

# HBR Series, 250 Watt

*½ Brick DC/DC Converter with 10:1 Input*



Typical Unit

The HBR series of isolated regulated converter modules, deliver an impressive 250W single output from an ultra wide input voltage range of 16V – 160V DC, complying with the input battery voltage transient ranges of EN50155 (2017). The industry standard half brick package offers high efficiency levels up to 91%. The fully isolated (4242Vdc) DC-DC module accepts a wide input voltage range of 16V – 160VDC, while maintaining a fully regulated single output. The output voltage features Overvoltage, Overcurrent, short circuit, Overtemperature and Vout overshoot protection. Other features include – adjustable Undervoltage lockout protection, adjustable Current limit threshold, Positive or Negative Logic enable and a Hold Up Pin to allow connection of an external capacitor.

## Safety Features

- 4242Vdc input to output isolation
- Reinforced isolation
- UL 60950-1, 2nd Edition
- IEC 60950-1, 2nd Edition
- RoHS compliant

## Features

- Efficiency up to 91% @ 72Vin, 12Vout
- Ultra wide input range: 16V-160V
- Output voltage/current: 12V/21A, 24V/10.5A, 54V/4.7A
- Vout external trim adjustment
- Output power 250W
- Package Dimension (inches):  
2.48 x 2.39 x 0.55, standard half-brick size
- OVP, OCP, OTP
- Positive or Negative Remote ON/OFF
- Operating Baseplate Temperature range - 40°C to +100°C
- 4242VDC input to output reinforced isolation
- Hold up time (10-30mS)
- UVLO Set up (resistor programmable)
- Conformally Coated PCB
- Encapsulated for harsh environment
- Meets requirements for EN50155



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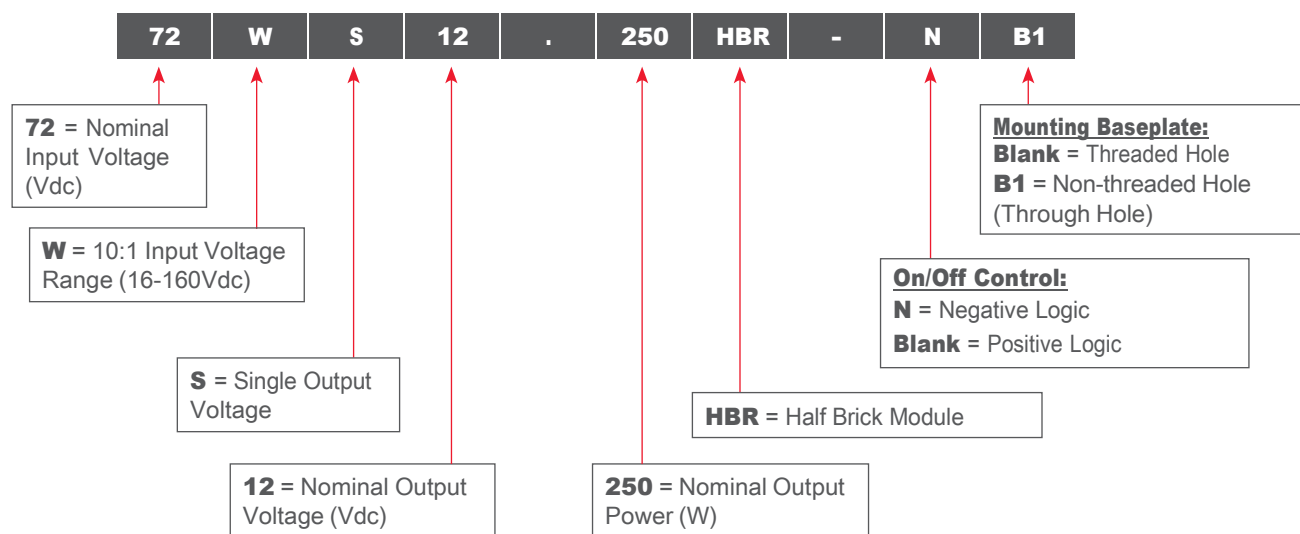
## Part Number Selection Table

| Voltage (Vdc) |           | Current  |              |              |            | Efficiency              | Ripple & Noise  | Regulation          | Capacitive Load      | Root Model                 |
|---------------|-----------|----------|--------------|--------------|------------|-------------------------|-----------------|---------------------|----------------------|----------------------------|
| Input         | Output    | Input    | Output       |              |            |                         |                 |                     |                      |                            |
| Vin Nom       | Vin Range | Vout Nom | No Load (mA) | Max Load (A) | Io Max (A) | Typical at Max Load (%) | Typical (mVp-p) | Line / Load Max (%) | Max. C external (µF) | Basic Model without option |
| 72            | 16-160    | 12       | 60           | 20           | 21         | 91.0                    | 150             | ±0.2%/±0.2%         | 2200                 | 72WS12.250HBR              |
|               |           | 24       | 60           | 20           | 10.5       | 90.0                    | 200             | ±0.25%/±0.25%       | 2200                 | 72WS24.250HBR              |
|               |           | 54       | 60           | 20           | 4.7        | 90.5                    | 400             | ±0.25%/±0.25%       | 470                  | 72WS54.250HBR              |

## Product Ordering Notes:

1. Please refer to the Part Number Structure when ordering.
2. All specifications are at nominal line voltage and full load, +25°C unless otherwise noted. See detailed specifications. Output capacitors are 1 µF ceramic multilayer in parallel with 10 µF. I/O caps are necessary for our test equipment and may not be needed for your application.
3. Regulation specifications describe output voltage deviations from a nominal/midpoint value to either extreme (50% load step).

## Part Number Structure



**NOTE:** Some model number combinations may not be available. Please contact CALEX.



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## Functional Specifications, 72WS12.250HBR

| Absolute Maximum Ratings  |  | Conditions | Min. | Typ. | Max. | Units            |
|---|--|------------|------|------|------|------------------|
| <b>Input Voltage</b>  |  |            |      |      |      |                  |
| Non-Operating   | Continuous   |            |      |      | 175  | Vdc              |
| Operating   | Continuous   |            |      |      | 160  | Vdc              |
| Transient Operating   | 100mS  |            |      |      | 170  | Vdc              |
| Operating Ambient Temperature   |  | -40        |      |      | 85   | °C               |
| Operating Case Temperature  |  | -40        |      |      | 100  | °C               |
| Storage Temperature   |  | -45        |      |      | 125  | °C               |
| Input/Output Isolation Voltage  |  |            |      |      | 4242 | Vdc              |
| Voltage at ON/OFF input pin   |  | 3          |      |      | 5    | Vdc              |
| Absolute maximums are stress ratings. Exposure of devices to greater than any of these conditions may adversely affect long-term reliability. Proper operation under conditions other than those listed in the Performance/Functional Specifications Table is not implied or recommended. |  |            |      |      |      |                  |
| <b>Input Characteristics</b>  |  |            |      |      |      |                  |
| Operating Input Voltage Range   |  | 16         | 72   | 160  |      | Vdc              |
| <b>Input Under-Voltage Lockout</b>  |  |            |      |      |      |                  |
| Turn-On Voltage Threshold   |  | 13         | 14   | 15   |      | Vdc              |
| Turn-Off Voltage Threshold  |  | 10         | 11   | 12   |      | Vdc              |
| Lockout Voltage Hysteresis  |  |            | 3    |      |      | Vdc              |
| <b>Programmable Undervoltage Lockout (via R_PUL):</b>   |  |            |      |      |      |                  |
| Turn-On Voltage Threshold   | R_PUL=6.81k  | 48         | 49.5 | 51   |      | Vdc              |
| Turn-Off Voltage Threshold  | R_PUL=6.81k  | 39         | 40.5 | 42   |      | Vdc              |
| Lockout Voltage Hysteresis  |  |            | 9    |      |      | Vdc              |
| Maximum Input Current   | 100% Load, 16Vin   |            |      | 20   |      | A                |
| No-Load Input Current   | Vin=72V, Io=0A   |            | 60   | 90   |      | mA               |
| Disabled Input Current (Option N)   |  |            |      | 20   |      | mA               |
| Disabled Input Current (Blank)  |  |            |      | 20   |      | mA               |
| Input Reflected Ripple Current  | Measured at the input of module with a simulated source impedance of 12μH, 220μF, 200V, across source, 220μF, 200V external capacitors across input pins |            |      |      | 600  | mAp-p            |
| Input Reflected Ripple Current  | No filtering   |            |      |      | 800  | mAp-p            |
| Recommended Input Capacitance   | An electrolytic cap (low ESR preferred)  |            | 100  |      |      | μF               |
| Recommended External BUS Capacitance  | An electrolytic cap (low ESR preferred)  |            | 240  |      |      | μF               |
| Inrush Current (I <sub>rt</sub> )   |  |            | 20   | 30   |      | A <sup>2</sup> S |



# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Functional Specifications, 72WS12.250HBR (continued)

| Output Characteristics                       |   |            |        |       |            |
|--|---|------------|--------|-------|------------|
| Output Voltage Set Point                     | Vin=72V, Io=0A, Ta=25°C                                 | 11.88      | 12.00  | 12.12 | Vdc        |
| Output Voltage Regulation                    |   |            |        |       |            |
| Over Load                                    | Iout = Iout min to Iout max                             |            | ±0.05  | ±0.20 | %          |
| Over Line                                    | Iout=Full load, Vin = 16 to 160V,                       |            | ±0.01  | ±0.20 | %          |
| Over Temperature                             | Vin=72V, Tc = Min to Max case temperature               |            | ±0.004 | ±0.01 | %/°C       |
| Total Output Voltage Range                   | Over sample, line, load, temperature & life             | 11.64      |        | 12.36 | Vdc        |
| Output Voltage Ripple and Noise              |   |            |        |       |            |
|  | 20MHz bandwidth   |            |        |       |            |
| Peak-to-Peak                                 |   |            | 150    | 300   | mVp-p      |
| Operating Output Current Range               |   | 0          |        | 21    | A          |
| Output DC Current-Limit Inception            | Output Voltage 10% Low                                  | 23         | 26     | 30    | A          |
| Output Capacitance                           | Nominal Vout at full load (resistive load)              | 0          |        | 2200  | µF         |
| Dynamic Characteristics                      |   |            |        |       |            |
| Output Voltage During Load Current Transient |   |            |        |       |            |
| Step Change in Output Current (0.1A/µS)      | 50% Iout Max to 75%                                     |            | 280    | 450   | mV         |
| Step Change in Output Current (0.1A/µS)      | 75% Iout max to 50%                                     |            | 280    | 450   | mV         |
| Settle Time                                  | To within 1% Vout nom                                   |            |        | 150   | µS         |
| Turn-On Transient                            |   |            |        |       |            |
| Start-up Time, From ON/OFF Control           | See Figures @ Vin=72V                                   |            | 95     | 460   | mS         |
| Start-up Time, From Input                    | See Figures @ Vin=72V                                   |            | 160    | 460   | mS         |
| Rise Time                                    | Time from 10% to 90% of nominal output voltage          |            |        | 100   | mS         |
| Output Voltage Overshoot                     |   |            |        | 2     | %          |
| General and Safety                           |   | Conditions | Min.   | Typ.  | Max. Units |
| Efficiency                                   |   |            |        |       |            |
| 100% Load                                    | Vin=72V, Details see Figures                            |            | 91     |       | %          |
| 50% Load                                     | Vin=72V, Details see Figures                            |            | 92     |       | %          |
| Isolation                                    |   |            |        |       |            |
| Isolation Voltage                            | Input to Output (Reinforced insulation)                 |            |        | 4242  | Vdc        |
|  | Input to Baseplate                                      |            |        | 2250  | Vdc        |
|  | Output to Baseplate                                     |            |        | 2250  | Vdc        |
| Isolation Resistance                         | Input/Output  |            | 20     |       | MΩ         |
| Isolation Capacitance                        | Input/Output  |            | 500    |       | pF         |
| Safety                                       | Certified to UL-60950-1, IEC-60950-1, 2nd edition       |            | Yes    |       |            |
| Calculated MTBF                              | Per Belcore Telcordia SR332, Issue 2, Method 1, Class 1 |            | 1.48   |       | MHrs       |



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½ Brick DC/DC Converter with 10:1 Input

