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POWERBOX Industrial Line
PHB300W-110S Series
300W 4:1 Single Output
DC/DC Converter
Manual V11

**Table of Contents**



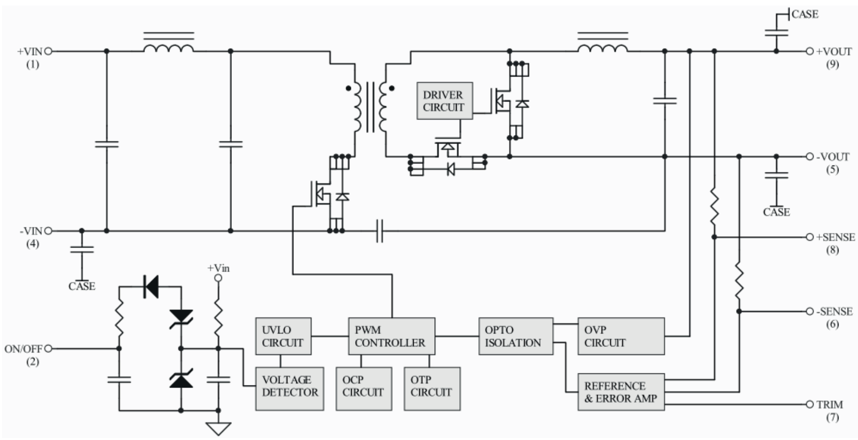
## 1. Introduction

The PHB300W-110S series of DC/DC converters offers 300 watts of output power @ single output voltages of 5, 12, 24, 28, 48VDC with industry standard half-brick. It has a wide (4:1) input voltage range of 43 to 160VDC (110VDC nominal) and 3000VDC basic isolation. Compliant with EN50155, EN45545, EN50121-3-2. High efficiency up to 91%, 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 (10mA), an ideal solution for energy critical systems. The standard control functions include remote on/off (positive or negative) and +10%, -10% 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. PHB300W-110S series is designed primarily for common railway applications of 72V, 96V, 110V nominal voltage and also suitable for distributed power architectures, telecommunications, battery operated equipment and industrial applications.

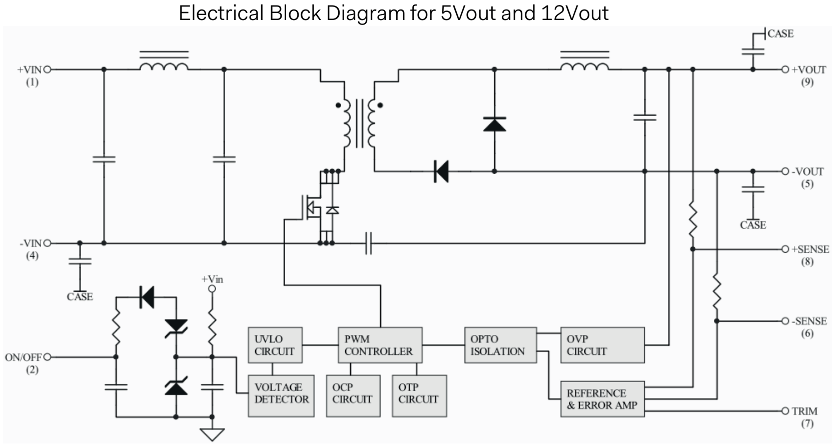
## 2. DC/DC Converter Features

- 300W isolated output
- Efficiency to 91%
- Low no load power consumption
- Fixed switching frequency
- 4:1 input range
- Regulated outputs
- Input under-voltage protection
- Over temperature protection
- Over voltage/current protection
- Remote On/Off
- Half 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 for 5Vout and 12Vout




Electrical Block Diagram for other modules

## 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, input/case | All | | | 3000 | VDC |
| | 1 minute: output/case | All | | | 500 | VAC |

**Input Characteristics**

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| Operating input voltage | | All | 43 | 110 | 160 | VDC |
| *Input Under Voltage Lockout* | | | | | | |
| Turn-on voltage threshold | | All | 40 | 42 | 43 | VDC |
| Turn-off voltage threshold | | All | 37 | 39 | 40 | VDC |
| Lockout hysteresis voltage | | All | | 3 | | VDC |
| Maximum input current | 100% Load, Vin=43V | All | | 8000 | | mA |
| No-load input current | | All | | 10 | | mA |
| Input Fflter | Pi filter. | All | | | | |
| Inrush current (I2t) | As per ETS300 132-2. | All | | | 0.1 | $A^2s$ |
| Input reflected ripple current | P-P thru 12uH inductor, 5Hz to 20MHz | All | | 40 | | 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=5.0V | 4.95 | 5 | 5.05 | VDC |
| | | Vo=12V | 11.88 | 12 | 12.12 | VDC |
| | | Vo=24V | 23.76 | 24 | 24.24 | VDC |
| | | Vo=28V | 27.72 | 28 | 28.28 | VDC |
| | | Vo=48V | 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 105°C | All | | | ±0.02 | %/°C |
| *Output voltage ripple and noise 5Hz to 20MHz bandwidth* | | | | | | |
| Peak-to-Peak | Full load, 5V: 47uF T521 KO CAP | Vo= 5.0V | | | 120 | mV |
| | <55mR and 1uF ceramic capacitors. | Vo=12V | | | 150 | mV |
| | Other: 10uF aluminum solid and | Vo=24V | | | 240 | mV |
| | 1uF ceramic capacitor. | Vo=28V | | | 280 | mV |
| | | Vo=48V | | | 480 | mV |
| RMS | | Vo= 5.0V | | | 60 | mV |
| | | Vo=12V | | | 80 | mV |
| | | Vo=24V | | | 120 | mV |
| | | Vo=28V | | | 140 | mV |
| | | Vo=48V | | | 220 | mV |
| Operating output current range | | Vo=5.0V | 0 | | 60 | A |
| | | Vo=12V | 0 | | 25 | A |
| | | Vo=24V | 0 | | 12.5 | A |
| | | Vo=28V | 0 | | 10.7 | A |
| | | Vo=48V | 0 | | 6.25 | A |
| Output DC current limit inception | Hiccup Mode. Auto Recovery. | All | 110 | 125 | 160 | % |
| Maximum output capacitance | Full load (resistive) | 110S05 | 0 | | 60000 | uF |
| | | 110S12 | 0 | | 25000 | uF |
| | | 110S24 | 0 | | 12500 | uF |
| | | 110S28 | 0 | | 10700 | uF |
| | | 110S48 | 0 | | 4700 | uF |
| Output voltage trim range | Pout=max rated power | All | -10 | | +10 | % |
| Output over voltage protection | Limited voltage | 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 | qdi/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 | | 20 | | ms |
| Turn-on delay time, from input | Vin_min to 10%Vo_set | All | | 20 | | ms |
| Output voltage rise time | 10%Vo_set to 90%Vo_set | All | | 15 | | ms |

**Efficiency**

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| *Efficiency* | | | | | | |
| 100% load | Vin=110V | Vo=5.0V | | 88 | | % |
| | | Vo=12V | | 90 | | % |
| | | Vo=24V | | 89 | | % |
| | | Vo=28V | | 89 | | % |
| | | Vo=48V | | 91 | | % |

**Isolation Characteristics**

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| Isolation voltage | 1 minute; input/output | All | | | 3000 | VDC |
| | 1 minute; input/case, | All | | | 3000 | VDC |
| | 1 minute; output/case | All | | | 500 | VAC |
| Isolation resistance | Input/output | All | 100 | | | MΩ |
| Isolation capacitance | Input/output | All | | 3000 | | pF |
| | Input/case | All | | 3000 | | pF |
| | Output/case | All | | 20000 | | pF |

**Feature Characteristics**

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| Switching frequency | Pulse wide modulation (PWM), fixed | All | 270 | 300 | 330 | KHz |
| *ON/OFF control, positive remote On/Off logic* | | | | | | |
| 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 high (module off) | Von/off at Ion/off=0.0mA | All | 3.5 or open circuit | | 160 | V |
| Logic low (module on) | Von/off at Ion/off=1.0uA | All | 0 | | 1.2 | V |
| On/off current (for both remote on/off logic) | Ion/off at Von/off=0.0V | All | | 0.3 | 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 recovery | | All | | 100 | | |

**General Specifications**

| Parameters | Notes and Conditions | Device | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| MTBF | Io=100% of Io_max: | Vo=48V | | 900 | | Khours |
| | MIL-HDBK-217F_notice 1 GB, 25°C | Others | | 600 | | Khours |
| Weight | | All | | 114 | | 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 EN50155 (EN50121-3-2) | with external input filter | | | | |
| ESD | Meets EN61000-4-2 | Level 3: Air ± 8 KV, Contanct ± 6 kV | | | Perf. Criteria A | |
| Radiated immunity | Meets EN61000-4-3 | Level 3: 80-10000MHz, 20 V/m | | | Perf. Criteria A | |
| Fast transient | Meets EN61000-4-4 | Level 3: On power input port, ± 2 kV, external input capacitor required | | | Perf. Criteria A | |
| Surge | Meets EN61000-4-5 | Level 4: Line to earth, ±4kV, Line to line, ±2kV | | | Perf. Criteria A | |
| Conducted immunity | Meets EN61000-4-6 | Level 3: 0.15-80MHz, 10V | | | Perf. Criteria A | |
| Interruptions of voltage supply | EN50155 | 10ms Interruptions | | | Class S2 | |
| Supply change over | EN50155 | During a supply break of 30 ms | | | Class C2 | |

## 5. Main Features and Functions

### 5.1 Operating Temperature Range

The PHB300W-110S 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 half brick models is influenced by usual factors, such as:

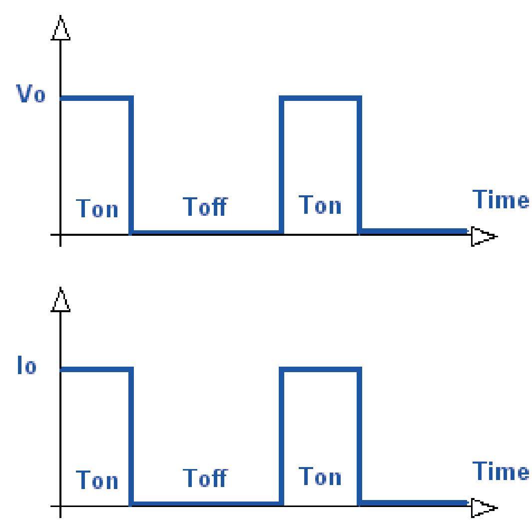
- Input voltage range
- Output load current
- Forced air or natural convection
- Heat sink optional

### 5.2 Output Voltage Adjustment

Section 6.10 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 –10%.

