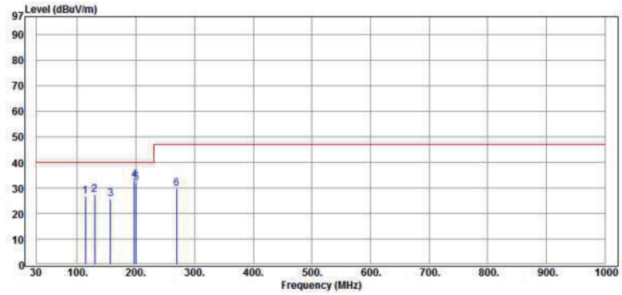


Radiated Emission:

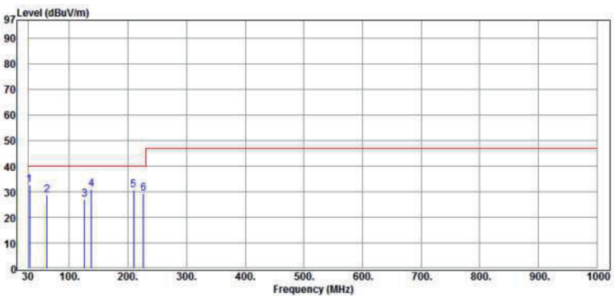
PQB50U-72S05
Vertical



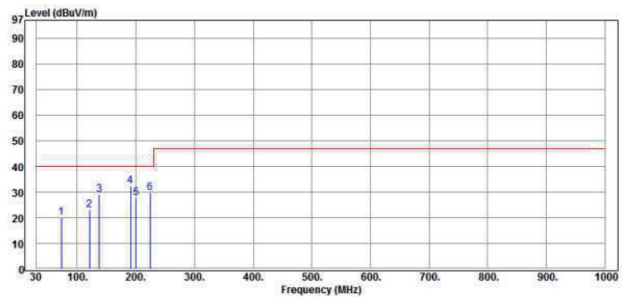

PQB50U-72S05
Horizontal



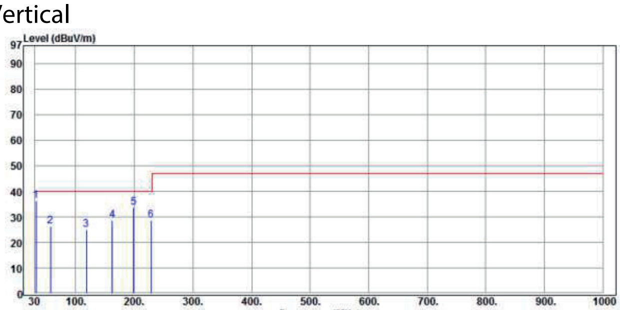

PQB50U-72S12
Vertical



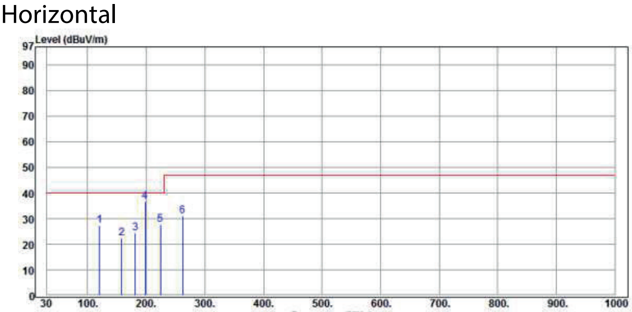

PQB50U-72S12
Horizontal



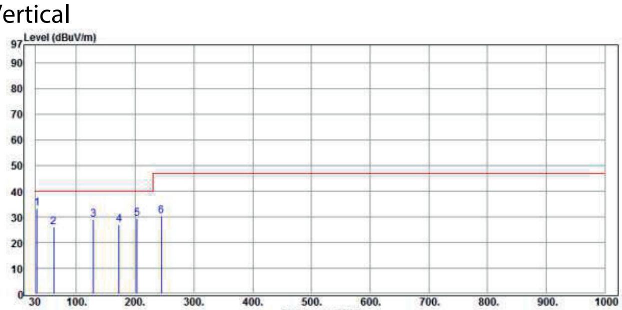

PQB50U-72S24
Vertical



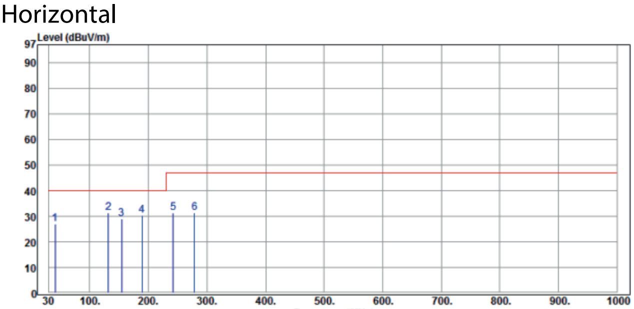

PQB50U-72S24
Horizontal



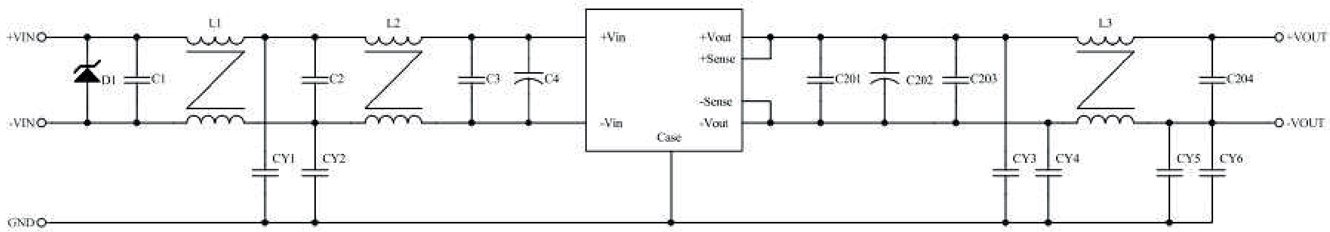

PQB50U-72S48
Vertical




PQB50U-72S48
Horizontal



(2) EMI meet EN50121-3-2:2015

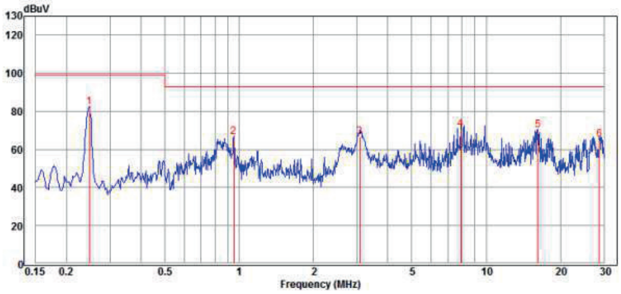



