# V-INFINITY
a division of CUI INC

**PART NUMBER:** VHB200W　　　　**DESCRIPTION:** half-brick dc-dc converter

## description
The VHB200W series of DC-DC converters are designed for high reliability applications, featuring over-temperature protection, and over-current protection. The wide 4:1 input range (10-36V or 18-75V) is very useful to stabilize an input source like batteries in various discharging and charging conditions. Additionally, high efficiency, fast response, tight regulations, remote sense and remote On/Off control make these converters very useful in many applications.

## features
· **132-200W isolated output**
· **Efficiency to 89%**
· **RoHS Compliant**
· **4:1 input range**
· **Regulated output**
· **Continuous short circuit protection**
· **remote on/off**
· **over-voltage/current protection**
· **over-temperature shutdown**
· **industry standard ½ brick size**

RoHS

## MODEL

| MODEL | input voltage | | output voltage (V dc) | output current [1] (A) | input current | | efficiency typ. [3] (%) |
|---|---|---|---|---|---|---|---|
| | nominal (V dc) | range (V dc) | | | no load [2] (mA) | full load [2] (mA) | |
| VHB200W-Q24-S3R3 | 24 | 10.0~36.0 | 3.3 | 50 | 150 | 7900 | 87 |
| VHB200W-Q24-S5 | 24 | 10.0~36.0 | 5 | 40 | 150 | 9580 | 87 |
| VHB200W-Q24-S12 | 24 | 10.0~36.0 | 12 | 16.7 | 100 | 9710 | 86 |
| VHB200W-Q24-S15 | 24 | 10.0~36.0 | 15 | 13.3 | 100 | 9670 | 86 |
| VHB200W-Q24-S24 | 24 | 10.0~36.0 | 24 | 8.3 | 100 | 9540 | 87 |
| VHB200W-Q24-S28 | 24 | 10.0~36.0 | 28 | 7.1 | 100 | | 87 |
| VHB200W-Q24-S48 | 24 | 10.0~36.0 | 48 | 4.2 | 100 | 6720 | 87 |
| VHB200W-Q48-S3R3 | 48 | 18.0~75.0 | 3.3 | 40 | 80 | 3125 | 88 |
| VHB200W-Q48-S5 | 48 | 18.0~75.0 | 5 | 40 | 80 | 4682 | 89 |
| VHB200W-Q48-S12 | 48 | 18.0~75.0 | 12 | 16.7 | 60 | 4744 | 88 |
| VHB200W-Q48-S15 | 48 | 18.0~75.0 | 15 | 13.3 | 60 | 4723 | 88 |
| VHB200W-Q48-S24 | 48 | 18.0~75.0 | 24 | 8.3 | 60 | 4716 | 88 |
| VHB200W-Q48-S28 | 48 | 18.0~75.0 | 28 | 7.1 | 60 | | 88 |
| VHB200W-Q48-S48 | 48 | 18.0~75.0 | 48 | 4.2 | 30 | 4730 | 88 |

notes:
1. see output derating (page 4)
2. input currents are measured at hominal input voltage
3. efficiency is measured at nominal line, full load

## INPUT

| parameter | conditions/description | min | nom | max | units |
|---|---|---|---|---|---|
| input voltage range | | 10 | 24 | 36 | V dc |
| | | 18 | 48 | 75 | V dc |
| under voltage lockout | 24 Vin power up | | 9.5 | | V dc |
| | 24 Vin power down | | 8.5 | | V dc |
| | 24 Vin power up (48V output) | | 9.5 | | V dc |
| | 24 Vin power down (48V output) | | 8.5 | | V dc |
| | 48 Vin power up | | 17 | | V dc |
| | 48 Vin power down | | 16 | | V dc |
| remote on/off control[4] | section 13 in the application notes | | | | |
| input filter | PI type | | | | |

notes:
4. add suffix "N" to the model number for negative logic on/off control

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## OUTPUT

| parameter | conditions/description | min | nom | max | units |
|---|---|---|---|---|---|
| voltage accuracy | | | | ±1 | % |
| | 48V | | | ±1.5 | % |
| transient response | 25% step load change | | | 500 | µ sec |
| external trim adj. range | | | | ±10 | % |
| ripple & noise (20MHz BW) | 3.3 V, 5 V | | | 40 | mV RMS |
| | | | | 100 | mV p-p |
| | 12 V, 15 V | | | 60 | mV RMS |
| | | | | 150 | mV p-p |
| | 24 V | | | 100 | mV RMS |
| | | | | 240 | mV p-p |
| | 28 V | | | 100 | mV RMS |
| | | | | 280 | mV p-p |
| | 48 V | | | 150 | mV RMS |
| | | | | 480 | mV p-p |
| temperature coefficient | | | ±0.03 | | %/°C |
| short circuit protection | continuous | | | | |
| line regulation[5] | | | | ±0.2 | % |
| load regulation[6] | | | | ±0.2 | % |
| over voltage protection trip range, % Vo nom. | | | | | |
| | | 115 | | 140 | % |
| | 48V | 90 | | 110 | % |
| over current protection | | 110 | | 160 | % |
| | 48 V, nominal output | 110 | | 150 | % |

