

# 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



## Table of Contents

Part Number Selection Table.....	2	Mechanical Specifications .....	18
Part Number Structure.....	2	Baseplate Mounting Information.....	19
Functional Specifications, 72WS12.250HBR.....	3	Shipping Box & Tray Information .....	20
Typical Performance Data, 72WS12.250HBR.....	7	Technical Notes .....	21
Functional Specifications, 72WS24.250HBR.....	8	Qualification Tests .....	27
Typical Performance Data, 72WS24.250HBR.....	11	Conducted Emissions Test Results .....	27
Functional Specifications, 72WS54.250HBR .....	13	EMI Filter, Schematic & Parts List .....	28



# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

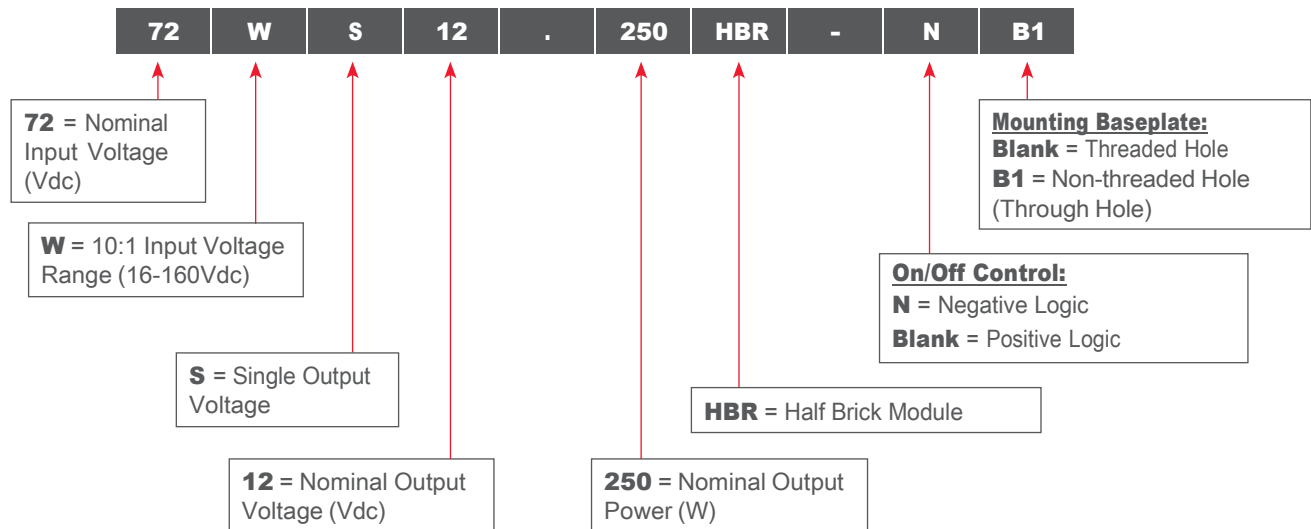
## Part Number Selection Table

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.



# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## 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	mA <sub>p-p</sub>
Input Reflected Ripple Current	No filtering				800	mA <sub>p-p</sub>
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						
Peak-to-Peak	20MHz bandwidth		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/uS)	50% Iout Max to 75%		280	450	mV	
Step Change in Output Current (0.1A/uS)	75% Iout max to 50%		280	450	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			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



# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

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

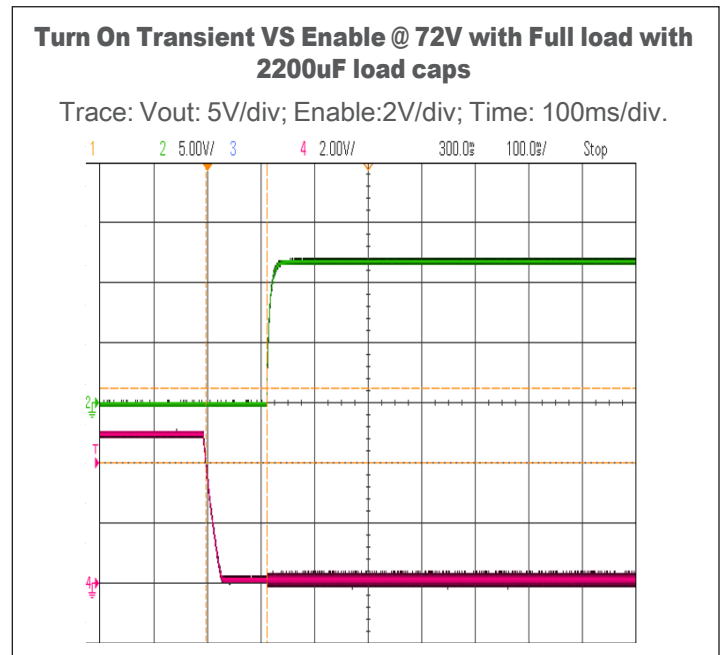
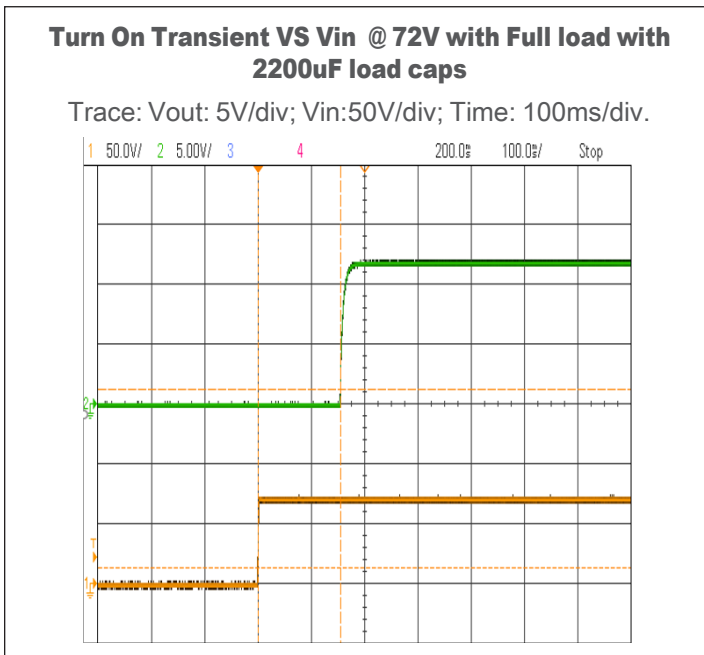
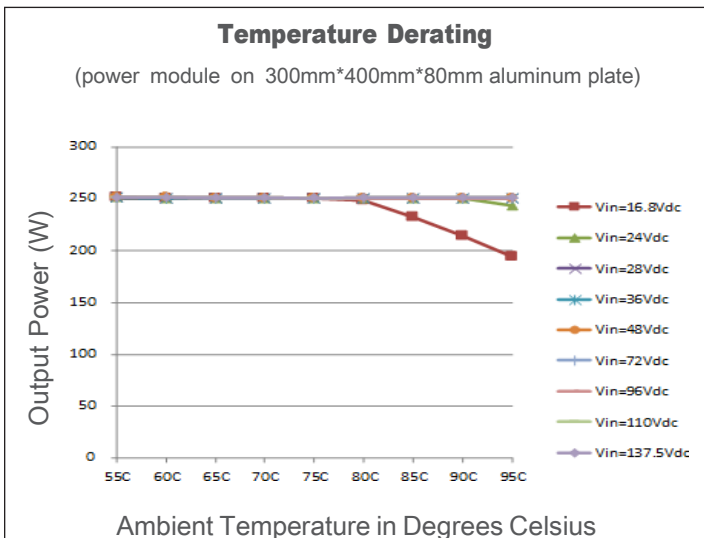
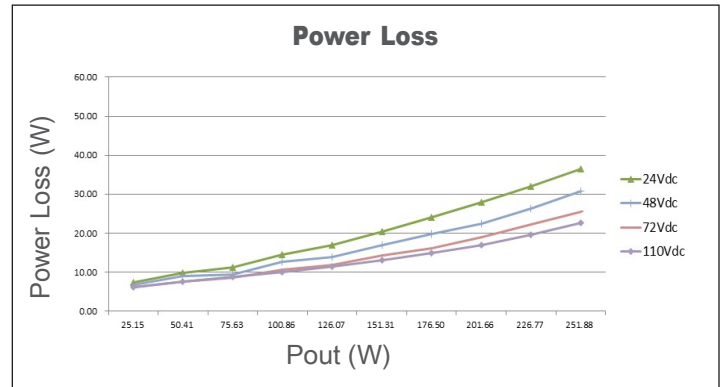
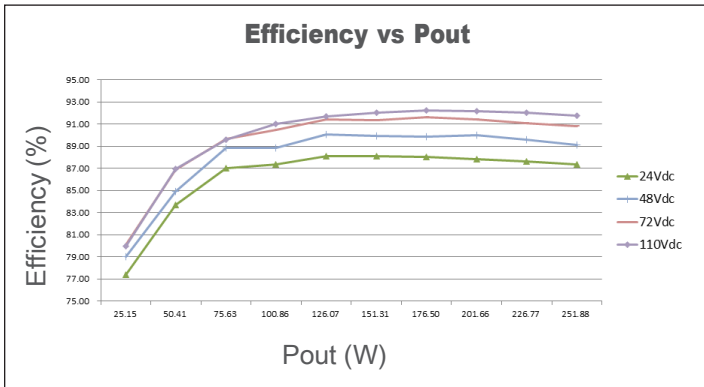
Temperature Limits for Power Derating Curves					
Semiconductor Junction Temperature				125	°C
Board Temperature	UL rated max operating temp 130°C			125	°C
Transformer/Inductor Temperature				125	°C
Feature Characteristics					
Switching Frequency		216	240	264	kHz
ON/OFF Control (Blank suffix)					
Off-State 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 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
Mechanical					
Outline Dimensions (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