## Functional Specifications, 72WS12.250HBR (continued)

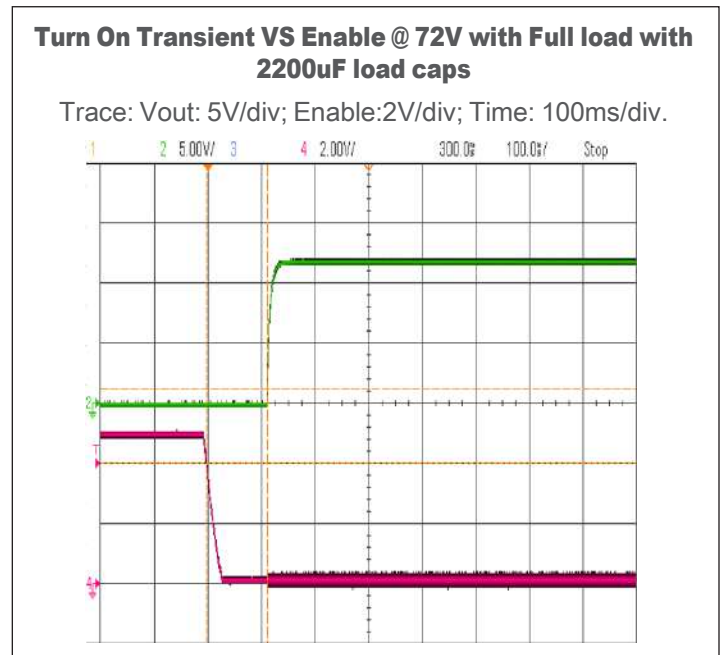
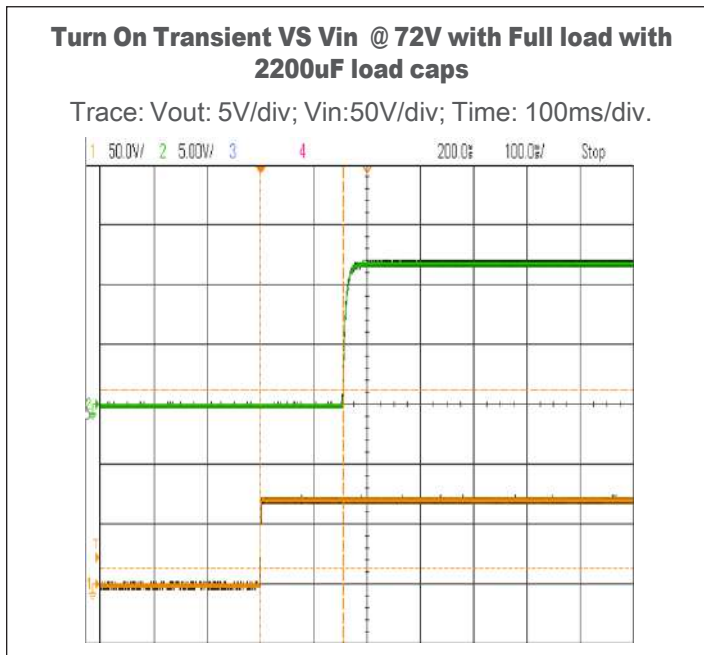
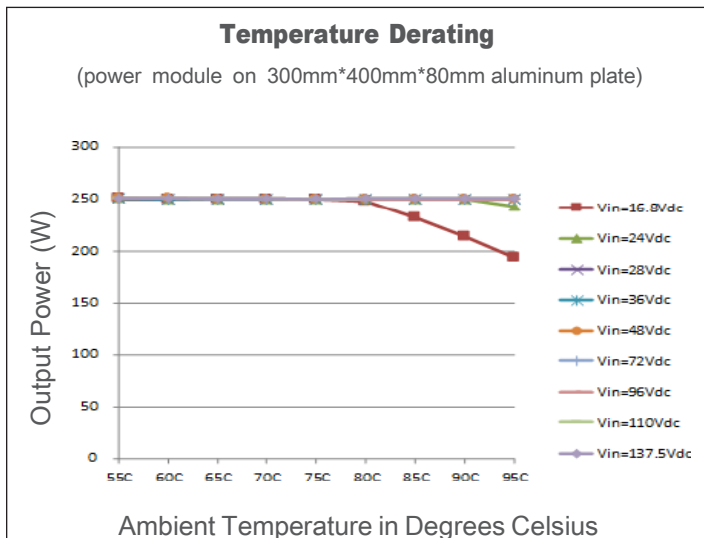
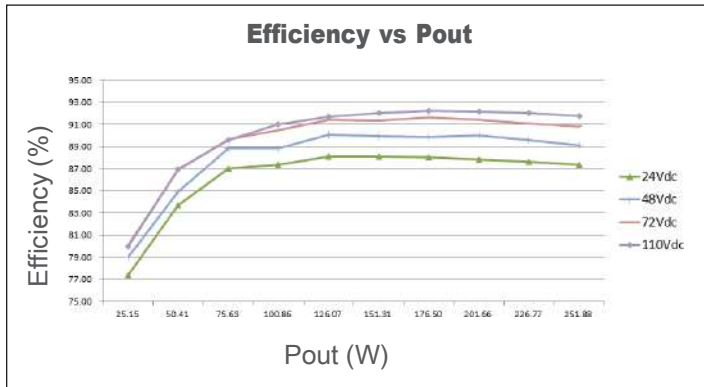
| Temperature Limits for Power Derating Curves            |   |                       |         |     |        |
|---|---|-----------------------|---------|-----|--------|
| Semiconductor Junction Temperature                      |   |                       |         | 125 | °C     |
| Board Temperature                                       | UL rated max operating temp<br>130°C                    |                       |         | 125 | °C     |
| Transformer/Inductor Temperature                        |   |                       |         | 125 | °C     |
| Feature Characteristics                                 |   |                       |         |     |        |
| Switching Frequency                                     |   | 216                   | 240     | 264 | kHz    |
| ON/OFF Control (Blank suffix)                           |   |                       |         |     |        |
| Off-State Voltage                                       |   | 0                     |         | 0.4 | V      |
| On-State Voltage  |   | 3                     |         | 5   | V      |
| ON/OFF Control (Option N suffix)                        |   |                       |         |     |        |
| Off-State Voltage                                       |   | 3                     |         | 5   | V      |
| On-State Voltage  |   | 0                     |         | 0.4 | V      |
| ON/OFF Control Current (Either Option)                  |   |                       |         |     |        |
| Current thru ON/OFF pin                                 | Von/off=0V  |                       |         | 1   | mA     |
| Current thru ON/OFF pin                                 | Von/off=5V  |                       |         | 2   | mA     |
| Output Voltage Trim Range                               | Pout<=Max rated power                                   | -20                   |         | 10  | %      |
| Trim Up Equations                                       | Please see TRIM functions<br>technical notes            |                       |         |     |        |
| Trim Down Equations                                     | Please see TRIM functions<br>technical notes            |                       |         |     |        |
| Output Over-Voltage Protection                          | Hiccup mode; over full temp<br>range; % of nominal Vout | 110                   | 120     | 130 | %      |
| Over-Temperature Shutdown                               |   |                       | 125     |     | °C     |
| Mechanical  |   |                       |         |     |        |
| Outline Dimensions<br>(Please refer to outline drawing) | L x W x H   | 2.488 x 2.390 x 0.55  |         |     | Inches |
|   | L x W x H   | 63.20 x 60.70 x 14.00 |         |     | mm     |
| Weight  |   |                       | 5       |     | Ounces |
|   |   |                       | 145     |     | Grams  |
| Through Hole Pin Diameter                               |   | 0.040 & 0.080         |         |     | Inches |
|   |   | 1.016 & 2.032         |         |     | mm     |
| Through Hole Pin Material                               |   | Copper alloy          |         |     |        |
| EMI   |   |                       |         |     |        |
| Conducted (FCC part 15, EN55022)                        | With External Filter                                    |                       | Class A |     |        |
| Radiated (FCC part 15, EN55022)                         | With External Filter                                    |                       | Class A |     |        |



# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Typical Performance Data: 72WS12.250HBR





## HBR Series, 250 Watt

*½ Brick DC/DC Converter with 10:1 Input*

### Typical Performance Data: 72WS12.250HBR (continued)

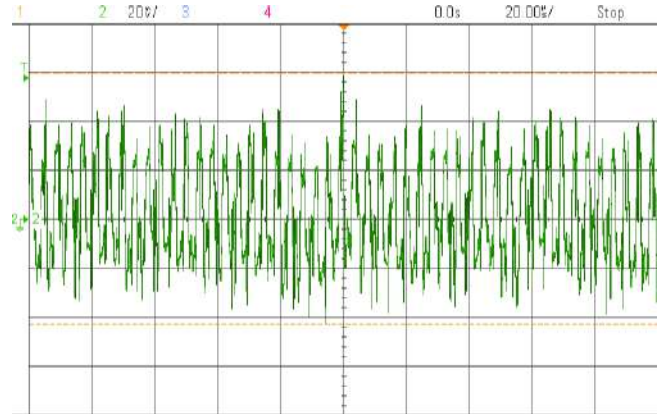
**Output voltage response to step-change in load current**  
**Vin=72V (50%-75%-50% of full load; di/dt = 0.1A/μs).**

Trace: Vout: 100mV/div; Iout: 5A/div; Time: 200us/div



**Output Ripple@20MHz BW,**  
**Vin = 72Vdc, Full Load with 2200uF output capacitance**

Trace: Vout: 20mV/div; Time: 20us/div





# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Functional Specifications, 72WS24.250HBR

| Absolute Maximum Ratings  |  | Conditions | Min. | Typ. | Max. | Units            |
|---|--|------------|------|------|------|------------------|
| <b>Input Voltage</b>  |  |            |      |      |      |                  |
| Non-Operating   | Continuous   |            |      |      | 175  | Vdc              |
| Operating   | Continuous   |            |      |      | 160  | Vdc              |
| Transient Operating   | 100mS  |            |      |      | 170  | Vdc              |
| Operating Ambient Temperature   |  |            | -40  |      | 85   | °C               |
| Operating Case Temperature  |  |            | -40  |      | 100  | °C               |
| Storage Temperature   |  |            | -45  |      | 125  | °C               |
| Input/Output Isolation Voltage  |  |            |      |      | 4242 | Vdc              |
| Voltage at ON/OFF input pin   |  |            | 3    |      | 5    | Vdc              |
| Absolute maximums are stress ratings. Exposure of devices to greater than any of these conditions may adversely affect long-term reliability. Proper operation under conditions other than those listed in the Performance/Functional Specifications Table is not implied or recommended. |  |            |      |      |      |                  |
| <b>Input Characteristics</b>  |  |            |      |      |      |                  |
| Operating Input Voltage Range   |  |            | 16   | 72   | 160  | Vdc              |
| <b>Input Under-Voltage Lockout</b>  |  |            |      |      |      |                  |
| Turn-On Voltage Threshold   |  |            | 13   | 14.5 | 15.5 | Vdc              |
| Turn-Off Voltage Threshold  |  |            | 10   | 11.5 | 12.5 | Vdc              |
| Lockout Voltage Hysteresis  |  |            |      | 3    |      | Vdc              |
| <b>Programmable Under-Voltage Lockout (via R_PUL):</b>  |  |            |      |      |      |                  |
| Turn-On Voltage Threshold   | R_PUL=6.81k  |            | 48   | 49.5 | 51   | Vdc              |
| Turn-Off Voltage Threshold  | R_PUL=6.81k  |            | 39   | 40.5 | 42   | Vdc              |
| Lockout Voltage Hysteresis  |  |            |      | 9    |      | Vdc              |
| Maximum Input Current   | 100% Load, 16Vin   |            |      |      | 20   | A                |
| No-Load Input Current   | Vin=72V, Io=0A   |            |      | 60   | 90   | mA               |
| Disabled Input Current (Option N)   |  |            |      |      | 20   | mA               |
| Disabled Input Current (Blank)  |  |            |      |      | 20   | mA               |
| Input Reflected Ripple Current  | Measured at the input of module with a simulated source impedance of 12μH, 220μF, 200V, across source, 220μF, 200V external capacitors across input pins |            |      |      | 1.5  | Ap-p             |
| Input Reflected Ripple Current  | No filtering   |            |      |      | 3.5  | Ap-p             |
| Recommended Input Capacitance   | An electrolytic cap (low ESR preferred)  |            |      | 100  |      | μF               |
| Recommended External BUS Capacitance  | An electrolytic cap (low ESR preferred)  |            |      | 240  |      | μF               |
| Inrush Current (I <sub>rt</sub> )   |  |            |      | 11   | 16   | A <sup>2</sup> S |





# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Functional Specifications, 72WS24.250HBR (continued)

| Output Characteristics                       |   |       |       |       |       |
|--|---|-------|-------|-------|-------|
| Output Voltage Set Point                     | Vin=72V, Io=0A, Ta=25°C                           | 23.76 | 24.00 | 24.24 | Vdc   |
| Output Voltage Regulation                    |   |       |       |       |       |
| Over Load                                    | Iout = Iout min to Iout max                       |       |       | ±0.25 | %     |
| Over Line                                    | Iout=Full load, Vin = 16 to 160V,                 |       |       | ±0.25 | %     |
| Over Temperature                             | Vin=72V, Tc = Min to Max case temperature         |       |       | ±0.02 | %/°C  |
| Total Output Voltage Range                   | Over sample, line, load, temperature & life       | 23.28 |       | 24.72 | Vdc   |
| Output Voltage Ripple and Noise              |   |       |       |       |       |
|  | 20MHz bandwidth                                   |       |       |       |       |
| Peak-to-Peak                                 |   |       | 200   | 300   | mVp-p |
| Operating Output Current Range               |   | 0     |       | 10.5  | A     |
| Output DC Current-Limit Inception            | Output Voltage 10% Low                            | 11.5  | 14    | 17    | A     |
| Output Capacitance                           | Nominal Vout at full load (resistive load)        | 0     |       | 2200  | µF    |
| Dynamic Characteristics                      |   |       |       |       |       |
| Output Voltage During Load Current Transient |   |       |       |       |       |
| Step Change in Output Current (0.1A/µS)      | 50% Iout Max to 75%                               |       | 280   | 450   | mV    |
| Step Change in Output Current (0.1A/µS)      | 75% Iout max to 50%                               |       | 280   | 450   | mV    |
| Settle Time                                  | To within 1% Vout nom                             |       |       | 150   | µS    |
| Turn-On Transient                            |   |       |       |       |       |
| Start-up Time, From ON/OFF Control           | See Figures @ Vin=72V                             |       | 95    | 460   | mS    |
| Start-up Time, From Input                    | See Figures @ Vin=72V                             |       | 160   | 460   | mS    |
| Rise Time                                    | Time from 10% to 90% of nominal output voltage    |       |       | 100   | mS    |
| Output Voltage Overshoot                     |   |       |       | 2     | %     |
| General and Safety                           | Conditions  | Min.  | Typ.  | Max.  | Units |
| Efficiency                                   |   |       |       |       |       |
| 100% Load                                    | Vin=72V, Details see Figures                      |       | 90    |       | %     |
| 50% Load                                     | Vin=72V, Details see Figures                      |       | 90    |       | %     |
| Isolation                                    |   |       |       |       |       |
| Isolation Voltage                            | Input to Output (Reinforced insulation)           |       |       | 4242  | Vdc   |
|  | Input to Baseplate                                |       |       | 2250  | Vdc   |
|  | Output to Baseplate                               |       |       | 2250  | Vdc   |
| Isolation Resistance                         | Input/Output                                      |       | 20    |       | MΩ    |
| Isolation Capacitance                        | Input/Output                                      |       | 500   |       | pF    |
| Safety                                       | Certified to UL-60950-1, IEC-60950-1, 2nd edition |       | Yes   |       |       |



# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Functional Specifications, 72WS24.250HBR (continued)

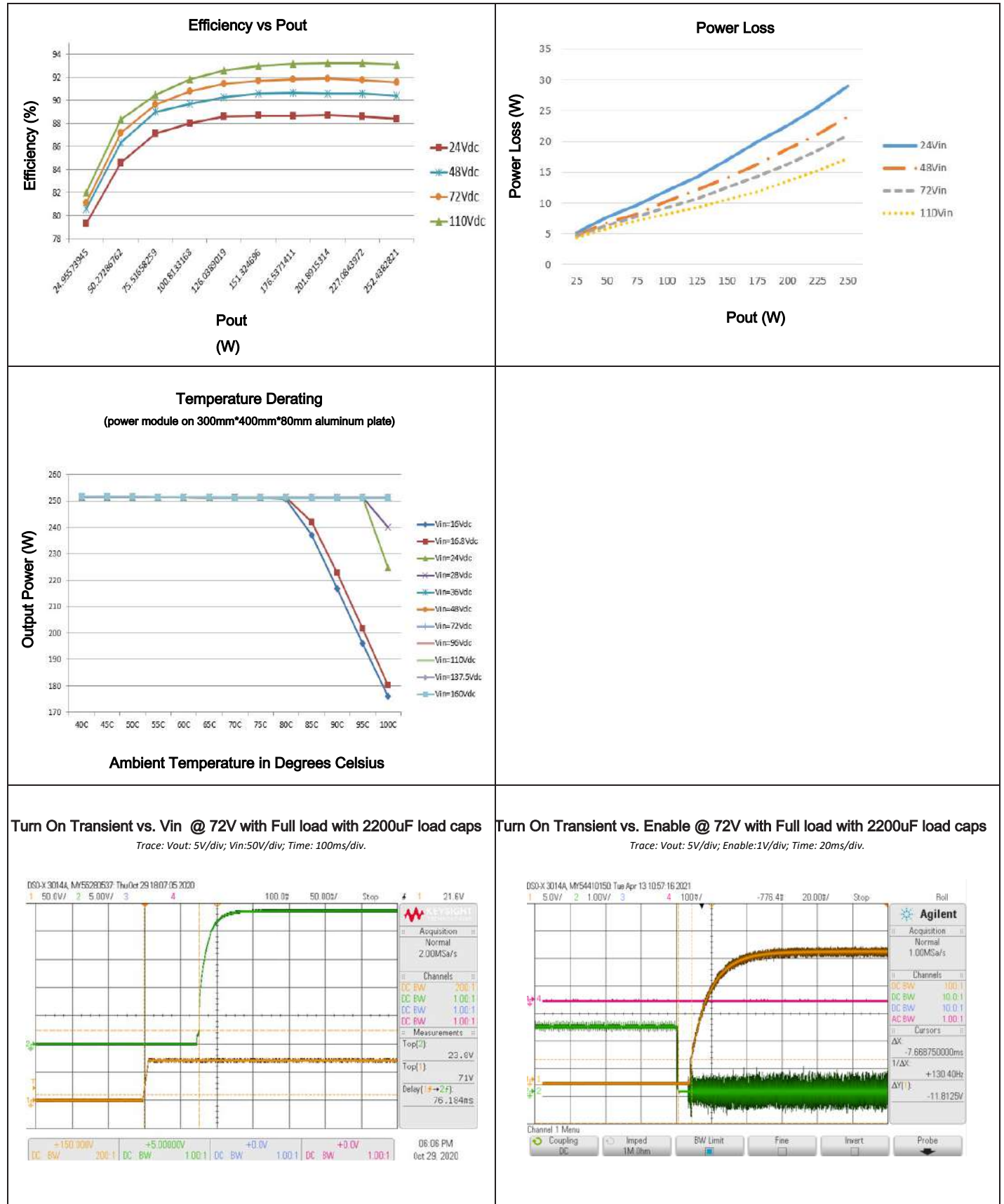
|   |   |                       |              |     |        |
|---|---|-----------------------|--------------|-----|--------|
| Calculated MTBF   | Per Belcore Telcordia SR332, Issue 2, Method 1, Class 1 |                       | 2.08         |     | MHrs   |
| <b>Temperature Limits for Power Derating Curves</b>     |   |                       |              |     |        |
| Semiconductor Junction Temperature                      |   |                       |              | 125 | °C     |
| Board Temperature                                       | UL rated max operating temp 130°C                       |                       |              | 125 | °C     |
| Transformer/Inductor Temperature                        |   |                       |              | 125 | °C     |
| <b>Feature Characteristics</b>                          |   |                       |              |     |        |
| Switching Frequency                                     |   | 216                   | 240          | 264 | kHz    |
| <b>ON/OFF Control (Blank suffix)</b>                    |   |                       |              |     |        |
| Off-State Voltage                                       |   | 0                     |              | 0.4 | V      |
| On-State Voltage  |   | 3                     |              | 5   | V      |
| <b>ON/OFF Control (Option N suffix)</b>                 |   |                       |              |     |        |
| Off-State Voltage                                       |   | 3                     |              | 5   | V      |
| On-State Voltage  |   | 0                     |              | 0.4 | V      |
| <b>ON/OFF Control Current (Either Option)</b>           |   |                       |              |     |        |
| Current thru ON/OFF pin                                 | Von/off=0V  |                       |              | 1   | mA     |
| Current thru ON/OFF pin                                 | Von/off=5V  |                       |              | 2   | mA     |
| Output Voltage Trim Range                               | Pout<=Max rated power                                   | -20                   |              | 10  | %      |
| Trim Up Equations                                       | Please see TRIM functions technical notes               |                       |              |     |        |
| Trim Down Equations                                     | Please see TRIM functions technical notes               |                       |              |     |        |
| Output Over-Voltage Protection                          | Hiccup mode; over full temp range; % of nominal Vout    | 110                   | 120          | 130 | %      |
| Over-Temperature Shutdown                               |   |                       | 125          |     | °C     |
| <b>Mechanical</b>                                       |   |                       |              |     |        |
| Outline Dimensions<br>(Please refer to outline drawing) | L x W x H   | 2.488 x 2.390 x 0.55  |              |     | Inches |
|   | L x W x H   | 63.20 x 60.70 x 14.00 |              |     | mm     |
| Weight  |   |                       | 5            |     | Ounces |
|   |   |                       | 145          |     | Grams  |
| Through Hole Pin Diameter                               |   | 0.040 & 0.080         |              |     | Inches |
|   |   | 1.016 & 2.032         |              |     | mm     |
| Through Hole Pin Material                               |   |                       | Copper alloy |     |        |
| <b>EMI</b>  |   |                       |              |     |        |
| Conducted (FCC part 15, EN55022)                        | With External Filter                                    |                       | Class A      |     |        |
| Radiated (FCC part 15, EN55022)                         | With External Filter                                    |                       | Class A      |     |        |



# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Typical Performance Data: 72WS24.250HBR





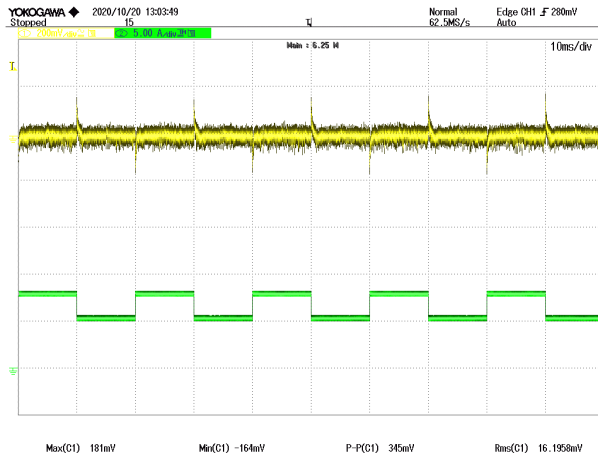
# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Output voltage response to step-change in load current

Vin=72V (50%-75%-50% of full load; di/dt = 0.1A/μs).

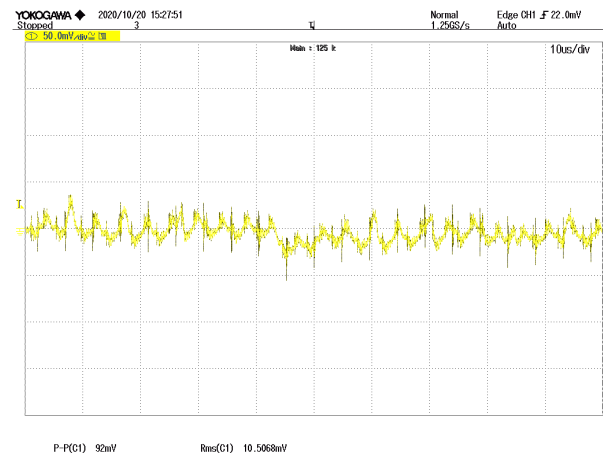
Trace: Vout: 200mV/div; Iout: 5A/div; Time: 10ms/div