## GENERAL SPECIFICATIONS

| parameter | conditions/description | min | nom | max | units |
|---|---|---|---|---|---|
| switching frequency | | | 300 | | kHz |
| | 48V | | 250 | | kHz |
| operating ambient temp.[7] | | -40 | | 100 | °C |
| storage temperature | | -55 | | 105 | °C |
| thermal shutdown case temp. | | | 110 | | °C |
| case material | aluminum | | | | |

## ISOLATION SPECIFICATIONS

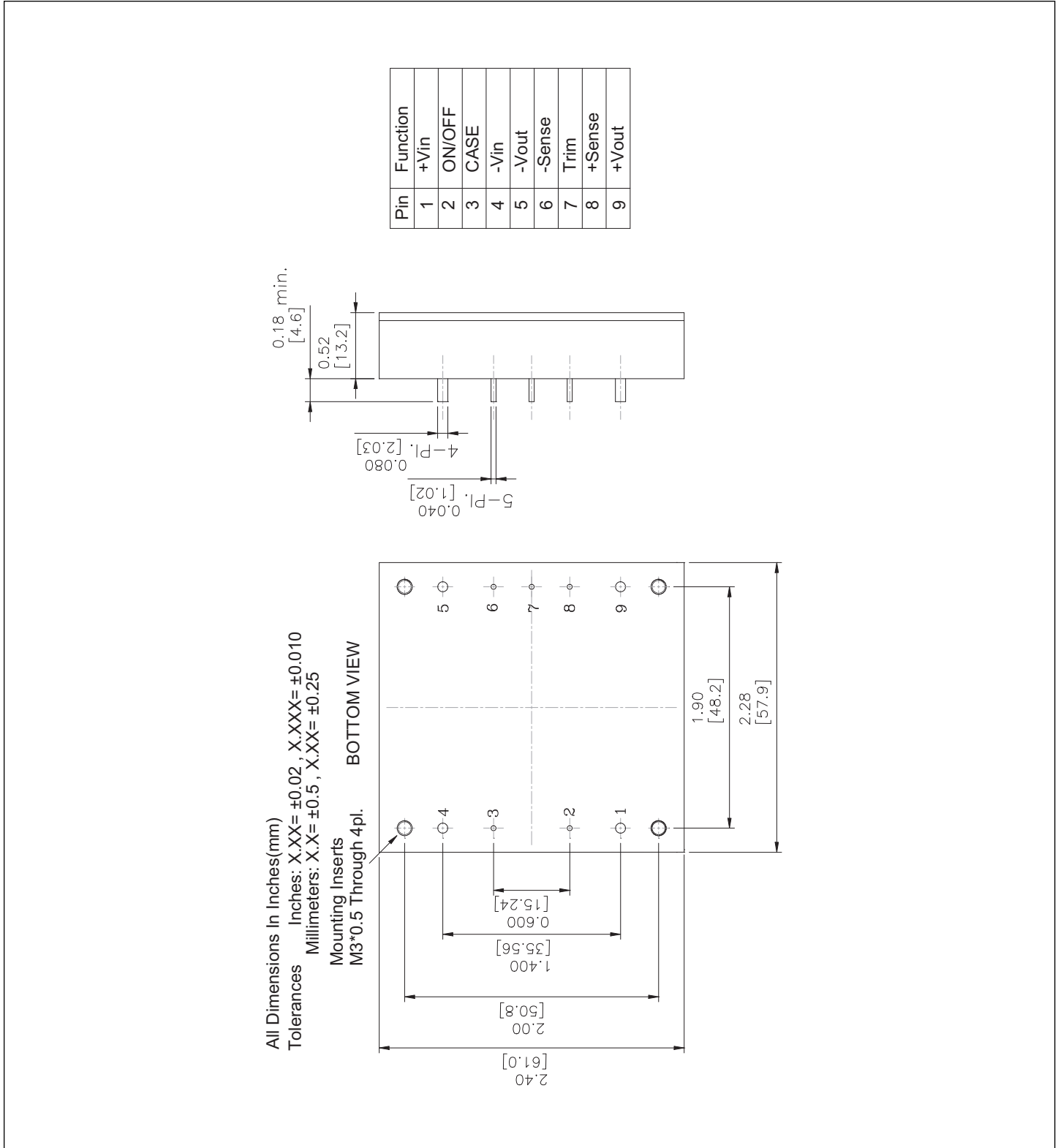| parameter | conditions/description | min | nom | max | units |
|---|---|---|---|---|---|
| isolation voltage | input/output | 1500 | | | V dc |
| | input/case | 1500 | | | V dc |
| | output/case | 1500 | | | V dc |
| isolation resistance | | 100 | | | MΩ |