### 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.

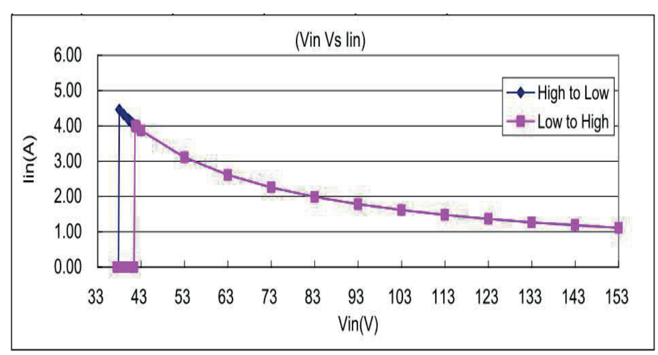
### 5.5 Remote On/Off

The PHB300W-110S 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 (>3.5Vdc 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 6.14

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

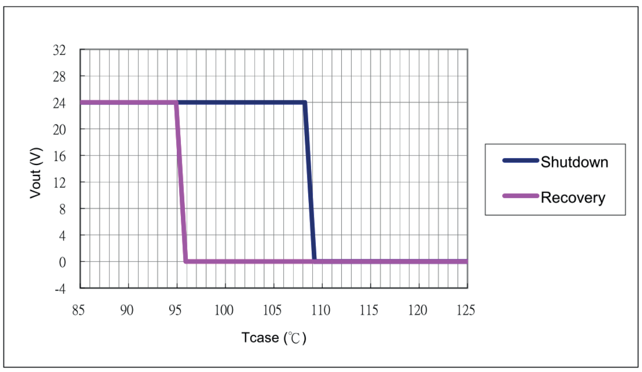
### 5.6 UVLO&OVLO (Under Voltage Lock Out)

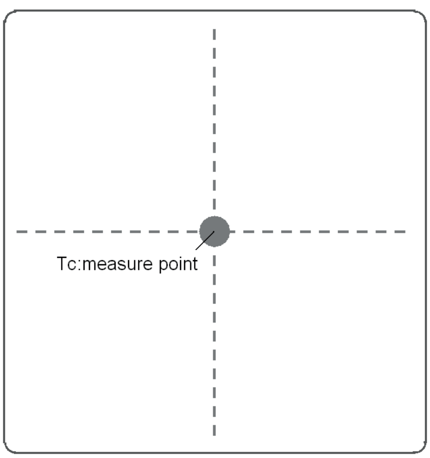
Input under voltage lockout is standard on the PHB300W-110S unit. The unit will shut down when the input voltage drops below a threshold, and the unit will operate when the input voltage goes above the upper threshold.



## 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.



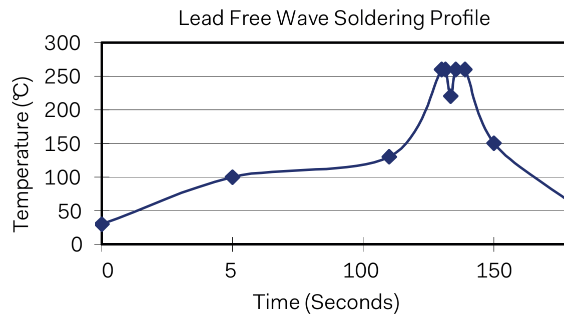



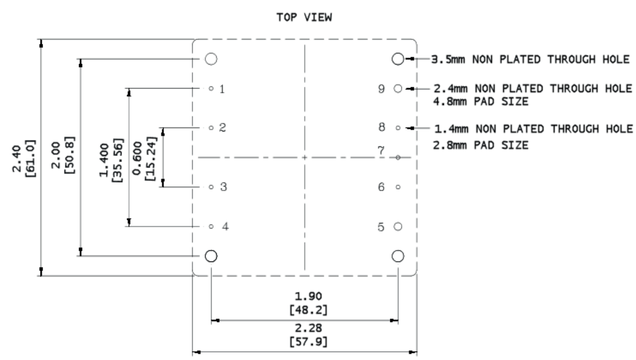

## 6. Applications

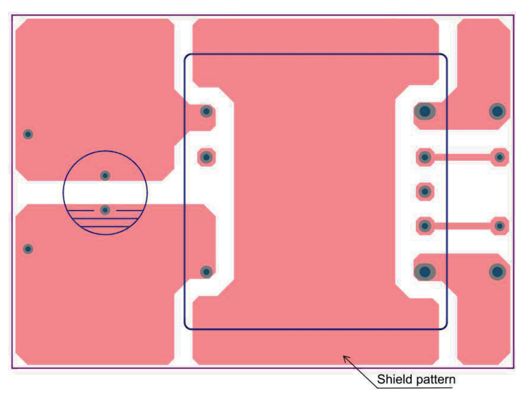
### 6.1 Recommended Layout, PCB Footprint and Soldering Information

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.
Clean the soldered side of the module with a brush, prevent liquid from getting into the module. Do not clean by soaking the module into liquid. Do not allow solvent to come in contact with product labels or resin case as this may changed the color of the resin case or cause deletion of the letters printed on the product label. After cleaning, dry the modules well.

The suggested soldering iron is 450°C for up to 5seconds(less than 50W). Furthermore, the recommended soldering profile and PCB layout are shown below.

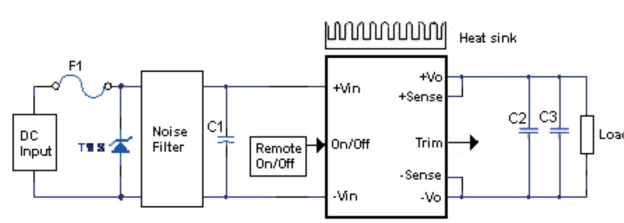



### 6.2 Connection for Standard Use

The connection for standard use is shown below. An external input capacitor (C1) 220uF for all models is recommended to reduce input ripple voltage. External output capacitors (C2, C3) are recommended to reduce output ripple and noise, 5Vout with 47uF T521 KO CAP. <55mR and 1uF ceramic capacitor, other modes with 10uF aluminum solid and 1uF ceramic capacitor.

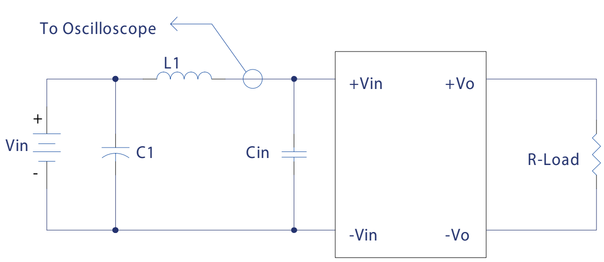


| Symbol | Component | Reference |
|---|---|---|
| F1 | Input fuse | Section 7.1 |
| C1 | External capacitor on input side | Note |
| C2,C3 | External capacitor on the output side | Section 6.12/6.13 |
| Noise Filter | External input noise filter | Section 7.2 |
| Remote On/Off | External Remote On/Off control | Section 6.16 |
| Trim | External output voltage adjustment | Section 6.10 |
| 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: 220uF ESR<0.14ohm @100KHz
Cin: 220uF ESR<0.14ohm @100KHz

## 6.4 Convection requirements for cooling

To predict the approximate cooling needed for the half 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).

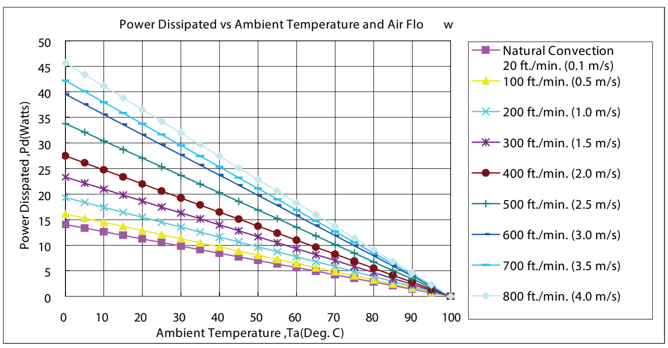
## 6.5 Thermal Considerations

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).

## 6.4 Power De-rating

The operating case temperature range of PHB150W-110S series is -40°C to +100°C. When operating the PHB150W-110S 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 de-rating curve of PHB150W-110S series without heat sink.




*Example*

What is the minimum airflow necessary for a PHB150W-110S24 operating at nominal line voltage, an output current of 12.5A, and a maximum ambient temperature of 15°C?

**Solution:**

Given: $V_{in}$=110Vdc Vo=24Vdc Io=12.5A

**Determine power dissipation (Pd):**

Pd =Pi-Po=Po(1-η)/η

Pd =24V×12.5A×(1-0.89)/0.89=37.08Watts

**Determine airflow:**

Given: Pd =37.08W and Ta=15°C

**Check above power de-rating curve:**

Minimum airflow= 800 ft./min.

**Verifying:**

The maximum temperature rise:

ΔT = Pd × Rca=37.08W×2.19=81.2°C

The maximum case temperature:

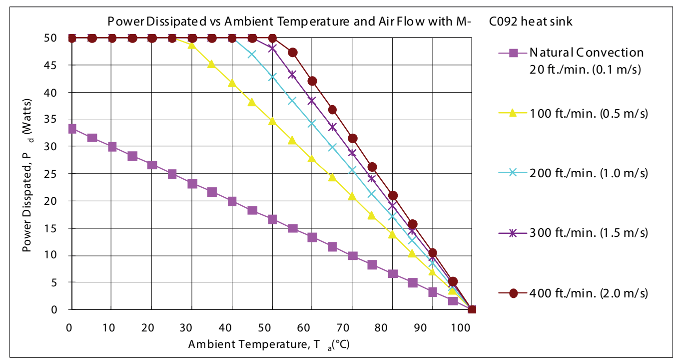
Tc=Ta+ΔT=96.2°C <100°C

**Where:**

The Rca is thermal resistance from case to ambient environment.

The Ta is ambient temperature and the Tc is case temperature.

| AIR FLOW RATE | TYPICAL Rca |
|---|---|
| Natural Convection 20ft./min. (0.1m/s) | 7.12 °C/W |
| 100 ft./min. (0.5m/s) | 6.21 °C/W |
| 200 ft./min. (1.0m/s) | 5.17 °C/W |
| 300 ft./min. (1.5m/s) | 4.29 °C/W |
| 400 ft./min. (2.0m/s) | 3.64 °C/W |
| 500 ft./min. (2.5m/s) | 2.96 °C/W |
| 600 ft./min. (2.5m/s) | 2.53 °C/W |
| 700 ft./min. (2.5m/s) | 2.37 °C/W |
| 800 ft./min. (2.5m/s) | 2.19 °C/W |




*Example (with heatsink M-C092):*

What is the minimum airflow necessary for a PHB150W-110S24 operating at nominal line voltage, an output current of 12.5A, and a maximum ambient temperature of 45°C?