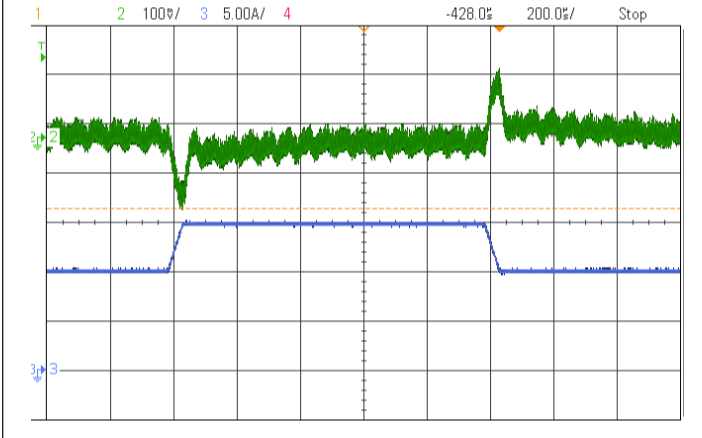
# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

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

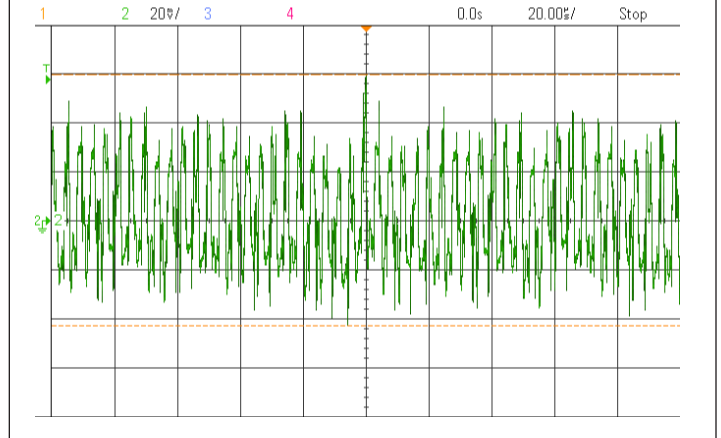
**Output voltage response to step-change in load current**  
**Vin=72V (50%-75%-50% of full load; di/dt = 0.1A/μs).**

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>t</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					
Peak-to-Peak	20MHz bandwidth		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)