notes:
5. measured from high line to low line at full load
6. measured from full load to zero load at nominal input
7. see output derating curve (page 4)

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## MECHANICAL DRAWING

| Pin | Function |
|-----|----------|
| 1 | +Vin |
| 2 | ON/OFF |
| 3 | CASE |
| 4 | -Vin |
| 5 | -Vout |
| 6 | -Sense |
| 7 | Trim |
| 8 | +Sense |
| 9 | +Vout |



All Dimensions In Inches(mm)
Tolerances    Inches: X.XX= ±0.02 , X.XXX= ±0.010
              Millimeters: X.X= ±0.5 , X.XX= ±0.25
Mounting Inserts
M3*0.5 Through 4pl.    BOTTOM VIEW

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## APPLICATION NOTES

### 1. OUTPUT DE-RATING

The operating case temperature range for VHB200W is -40 ~ +100°C.  When operating the VHB200W series, proper derating or cooling is needed.  The maximum case temperature under any operating condition should not exceed 100°C.
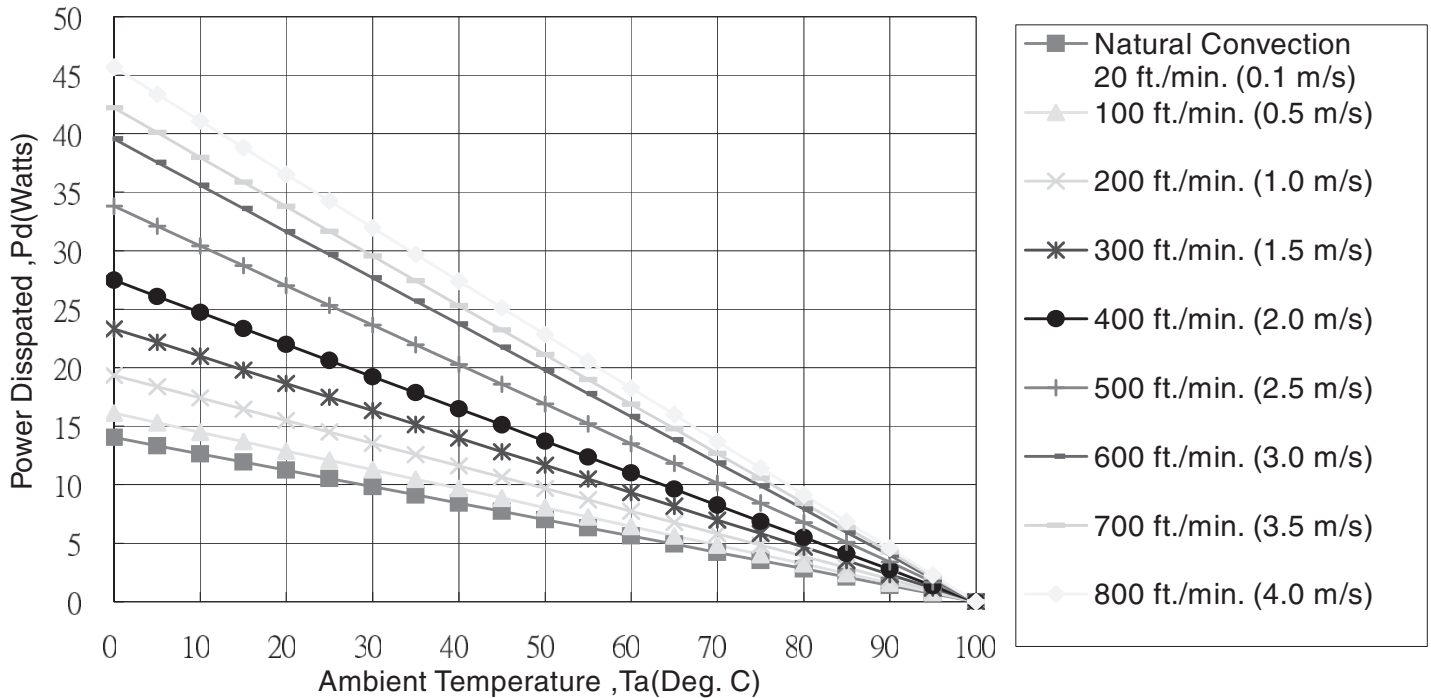