**Solution:**

Given: Vin=110Vdc, Vo=24Vdc, Io=12.5A

**Determine power dissipation (Pd):**

Pd=Pi-Po=Po(1-η)/ η

Pd=24.0x12.5x(1-0.89)/0.89=37.08Watts

**Determine airflow:**

Given: $P_d$=37.08W and Ta=45°C

**Check above power de-rating curve:**

Minimum airflow=100 ft./min

**Verifying:**

The maximum temperature rise ΔT = Pd × Rca=37.08×1.44=53.40°C

The maximum case temperature Tc=Ta+ΔT=98.40°C <100°C

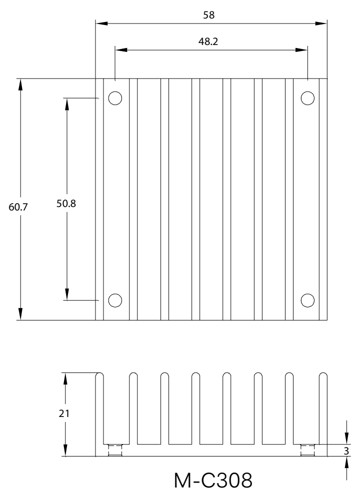
**Where:**

The Rca is thermal resistance from case to ambient environment.

The Ta is ambient temperature and the Tc is case temperature.

| AIR FLOW RATE | TYPICAL Rca |
|---|---|
| Natural convection 20ft./min. (0.1m/s) | 3.00°C/W |
| 100 ft./min. (0.5m/s) | 1.44°C/W |
| 200 ft./min. (1.0m/s) | 1.17°C/W |
| 300 ft./min. (1.5m/s) | 1.04°C/W |
| 400 ft./min. (2.0m/s) | 0.95 °C/W |

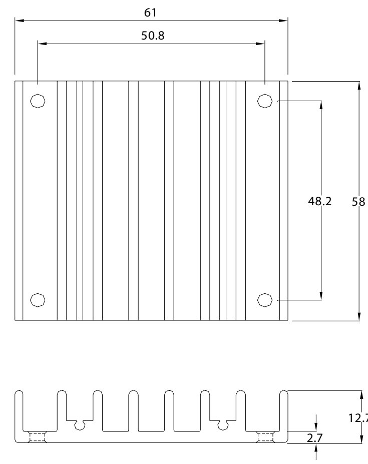
## 6.7 Quarter Brick Heat Sinks




M-C308

M-C308 (G6620400201)
Longitudinal Heat Sink

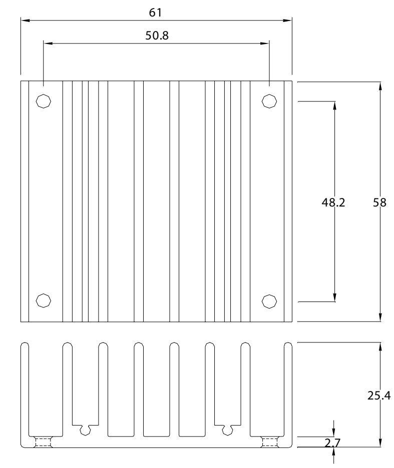
Rca:
3.90°C/W (typ.), natural convection
1.74°C/W (typ.), at 100LFM
1.33°C/W (typ.), at 200LFM
1.12°C/W (typ.), at 300LFM
0.97°C/W (typ.), at 400LFM




M-C091

M-C091 (G6610120402)
Transverse Heat Sink

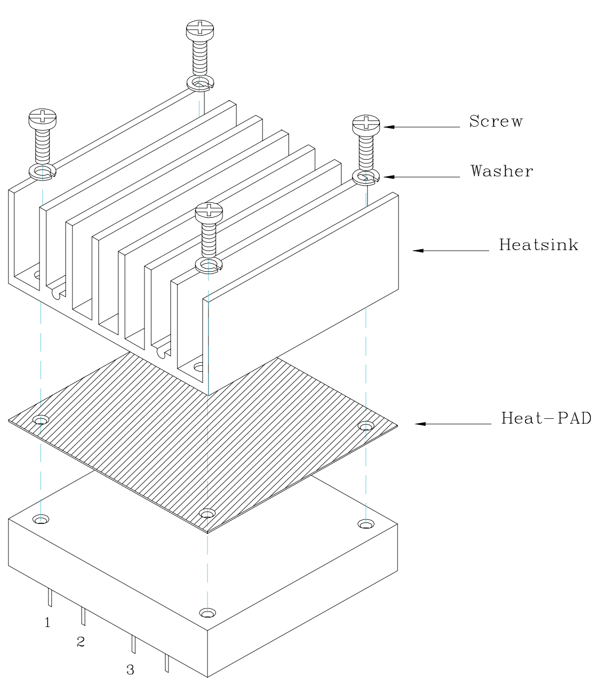
Rca:
4.70°C/W (typ.), natural convection
2.89°C/W (typ.), at 100LFM
2.30°C/W (typ.), at 200LFM
1.88°C/W (typ.), at 300LFM
1.59°C/W (typ.), at 400LFM




M-C092

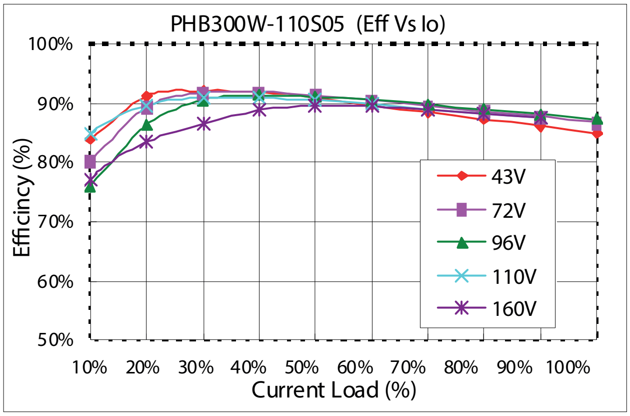
M-C092 (G6610130402)
Transverse Heat Sink

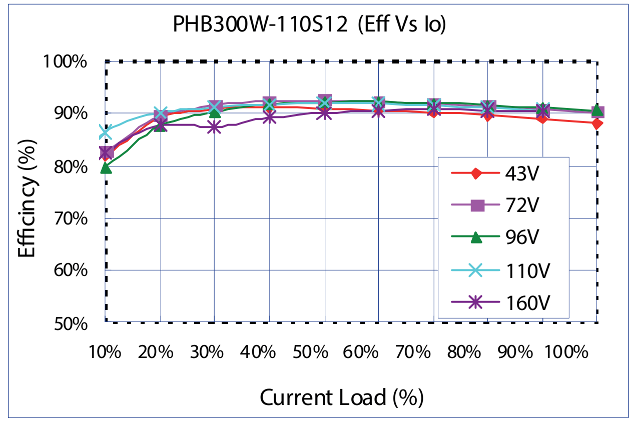
Rca:
3.00°C/W (typ.), natural convection
1.44°C/W (typ.), at 100LFM
1.17°C/W (typ.), at 200LFM
1.04°C/W (typ.), at 300LFM
0.95°C/W (typ.), at 400LFM

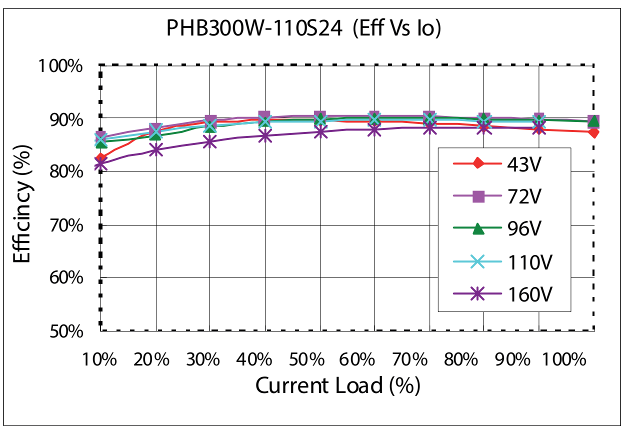


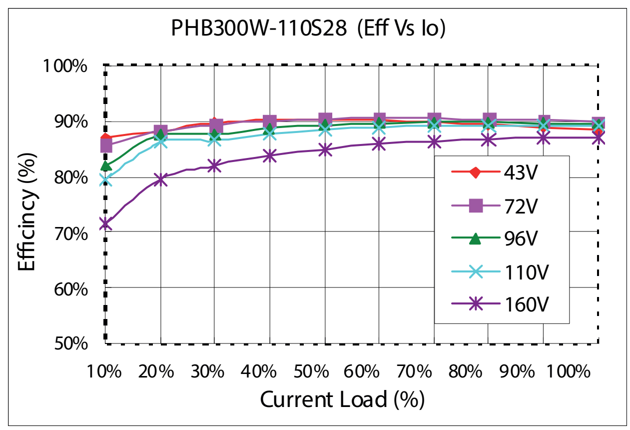

THERMAL PAD: SZ 56.9*60*0.25 mm (G6135041091)
SCREW: SMP+SW M3*8L (G75A1300322)

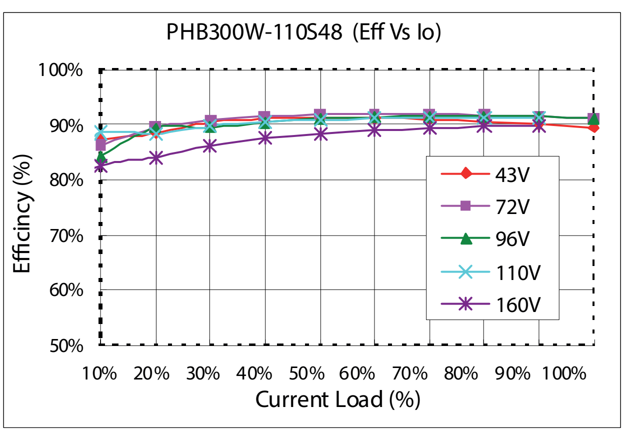
## 6.8 Efficiency VS. Load



## 6.9 Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown 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:

- 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:

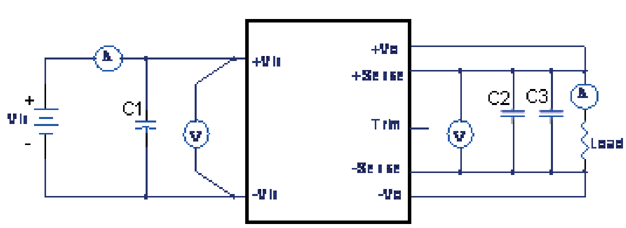
$$Load.reg = \frac{V_{FL} - V_{NL}}{V_{NL}} \times 100\%$$

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:

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

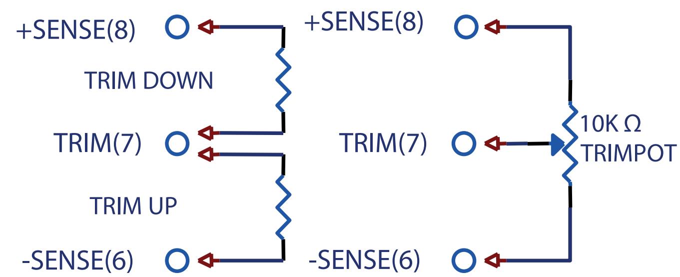
Where: $V_{HL}$ is the output voltage of maximum input voltage at full load.
$V_{LL}$ is the output voltage of minimum input voltage at full load.