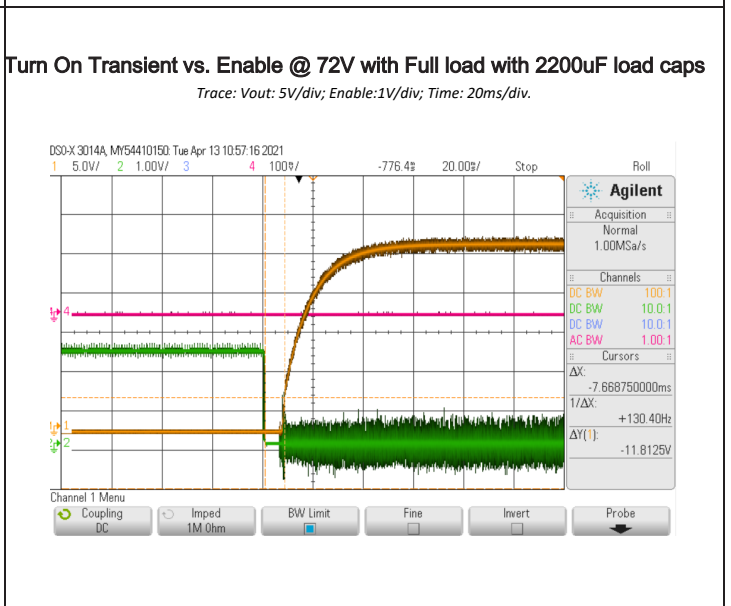
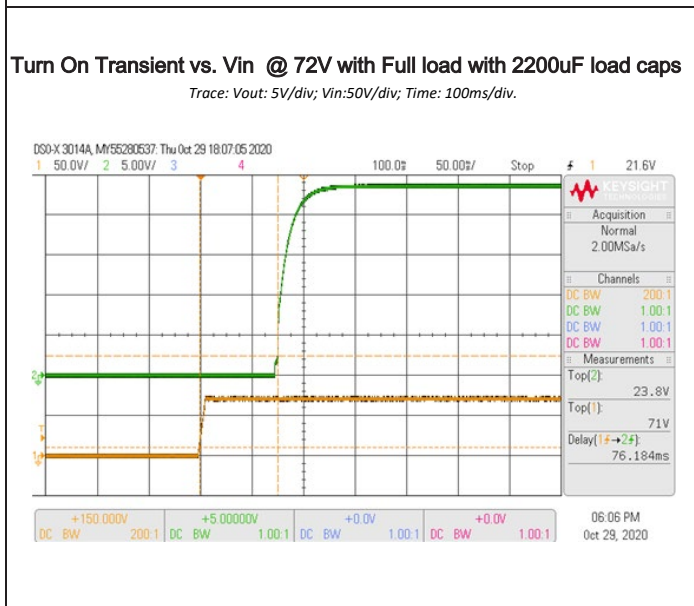
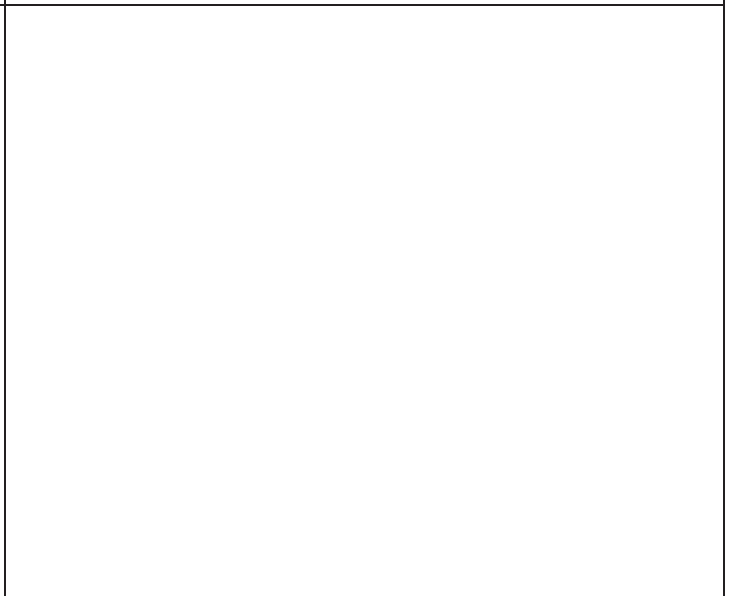
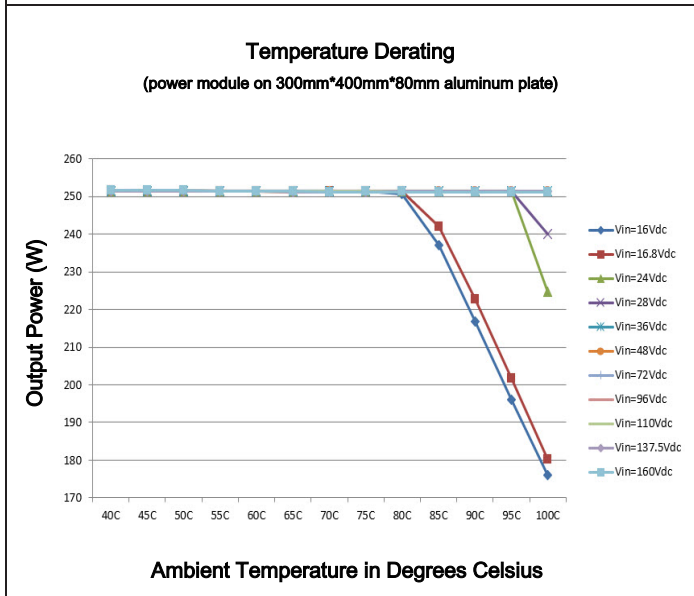
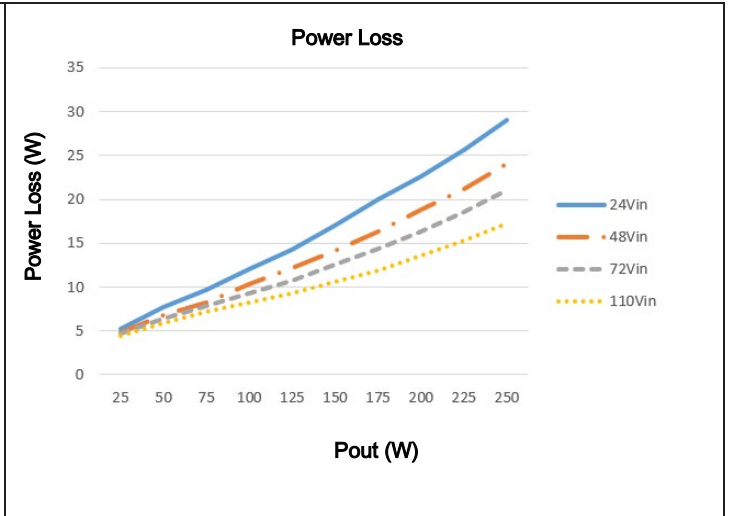
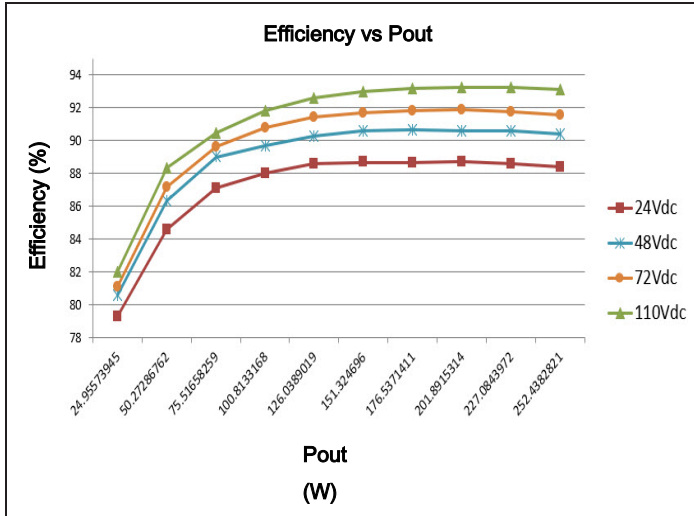
Calculated MTBF	Per Belcore Telcordia SR332, Issue 2, Method 1, Class 1		2.08		MHrs
<b>Temperature Limits for Power Derating Curves</b>					
Semiconductor Junction Temperature				125	°C
Board Temperature	UL rated max operating temp 130°C			125	°C
Transformer/Inductor Temperature				125	°C
<b>Feature 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
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 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 (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: 72WS24.250HBR





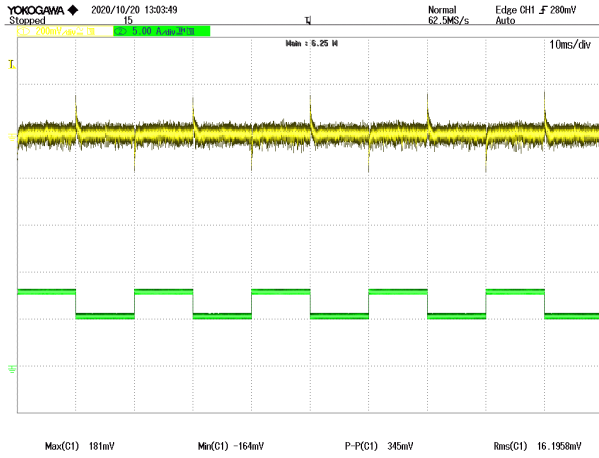
# HBR Series, 250 Watt

1/2 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/ $\mu$ s).

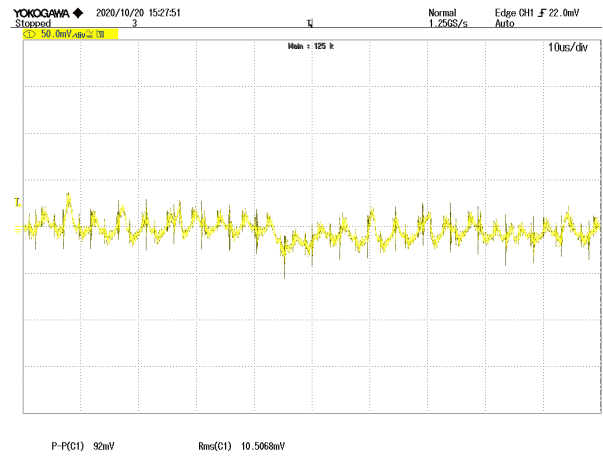
Trace: Vout: 200mV/div; Iout: 5A/div; Time: 10ms/div



## 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>t</sub> )			3.7	5	A <sup>2</sup> S



# 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					
Peak-to-Peak	20MHz bandwidth		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/µS)	50% Iout Max to 75%		400	600	mV
Step Change in Output Current (0.1A/µS)	75% Iout max to 50%		400	600	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		90.5		%
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)

