

## 12V 60A Quarter Brick Converter



### Features

- High efficiency, 94.5% (12V/60A)
- Excellent thermal performance
- Fully regulated output voltage
- Over-voltage, over-current, short-circuit and over-temperature protections
- Monotonic start-up
- Fixed frequency operation
- Basic Insulation, 2,250Vdc input-to-output isolation
- UL 62368-1 2nd edition recognized†



### Options

- Baseplate
- Auto-restart / Latch off after fault shutdown
- Negative / Positive enable logic
- Output voltage adjustment (Trim)
- Parallel operation
- Case ground pin
- Synchronous startup

### Part Numbering System

QBE	4	120	□	060	□	□	□
Series Name	Input Voltage	Output Voltage	Enabling Logic	Rated Output Current	Pin Length Options	Electrical Options	Mechanical Options
							Lead-free (ROHS-6 Compliant)
	4: 36-75V	Unit: 0.1V 120: 12V	P: Positive N: Negative	Unit: A 060: 60A	K: 0.110" N: 0.145" R: 0.180"	5: Latch off 6: Parallel & latch off 7: Auto-restart 8: Trim & latch off 9: Trim & auto-restart A: Parallel & auto-restart S: Parallel & auto-restart with S-Pin for synchronous startup	5: Open-frame 6: Baseplate 8: Baseplate & case pin (this option is available when "Electrical Option" is not "S")

† UL is a registered trademark of Underwriters Laboratory Inc.

## Absolute Maximum Rating

Excessive stresses over these absolute maximum ratings can cause permanent damage to the converter. Operation should be limited to the conditions outlined under the Electrical Specification Section.

Parameter	Min	Max	Unit
Input Voltage (continuous)	-0.5	75	Vdc
Input Voltage (< 100ms, operating)	-	100	Vdc
Input Voltage (continuous, non-operating)	-	100	Vdc
Operating Ambient Temperature (See Thermal Considerations section)	-40	85*	°C
Storage Temperature	-55	125	°C

\* Derating curves provided in this datasheet end at 85°C ambient temperature. Operation above 85°C ambient temperature is allowed provided the temperatures of the key components or the baseplate do not exceed the limit stated in the Thermal Considerations section.

## Electrical Specifications

These specifications are valid over the converter's full range of input voltage, resistive load, and operating temperature unless noted otherwise.

### Input Specifications

Parameter	Min	Typical	Max	Unit
Input Voltage	36	48	75	Vdc
Input Current	-	-	24	A
Quiescent Input Current (typical Vin)	-	140	160	mA
Standby Input Current	-	4	6	mA
Input Reflected-ripple Current, Peak-to-peak (5 Hz to 20 MHz, 12 µH source impedance)	-	20	-	mA
Input Turn-on Voltage Threshold	34	35	36	V
Input Turn-off Voltage Threshold	32	33	34	V
Input Voltage ON/OFF Hysteresis	1	2	3	V

### Output Specifications

Parameter	Min	Typical	Max	Unit
Output Voltage Set Point (typical Vin; full load; Ta = 25°C)	11.8	12.0	12.2	Vdc
Output Voltage Set Point Accuracy (typical Vin; full load; Ta = 25°C)	-1.5	-	+1.5	%Vo
Output Voltage Set Point Accuracy (over all conditions)	-3	-	+3	%Vo
Output Regulation:				
Line Regulation (full range input voltage, 1/2 full load)	-	0.05	0.2	%Vo
Load Regulation <sup>1</sup> (full range load, typical Vin)	-	0.05	0.2	%Vo
Temperature (Ta = -40°C to 85 °C)	-	15	50	mV
Output Ripple and Noise Voltage				
RMS	-	140	180	mVrms
Peak-to-peak (5 Hz to 20 MHz bandwidth, typical Vin)	-	180	220	mVp-p
Output Current	0	-	60	A
Output Power	0	-	720	W

<sup>1</sup> Output voltage will droop with increasing load current when the parallel option is selected to enhance the accuracy of current sharing among modules connected in parallel.