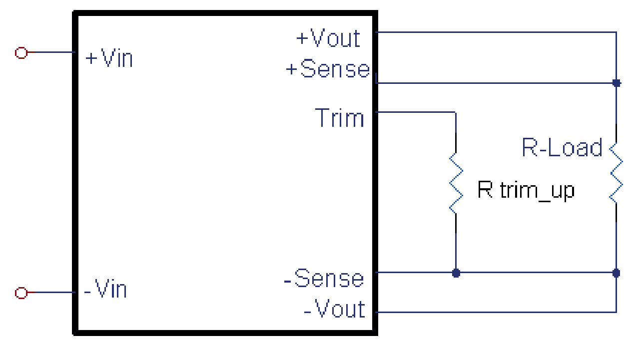

C1: 220uF/200V ESR<0.14Ω
C2: 1uF/ 1210 ceramic capacitor
C3: 10uF aluminum solid capacitor for other models.
47uF T521 KO CAP. <55mR for 5Vout

## 6.10 Output Voltage Adjustment

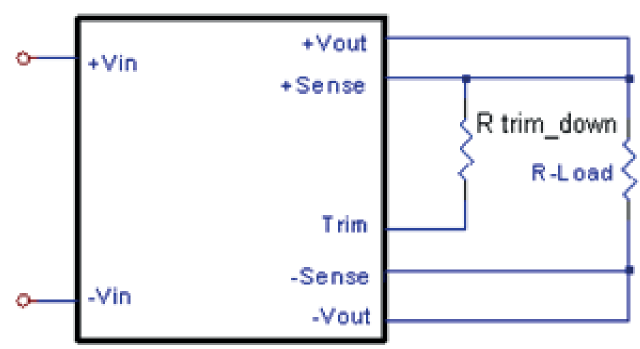
Output may be externally trimmed (±10%) with a fixed resistor or an external trim pot as shown (optional). Model specific formulas for calculating trim resistors are available upon request as a separate document.




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 ±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 | 2.32 | 3.3 | 0 | 2.5 | 0 |
| 12V | 9.1 | 51 | 5.1 | 2.5 | 0.46 |
| 24V | 20 | 100 | 7.5 | 2.5 | 0.46 |
| 28V | 23.7 | 150 | 6.2 | 2.5 | 0.46 |
| 48V | 36 | 270 | 5.1 | 2.5 | 0.46 |

Trim Resistor Values

**The value of Rtrim_up defined as:**

For Vo=5V Rtrim_up decision:

$$R_{trim\_up} = \frac{R_1 V_r}{Vo - V_{o\_nom}} - R_2 \ \ (K\Omega)$$

For other Rtrim_up decision:

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

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

For example, to trim-up the output voltage of 12V module (PHB150W-110S12) by 5% to 12.6V, Rtrim_up is calculated as follows:

Vo – Vo_nom = 12.6 – 12 = 0.6V
R1 = 9.1 KΩ, R2 = 51 KΩ, R3 = 5.1KΩ
Vr= 2.5 V, Vf=0.46 V

$$R_{trim\_up} = \frac{18.944}{0.6} - 4.636 = 26.94 \ (K\Omega)$$

**The value of Rtrim_down defined as:**

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

Where:
Rtrim_down 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-down the output voltage of 12V module (PHB150W-110S12) by 5% to 11.4V, Rtrim_down is calculated as follows:

Vo_nom – Vo = 12 – 11.4 = 0.6 V
R1 = 9.1 KΩ, R2 = 51 KΩ, Vr = 2.5 V

$$R_{trim\_down} = \frac{9.1 \times (11.4 - 2.5)}{0.6} - 51 = 83.98 \ \ (K\Omega)$$

The typical value of Rtrim_up

| | 5V | 12V | 24V | 28V | 48V |
|---|---|---|---|---|---|
| **Trim up%** | **Rtrim_up (KΩ)** | | | | |
| 1% | 112.7 | 153.2 | 165.7 | 168.3 | 148.6 |
| 2% | 54.70 | 74.30 | 79.36 | 81.16 | 71.81 |
| 3% | 35.37 | 47.99 | 50.58 | 52.12 | 46.21 |
| 4% | 25.70 | 34.83 | 36.19 | 37.60 | 33.40 |
| 5% | 19.90 | 26.94 | 27.56 | 28.86 | 25.72 |
| 6% | 16.03 | 21.68 | 21.80 | 23.08 | 20.60 |
| 7% | 13.27 | 17.92 | 17.69 | 18.93 | 16.94 |
| 8% | 11.20 | 15.10 | 14.61 | 15.82 | 14.20 |
| 9% | 9.589 | 12.91 | 12.21 | 13.40 | 12.07 |
| 10% | 8.300 | 11.15 | 10.29 | 11.47 | 10.36 |

The typical value of Rtrim_down

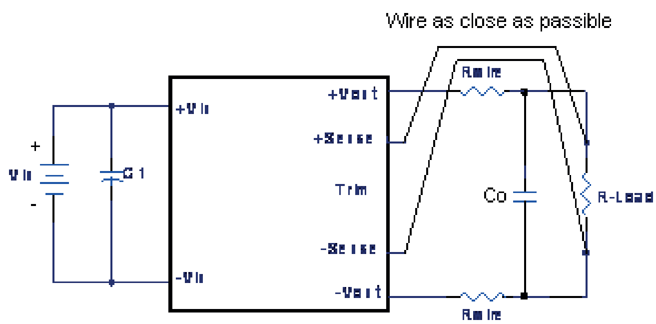
| | 5V | 12V | 24V | 28V | 48V |
|---|---|---|---|---|---|
| **Trim down%** | **Rtrim_down (KΩ)** | | | | |
| 1% | 110.4 | 660.3 | 1671 | 1984 | 3106 |
| 2% | 52.38 | 300.1 | 775.8 | 905.5 | 1400 |
| 3% | 33.05 | 180.0 | 477.2 | 545.8 | 831.5 |
| 4% | 23.38 | 120.0 | 327.9 | 365.9 | 547.1 |
| 5% | 17.58 | 83.98 | 238.3 | 258.0 | 376.5 |
| 6% | 13.71 | 59.97 | 178.6 | 186.0 | 262.8 |
| 7% | 10.95 | 42.82 | 136.0 | 134.6 | 181.5 |
| 8% | 8.880 | 29.95 | 104.0 | 96.10 | 120.6 |
| 9% | 7.269 | 19.95 | 79.07 | 66.12 | 73.17 |
| 10% | 5.980 | 11.94 | 59.17 | 42.14 | 35.25 |

## 6.11 Output Remote Sensing

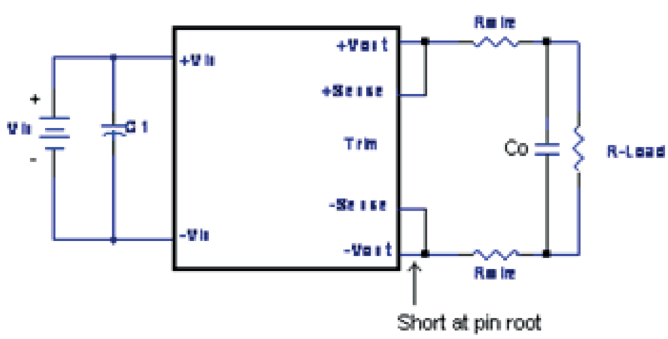
The PHB300W-110S series converter has the capability to remotely sense both lines of its output. This feature moves the effective output voltage regulation point from the output of the unit to the point of connection of the remote sense pins. This feature automatically adjusts the real output voltage of the PHB300W-110 series in order to compensate for voltage drops in distribution and maintain a regulated voltage at the point of load. The remotesense 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.

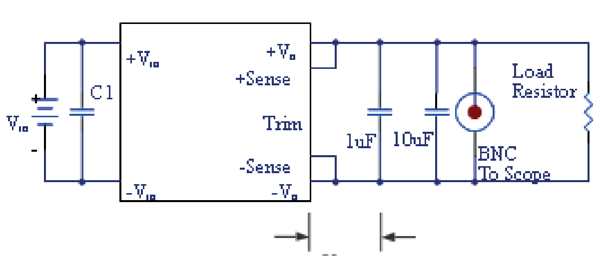



If the remote sense feature is not to be used, the sense pins should be connected locally. The +Sense pin should be connected to the +Vout pin at the module and the -Sense pin should be connected to the -Vout pin at the module. Wire between +Sense and +Vout and between -Sense and –Vout as short as possible.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



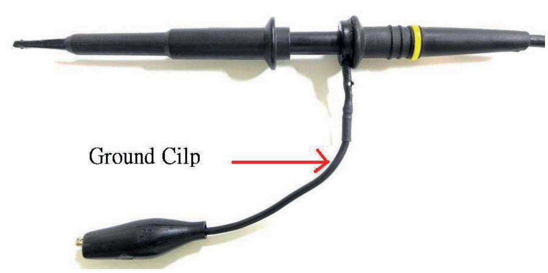

Note: Although the output voltage can be varied (increased or decreased) by both remote sense and trim, the maximum variation for the output voltage is the larger of the two values not the sum of the values. The output power delivered by the module is defined as the voltage at the output terminals multiplied 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 Vo.set is below nominal value, Pout.max will also decrease accordingly because Io.max is an absolute limit. Thus, Pout.max = Vo.set x Io.max is also an absolute limit.