## Output Ripple@20MHz BW,

Vin = 72Vdc, Full Load with 2200uF output capacitance

Trace: Vout: 50mV/div; Time: 10us/div





# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Functional Specifications, 72WS54.250HBR

| Absolute Maximum Ratings  |  | Conditions | Min. | Typ. | Max. | Units |
|---|--|------------|------|------|------|-------|
| <b>Input Voltage</b>  |  |            |      |      |      |       |
| Non-Operating   | Continuous   |            |      |      | 175  | Vdc   |
| Operating   | Continuous   |            |      |      | 160  | Vdc   |
| Transient Operating   | 100mS  |            |      |      | 170  | Vdc   |
| Operating Ambient Temperature   |  | -40        |      |      | 85   | °C    |
| Operating Case Temperature  |  | -40        |      |      | 100  | °C    |
| Storage Temperature   |  | -45        |      |      | 125  | °C    |
| Input/Output Isolation Voltage  |  |            |      |      | 4242 | Vdc   |
| Voltage at ON/OFF input pin   |  | 3          |      |      | 5    | Vdc   |
| Absolute maximums are stress ratings. Exposure of devices to greater than any of these conditions may adversely affect long-term reliability. Proper operation under conditions other than those listed in the Performance/Functional Specifications Table is not implied or recommended. |  |            |      |      |      |       |
| <b>Input Characteristics</b>  |  |            |      |      |      |       |
| Operating Input Voltage Range   |  | 16         | 72   | 160  |      | Vdc   |
| <b>Input Under-Voltage Lockout</b>  |  |            |      |      |      |       |
| Turn-On Voltage Threshold   |  | 14         | 15   | 16   |      | Vdc   |
| Turn-Off Voltage Threshold  |  | 11         | 12.5 | 14   |      | Vdc   |
| Lockout Voltage Hysteresis  |  |            | 2.5  |      |      | Vdc   |
| <b>Programmable Under-Voltage Lockout (via R_PUL):</b>  |  |            |      |      |      |       |
| Turn-On Voltage Threshold   | R_PUL=6.81k  | 48         | 49.5 | 51   |      | Vdc   |
| Turn-Off Voltage Threshold  | R_PUL=6.81k  | 39         | 40.5 | 42   |      | Vdc   |
| Lockout Voltage Hysteresis  |  |            | 9    |      |      | Vdc   |
| Maximum Input Current   | 100% Load, 16Vin   |            |      | 20   |      | A     |
| No-Load Input Current   | Vin=72V, Io=0A   |            | 60   | 90   |      | mA    |
| Disabled Input Current (Option N)   |  |            |      | 20   |      | mA    |
| Disabled Input Current (Blank)  |  |            |      | 20   |      | mA    |
| Input Reflected Ripple Current  | Measured at the input of module with a simulated source impedance of 12μH, 220μF, 200V, across source, 220μF, 200V external capacitors across input pins |            |      | 2    |      | Ap-p  |
| Input Reflected Ripple Current  | No filtering   |            |      | 3.5  |      | Ap-p  |
| Recommended Input Capacitance   | An electrolytic cap (low ESR preferred)  |            | 100  |      |      | μF    |
| Recommended External BUS Capacitance  | An electrolytic cap (low ESR preferred)  |            | 240  |      |      | μF    |
| Inrush Current (I <sub>rt</sub> )   |  |            | 3.7  | 5    |      | A²S   |



# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Functional Specifications, 72WS54.250HBR (continued)

| Output Characteristics                       |   |            |       |       |       |       |
|--|---|------------|-------|-------|-------|-------|
| Output Voltage Set Point                     | Vin=72V, Io=0A, Ta=25°C                           | 53.46      | 54.00 | 54.54 | Vdc   |       |
| Output Voltage Regulation                    |   |            |       |       |       |       |
| Over Load                                    | Iout = Iout min to Iout max                       |            |       | ±0.25 | %     |       |
| Over Line                                    | Iout=Full load, Vin = 16 to 160V,                 |            |       | ±0.25 | %     |       |
| Over Temperature                             | Vin=72V, Tc = Min to Max case temperature         |            |       | ±0.02 | %/°C  |       |
| Total Output Voltage Range                   | Over sample, line, load, temperature & life       | 53.28      |       | 55.62 | Vdc   |       |
| Output Voltage Ripple and Noise              |   |            |       |       |       |       |
|  | 20MHz bandwidth                                   |            |       |       |       |       |
| Peak-to-Peak                                 |   |            | 400   | 500   | mVp-p |       |
| Operating Output Current Range               |   | 0          |       | 4.7   | A     |       |
| Output DC Current-Limit Inception            | Output Voltage 10% Low                            | 5.1        | 6.4   | 7.5   | A     |       |
| Output Capacitance                           | Nominal Vout at full load (resistive load)        | 0          |       | 470   | µF    |       |
| Dynamic Characteristics                      |   |            |       |       |       |       |
| Output Voltage During Load Current Transient |   |            |       |       |       |       |
| Step Change in Output Current (0.1A/uS)      | 50% Iout Max to 75%                               |            | 400   | 600   | mV    |       |
| Step Change in Output Current (0.1A/uS)      | 75% Iout max to 50%                               |            | 400   | 600   | mV    |       |
| Settle Time                                  | To within 1% Vout nom                             |            | 150   |       | uS    |       |
| Turn-On Transient                            |   |            |       |       |       |       |
| Start-up Time, From ON/OFF Control           | See Figures @ Vin=72V                             |            | 95    | 460   | mS    |       |
| Start-up Time, From Input                    | See Figures @ Vin=72V                             |            | 160   | 460   | mS    |       |
| Rise Time                                    | Time from 10% to 90% of nominal output voltage    |            |       | 100   | mS    |       |
| Output Voltage Overshoot                     |   |            |       | 2     | %     |       |
| General and Safety                           |   | Conditions | Min.  | Typ.  | Max.  | Units |
| Efficiency                                   |   |            |       |       |       |       |
| 100% Load                                    | Vin=72V, Details see Figures                      |            | 90.5  |       |       | %     |
| 50% Load                                     | Vin=72V, Details see Figures                      |            | 90.0  |       |       | %     |
| Isolation                                    |   |            |       |       |       |       |
| Isolation Voltage                            | Input to Output (Reinforced insulation)           |            |       | 4242  |       | Vdc   |
|  | Input to Baseplate                                |            |       | 2250  |       | Vdc   |
|  | Output to Baseplate                               |            |       | 2250  |       | Vdc   |
| Isolation Resistance                         | Input/Output                                      |            | 20    |       |       | MΩ    |
| Isolation Capacitance                        | Input/Output                                      |            | 500   |       |       | pF    |
| Safety                                       | Certified to UL-60950-1, IEC-60950-1, 2nd edition |            | Yes   |       |       |       |



# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Functional Specifications, 72WS54.250HBR (continued)

|   |   |                       |              |     |        |
|---|---|-----------------------|--------------|-----|--------|
| Calculated MTBF   | Per Belcore Telcordia SR332, Issue 2, Method 1, Class 1 |                       | 2.49         |     | MHrs   |
| <b>Temperature Limits for Power Derating Curves</b>     |   |                       |              |     |        |
| Semiconductor Junction Temperature                      |   |                       |              | 125 | °C     |
| Board Temperature                                       | UL rated max operating temp 130°C                       |                       |              | 125 | °C     |
| Transformer/Inductor Temperature                        |   |                       |              | 125 | °C     |
| <b>Feature Characteristics</b>                          |   |                       |              |     |        |
| Switching Frequency                                     |   | 216                   | 240          | 264 | kHz    |
| <b>ON/OFF Control (Option P)</b>                        |   |                       |              |     |        |
| Off-State Voltage                                       |   | 0                     |              | 0.4 | V      |
| On-State Voltage  |   | 3                     |              | 5   | V      |
| <b>ON/OFF Control (Blank)</b>                           |   |                       |              |     |        |
| Off-State Voltage                                       |   | 3                     |              | 5   | V      |
| On-State Voltage  |   | 0                     |              | 0.4 | V      |
| <b>ON/OFF Control Current (Either Option)</b>           |   |                       |              |     |        |
| Current thru ON/OFF pin                                 | Von/off=0V  |                       |              | 1   | mA     |
| Current thru ON/OFF pin                                 | Von/off=5V  |                       |              | 2   | mA     |
| Output Voltage Trim Range                               | Pout<=Max rated power                                   | -20                   |              | 10  | %      |
| Trim Up Equations                                       | Please see TRIM functions technical notes               |                       |              |     |        |
| Trim Down Equations                                     | Please see TRIM functions technical notes               |                       |              |     |        |
| Output Over-Voltage Protection                          | Hiccup mode; over full temp range; % of nominal Vout    | 110                   | 120          | 130 | %      |
| Over-Temperature Shutdown                               |   |                       | 125          |     | °C     |
| <b>Mechanical</b>                                       |   |                       |              |     |        |
| Outline Dimensions<br>(Please refer to outline drawing) | L x W x H   | 2.488 x 2.390 x 0.55  |              |     | Inches |
|   | L x W x H   | 63.20 x 60.70 x 14.00 |              |     | mm     |
| Weight  |   |                       | 5            |     | Ounces |
|   |   |                       | 145          |     | Grams  |
| Through Hole Pin Diameter                               |   | 0.040 & 0.080         |              |     | Inches |
|   |   | 1.016 & 2.032         |              |     | mm     |
| Through Hole Pin Material                               |   |                       | Copper alloy |     |        |
| <b>EMI</b>  |   |                       |              |     |        |
| Conducted (FCC part 15, EN55022)                        | With External Filter                                    |                       | Class A      |     |        |
| Radiated (FCC part 15, EN55022)                         | With External Filter                                    |                       | Class A      |     |        |

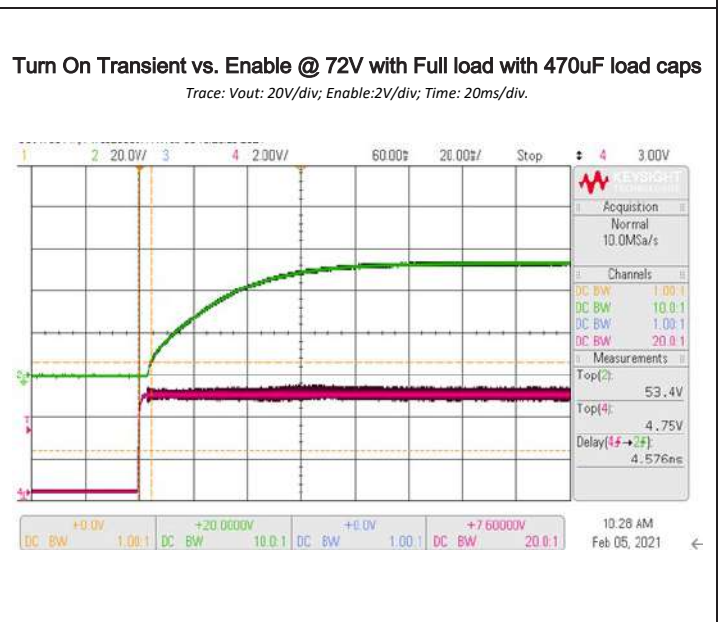
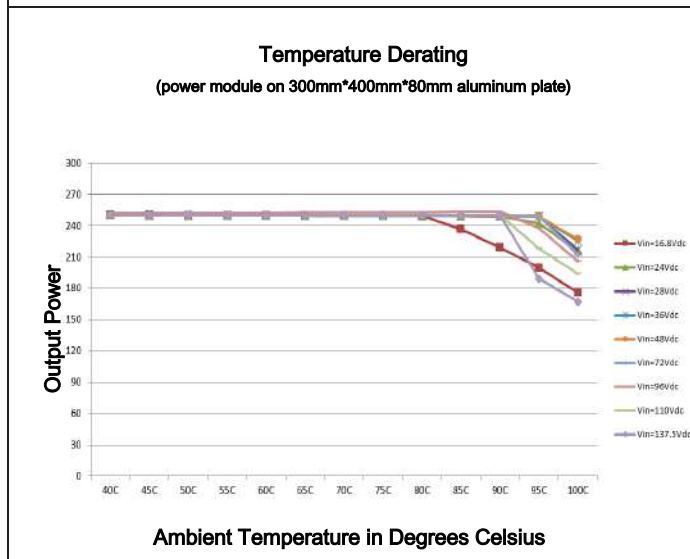
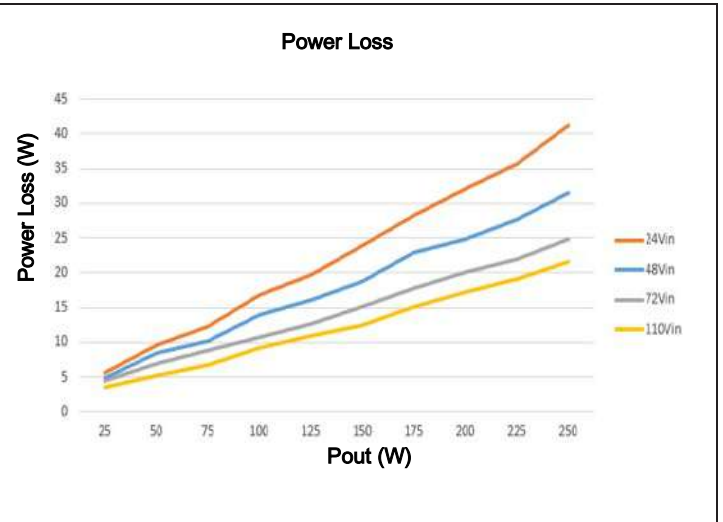
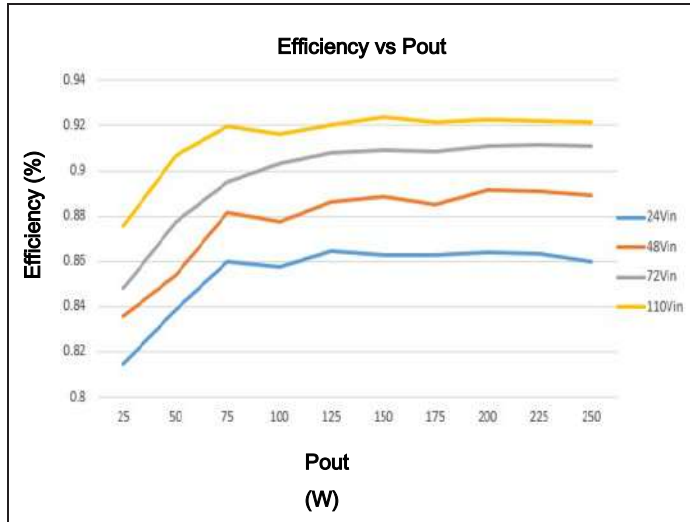




# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Typical Performance Data: 72WS54.250HBR







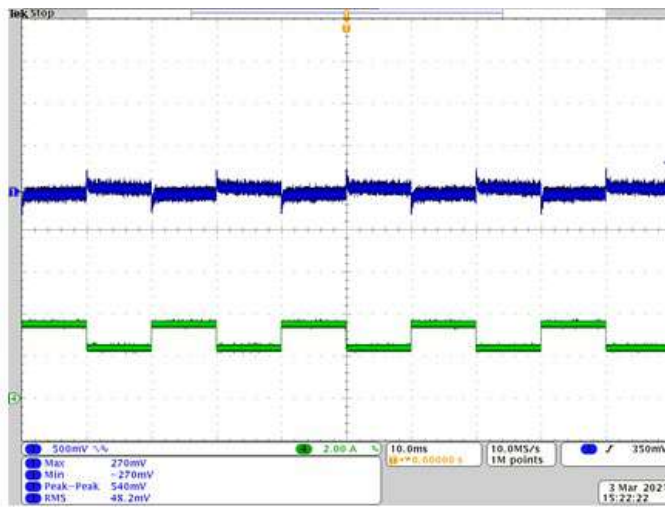
## HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

Output voltage response to step-change in load current

Vin=72V (50%-75%-50% of full load; di/dt = 0.1A/μs)

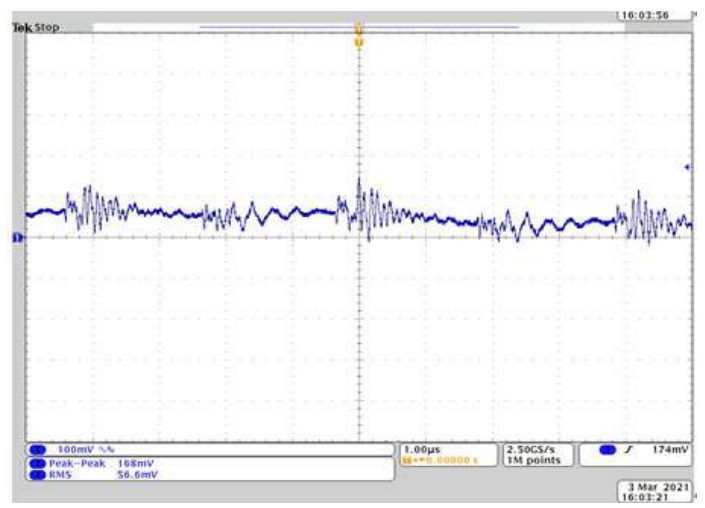
Trace: Vout: 500mV/div; Iout: 2A/div; Time: 10ms/div



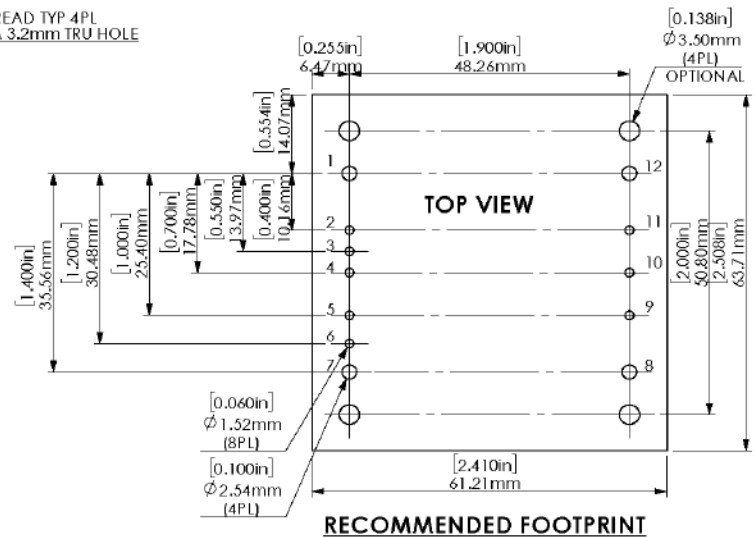
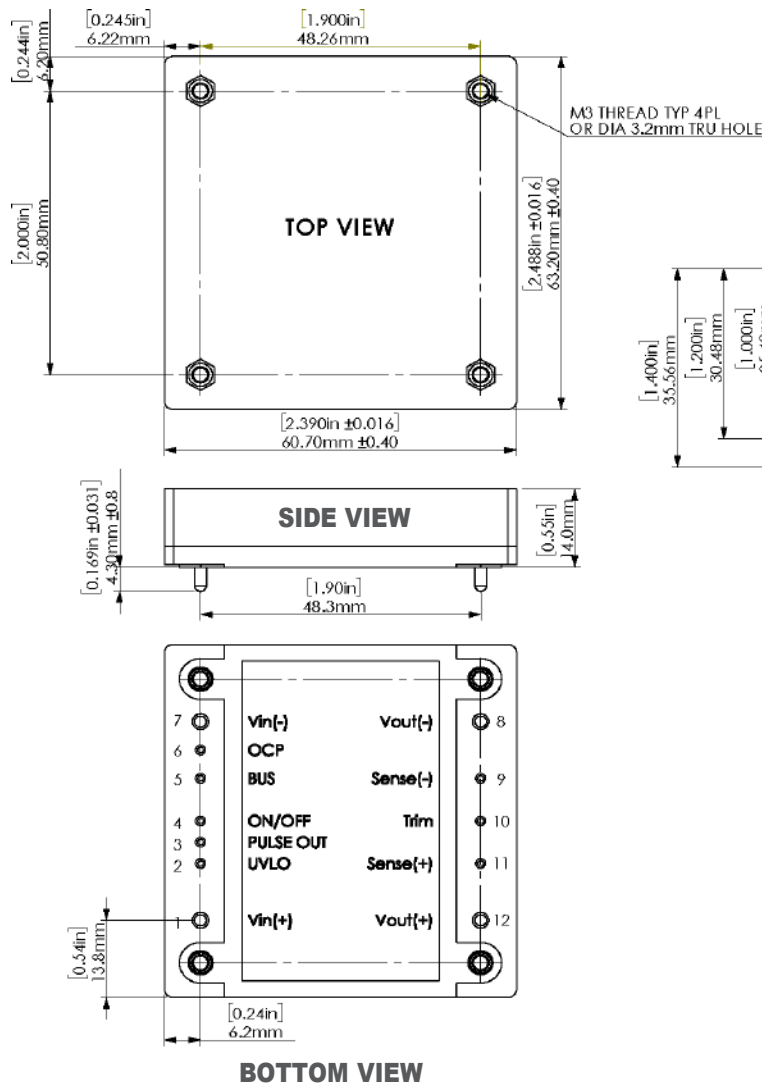
Output Ripple@20MHz BW,

Vin = 72Vdc, Full Load with 470uF output capacitance

Trace: Vout: 100mV/div; Time: 1μs/div



### Mechanical Specifications



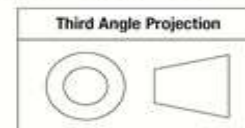
| INPUT/OUTPUT CONNECTIONS |             |                         |
|--------------------------|-------------|-------------------------|
| Pin                      | Designation | Function                |
| 1                        | Vin (+)     | Positive Input          |
| 2                        | UVLO        | Under Voltage Lockout   |
| 3                        | PULSE OUT   | PULSE OUT               |
| 4                        | ON/OFF      | ENABLE                  |
| 5                        | BUS         | BUS Voltage             |
| 6                        | OCP         | Over Current Protection |
| 7                        | Vin (-)     | Negative Input          |
| 8                        | Vout (-)    | Negative Output         |
| 9                        | Sense (-)   | Sense (-)               |
| 10                       | Trim        | Trim                    |
| 11                       | Sense (+)   | Sense (+)               |
| 12                       | Vout (+)    | Positive Output         |

### NOTES:

UNLESS OTHERWISE SPECIFIED:

- ALL DIMENSION ARE IN INCHES [MILIMETER].
- ALL TOLERANCES:  
 $x.xx\text{in}$ ,  $\pm 0.02\text{in}$  ( $x.xx\text{mm}$ ,  $\pm 0.5\text{mm}$ ).  
 $x.xxx\text{in}$ ,  $\pm 0.01\text{in}$  ( $x.xx\text{mm}$ ,  $\pm 0.25\text{mm}$ ).
- APPLIED TORQUE PER SCREW SHOULD NOT EXCEED 5.3in-lb (0.6Nm).
- PIN 2-6, 9-11: DIA 0.040in PINS: COPPER ALLOY. PIN 1, 7, 8, 12: DIA 0.080in PINS: COPPER ALLOY. FINISH: GOLD (5u" MIN) OVER NICKEL (100u" MIN).

Dimensions are in inches (mm) shown for ref. only.

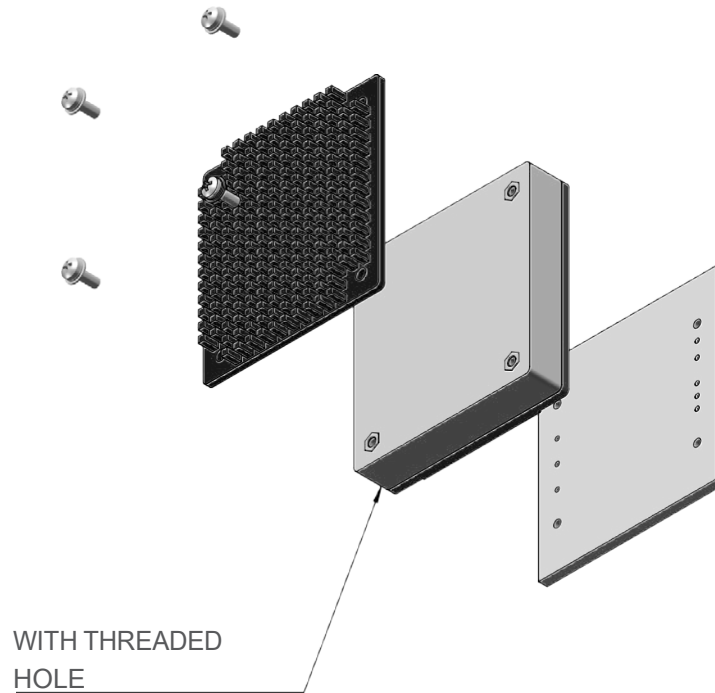


Tolerances (unless otherwise specified):  
 $.XX \pm 0.02$  (0.5)  
 $.XXX \pm 0.010$  (0.25)  
 Angles  $\pm 1^\circ$

Components are shown for reference only  
and may vary between units.