Power Dissipated vs Ambient Temperature and Air Flow

Legend:
- Natural Convection 20 ft./min. (0.1 m/s)
- 100 ft./min. (0.5 m/s)
- 200 ft./min. (1.0 m/s)
- 300 ft./min. (1.5 m/s)
- 400 ft./min. (2.0 m/s)
- 500 ft./min. (2.5 m/s)
- 600 ft./min. (3.0 m/s)
- 700 ft./min. (3.5 m/s)
- 800 ft./min. (4.0 m/s)

**FIGURE 1. OUTPUT DERATING (FORCED CONVECTION WITH NO HEAT SINK)**

**Example:**

What is the minimum airflow necessary for a VHB200W-Q48-S12 operating at nominal line, an output current of 16.7 A, and a maximum ambient temperature of 40°C?

**Solution:**

Given: Vin=48 V dc, Vo=12 V dc, Io=16.7 A

**Determine Power dissipation (Pd):**

$Pd=Pi-Po=Po(1-\eta)/\eta$

$Pd=12 \times 16.7 \times (1-0.88)/0.88=27.32$ W

**Determine airflow:**

Given: Pd=27.32 W and Ta=40°C

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

minimum airflow= 800 ft./min.

**Verifying:**

The maximum temp. rise $\Delta T = Pd \times Rca=27.32 \times 2.19=59.83$°C.  The maximum case temperature Tc=Ta+$\Delta T$=99.83°C<100°C

**Where:**

The Rca is thermal resistance from case to ambience.The Ta is ambient temperature and the Tc is case temperature.

| AIR FLOW RATE | TYPICAL Rca |
|---|---|
| Natural Convection 20ft./min. (0.1m/s) | 7.12 ℃/W |
| 100 ft./min. (0.5m/s) | 6.21 ℃/W |
| 200 ft./min. (1.0m/s) | 5.17 ℃/W |
| 300 ft./min. (1.5m/s) | 4.29 ℃/W |
| 400 ft./min. (2.0m/s) | 3.64 ℃/W |
| 500 ft./min. (2.5m/s) | 2.96 ℃/W |
| 600 ft./min. (3.0m/s) | 2.53 ℃/W |
| 700 ft./min. (3.5m/s) | 2.37 ℃/W |
| 800 ft./min. (4.0m/s) | 2.19 ℃/W |

Chart of Thermal Resistance vs Air Flow

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## 2. INPUT VOLTAGE RANGE

It is important to ensure the input voltage measured at the converter input pins is within the range for that converter.  Make sure wire losses and voltage ripples are accounted for.  One possible problem is driving the converter with a linear unregulated power supply.  For example, if the average voltage measured by a DMM is 9V, with a voltage ripple of 3Vpp, the actual input can swing from 7.5V to 10.5V. This will be outside the specified input range of 10~36V and the converter may not function properly.  On the other end, make sure the actual input voltage does not exceed the highest voltage of 36V or75V.

## 3. LEAD WIRES

Make sure the input and output wires are of adequate AWG size to minimize voltage drop, and ensure the voltage across the input terminals is above the converter's rated minimum voltage at all times.  It is recommended to have the wire pairs twisted, respectively for the input pair and the output pair, so as to minimize noise pickup.