## 6.12 Output Ripple and Noise

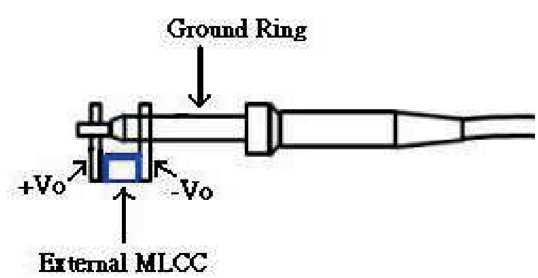



Output ripple and noise measured with 47uF T521 KO CAP. <55mR capacitor and 1uF ceramic capacitor across output for 5Vout and 10uF aluminum solid and 1uF ceramic capacitor for other models. A 20 MHz bandwidth oscilloscope is normally used for the measurement.

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.

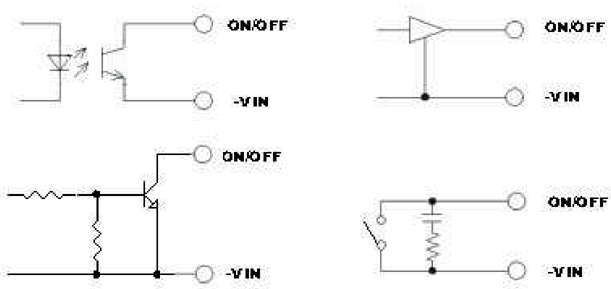



## 6.13 Output Capacitance

The PHB300W-110S 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.

## 6.14 Remote On/Off Circuit

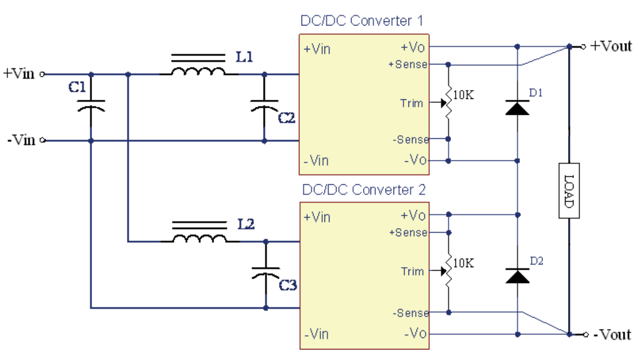
The converter remote On/Off circuit built-in on input side. The ground pin of input side Remote On/Off circuit is –Vin pin. Refer to 5.6 for more details. Connection examples see below.




Remote On/Off Connection Example

## 6.15 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.

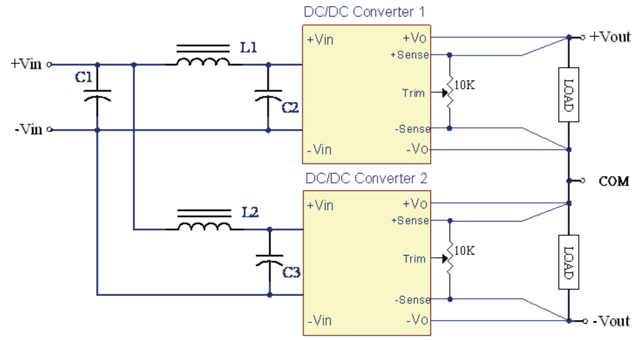



Simple Series Operation Connect Circuit

L1, L2: 1.0uH
C1, C2, C3: 220uF/200V ESR<0.140Ω

**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.



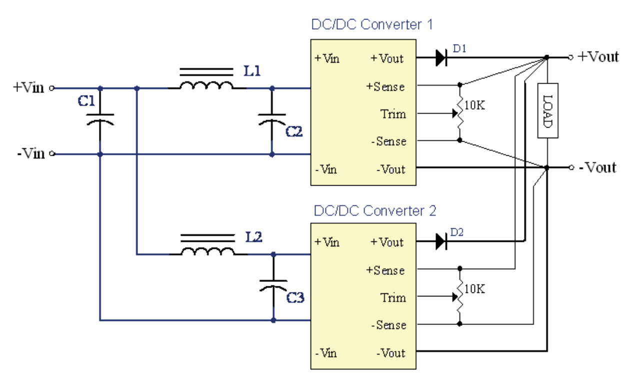

Simple ±Output Operation Connect Circuit

L1, L2:1.0uH
C1, C2, C3:220uF/200V ESR<0.140Ω

**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.

## 6.16 Parallel/Redundant Operation

The PHB300W-110S 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.



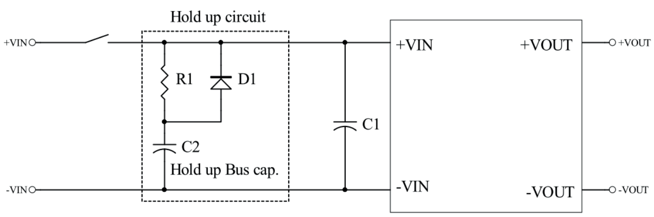

Simple Redundant Operation Connect Circuit

L1, L2: 1.0uH
C1, C2, C3: 220uF/200V ESR<0.140Ω

**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 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.



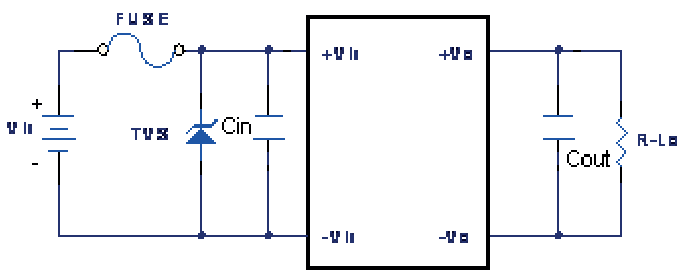

D1:200V/10A R1:100Ω/10W
C1:220uF/200V ESR<0.140Ω

| C2 | 72Vin | 96Vin | 110Vin |
|---|---|---|---|
| Hold up time for 10ms | 2700uF | 1000uF | 700uF |
| Hold up time for 30ms | 8000uF | 3400uF | 2400uF |

# 7. Safety & EMC

## 7.1 Input Fusing and Safety Considerations

The PHB300W-110S series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a 10A time delay 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 PHB300W-110S series has to meet EN61000-4-4, EN61000-4-5. The PHB300W-110S recommended a TVS (Littelfuse 1.5KE180A) to connect parallel.

## 7.2 EMC Considerations

EMI Test standard: EN50121-3-2:2015 Conducted & Radiated Emission
Test Condition: Input Voltage: 110Vdc, Output Load: Full Load
(1) EMI meet EN50121-3-2:2015

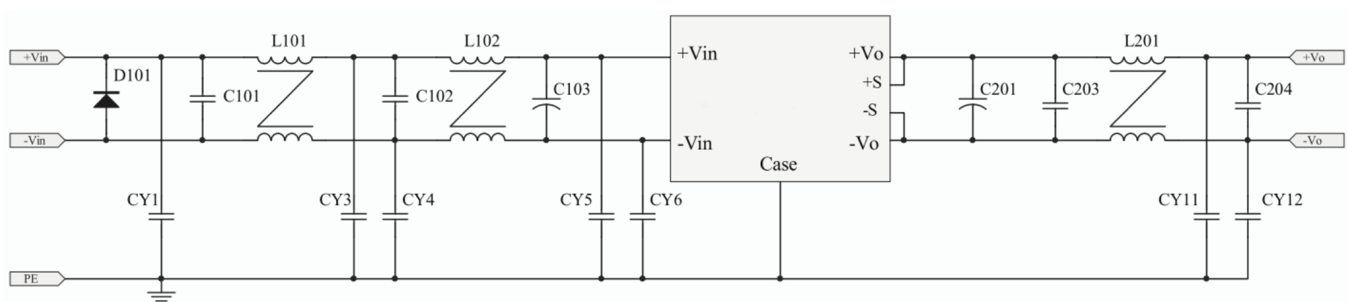


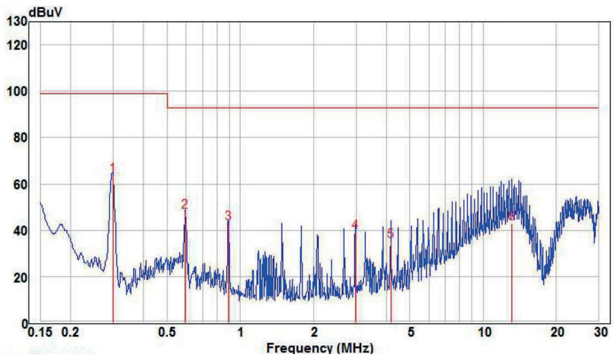

Figure1 Connection circuit for EMI testing

| **Model No.** | **PHB300W-110S05** | **PHB300W-110S12** | **PHB300W-110S24** | **PHB300W-110S28** | **PHB300W-110S48** |
|---|---|---|---|---|---|
| C101 | 1uF/250V X7R | 1uF/250V X7R | 1uF/250V X7R | 1uF/250V X7R | 1uF/250V X7R |
| C102 | 1812 | 1812 | 1812 | 1812 | 1812 |
| C103 | 220uF/200V | 220uF/200V | 220uF/200V | 220uF/200V | 220uF/200V |
| | Aluminum cap. | Aluminum cap. | Aluminum cap. | Aluminum cap. | Aluminum cap. |
| | YXF series | YXF series | YXF series | YXF series | YXF series |
| C201 | 47uF/20V | 10uF/50V X5R | 10uF/50V X5R | 10uF/50V X5R | 22uF/100V |
| | Polymer tantalum cap. | 1210 | 1210 | 1210 | |
| C203 | 1uF/100V X7R | 1uF/100V X7R | 1uF/100V X7R | 1uF/100V X7R | 1uF/100V X7R |
| C204 | 1206 | 1206 | 1206 | 1206 | 1206 |
| CY1 | NC | NC | 1000pF/Y2 | NC | NC |
| CY3 | 220pF/Y2 | 220pF/Y2 | 220pF/Y2 | 220pF/Y2 | 220pF/Y2 |
| CY4 | 4700pF/Y2 | 4700pF/Y2 | 4700pF/Y2 | 4700pF/Y2 | 4700pF/Y2 |
| CY5 | 2200pF/Y2 | 2200pF/Y2 | 2200pF/Y2 | 2200pF/Y2 | 2200pF/Y2 |
| CY6 | 1000pF/Y2 | 1000pF/Y2 | 1000pF/Y2 | 1000pF/Y2 | 1000pF/Y2 |
| CY11 | 10000pF/Y2 | 10000pF/Y2 | 10000pF/Y2 | 10000pF/Y2 | 10000pF/Y2 |
| CY12 | | | | | |
| D101 | 1.5KE180A | 1.5KE180A | 1.5KE180A | 1.5KE180A | 1.5KE180A |
| | Littelfuse | Littelfuse | Littelfuse | Littelfuse | Littelfuse |
| L101 | ACME | ACME | ACME | ACME | ACME |
| L102 | A10 T25*15*15C | A10 T25*15*15C | A10 T25*15*15C | A10 T25*15*15C | A10 T25*15*15C |
| | 3.5mH, ϕ1.0mm*1/16T | 3.5mH, ϕ1.0mm*1/16T | 3.5mH, ϕ1.0mm*1/16T | 3.5mH, ϕ1.0mm*1/16T | 3.5mH, ϕ1.0mm*1/16T |
| L201 | FERROXCUBE | VAKOS | VAKOS | VAKOS | VAKOS |
| | T29/19/15-3E6 | R10K T22*16*6.5C | R12K T18*12*6C | R12K T18*12*6C | R12K T18*12*6C |
| | 0.17mH, ϕ1.0mm*4/4T | 0.28mH, ϕ1.0mm*2/7T | 0.28mH, ϕ1.0mm*1/7T | 0.28mH, ϕ1.0mm*1/7T | 0.28mH, ϕ1.0mm*1/7T |