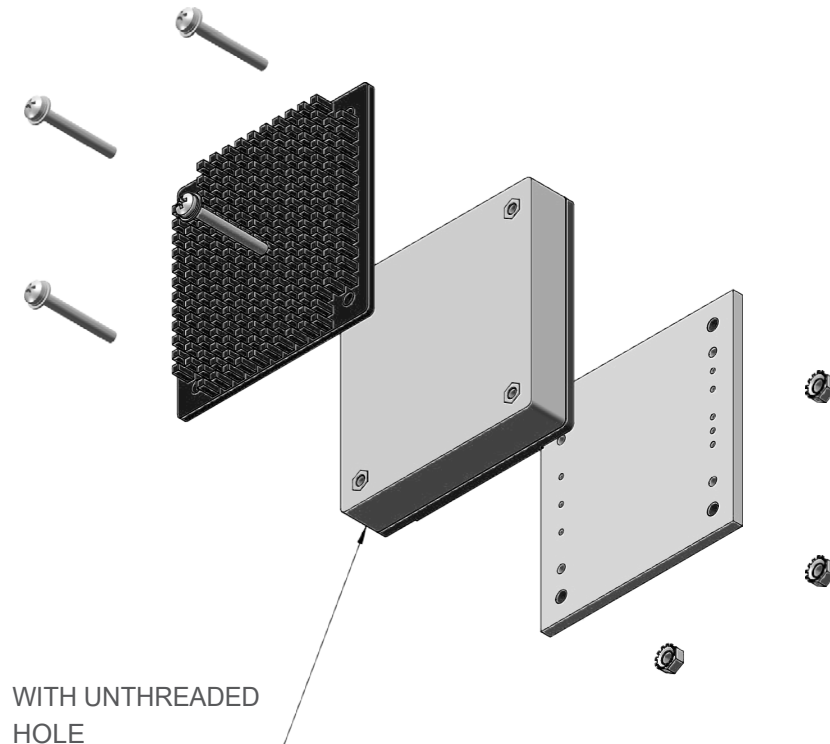
## Mounting Baseplate with Standard M3 Threaded Rivet

**NOTE:** The mounting screws and heat sink are for reference only. They are not included with the HBR.



## Mounting Baseplate with Unthreaded Insert

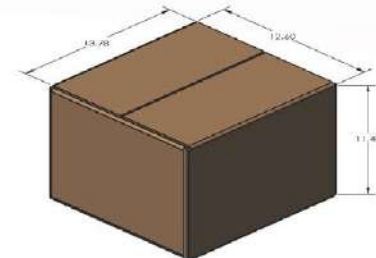
**NOTE:** The mounting screws and heat sink are for reference only. They are not included with the HBR.



### Shipping Box Dimensions

| ITEM NO.<br>(7770547) | PART NUMBER  | DESCRIPTION                       | QTY        |
|-----------------------|--------------|-----------------------------------|------------|
| 1                     | 2300214      | SHIPPING BOX, 10" X 10" X 4.25"   | 2          |
| 2                     | 2300212      | Pack ESD Foam, 2.92" SQ, 1/2" Thk | 2 (NOTE 8) |
| 3                     | 2300232      | Shipping Tray, 3 x 3 Array (9 UP) | 8          |
| 4                     | 2300159      | LABEL, 1.0" X 1.5" PAPER          | 2          |
| 5                     | 5600-01098-0 | LABEL, PRE-PRINTED ESD ATTENTION  | 2          |
| 6                     | 6256-01166-0 | LABEL, PAPER, 2.0" X 4.0"         | 2 (NOTE 6) |
| 7                     | 6256-01211-0 | ESD TAPE, 3/4" WIDE               | 0.67       |
| 8                     | 6256-01125-0 | ESD PAD 335mm X 305mm             | 2          |
| 9                     | 6256-01124-0 | ESD PAD 335mm X 225mm             | 2          |
| 10                    | 6256-01126-0 | ESD PAD 255mm X 225mm             | 2          |
| 11                    | 6256-01127-0 | RIGHT ANGLE CLIP                  | 4          |
| 12                    | 6256-01128-0 | OUTER PACKAGE CARTON              | 1          |

ITEM NUMBERS REFER TO 7770547 BOM. ITEMS ABOVE ARE FOR REFERENCE ONLY, REFER TO APPROPRIATE BOM FOR COMPLETE LIST OF PARTS

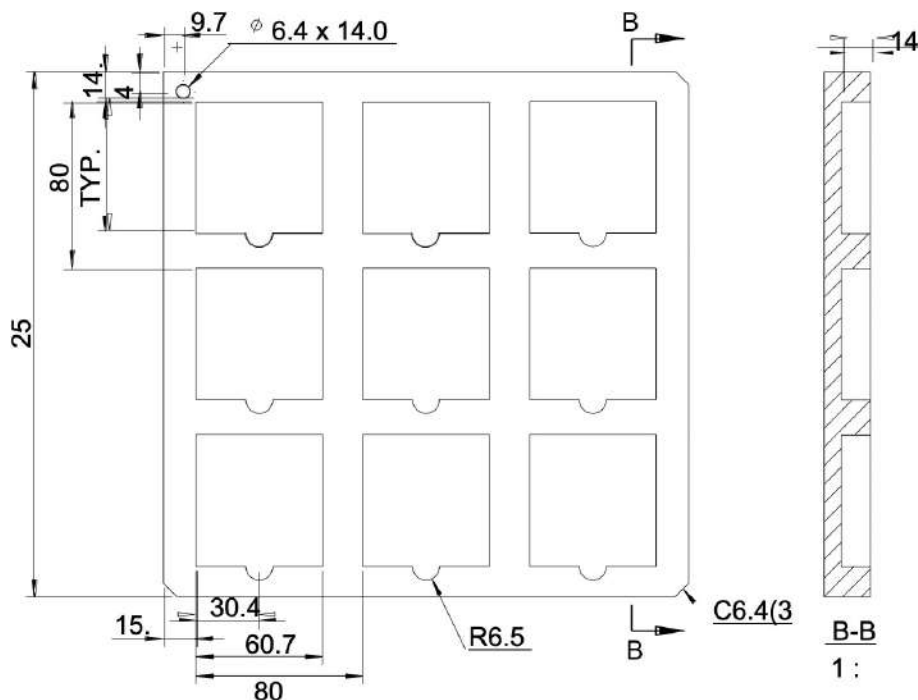


#### NOTES

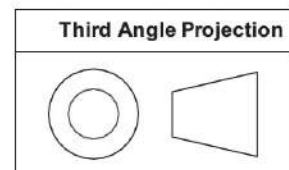
- THIS DOCUMENT DEFINES THE GENERAL PACKING RULES FOR APPLICABLE SHIPPING KIT. INFORMATION FOR SEALING AND MARKING IS NOT PART OF THIS DOCUMENT.
- REFER TO SHIPPING KIT BOM DETAILS.
- INSERT UNITS INTO FOAM POCKETS IN TRAYS APPROX AS SHOWN
- EACH FOAM TRAY (ITEM 3) CONTAINS 9 UNITS. EACH BOX (ITEM 1) CONTAINS 36 UNITS. IN FULL CARTON (ITEM 12) QUANTITIES, 2 BOXES (ITEM 1) EQUAL A TOTAL OF 72 UNITS.
- IF SHIPPING QTY IS 36PCS, PLEASE ALSO USE ITEM 12 TO MARK THE PACKAGE (ONE EMPTY BOX ITEM PUT ON THE BOX ITEM WITH PRODUCTS).
- FRONT FLAP SHALL BE SEALED WITH ESD TAPE SPECIFIED OR EQUIVALENT AFTER THE BOX IS CLOSED.
- LABEL (ITEM 4) USED FOR MFR OVERPACK CARTON
- APPLY ESD LABEL (ITEM 5) OVER TAPE USED TO SEAL BOX AND APPLY IDENTIFICATION LABEL (ITEM 6) APPROX AS SHOWN
- PAD (ITEM 8) MAY, AT MFR'S OPTION, BE EXCHANGED FOR THINNER PAD IF FOAM STACKUP EXCEEDS CARTON HEIGHT BY 2.0" OR ADDITIONAL PAD MAY BE ADDED IF STACKUP IS BELOW INSIDE CARTON HEIGHT BY 1.0". ALTERNATE PADS: 1/4" THK-2300216, 3/8" THK-2300215, 1/2" THK-2300219, 3/4" THK-2300221

MPQ = 36

### Shipping Tray Dimensions



Dimensions are in mm shown for



Tolerances (unless otherwise specified):  
 .XX ± 0.02 (0.5)  
 .XXX ± 0.010 (0.25)  
 Angles ± 1°

#### NOTES:

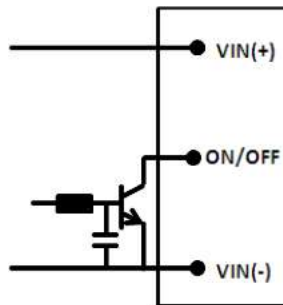
- ESD FOAM REQUEST.
- TOLERANCE: 2

## Technical Notes

### On/Off Control

The input-side, remote On/Off Control function (pin 4) can be ordered to operate with either logic type:

Negative ("N" suffix): Negative-logic devices are off when pin 4 is left open (or pulled high, applying +3V to +5V), and on when pin 4 is pulled low (0 to 0.4V) with respect to – Input as shown in Figure 1.



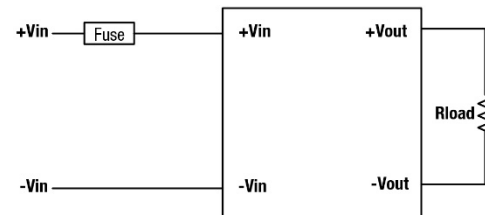
**Figure 1.** Driving the Negative Logic On/Off Control Pin

Remote On/Off can be controlled by an external switch between the On/Off terminal and the Vin(-) terminal. The switch can be an open collector or open drain. For negative logic if the remote on/off feature is not used, please short the On/Off pin to Vin(-). For positive logic if the remote On/Off feature is not used, please leave the On/Off pin floating. NOTE: Applying an external voltage to pin 4 when no input power is applied to the converter can cause permanent damage to the converter.

### Input Fusing

Certain applications and/or safety agencies may require fuses at the inputs of power conversion components. Fuses should also be used when there is the possibility of sustained input voltage reversal which is not current-limited. For greatest safety, we recommend a fast blow fuse installed in the ungrounded input supply line.

| Vin  | Fuse Recommended |
|------|------------------|
| 24V  | 25A fast         |
| 48V  | 12A fast         |
| 72V  | 8A fast          |
| 110V | 5A fast          |



**Figure 2.** Input Fusing

### Start-Up Time

Assuming that the output current is set at the rated maximum, the Vin to Vout Start-Up Time (see Specifications) is the time interval between the point when the rising input voltage crosses the Start-Up Threshold and the fully loaded output voltage enters and remains within its specified accuracy band. Actual measured times will vary with input source impedance, external input capacitance, input voltage slew rate and final value of the input voltage as it appears at the converter.

These converters include a soft start circuit to moderate the duty cycle of its PWM controller at power up, thereby limiting the input inrush current.

The On/Off Remote Control interval from On command to Vout (final  $\pm 2\%$ ) assumes that the converter already has its input voltage stabilized above the Start-Up Threshold before the On command. The interval is measured from the On command until the output enters and remains within its specified accuracy band. The specification assumes that the output is fully loaded at maximum rated current. Similar conditions apply to the On to Vout regulated specification such as external load capacitance and soft start circuitry.

## Recommended Input Filtering

The user must assure that the input source has low AC impedance to provide dynamic stability and that the input supply has little or no inductive content, including long distributed wiring to a remote power supply. The converter will operate with no additional external capacitance if these conditions are met.

For best performance, we recommend installing a low-ESR capacitor immediately adjacent to the converter's input terminals. The capacitor should be a ceramic type such as the Murata GRM32 series or a polymer type. Make sure that the input terminals do not go below the undervoltage shutdown voltage at all times. More input bulk capacitance may be added in parallel (either electrolytic or tantalum) if needed.

## Recommended Output Filtering

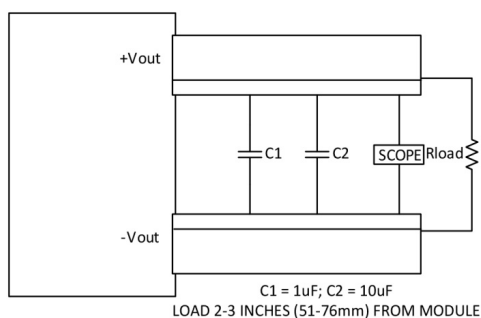
The converter will achieve its rated output ripple and noise with no additional external capacitor. However, the user may install more external output capacitance to reduce the ripple even further or for improved dynamic response.

Again, use low-ESR ceramic (Murata GRM32 series) or polymer capacitors. Mount these close to the converter. Measure the output ripple under your load conditions.

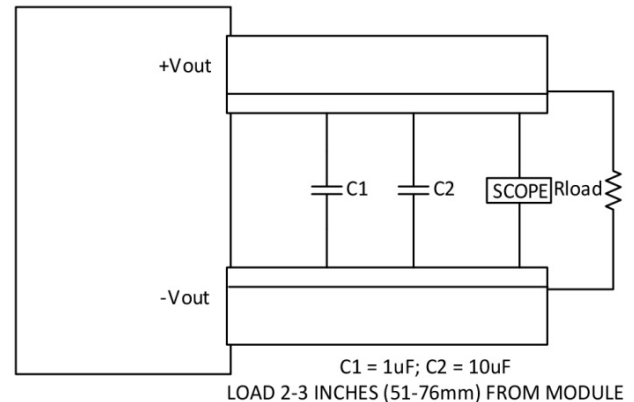
Use only as much capacitance as required to achieve your ripple and noise objectives. Excessive capacitance can make step load recovery sluggish or possibly introduce instability. Do not exceed the maximum rated output capacitance listed in the specifications.