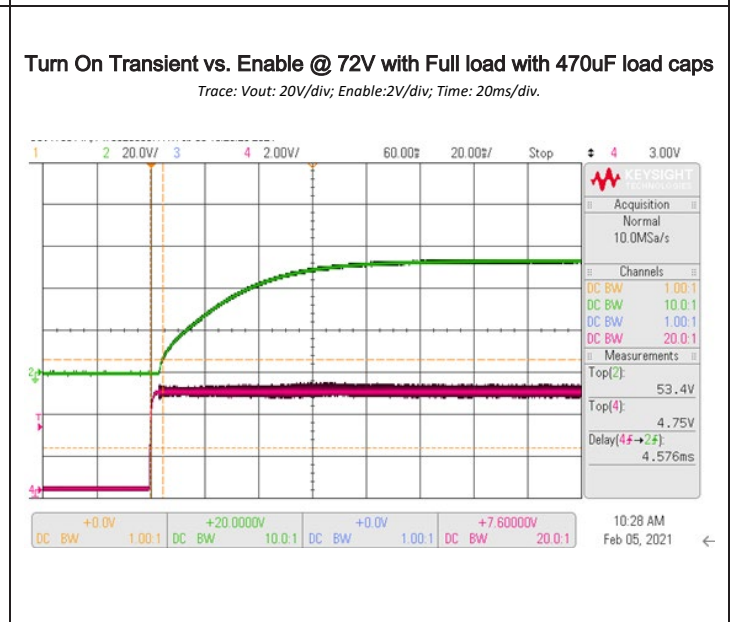
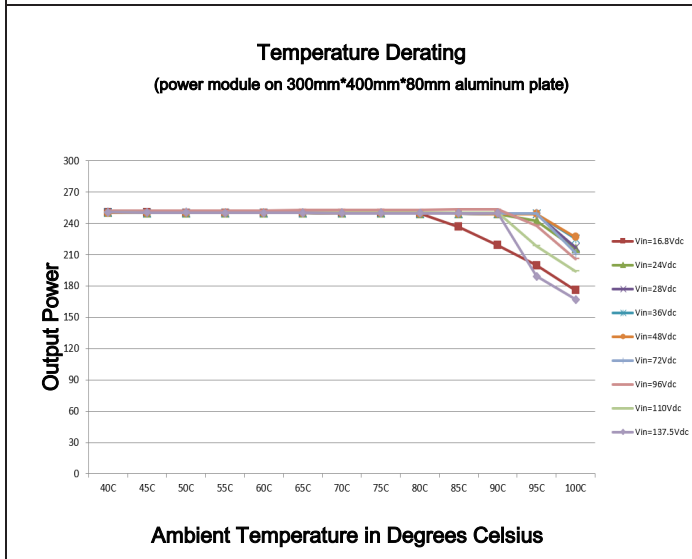
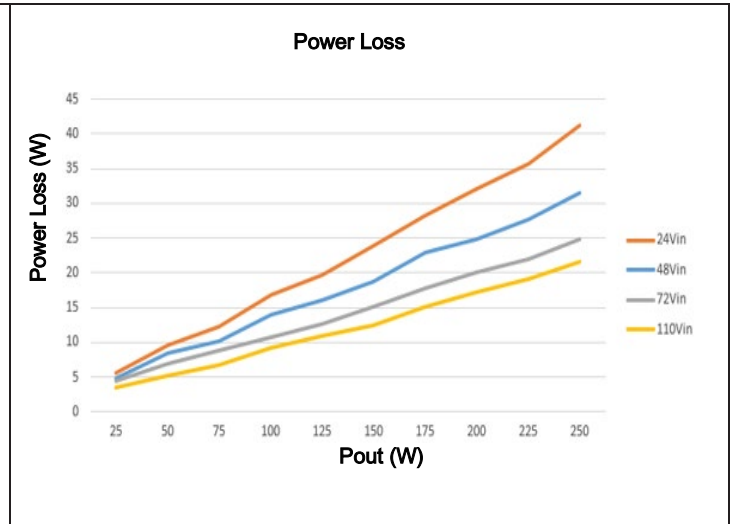
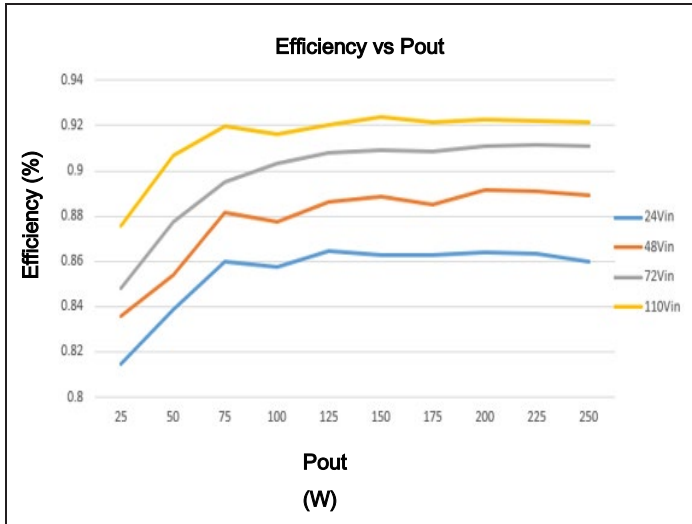
Calculated MTBF	Per Belcore Telcordia SR332, Issue 2, Method 1, Class 1		2.49		MHrs
<b>Temperature Limits for Power Derating Curves</b>					
Semiconductor Junction Temperature				125	°C
Board Temperature	UL rated max operating temp 130°C			125	°C
Transformer/Inductor Temperature				125	°C
<b>Feature 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
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 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 (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: 72WS54.250HBR







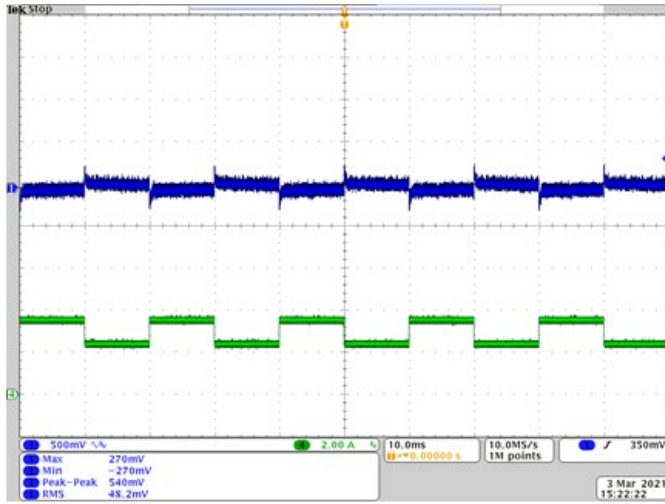
# HBR Series, 250 Watt

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)

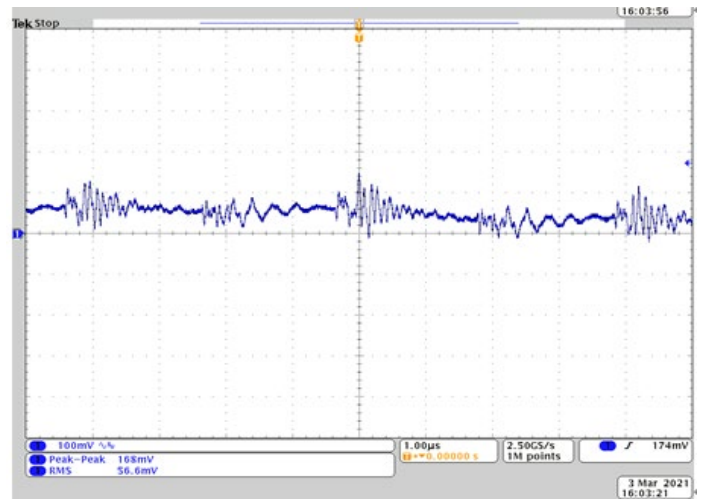
Trace: Vout: 500mV/div; Iout: 2A/div; Time: 10ms/div