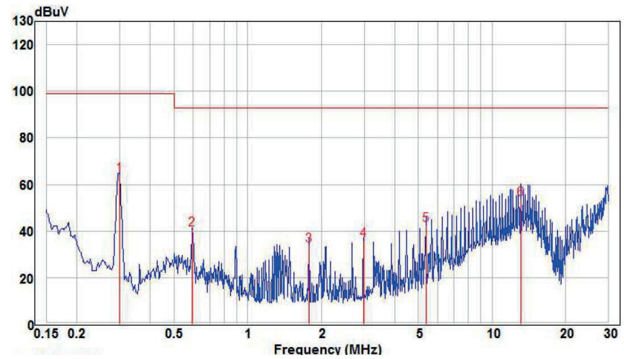
Note: C103 is RUBYCON YXF series aluminum capacitors or equivalent, CYxx is MURATA Y2 capacitor or equivalent.

PHB300W-110S05

Line

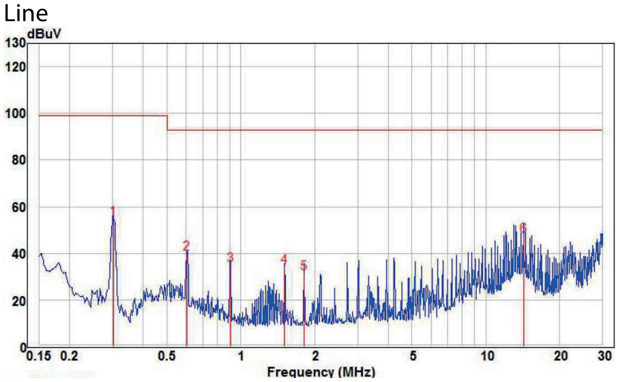



Neutral

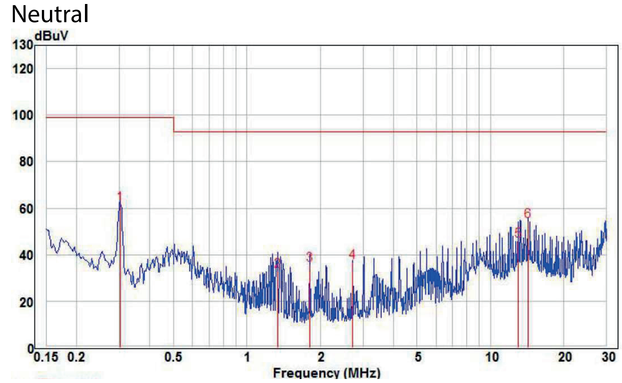



PHB300W-110S12

Line

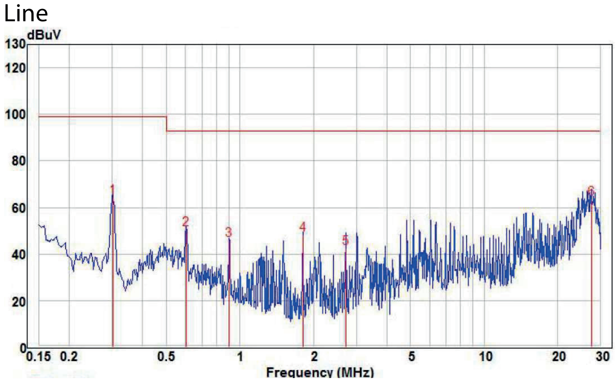



Neutral

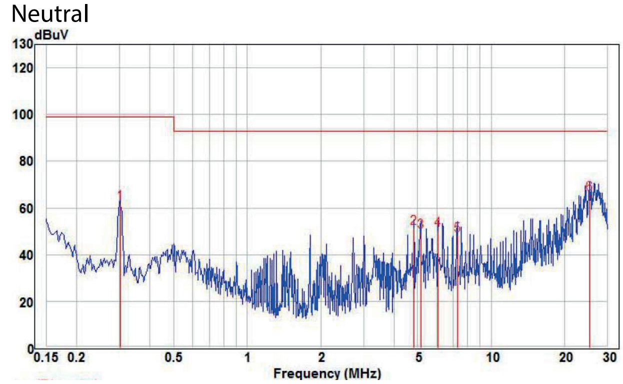



PHB300W-110S24

Line

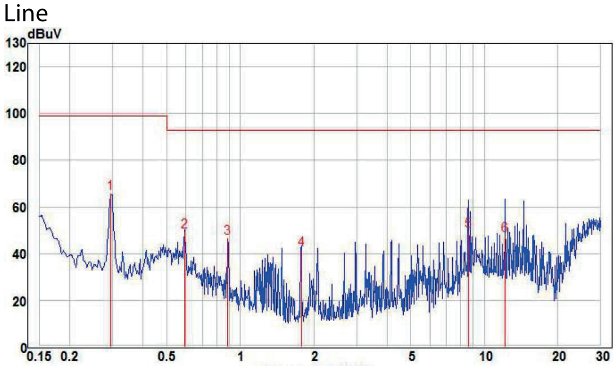



Neutral

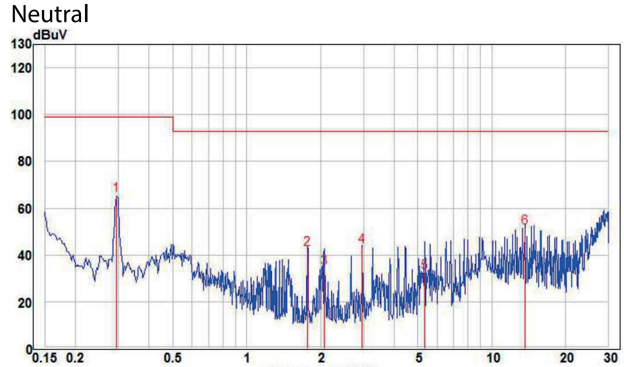



PHB300W-110S28

Line

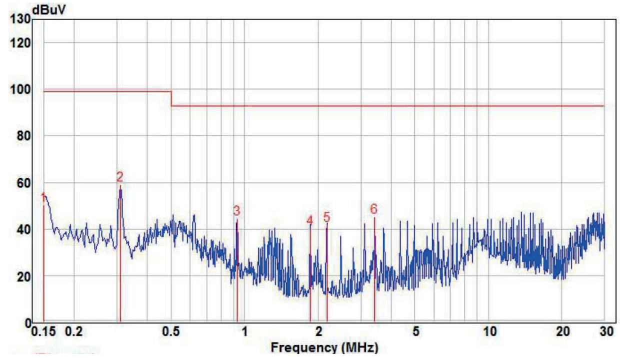



Neutral

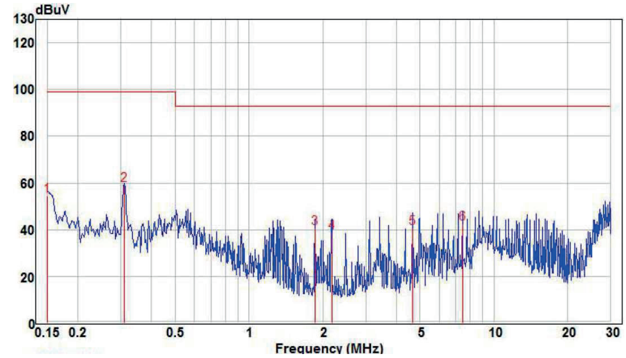


PHB300W-110S48

Line



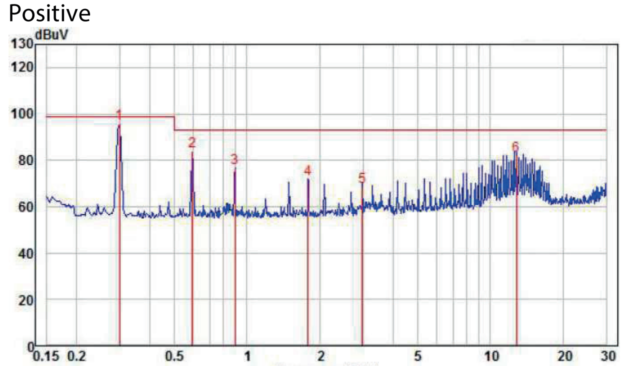

Neutral



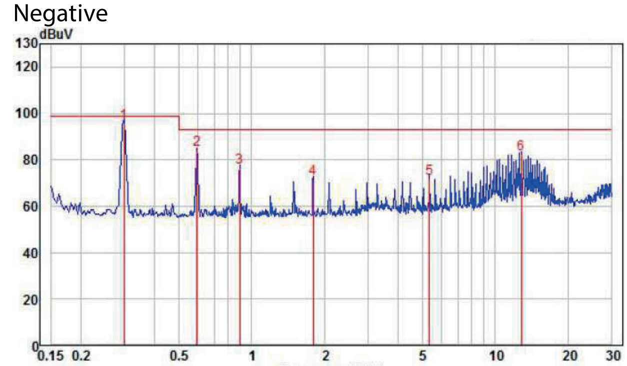

## Conducted Emission(Output):

PHB300W-110S05

Positive

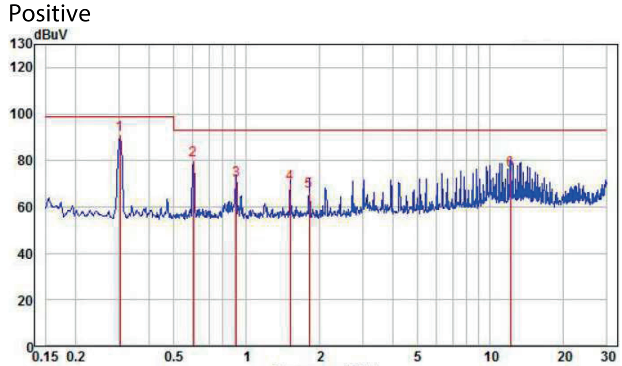



Negative

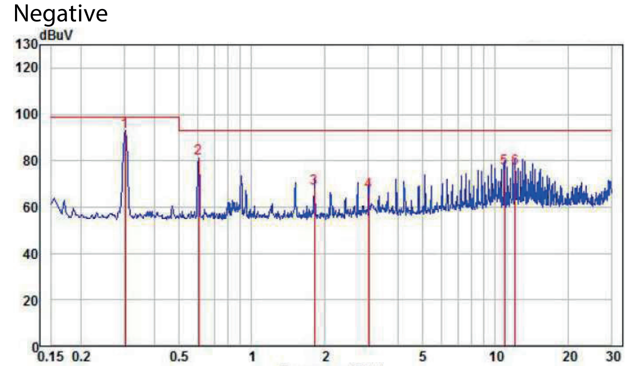



PHB300W-110S12

Positive

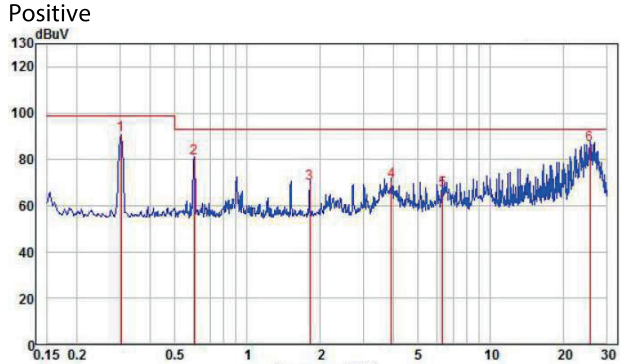



Negative

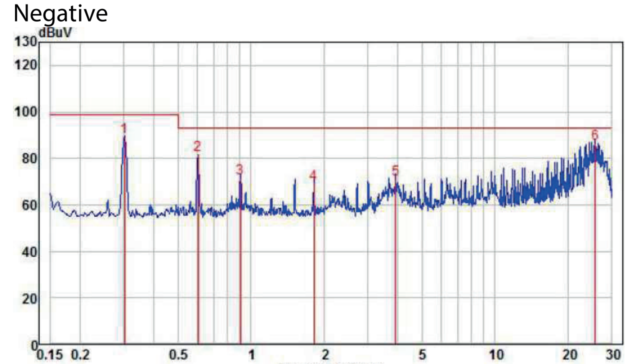