## 4. INPUT CURRENT

The input voltage source must be able to provide enough current to the converter, otherwise it may not start up or operate properly.  A typical symptom is not starting or unusually low output voltage.  In general, it is recommended to be able to provide at least:
**Ipeak = 150%\*Pout/($\eta$\*Vmin)** where Pout is the maximum output power, Vmin is the minimum input voltage and $\eta$ is the converter's efficiency.  As an example, for VHB200W-Q24-S5 to operate with 10~36 V input, 200 W output and an efficiency of 87%, the minimum source current is recommended to be: **Ipeak = 150% \* 200 / (87% \* 10) = 34.48 A**.
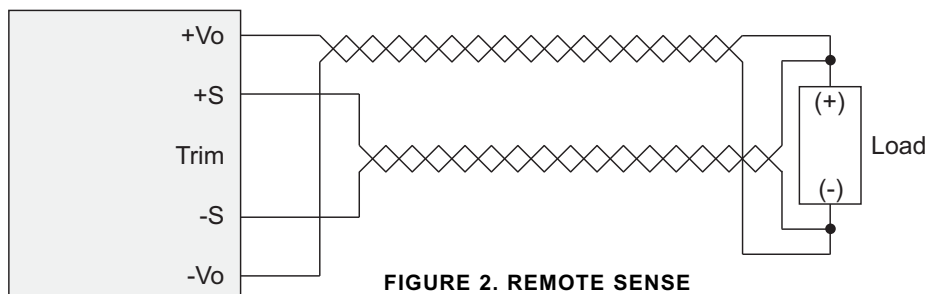
## 5. INPUT FUSE

To limit the input current and to facilitate input reversal protection and input OVP protection, a fast-acting input fuse is recommended for the input line.  The fuse rating will depend on the input range and should allow for the maximum current at the lowest input voltage, as shown in this equation: **Ipeak = 150%\*Pout/($\eta$\*Vmin)**.
In the previous example of VHB200W-Q24-S5, the peak input current at 10V was calculated to be 34.48 A.  A 40 A fuse may be suitable for this application.  Make sure the fuse voltage rating is higher than the maximum input voltage.

## 6. REMOTE SENSE

The converter provides regulated outputs at the output terminals. When there is a large current and/or the output cable is of some length, the voltage at the end of the output cable may be noticeably lower than at the terminals.  The converter can compensate up to 0.5V of voltage drop through remote sense terminals.  To ensure accurate regulation, run two separate wires (twisted) from the desired regulation points to the remote sense terminals, as shown below.



**FIGURE 2. REMOTE SENSE**

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#### 7. OUTPUT TRIMMING (OPTIONAL)

The output voltages are preset to nominal values as indicated by the models table at the factory. If desired, the output voltage may optionally be trimmed to a different value (+/- 10%) with external resistors and/or potentiometer as shown below. Care should be taken to ensure that the maximum ouput power of the module remains at or below the maximum rated power (Maximum rate power = $V_{o,set}$ x $I_{o,max}$).

**FIGURE 3. TRIMMING WITH EXTERNAL POTENTIOMETER**
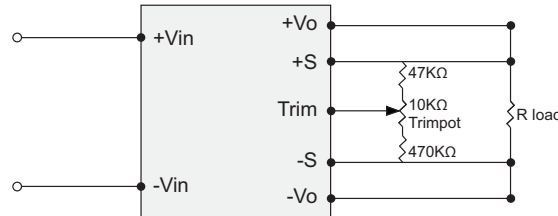


To trim the output voltage with fixed resistors, the output voltage can be calculated as follows.
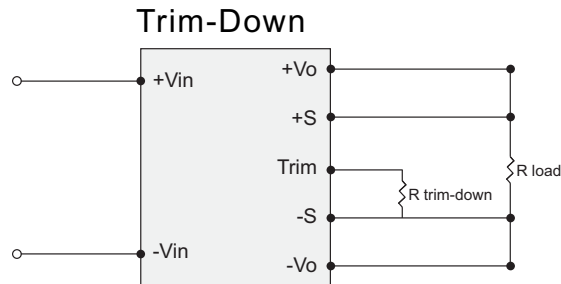
## Trim-Down



**FIGURE 4: TRIM-DOWN VOLTAGE SETUP**

The value of $R_{trim-down}$ is defined as:

$$R_{trim-down} = \left[ \frac{B}{\Delta\%} - C \right] (K\Omega)$$

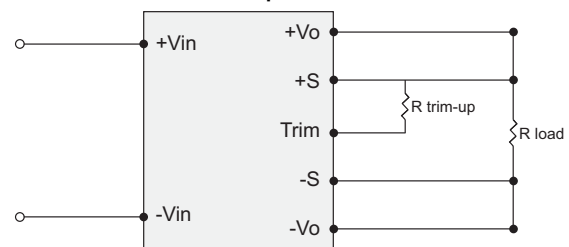$$\Delta\% = \left[ \frac{V_{o,nom} - V_o}{V_{o,nom}} \right] x\ 100$$