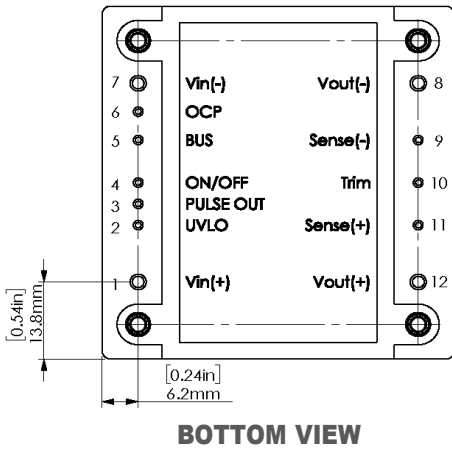
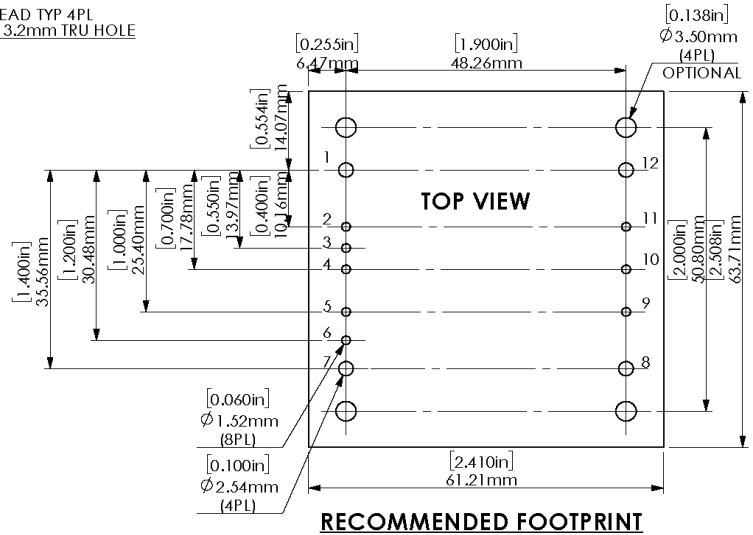
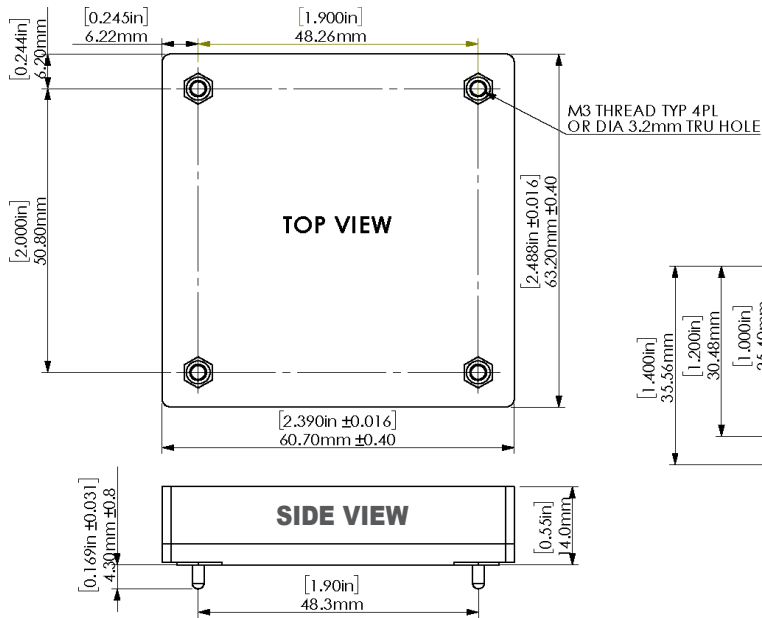
Output Ripple@20MHz BW,

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

Trace: Vout: 100mV/div; Time: 1us/div



### Mechanical Specifications



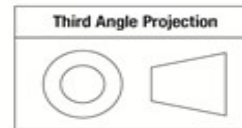
INPUT/OUTPUT CONNECTIONS		
Pin	Designation	Function
1	Vin (+)	Positive Input
2	UVLO	Under Voltage Lockout
3	PULSE OUT	PULSE OUT
4	ON/OFF	ENABLE
5	BUS	BUS Voltage
6	OCP	Over Current Protection
7	Vin (-)	Negative Input
8	Vout (-)	Negative Output
9	Sense (-)	Sense (-)
10	Trim	Trim
11	Sense (+)	Sense (+)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

#### NOTES:

UNLESS OTHERWISE SPECIFIED:

- ALL DIMENSION ARE IN INCHES [MILIMETER].
- ALL TOLERANCES:  
 $x.xx\text{in}$ ,  $\pm 0.02\text{in}$  ( $x.x\text{mm}$ ,  $\pm 0.5\text{mm}$ ).  
 $x.xxx\text{in}$ ,  $\pm 0.01\text{in}$  ( $x.xx\text{mm}$ ,  $\pm 0.25\text{mm}$ ).
- 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.

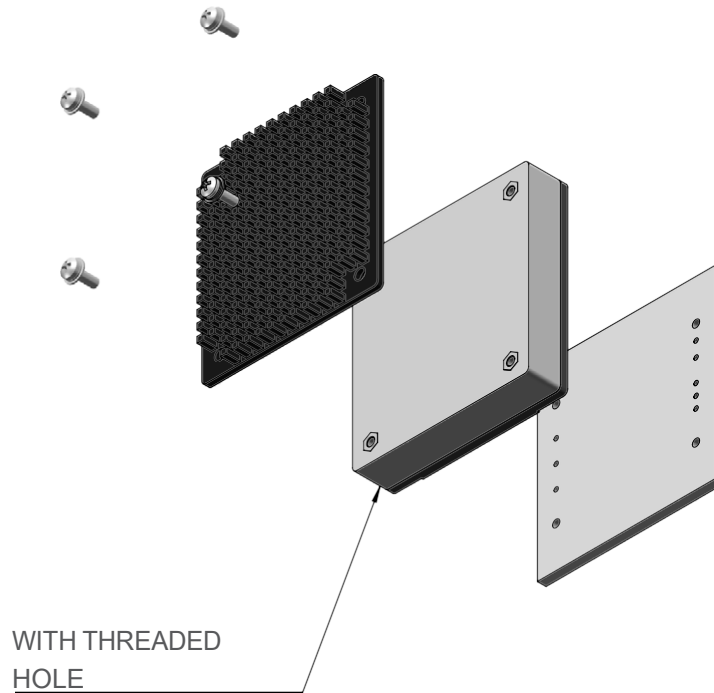


Tolerances (unless otherwise specified):  
 $.XX \pm 0.02$  (0.5)  
 $.XXX \pm 0.010$  (0.25)  
 Angles  $\pm 1^\circ$