| **C1,C2,C3** | **C4** | **C201** | **C202** | **C203,C204** | **CY1,CY2** | **CY3,CY4,CY5,CY6** |
|---|---|---|---|---|---|---|
| 1uF/250V 1812 Ceramic Cap. | 82uF/250V KXJ Series Aluminum Cap. | 1uF/100V 1206 Ceramic Cap. | 22uF/100V Solid Aluminum Cap. | 2.2uF/100V 1210 Ceramic Cap. | 1500pF | 0.047uF/1KV 1812 Ceramic Cap. |
| **D1** | **L1,L2** | **L3** | | | | |
| 1.5KE180A | URT24-050055H 5.5mH | Core P/N: CM15*10*4.5 Winding: 1.0mm*2 / 4Turns 0.4mH | | | | |

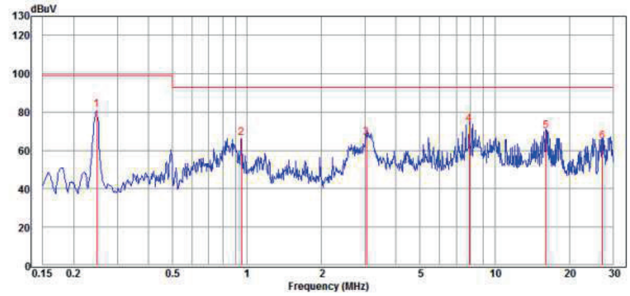
Note: C4 UNITED CHEMI-CON KXJ series or equivalent, CY1, CY2 MURATA Y1 capacitors or equivalent, L1, L2 BULL WILL URT24-05055H or equivalent.

Output Conducted Emission:

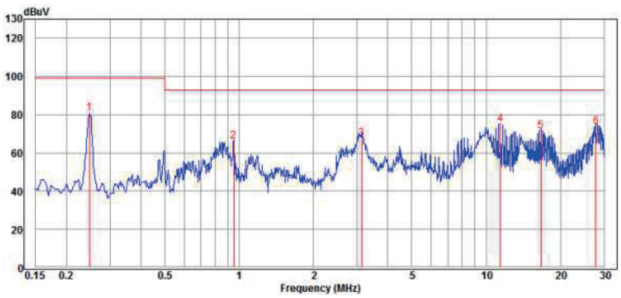
PQB50U-72S05
Pos



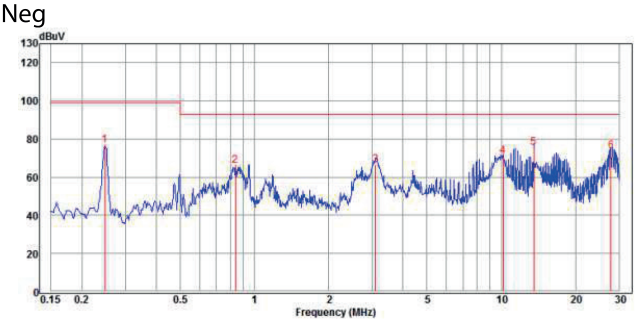

PQB50U-72S05
Neg



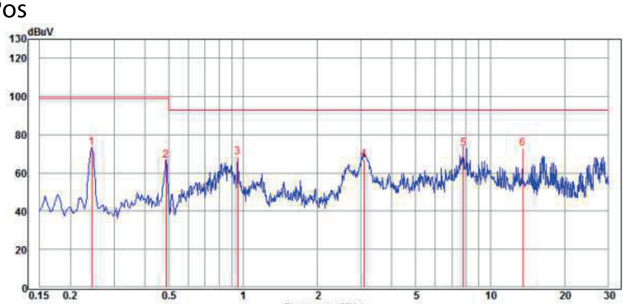

PQB50U-72S12
Pos



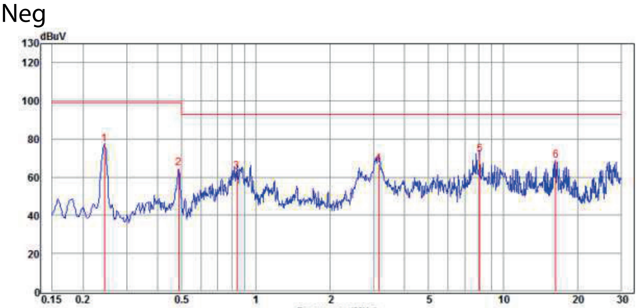

PQB50U-72S12
Neg



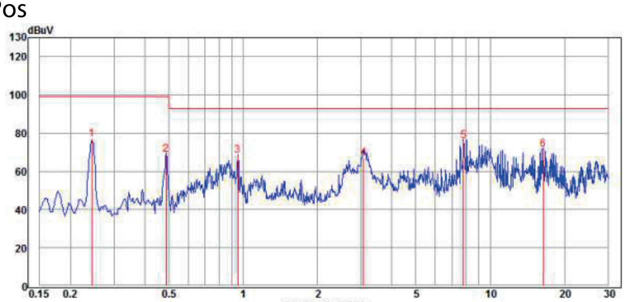

PQB50U-72S24
Pos



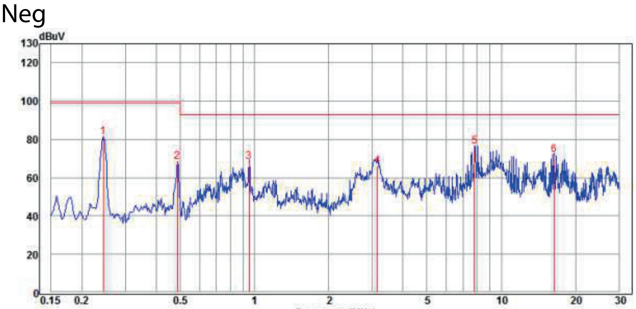

PQB50U-72S24
Neg



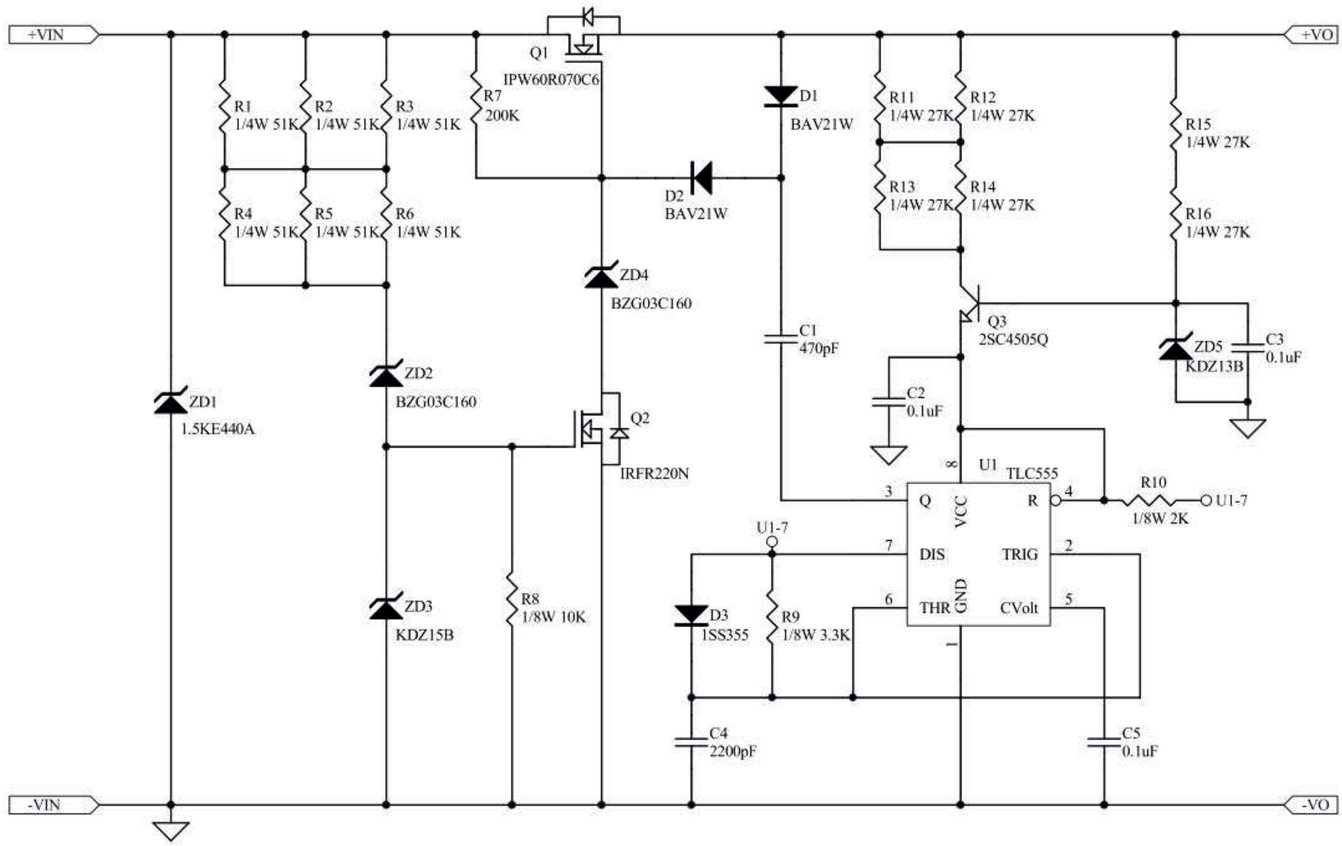

PQB50U-72S48
Pos




PQB50U-72S48
Neg



## 7.3. Suggested Configuration for RIA12 Surge Test



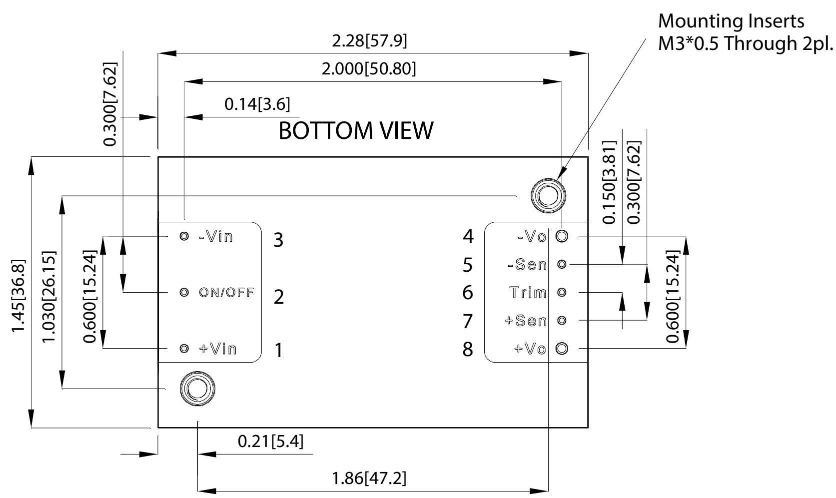

Note: Q1 suggest use Infineon IPW60R070C6 or equivalent, and provide good heat dissipation conditions

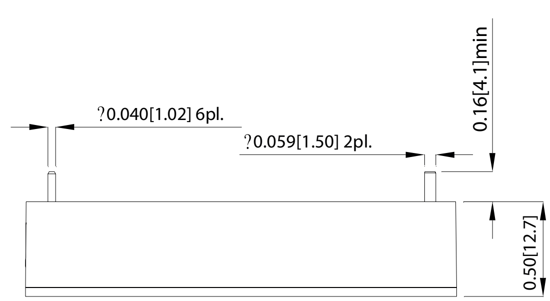
## 8. Mechanical Specifications

### 8.1 Mechanical Outline Diagrams

All Dimensions In Inches(mm)

Tolerances  Inches: X.XX= ±0.02 , X.XXX= ±0.010
Millimeters: X.X= ±0.5 , X.XX=±0.25




| PIN CONNECTION | |
|---|---|
| PIN | Function |
| 1 | +V Input |
| 2 | On/Off |
| 3 | -V Input |
| 4 | -V Output |
| 5 | -Sense |
| 6 | Trim |
| 7 | +Sense |
| 8 | +V Output |