PHB300W-110S24

Positive

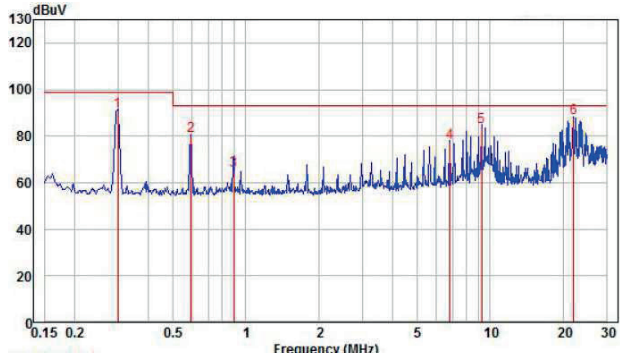



Negative

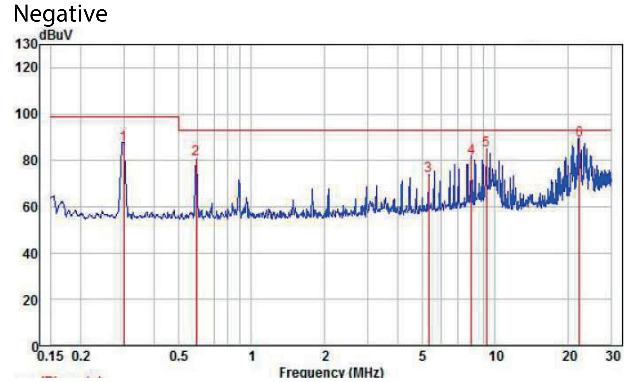


PHB300W-110S28

Positive

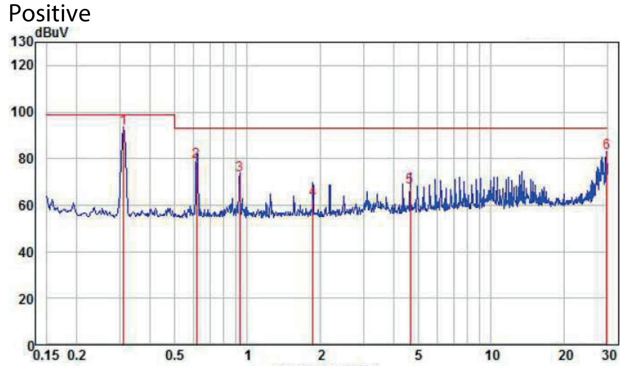



Negative

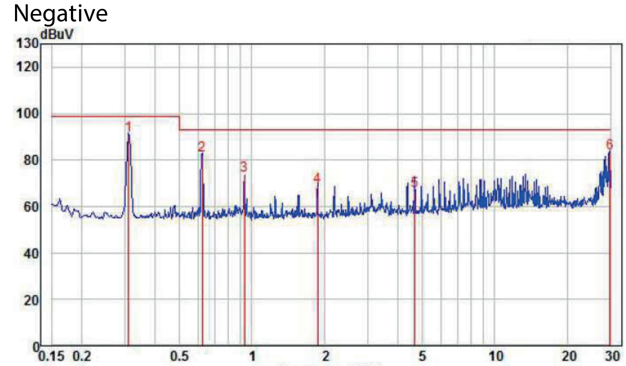



PHB300W-110S48

Positive



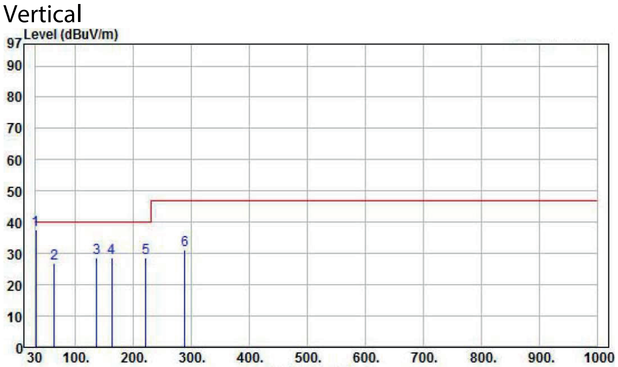

Negative



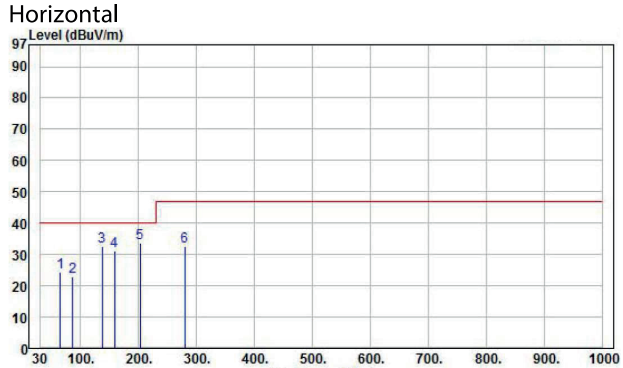

## Radiated Emission:

PHB300W-110S05

Vertical

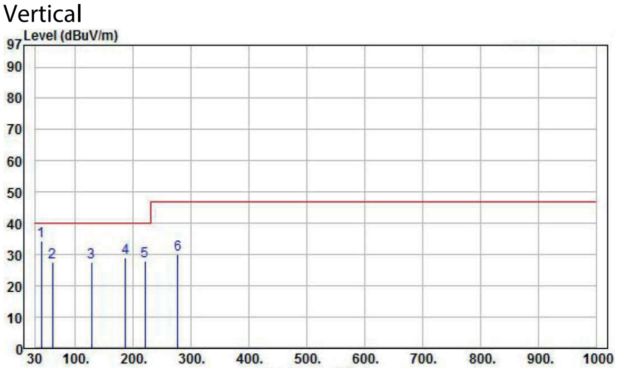



Horizontal

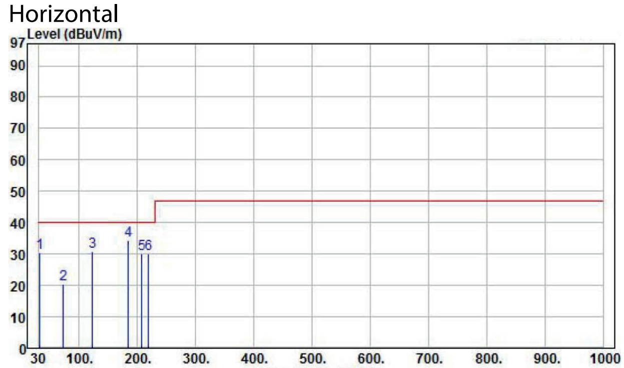



PHB300W-110S12

Vertical

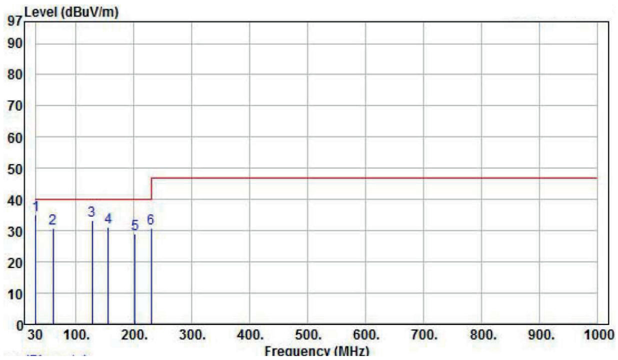



Horizontal

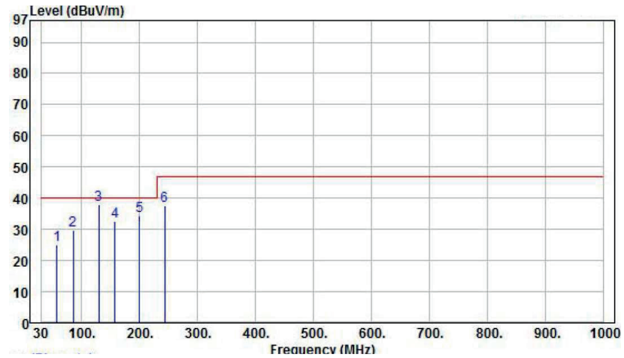


PHB300W-110S24

Vertical

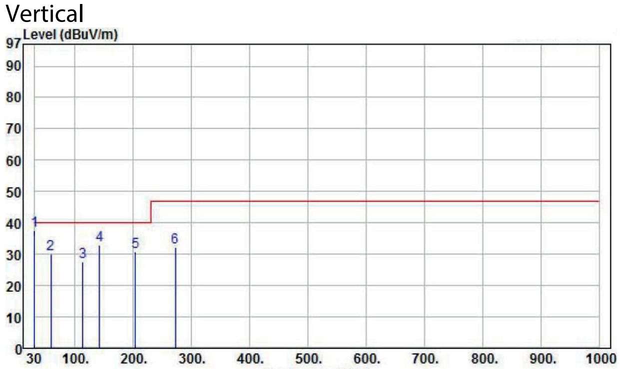



Horizontal

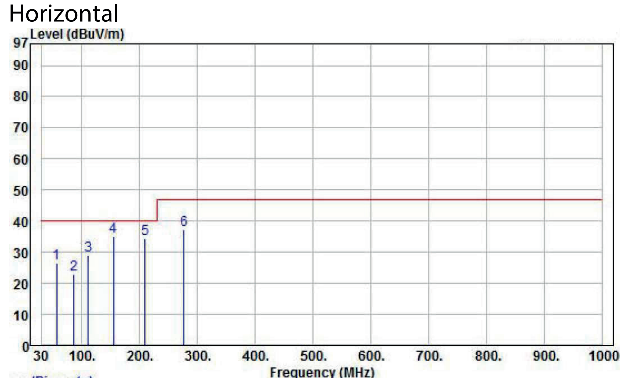



PHB300W-110S28

Vertical

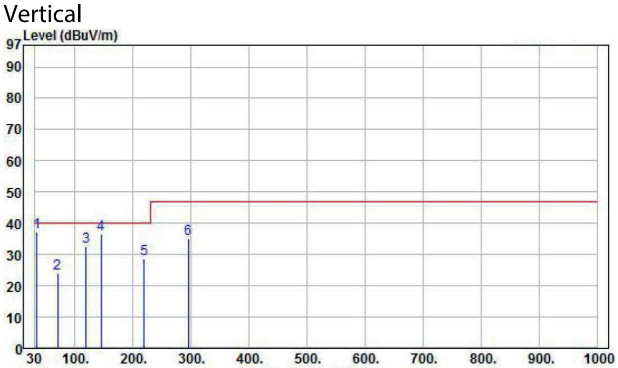



Horizontal

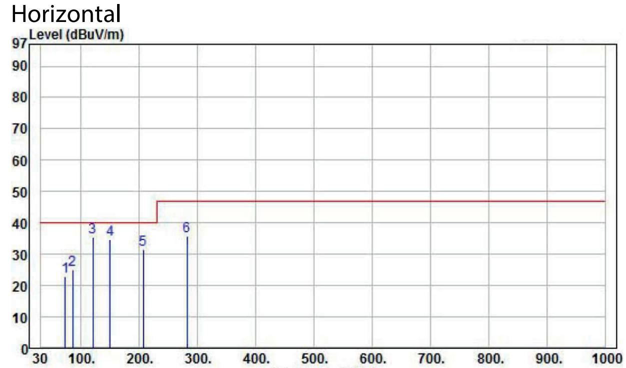



PHB300W-110S48

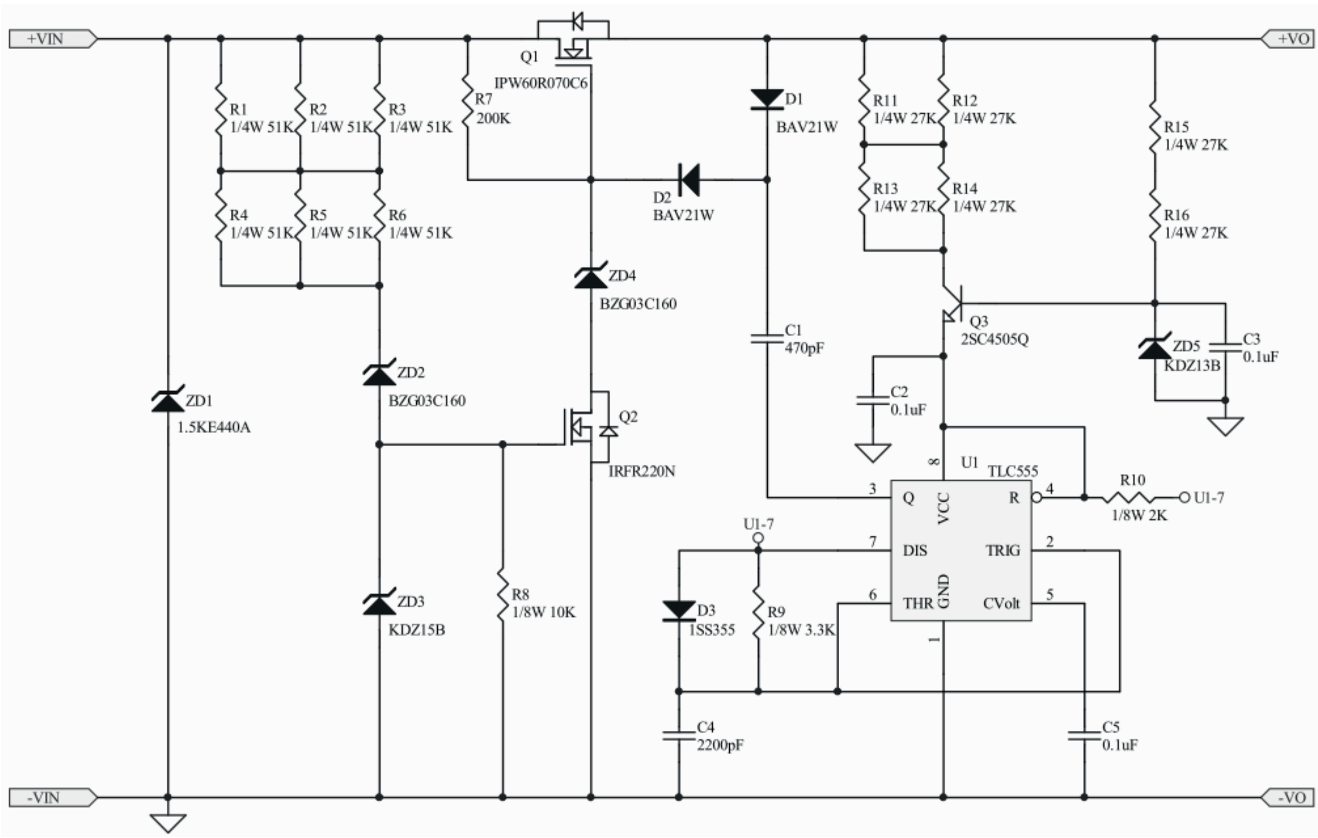
Vertical




Horizontal