Where: $R_{trim-down}$ is the external resistor in $K\Omega$. $V_{o,nom}$ is the nominal output voltage. $V_o$ is the desired output voltage. B and C values are defined in Table 1. For example, to trim-down the 24V module (VHB200W-Q24-S24) by 8% to 22.08V, $R_{trim-down}$ is calculated:

$$B = 511, C = 10.22$$
$$\Delta\% = 8$$

$$R_{trim-down} = \left[ \frac{511}{8} - 10.22 \right] K\Omega$$

$$R_{trim-down} = 53.66\ K\Omega$$

## Trim-Up



**FIGURE 5: TRIM-UP VOLTAGE SETUP**

The value of $R_{trim-up}$ is defined as:

$$R_{trim-up} = \left[ \frac{A(V_o)(100+\Delta\%)}{1.225\ x\ \Delta\%} - \frac{B}{\Delta\%} - C \right] (K\Omega)$$

$$\Delta\% = \left[ \frac{V_o - V_{o,nom}}{V_{o,nom}} \right] x\ 100$$

Where: $R_{trim-up}$ is the external resistor in $K\Omega$. $V_{o,nom}$ is the nominal output voltage. $V_o$ is the desired output voltage. A, B and C values are defined in Table 1. For example, to trim-down the 24V module (VHB200W-Q24-S24) by 8% to 25.92V, $R_{trim-up}$ is calculated:

$$A = 5.11, B = 511, C = 10.22$$
$$\Delta\% = 8$$

$$R_{trim-up} = \left[ \frac{511\ (25.92)\ (100 + 8)}{1.225 + 8} - \frac{511}{8} - 10.22 \right] K\Omega$$

$$R_{trim-up} = 1476.55\ K\Omega$$

Table 1

| Output Voltage(V) | A | B | C |
|---|---|---|---|
| 3, 5, 12, 15, 24, 28V | 5.11 | 511 | 10.22 |
| 48V | 20 | 2000 | 40 |

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## 8. OUTPUT OCP AND SHORT-CIRCUIT PROTECTION

Output overload and short circuit conditional will cause the output voltage to decline or shutdown altogether.   If the case temperature is not over 110°C, the output recovers automatically when the short or OCP conditions are removed.  In the case of slight overloading, the output voltage may not shut down, but the converter may build up heat over time, causing over-temperature shutdown.

## 9. OVER-TEMPERATURE PROTECTION

When the case temperature reaches about 110°C, the converter's built-in protection circuit will shut down the output.  When the temperature is reduced enough to a safe operating level, the converter will recover to normal operations automatically.
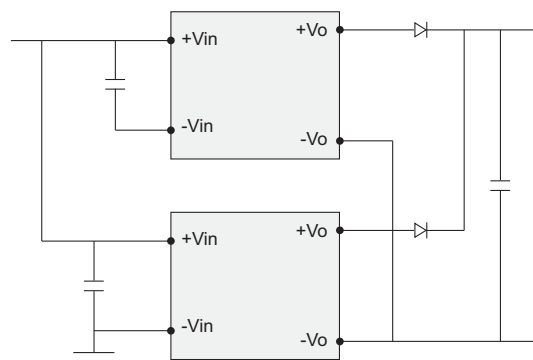
## 10. OUTPUT OVP

In case the output voltage exceeds the OVP threshold, the converter shuts down.

## 11. OUTPUT PARALLEL CONNECTIONS

The converter is not designed for load share on the output.  However, for redundancy, the outputs of two or more converters can be connected in parallel through OR-ing diodes, as shown below.
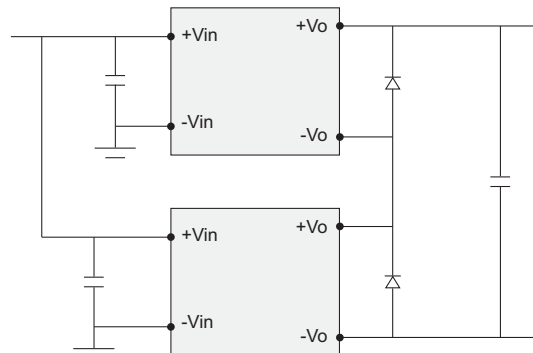
**FIGURE 6. OUTPUT PARALLEL CONNECTIONS**

## 12. OUTPUT SERIES CONNECTIONS

Two or more converters can be connected in series to obtain a higher output voltage.  To prevent output reverse biasing each other in case of a short, add a Schottky diode on each output in reverse polarity, as shown in the diagram.  In the event of a short, the converters will forward-bias the diodes and the output reversal will be limited to one diode drop (about 0.5V) only, so as not to damage the converters.  The forward current will cause each converter to go into short-circuit protection.   For proper diode selection, make sure that: 1) the diodes voltage rating is higher than each converter output; 2) the rated diode current can carry the short-circuit current; 3) the diodes do not overheat before the short is removed.