**Output Specifications (Continued)**

Parameter	Min	Typical	Max	Unit	
Efficiency, (typical $V_{in}$ ; $T_a = 25^\circ\text{C}$ )	$I_o = 60\text{A}$	-	94.5	-	%
	$I_o = 30\text{A}$	-	95.8	-	
Output Ripple Frequency	280	330	380	kHz	
External Load Capacitance	0	-	20,000	$\mu\text{F}$	
Startup Delay (from enabling to $V_o$ reaching 10% of set point, typical $V_{in}$ ; full load, $T_a = 25^\circ\text{C}$ )	2.5	4	5.5	ms	
Startup Time ( $V_o$ from 10% to 90% of output set point, zero load, 1000 $\mu\text{F}$ output external capacitance, $T_a = 25^\circ\text{C}$ )	4	6	8	ms	
Output Over Current Protection Set Point	65	72	80	A	
Output Over Voltage Protection Set Point	13.5	15.0	16.5	V	
Output Trim Range in % of typical $V_o$	80	-	110	%	
Output Current Sharing Accuracy (at rated load)	-	-	10	%	
Dynamic Response (typical $V_{in}$ ; $T_a = 25^\circ\text{C}$ ; load transient 0.1A/ $\mu\text{s}$ )					
Load step from 25% to 75% of $I_o$ ,max:					
Peak deviation		3		% $V_o$	
Settling time (within 10% band of $V_o$ deviation)		300		$\mu\text{s}$	
Load step from 75% to 25% of full load:					
Peak deviation		3		% $V_o$	
Settling time (within 10% band of $V_o$ deviation)		300		$\mu\text{s}$	

**General Specifications**

Parameter	Min	Typical	Max	Unit
Remote Enable				
Logic Low:				
ION/OFF = 1.0mA	0	-	1.2	V
VON/OFF = 0.0V	-	-	1.0	mA
Logic High:				
ION/OFF = 0.0 $\mu\text{A}$	3.5	-	15	V
Leakage Current	-	-	50	$\mu\text{A}$
Isolation Capacitance	-	2,700	-	pF
Insulation Resistance	10	-	-	M $\Omega$
Calculated MTBF (Telecordia SR-332, 2011, Issue 3), $I_o$ ,max, 40 $^\circ\text{C}$ , typical input voltage	-	4.3	-	10 <sup>6</sup> -hour

## Characteristic Curves

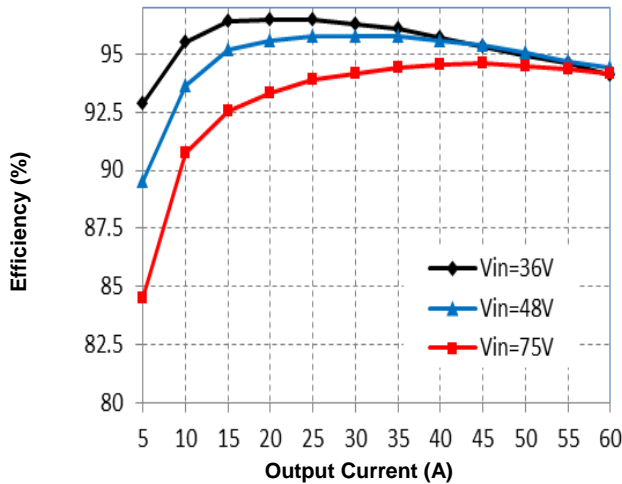


Figure 1. Efficiency vs. Load Current (25°C)

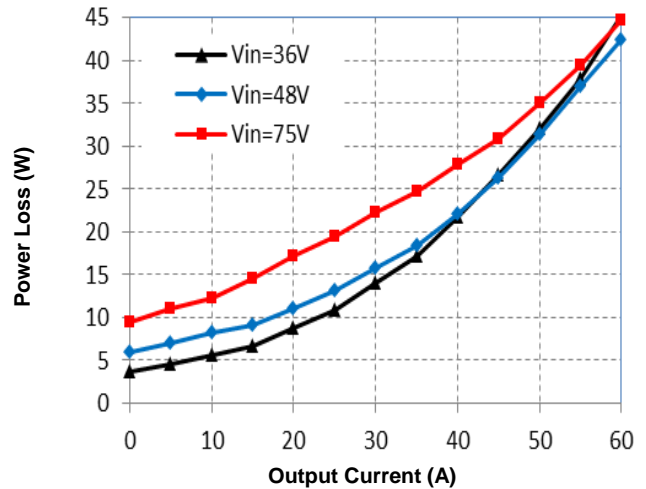


Figure 2. Power Loss vs. Load Current (25°C)

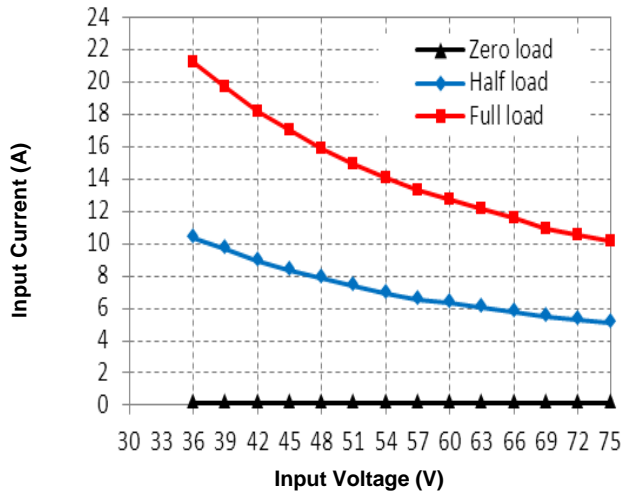


Figure 3. Input Characteristic (25°C)