## 7.3 Suggested Configuration for RIA12 Surge Test




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

## 8. Part Number

Format: PHB150W – II O XX L-Y

| **Parameter**<br>**Symbol** | **Series**<br>**PHB150W** | **Nominal Input Voltage**<br>**II** | **Number of Outputs**<br>**O** | **Output Voltage**<br>**XX** | **Remote ON/OFF Logic**<br>**L** | **Mounting Inserts**<br>**Y (Option)** |
|---|---|---|---|---|---|---|
| Value | PHB150W | 110: 110 Volts | S: Single | 05: 5 Volts<br>12: 12 Volts<br>24: 24 Volts<br>28: 28 Volts<br>48: 48 Volts | None: Positive<br>N: Negative | C: Clear Mounting Insert (3.2mm DIA) |

## 9. Mechanical Specifications

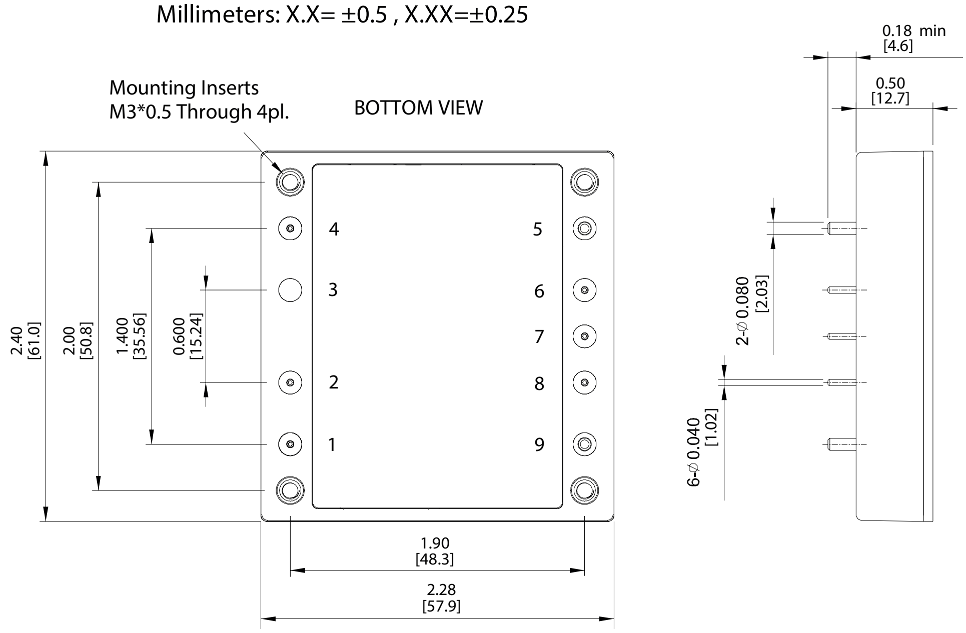
### 9.1 Mechanical Outline Diagrams

CASE HB

All Dimensions In Inches(mm)

Tolerances Inches: X.XX= ±0.02 , X.XXX= ±0.0 10

Millimeters: X.X= ±0.5 , X.XX=±0.25




| Pin | Function |
|---|---|
| 1 | +V Input |
| 2 | On/Off |
| 3 | NP |
| 4 | -V Input |
| 5 | -V Output |
| 6 | -Sense |
| 7 | Trim |
| 8 | +Sense |
| 9 | +V Output |