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

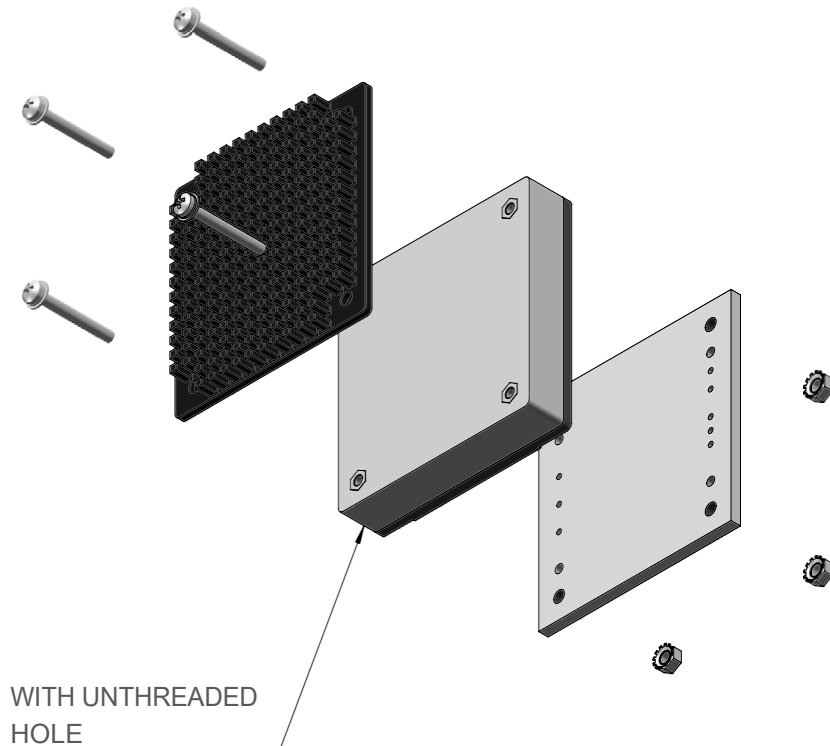
## Mounting Baseplate with Standard M3 Threaded Rivet

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



## Mounting Baseplate with Unthreaded Insert

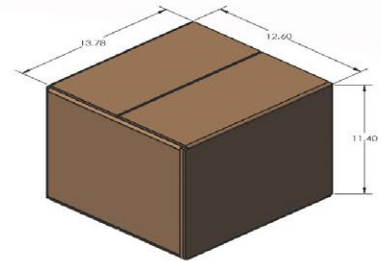
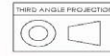
**NOTE:** The mounting screws and heat sink are for reference only. They are not included with the HBR.



## Shipping Box Dimensions

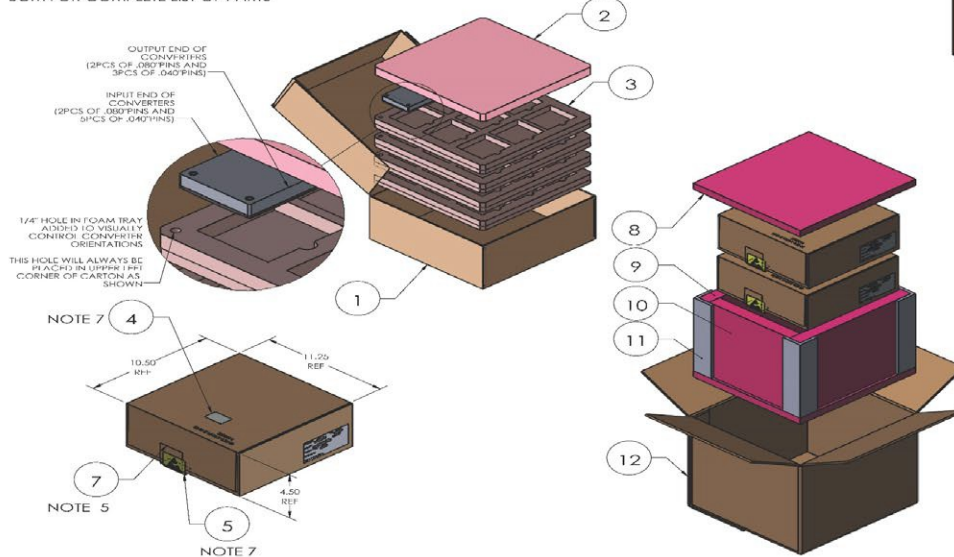
ITEM NO. (7770547)	PART NUMBER	DESCRIPTION	QTY
1	2300214	SHIPPING BOX, 10" X 10" X 4.25"	2
2	2300219	Pad, ESD Foam, 9.92" SQ, 1/2" Thk	2 (NOTE 8)
3	2300232	Shipping Tray, 3 x 3 Array (9 UP)	8
4	2300159	LABEL, 1.0" X 1.5" PAPER	2
5	5600-01098-0	LABEL, PRE-PRINTED ESD ATTENTION	2
6	5652-01166-0	LABEL, PAPER, 2.0" X 4.0"	2 (NOTE 6)
7	6200-01211-0	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



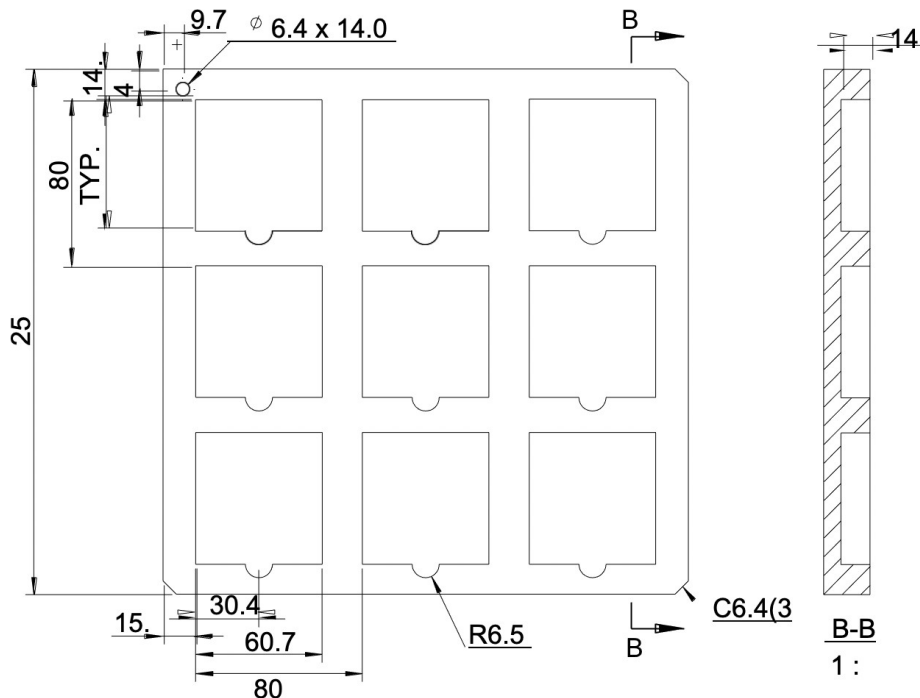
### NOTES

- 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 (ITEM3) CONTAINS 9 UNITS. EACH BOX (ITEM 1) CONTAINS 36 UNITS. IN FULL CARTON ITEM12 QUANTITIES, 2 BOXES (ITEM 1) EQUAL A TOTAL OF 72 UNITS.
- IF SHIPPING QTY IS 36PCS, PLEASE ALSO USE ITEM12 TO MARK THE PACKAGE (ONE EMPTY BOX ITEM1 PUT ON THE BOX ITEM1 WITH PRODUCTS).
- FRONT FLAP SHALL BE SEALED WITH ESD TAPE SPECIFIED OR EQUIVALENT AFTER THE BOX IS CLOSED.
- LABEL (ITEM 6) USED FOR MFR OVERPACK CARTON.
- APPLY ESD LABEL (ITEM 5) OVER TAPE USED TO SEAL BOX AND APPLY IDENTIFICATION LABEL (ITEM 4) APPROX AS SHOWN.
- PAD (ITEM 2) MAY, AT MFR'S OPTION, BE EXCHANGED FOR THINNER PAD IF FOAM STACKUP EXCEEDS CARTON HEIGHT BY >1/8" OR ADDITIONAL PAD MAY BE ADDED IF STACKUP IS BELOW INSIDE CARTON HEIGHT BY >1/8". ALTERNATE PADS: 1/4" THK=2300216, 3/8" THK=2300215, 1/2" THK=2300219, 3/4" THK=2300221.