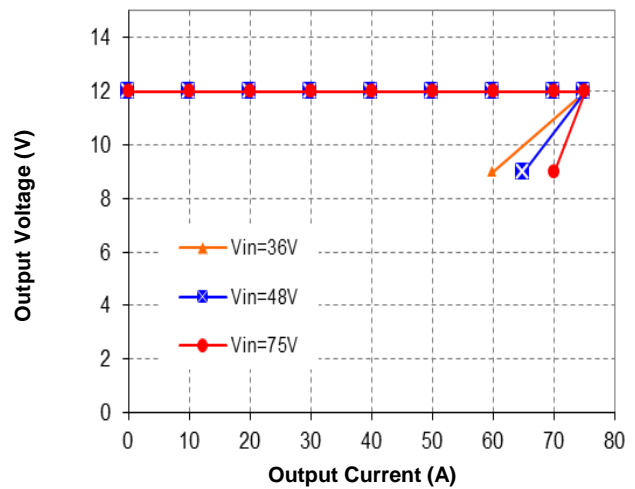


Figure 4. Output Characteristic (Non-parallel; 25°C)

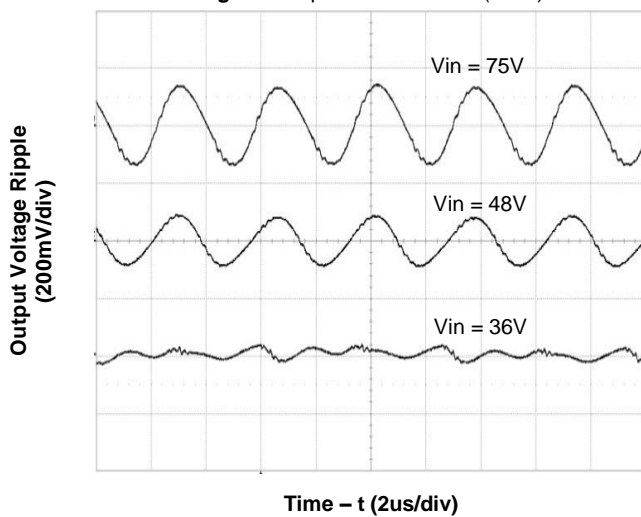


Figure 5. Output Ripple Voltage at Full Load

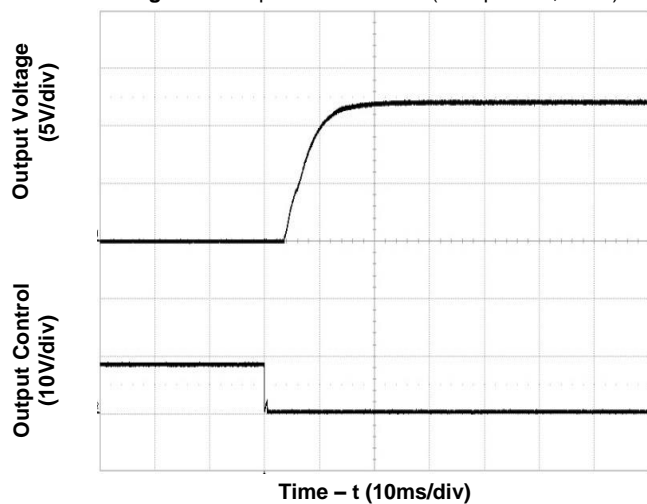
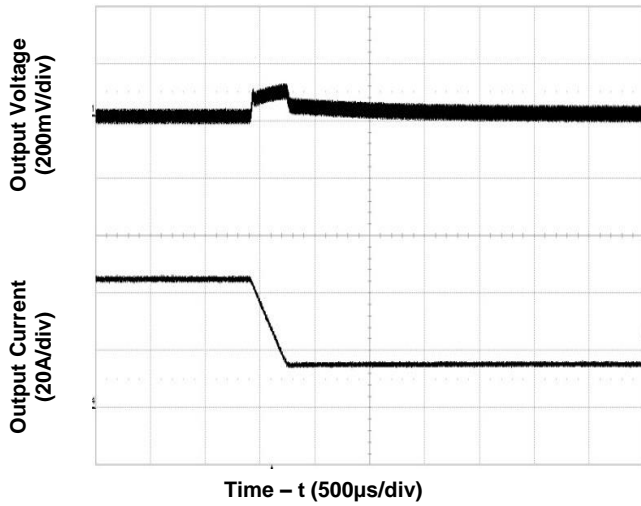
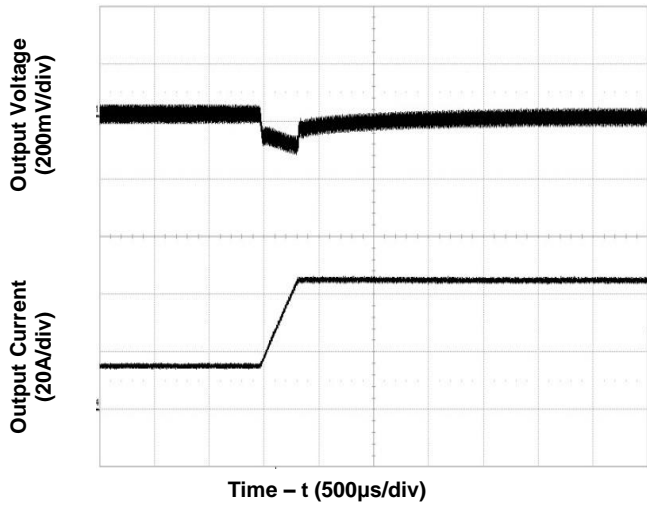