## Input Ripple Current and Output Noise

All models in this converter series are tested and specified for input reflected ripple current and output noise using designated external input/output components, circuits and layout as shown in the figures below. The Cbus and Lbus components simulate a typical DC voltage bus.



**Figure 3.** Measuring Input Ripple Current



**Figure 4.** Measuring Output Ripple and Noise (PARD)

## Output Over-Voltage Protection

The HBR output voltage is monitored for an over-voltage condition using a comparator. The signal is optically coupled to the primary side and if the output voltage rises to a level which could be damaging to the load, the sensing circuitry will disable the PWM controller drive causing the output voltage to decrease. Following a time-out period, the PWM will restart, causing the output voltage to begin rising to its appropriate value. If the Over-Voltage condition persists, another shutdown cycle will initiate. This rapid on/off cycling is called "hiccup mode".

The "hiccup" system differs from older latching circuit systems because you do not have to power down the converter to make it restart. The system will automatically restore operation as soon as the condition is removed.

## Thermal Shutdown

**CAUTION:** If you operate too close to the thermal limits, the converter may shut down suddenly without warning. Be sure to thoroughly test your application to avoid unplanned thermal shutdown.

## Output Fusing

The converter is extensively protected against current, voltage and temperature extremes. However, your output application circuit may need additional protection. In the extremely unlikely event of output circuit failure, excessive voltage could be applied to your circuit. Consider using an appropriate fuse in series with the output.





# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## Output Current Limiting & Over-Current Protection

Current limiting inception is defined as the point at which full power falls below the rated tolerance. See the Performance/Functional Specifications. Note particularly that the output current may briefly rise above its rated value in normal operation as long as the average output power is not exceeded. This enhances reliability and continued operation of your application. If the output current is too high, the converter will enter the short circuit condition. The modules include an internal output over-current protection circuit, which will endure current limiting for an unlimited duration during output overload. If the output current exceeds the OCP set point, the module will shut down, and always try to restart (hiccup mode) until the over current condition is corrected. The OCP pin is used to adjust the OCP value by connecting a resistor between OCP (PIN #6) and Vin(-)(PIN #7) if needed. The OCP pin is left floating if not used. Please see the external resistor table below.

| 72WS12.250HBR, OCP (A) with External Resistor |                         |       |       |       |       |       |       |       |       |
|---|-------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Vin(V)  | *External Resistor (kΩ) |       |       |       |       |       |       |       |       |
|   | 0.562                   | 0.665 | 0.845 | 1.13  | 1.33  | 1.69  | 3.32  | 6.65  | 10    |
| 24  | 14.40                   | 16.20 | 18.40 | 20.45 | 21.10 | 22.14 | 23.90 | 24.70 | 25.00 |
| 48  | 15.20                   | 17.20 | 19.10 | 20.90 | 21.80 | 22.70 | 24.40 | 25.30 | 25.60 |
| 72  | 15.50                   | 17.10 | 19.20 | 21.10 | 21.80 | 22.70 | 24.50 | 25.20 | 25.60 |
| 96  | 14.90                   | 17.40 | 19.80 | 22.00 | 22.60 | 24.07 | 25.90 | 26.90 | 27.20 |
| 110   | 11.50                   | 13.90 | 17.00 | 19.70 | 20.80 | 22.10 | 24.50 | 25.60 | 26.00 |

\* The OCP current with different external resistor and input voltage are typical values for reference and have a tolerance of about ±2.5A.

## Output Short Circuit Condition

The PWM controller will shut down at a short condition, and always try to restart (hiccup mode) until the short condition is corrected. The hiccup cycling reduces the average output current, thereby preventing excessive internal temperatures and/ or component damage.

## Output Capacitive Load

These converters do not require external capacitance added to achieve rated specifications. Users should only consider adding capacitance to reduce switching noise and/ or to handle spike current load steps. Install only enough capacitance to achieve noise objectives. Excess external capacitance may cause degraded transient response and possible oscillation or instability.

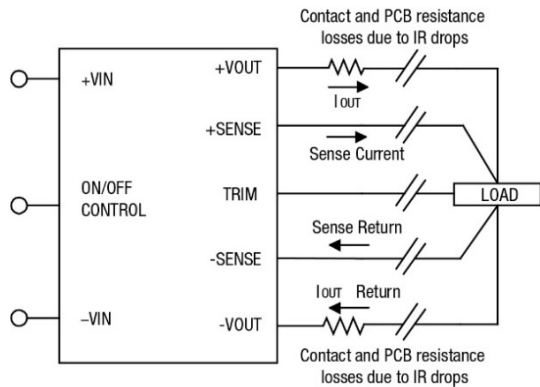
## Remote Sense Input

Use the Sense inputs with caution. Sense is normally connected at the load. Sense inputs compensate for output voltage inaccuracy delivered at the load. This is done by correcting IR voltage drops along the output wiring and the current carrying capacity of PC board etch. Sense inputs also improve the stability of the converter and load system by optimizing the control loop phase margin.

**NOTE:** The Sense input and power Vout lines are internally connected through low value resistors to their respective polarities so that the converter can operate without external connection to the Sense. Nevertheless, if the Sense function is not used for remote regulation, the user should connect +Sense to +Vout and –Sense to –Vout at the converter pins.

The remote Sense lines carry very little current. They are also capacitively coupled to the output lines and therefore are in the feedback control loop to regulate and stabilize the output. As such, they are not low impedance inputs and must be treated with care in PC board layouts. Sense lines on the PCB should run adjacent to DC signals, preferably Ground. In cables and discrete wiring, use twisted pair, shielded tubing or similar techniques.

Any long, distributed wiring and/or significant inductance introduced into the Sense control loop can adversely affect overall system stability. If in doubt, test your applications by observing the converter's output transient response during step loads. There should not be any appreciable ringing or oscillation. You may also adjust the output trim slightly to compensate for voltage loss in any external filter elements. Do not exceed maximum power ratings.



**Figure 5** Remote Sense Circuit Configuration

$$[V_{out}(+) - V_{out}(-)] - [Sense(+) - Sense(-)] \leq \text{Output Sense Range}$$

| V <sub>o</sub>     | 12V | 24V | 54V |
|--------------------|-----|-----|-----|
| Output Sense Range | 10% | 5%  | 4%  |

Output overvoltage protection is monitored at the output voltage pin, not the Sense pin. Therefore, excessive voltage differences between V<sub>out</sub> and Sense together with trim adjustment of the output can cause the overvoltage protection circuit to activate and shut down the output. Power derating of the converter is based on the combination of maximum output current and the highest output voltage. Therefore, the designer must ensure: (V<sub>out</sub> at pins) x (I<sub>out</sub>) ≤ (Max. rated output power)

## Trimming the Output Voltage

The Trim input to the converter allows the user to adjust the output voltage over the rated trim range (please refer to the Specifications). In the trim equations and circuit diagrams that follow, trim adjustments use either a trimpot or a single fixed resistor connected between the Trim input and either the +Sense or -Sense terminals. Trimming resistors should have a low temperature coefficient (±100 ppm/deg.C or less) and be mounted close to the converter. Keep leads short. If the trim function is not used, leave the trim unconnected. With no trim, the converter will exhibit its specified output voltage accuracy.

There are two CAUTIONs to observe for the Trim input:

**CAUTION:** To avoid unplanned power down cycles, do not exceed EITHER the maximum output voltage OR the maximum output power when setting the trim. Be particularly careful with a trimpot. If the output voltage is excessive, the OVP circuit may inadvertently shut down the converter. If the maximum power is exceeded, the converter may enter current limiting. If the power is exceeded for an extended period, the converter may overheat and encounter overtemperature shut down.

**CAUTION:** Be careful of external electrical noise. The Trim input is a sensitive input to the converter's feedback control loop. Excessive electrical noise may cause instability or oscillation. Keep external connections short to the Trim input. Use shielding if needed.

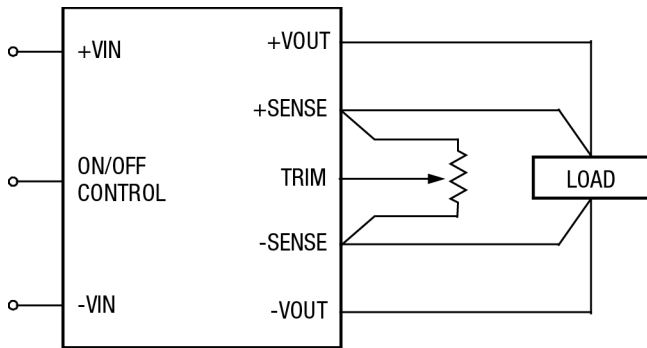
## Trim Equations

| Trim Equations |   |                                 |
|----------------|---|---------------------------------|
| Model          | R <sub>t up</sub> (kΩ)                      | R <sub>t down</sub> (kΩ)        |
| 72WS12.250HBR  | $V_o * (1 - 0.102) / (V_o * 0.102 - 1.225)$ | $1 / (1.225 / 0.102 / V_o - 1)$ |
| 72WS24.250HBR  | $V_o * (1 - 0.051) / (V_o * 0.051 - 1.225)$ | $1 / (1.225 / 0.051 / V_o - 1)$ |
| 72WS54.250HBR  | $V_o * 2.05 * 45.3 / (V_o - 54) / 1.05$     | $V_o * 2.05 / (54 - V_o)$       |

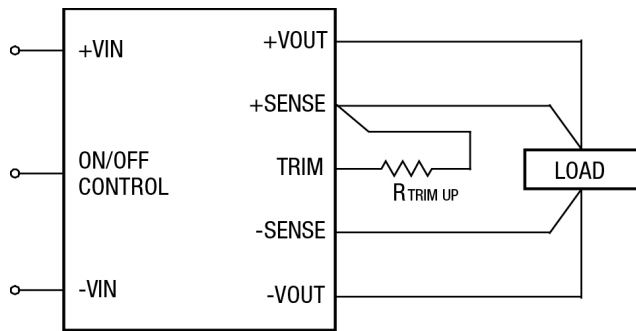
|               |                | Trim up       |                |                | Trim down       |                 |
|---------------|----------------|---------------|----------------|----------------|-----------------|-----------------|
| 72WS12.250HBR | V <sub>o</sub> | 12.6V<br>(5%) | 13.2V<br>(10%) | 11.4V<br>(-5%) | 10.8V<br>(-10%) | 9.6V<br>(-20%)  |
|               | Trim-Sense+    | 188kΩ         | 97kΩ           | NA             | NA              | NA              |
|               | Trim-Sense-    | NA            | NA             | 18.7kΩ         | 8.9kΩ           | 4kΩ             |
| 72WS24.250HBR | V <sub>o</sub> | 25.2V<br>(5%) | 26.4V<br>(10%) | 22.8V<br>(-5%) | 21.6V<br>(-10%) | 19.2V<br>(-20%) |
|               | Trim-Sense+    | 391kΩ         | 205kΩ          | NA             | NA              | NA              |
|               | Trim-Sense-    | NA            | NA             | 19kΩ           | 9kΩ             | 4kΩ             |
| 72WS54.250HBR | V <sub>o</sub> | 56.7V<br>(5%) | 59.4V<br>(10%) | 51.3V<br>(-5%) | 48.6V<br>(-10%) | 43.2V<br>(-20%) |
|               | Trim-Sense+    | 1857kΩ        | 972Ω           | NA             | NA              | NA              |
|               | Trim-Sense-    | NA            | NA             | 39kΩ           | 18.4kΩ          | 8.2kΩ           |



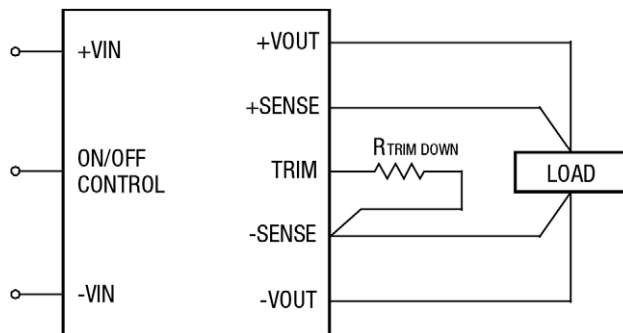
## Trim Circuits



**Figure 6.** Trim Connections Using a Trimpot



**Figure 7.** Trim Connections to Increase Output Voltage

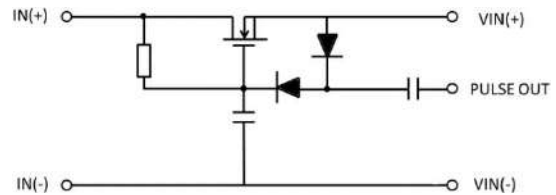


**Figure 8.** Trim Connections to Decrease Output Voltage

Do not exceed the specified trim range or maximum power ratings when adjusting trim. Use 1% precision resistors mounted close to the converter on short leads. If sense is not installed, connect the trim resistor to the respective Vout pin.