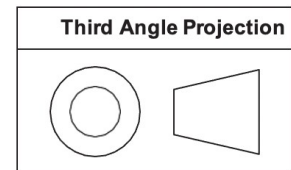


**MPQ = 36**

## 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:

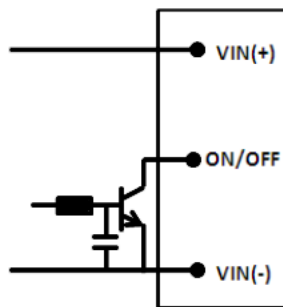
- ESD FOAM REQUEST.
- TOLERANCE: 2

## 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.



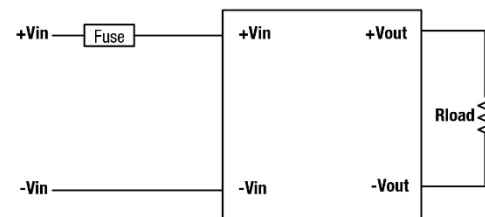
**Figure 1.** Driving the Negative Logic On/Off Control Pin

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

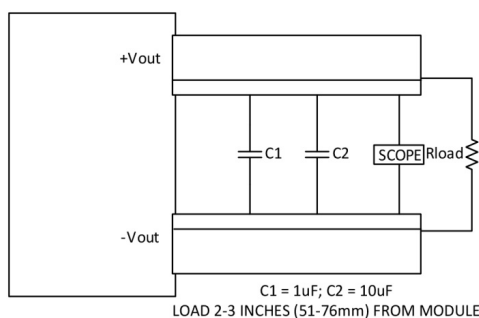
The converter will achieve its rated output ripple and noise with no additional external capacitor. However, the user may install more external output capacitance to reduce the ripple even further or for improved dynamic response.

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.

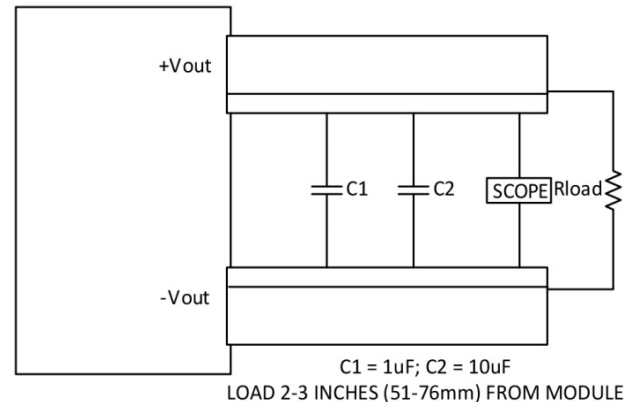
Use only as much capacitance as required to achieve your ripple and noise objectives. Excessive capacitance can make step load recovery sluggish or possibly introduce instability. Do not exceed the maximum rated output capacitance listed in the specifications.

## 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.

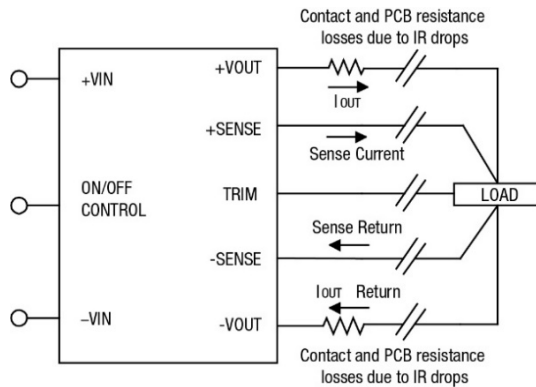
## Remote Sense Input

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

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

$V_o$	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  $V_{out}$  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:  $(V_{out \text{ at pins}}) \times (I_{out}) \leq (\text{Max. rated output power})$

### 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 ( $\pm 100$  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.

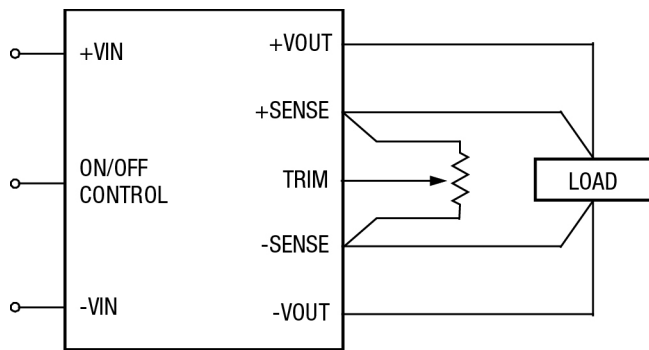
### Trim Equations

Trim Equations		
Model	$R_{t\_up}$ (k $\Omega$ )	$R_{t\_down}$ (k $\Omega$ )
72WS12.250HBR	$V_o \cdot (1 - 0.102) / (V_o \cdot 0.102 - 1.225)$	$1 / (1.225 / 0.102 / V_o - 1)$
72WS24.250HBR	$V_o \cdot (1 - 0.051) / (V_o \cdot 0.051 - 1.225)$	$1 / (1.225 / 0.051 / V_o - 1)$
72WS54.250HBR	$V_o \cdot 2.05 \cdot 45.3 / (V_o - 54) / 1.05$	$V_o \cdot 2.05 / (54 - V_o)$

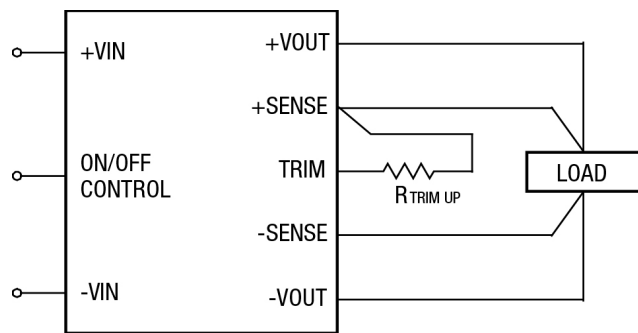
		Trim up			Trim down	
72WS12.250HBR	$V_o$	<b>12.6V (5%)</b>	<b>13.2V (10%)</b>	<b>11.4V (-5%)</b>	<b>10.8V (-10%)</b>	<b>9.6V (-20%)</b>
	Trim-Sense+	188k $\Omega$	97k $\Omega$	NA	NA	NA
	Trim-Sense-	NA	NA	18.7k $\Omega$	8.9k $\Omega$	4k $\Omega$
72WS24.250HBR	$V_o$	<b>25.2V (5%)</b>	<b>26.4V (10%)</b>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



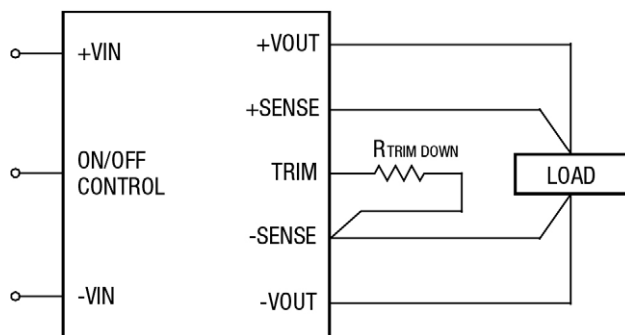
## Trim Circuits



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



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

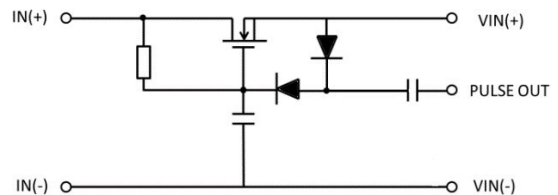


**Figure 8.** Trim Connections to Decrease Output Voltage

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.