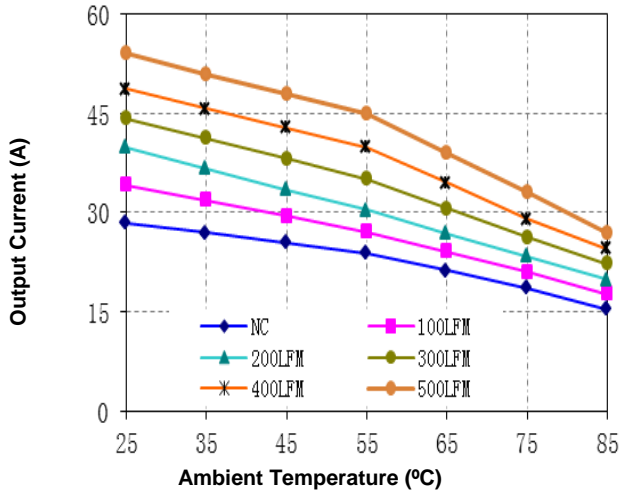
Figure 6. Start-Up from Enable Control (typical Input voltage and zero load)



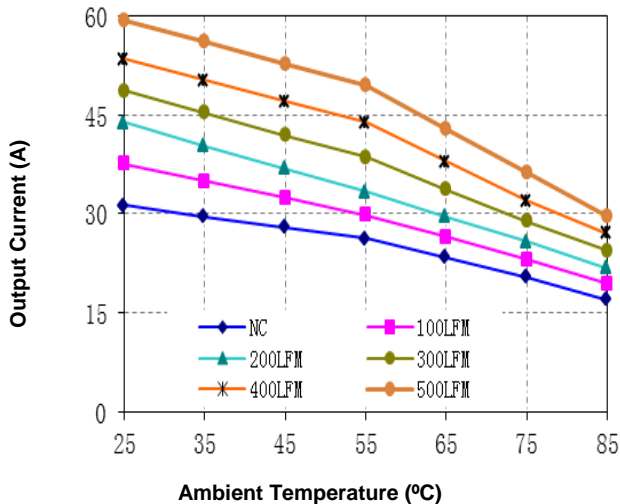
**Figure 7. Transient Load Response**  
(typical Vin, load current steps from 75% to 25% at a slew rate 0.1A/µs)



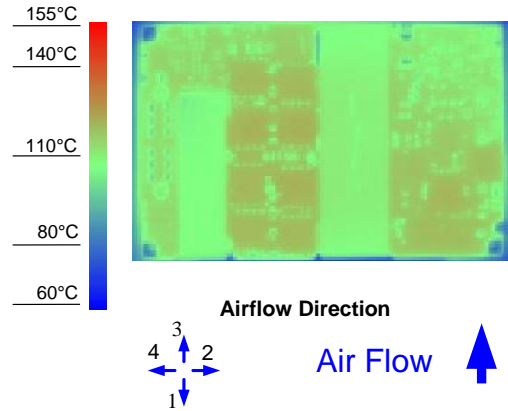
**Figure 8. Transient Load Response**  
(typical Vin, load current steps from 25% to 75% at a slew rate 0.1A/µs)