## PULSE OUT

This pin outputs a 1kHz 50% duty cycle pulse voltage with 12V amplitude. It is designed to provide a bootstrap signal for the input inrush current limit circuit, and also could indicate operating status with a LED connected. Please leave the PULSE OUT pin open if not required.

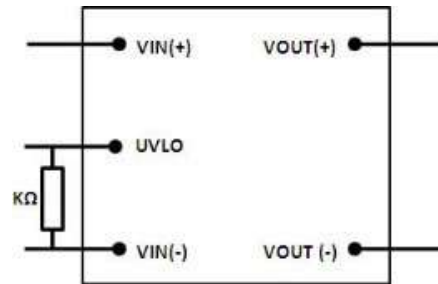


**Figure 9.** Active Circuit Design for Inrush Current Limit

## UVLO

The HBR Series converters have an under voltage lockout feature that will shut down the converter if the input voltage falls below the adjustable threshold. Devices will automatically restart when input voltage rises above the UVLO threshold. The hysteresis built into this function prevents an indeterminate on/off condition at a single input voltage. The under voltage threshold is determined by the value of a resistor placed between the UVLO and VIN (-).

Figure 10 shows a typical configuration.



**Figure 10.** Under Voltage Lockout Configuration

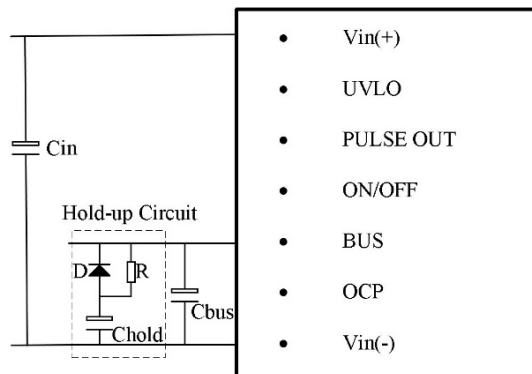
The table below shows the UVLO values for various nominal input voltages and the required resistor values for each.

| Nominal Vin              | 24V        | 36V        | 48V        | 72V        | 96V       | 110V      |
|--------------------------|------------|------------|------------|------------|-----------|-----------|
| External Resistor (kΩ)   | open       | 27.4       | 13         | 6.81       | 4.32      | 3.57      |
| Turn-on Threshold ±0.5V  | 14.5 ±0.5V | 22.8 ±0.5V | 32.7 ±0.5V | 49.5 ±1.5V | 70.25 ±2V | 82.08 ±2V |
| Turn-off Threshold ±0.5V | 11.5 ±0.5V | 18.7 ±0.5V | 26.9 ±0.5V | 40.5 ±1.5V | 57.48 ±2V | 65.04 ±2V |

## Hold-up Time

The BUS pin is for the hold-up time function. It is designed to work with an external circuit that is comprised of a hold-up cap ( $C_{hold}$ ), a resistor ( $R$ ) and a diode ( $D$ ). The hold-up time is defined as the duration of time that the DC-DC converter output will remain active following a loss of input power. When this function is activated, the HBR uses the energy stored in the external hold-up circuit to support operation. Please note that the BUS pin is a voltage source output of 80Vdc to allow external capacitors to be connected in order to provide hold up power of the converter. After 80Vdc input, it tracks the DC input voltage range up to 160Vdc.

**NOTE:** A 100 $\mu$ F ( $C_{in}$ ) and 240 $\mu$ F ( $C_{bus}$ ) are required for normal operation.



**Figure 11.** Connection of External Hold-up Circuit

The hold-up function provides energy that maintains the DC-DC converter in operation for 10mS, 20mS or 30mS of hold-up time. The recommended value of the hold-up capacitor ( $C_{hold}$ ) is shown in the table below.

| 72WS12.250HBR |        |        |        |        |        |        |
|---------------|--------|--------|--------|--------|--------|--------|
| Chold         | 24Vin  | 36Vin  | 48Vin  | 72Vin  | 96Vin  | 110Vin |
| For 10 mS     | 2200uF | 2200uF | 2200uF | 2200uF | 1100uF | 700uF  |
| For 20 mS     | 4400uF | 4400uF | 4400uF | 4400uF | 2200uF | 1400uF |
| For 30 mS     | 6600uF | 6600uF | 6600uF | 6600uF | 3300uF | 2100uF |

## Through-Hole Soldering Guidelines

CALEX recommends the TH soldering specifications below when installing these converters. These specifications vary depending on the solder type. Exceeding these specifications may cause damage to the product. Your production environment may differ; therefore, please thoroughly review these guidelines with your process engineers.

| Wave Solder Operations for Through-Hole mounted products (THMT) |           |
|---|-----------|
| For Sn/Ag/Cu based solders:                                     |           |
| Maximum Preheat Temperature                                     | 115° C.   |
| Maximum Pot Temperature   | 270° C.   |
| Maximum Solder Dwell Time                                       | 7 seconds |
| For Sn/Pb based solders:  |           |
| Maximum Preheat Temperature                                     | 105° C.   |
| Maximum Pot Temperature   | 250° C.   |
| Maximum Solder Dwell Time                                       | 6 seconds |



# HBR Series, 250 Watt

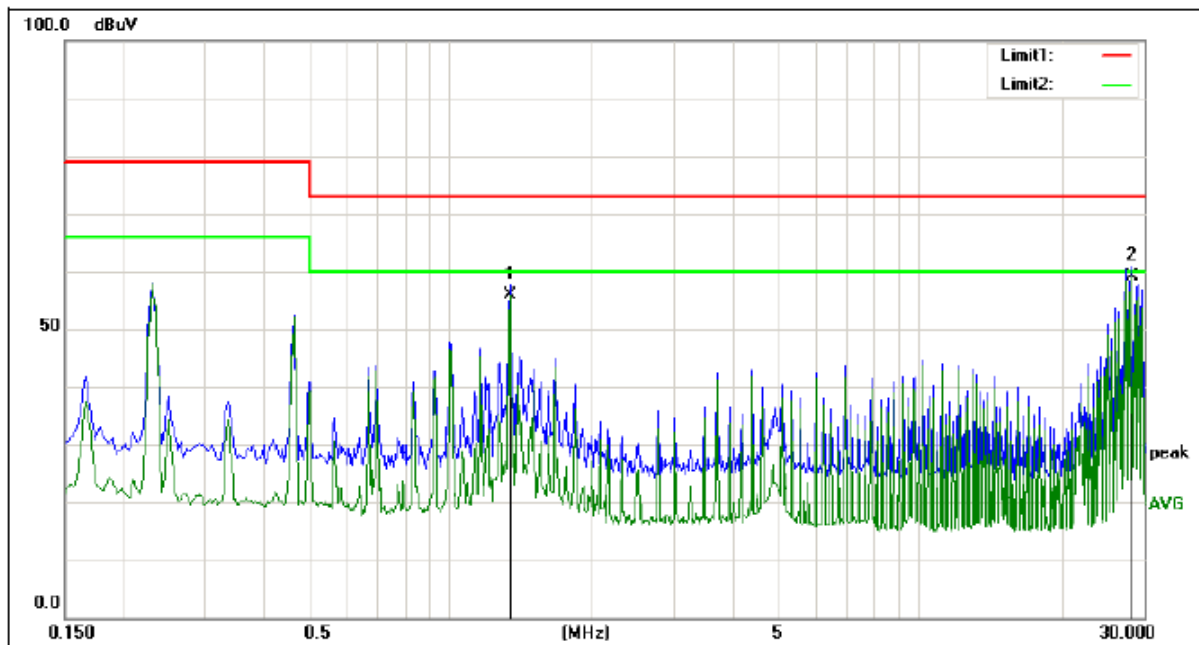
½ Brick DC/DC Converter with 10:1 Input

## Qualification Tests

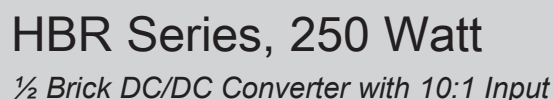
| Parameters                           | Test Conditions  | Operating |
|--------------------------------------|--|-----------|
| Vibration                            | EN 61373:1999 Category I, Class B, Body mounted  | Yes       |
| Mechanical Shock                     | EN 61373:1999 Category I, Class B, Body mounted  | Yes       |
| Temperature Cycling Test (TCT)       | -40°C to 125°C, unit temp. ramp 15°C/min., 500 cycles  | Yes       |
| Temperature, Humidity and Bias (THB) | 85°C, 85RH, Vin=max, Load=min load, 1072 hours (72hours with a pre-conditioning soak, unpowered)                             | No        |
| Damp heat test, cyclic               | EN60068-2-30: Temperature +55°C and +25°C; Number of cycles 2 (respiration effect); Time 2 x 24 hours; Relative Humidity 95% | No        |
| Dry heat test                        | EN60068-2-2, Vin=nom, Full load, 85°C for 6 hours  | Yes       |
| Low Temperature Operating            | Vin=nom, Full load, -40°C for 2 hours  | Yes       |
| Highly Accelerated Life Test (HALT)  | High temperature limits, low temperature limits, Vibration limits, Combined Environmental Tests.                             | Yes       |
| EMI                                  | CISPR 22 Class A, or IEC62236-3-2 (GB/T 24338.4)   | Yes       |
| Surge Protection                     | EN50121-3-2  | Yes       |
| Solderability                        | MIL-STD-883, method 2003 (IPC/EIA/JEDEC J-SID-002B)  | No        |

## Conducted Emissions Test Results EN:55011 CLASS A (24Vout)

Vin = 110V, Line L



| No. | Frequency<br>(MHz) | Reading<br>(dBuV) | Correct<br>Factor(dB) | Result<br>(dBuV) | Limit<br>(dBuV) | Margin<br>(dB) | Remark |
|-----|--------------------|-------------------|-----------------------|------------------|-----------------|----------------|--------|
| 1   | 1.3340             | 36.04             | 19.72                 | 55.76            | 60.00           | -4.24          | AVG    |
| 2   | 28.4140            | 38.79             | 20.26                 | 59.05            | 60.00           | -0.95          | AVG    |

[illegible]

| Reference  | Manufacturer | MPN                 | Type                | Specifications | Qty |
|------------|--------------|---------------------|---------------------|----------------|-----|
| MOV1       | Epcos        | B72214S0141K101     | Varistor            | 180V, 36J      | 1   |
| TVS1       | Littell Fuse | 1.5KE220A           | TVS diode           | 185V, 1.5KW    | 1   |
| C1         | Faratronic   | C212E475K9AC000     | Polyester capacitor | 250V, 4.7uF    | 1   |
| C2, C3, C4 | Murata       | GRM43DR72E474KW01L  | Capacitor MLCC      | 250V, 0.47uF   | 3   |
| C5, C6     | Murata       | DE1E3RA102MA4BQ01F  | Safety ceramic cap  | 500V, 1000pF   | 2   |
| C11        | Murata       | DE2E3KY222MA3BM02F  | Safety ceramic cap  | 2200pF         | 1   |
| C12        | Murata       | DE1E3KX472MA4BN01F  | Safety ceramic cap  | 4700pF         | 2   |
| C9, C10    | NCC          | EKXJ251EXX271ML40S  | E-cap               | 250V, 270uF    | 2   |
| C13, C14   | Murata       | DE2E3KY332MA3BM02F  | Safety ceramic cap  | 3300pF         | 2   |
| C15, C16   | Murata       | DE1E3KX472MA4BN01F  | Safety ceramic cap  | 500V, 4700pF   | 2   |
| L1         | Würth        | 7448262013          | CM choke            | 1.3mH, 20A     | 1   |
| L2, L3     | Bourns       | 2300HT-220-V-RC1951 | DM choke            | 22uH, 19A      | 2   |
| C7, C8     | NA           | NOT USED            | NA                  | NA             | 0   |
| C17, C18   | NA           | NOT USED            | NA                  | NA             | 0   |