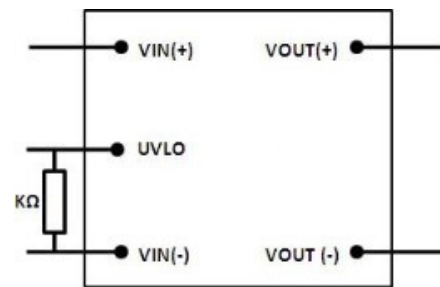


**Figure 9.** Active Circuit Design for Inrush Current Limit

## 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

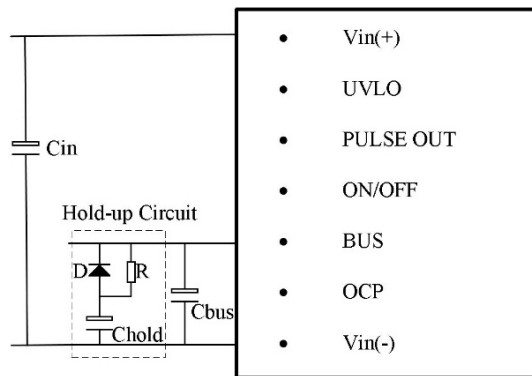
The table below shows the UVLO values for various nominal input voltages and the required resistor values for each.

Nominal Vin	24V	36V	48V	72V	96V	110V
External Resistor (kΩ)	open	27.4	13	6.81	4.32	3.57
Turn-on Threshold	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	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<sub>hold</sub>), 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 100µF (C<sub>in</sub>) and 240µF (C<sub>bus</sub>) 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<sub>hold</sub>) is shown in the table below.

72WS12.250HBR						
C <sub>hold</sub>	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

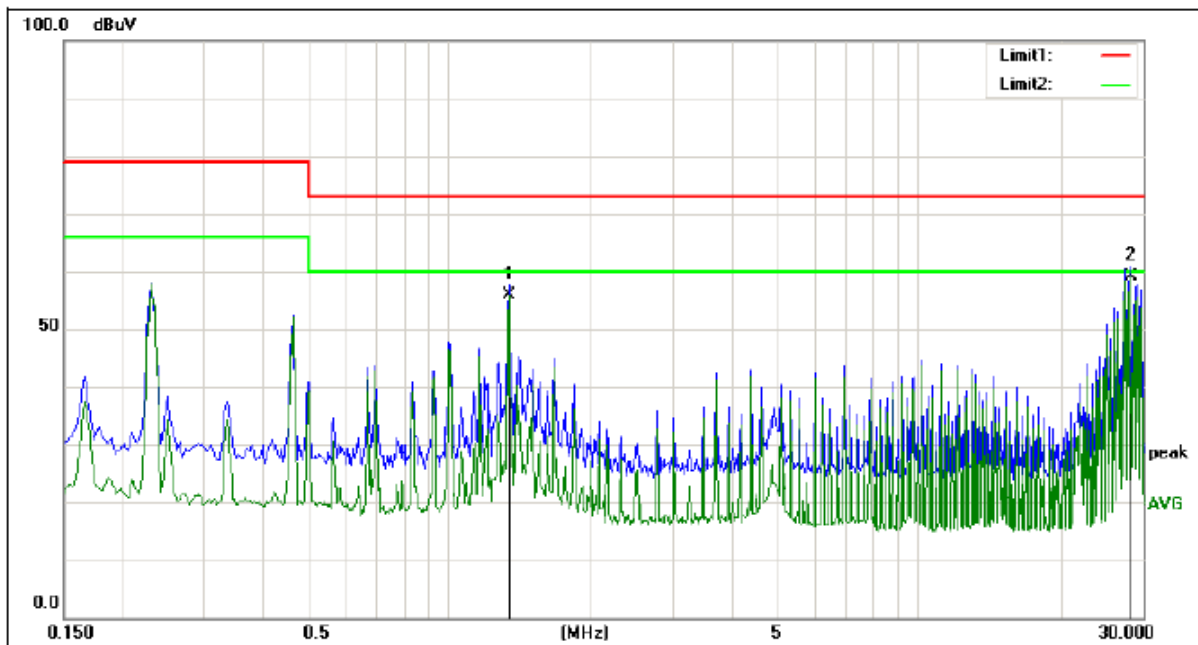
½ Brick DC/DC Converter with 10:1 Input

## 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	CISSPR 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



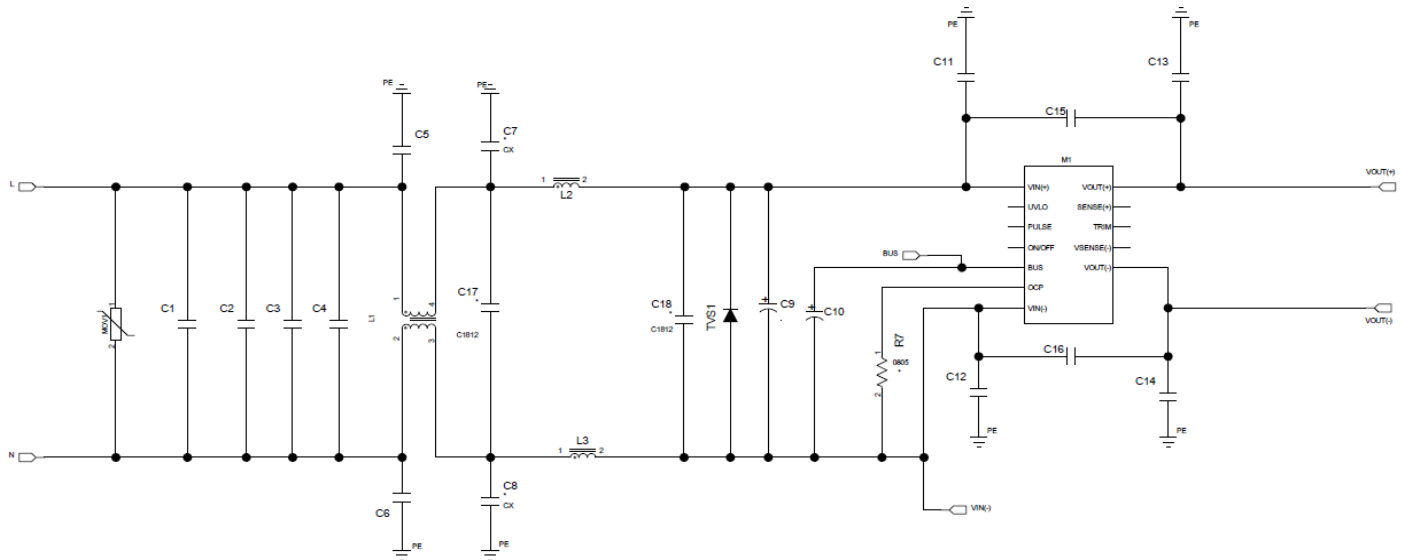
No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB)	Result (dBuV)	Limit (dBuV)	Margin (dB)	Remark
1	1.3340	36.04	19.72	55.76	60.00	-4.24	AVG
2	28.4140	38.79	20.26	59.05	60.00	-0.95	AVG



# HBR Series, 250 Watt

½ Brick DC/DC Converter with 10:1 Input

## EMI Filter, Schematic & Parts List



Reference	Manufacturer	MPN	Type	Specifications	Qty
MOV1	Epcos	B72214S0141K101	Varistor	180V, 36J	1
TVS1	Littel 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

© Calnex Manufacturing Company, Inc., a division of Murata Power Solutions • +1 (925) 687-4411 • (800) 542-3355 • e-mail: sales@calnex.com

Calnex Manufacturing, Inc. ("Calnex") makes no representation that the use of its products in the circuits described herein, or the use of other technical information contained herein, will not infringe upon existing or future patent rights. The descriptions contained herein do not imply the granting of licenses to make, use, or sell equipment constructed in accordance therewith. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards that anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm, and take appropriate remedial actions. Buyer will fully indemnify Calnex, its affiliated companies, and its representatives against any damages arising out of the use of any Calnex products in safety-critical applications. Specifications are subject to change without notice.