**FIGURE 7. OUTPUT SERIES CONNECTIONS**

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## 13. REMOTE OUTPUT ON/OFF CONTROL

The converter output can be enabled or disabled through the On/Off pin.  The control logic is shown in this table.  A common control circuit is shown below.
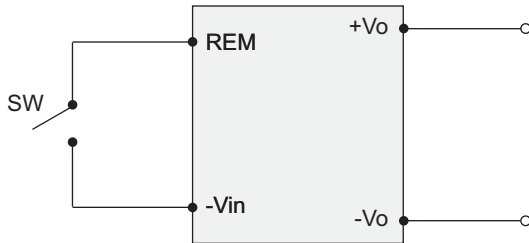


FIGURE 8. REMOTE ON/OFF CONTROL
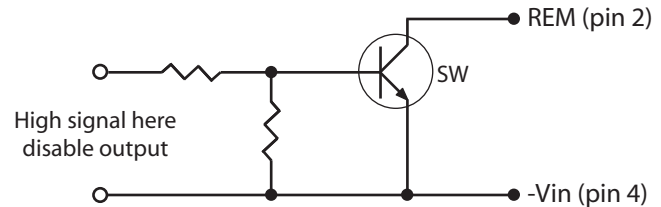


FIGURE 9. REMOTE ON/OFF CONTROL
WITH TRANSISTOR SWITCH

| Logic Table | Negative logic | Positive logic |
|---|---|---|
| SW Closed ($V_{REM}$ <0.8 V) | Output on | Output off |
| SW Open ($V_{REM}$ >2.4 V) | Output off | Output on |

## 14. ISOLATION

The input and output of the converter are electrically isolated.  If needed, an output terminal can be connected to an input terminal, resulting in the converter non-isolated.

## 15. INPUT FILTERING AND EMI INTERFERENCE

The VHB200W converters have input capacitors that control input current ripple and the associated EMI interference.  However, it has not been tested to a formal standard for conducted emissions.  Additional filtering may be needed to ensure compliance to an EMI standard.  Refer to FIGURE 10 for a reference circuit.

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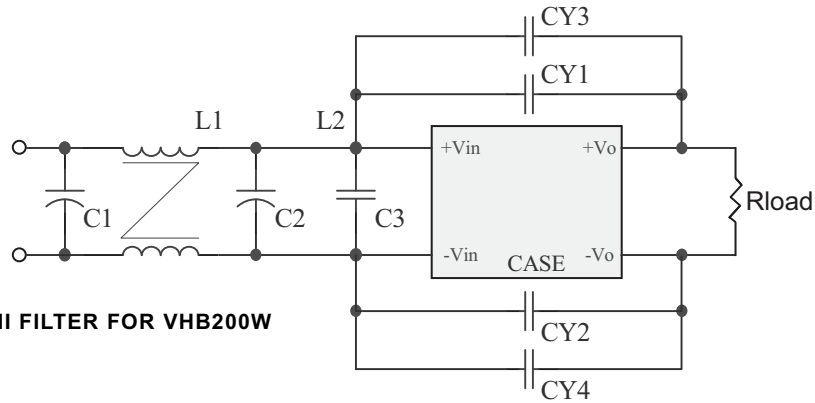## 15. INPUT FILTERING AND EMI INTERFERENCE

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**FIGURE 10. EMI FILTER FOR VHB200W**

| Model No. | | C1 | C2 | C3 | CY1 | CY2 | L1 | CY3 | CY4 |
|---|---|---|---|---|---|---|---|---|---|
| VHB200W-Q24-S5 | Class B | 82uF/100V KY | 82uF/100V KY | 10uF/50V X7R 2220 | NC | 1000pF/2KV | 0.5mH | NC | NC |
| VHB200W-Q24-S12 | Class B | 82uF/100V KY | 82uF/100V KY | 10uF/50V X7R 2221 | 1000pF/2KV | 1000pF/2KV | 0.5mH | NC | NC |
| VHB200W-Q24-S24 | Class B | 120uF/100V KY | 120uF/100V KY | 10uF/50V X7R 2220 | 1000pF/2KV | 1000pF | 0.5mH | NC | NC |
| VHB200W-Q24-S28 | Class A | 100uF/100V KY | 100uF/100V KY | NC | NC | NC | 0.5mH | NC | NC |
| VHB200W-Q24-S28 | Class B | 120uF/100V KY | 120uF/100V KY | 470uF/100V KY | 1000pF/2KV | NC | 0.45mH | 1000pF/2KV | NC |
| VHB200W-Q24-S48 | Class A | 100uF/100V KY | 100uF/100V KY | 100uF/100V KY | 680pF/2KV | 680pF/2KV | 1.0mH | NC | NC |
| VHB200W-Q24-S48 | Class B | 82uF/100V KY | 82uF/100V KY | 4.7uF/100V 2220 | 1000pF/2KV | 1000pF/2KV | 0.45mH | 680pF/2KV | 680pF/2KV |
| | | | | | | | | | |
| VHB200W-Q48-S5 | Class B | 82uF/100V KY | 82uF/100V KY | 4.7uF/100V X7R 2220 | NC | 680pF/2KV | 0.5mH | NC | NC |
| VHB200W-Q48-S12 | Class B | 120uF/100V KY | 120uF/100V KY | 4.7uF/100V X7R 2220 | 1000pF/2KV | 680pF/2KV | 0.5mH | NC | NC |
| VHB200W-Q48-S24 | Class B | 120uF/100V KY | 120uF/100V KY | 4.7uF/100V X7R 2220 | 1500pF/2KV | 680pF/2KV | 0.5mH | NC | NC |
| VHB200W-Q48-S28 | Class A | 150uF/100V KY | 150uF/100V KY | NC | NC | NC | 0.5mH | NC | NC |
| VHB200W-Q48-S28 | Class B | 120uF/100V KY | 120uF/100V KY | 470uF/100V KY | 1000pF/2KV | NC | 0.45mH | 1000pF/2KV | 680pF/2KV |
| VHB200W-Q48-S48 | Class A | 100uF/100V KY | 100uF/100V KY | 100uF/100V KY | 680pF/2KV | 680pF/2KV | 1.0mH | NC | NC |
| VHB200W-Q48-S48 | Class B | 82uF/100V KY | 82uF/100V KY | 4.7uF/100V 2220 | 2200pF/2KV | 2200pF/2KV | 0.45mH | NC | 680pF/2KV |

**NOTE: The recommended components are a starting point <u>but not guaranteed</u> for meeting EMI**

**requirements.   More or less filtering may be required for a specific application or to meet other EMI standards.**

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### 16. OUTPUT FILTERING

The converter has built-in capacitors at the output to control ripple and noise. If desired, additional output capacitance can be introduced at the input to the powered equipment. Recommended starting point: one 10μF tantalum and one 1μF ceramic capacitor in parallel at the output.

### 17. OUTPUT NOISE MEASUREMENT SCHEMATIC

For proper output ripple and noise measurement, connect a 10μF tantalum and a 1μF ceramic capacitor across the output. Set the scope bandwidth to 20MHz. Probe directly off of one of the capacitors, using a small ground clip to minimize measurement error.
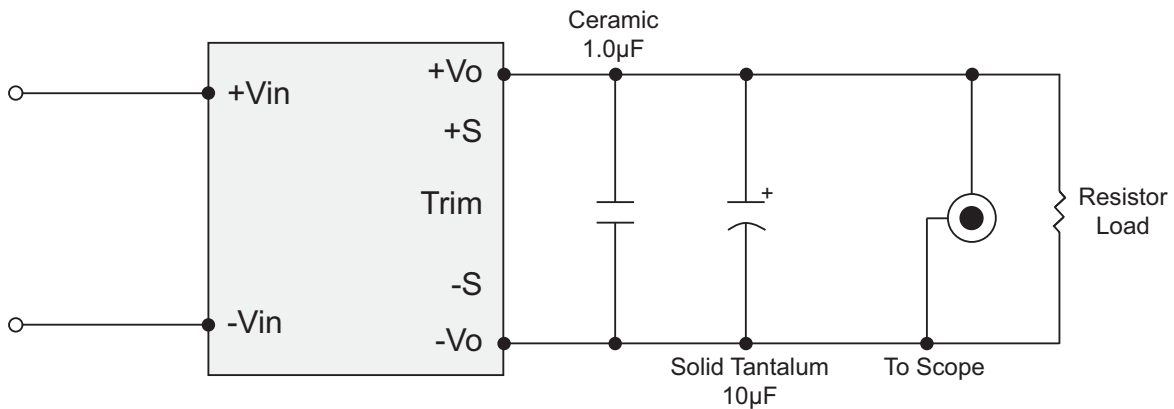


**FIGURE 11. OUTPUT NOISE MEASUREMENT CIRCUIT**

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