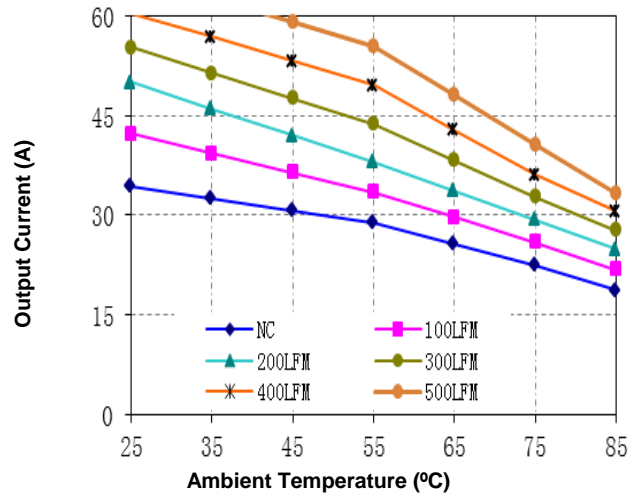
**Figure 9. Derating Curve for Airflow Direction 3**  
(Ref. Figure 10 for Airflow Direction; Vin = 48V; open frame unit)



**Figure 11. Derating Curve for Airflow Direction 3**  
(Ref. Figure 10 for Airflow Direction; Vin = 48V; unit with baseplate)



**Figure 10. Thermal Image for Airflow Direction 3**  
(30A output, 55°C ambient, 200 LFM, typical Vin)



**Figure 12. Derating Curve for Airflow Direction 3**  
(Ref. Figure 10 for Airflow Direction; Vin = 48V; unit with baseplate + 1/2" heatsink)

## Feature Descriptions

### Remote ON/OFF

The converter can be turned on and off by changing the voltage between the ON/OFF pin and  $V_{in(-)}$ . The QBE4 Series of converters are available with factory selectable positive logic or negative enabling logic.

For the negative control logic, the converter is ON when the ON/OFF pin is at a logic low level and OFF when the ON/OFF pin is at a logic high level. With positive control logic, the converter is ON when the ON/OFF pin is at a logic high level and OFF when the ON/OFF pin is at a logic low level.

With the internal pull-up circuitry, a simple external switch between the ON/OFF pin and  $V_{in(-)}$  can control the converter. A few example circuits for controlling the ON/OFF pin are shown in Figures 13, 14 and 15.

The logic low level is from 0V to 1.2V and the maximum sink current during logic low is 1mA. The external switch must be capable of maintaining a logic-low level while sinking up to this current. The logic high level is from 3.5V to 15V. The converter has an internal pull-up circuit that ensures the ON/OFF pin at a high logic level when the leakage current at ON/OFF pin is no greater than 50 $\mu$ A.

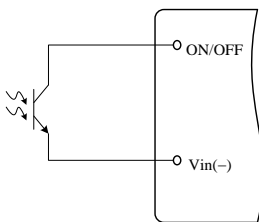


Figure 13: Opto Coupler Enable Circuit

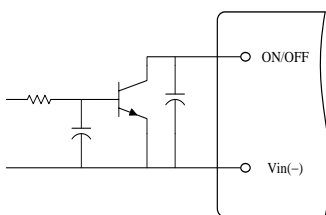


Figure 14: Open Collector Enable Circuit

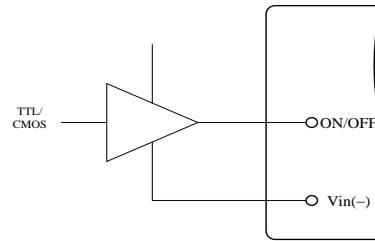


Figure 15: Direct Logic Drive

### Output Voltage Adjustment (optional)

Output Voltage Adjustment (Trim) function is an optional feature. If this feature is selected, a trim pin is available at the output side of the QBE4 converter. The trim pin allows the user to adjust the output voltage set point. To increase the output voltage, an external resistor is connected between the TRIM pin and  $V_o(+)$  pin. To decrease the output voltage, an external resistor is connected between the TRIM pin and  $V_o(-)$  pin. The output voltage trim range is 80% to 110% of its specified typical output voltage.

The circuit configuration for trim down application is shown in Figure 16. To decrease the output voltage set point, the value of the external resistor can be set by

$$R_{down} = \left( \frac{511}{\Delta} - 10.22 \right) (k\Omega)$$

Where

$$\Delta = \frac{|V_{nom} - V_{adj}|}{V_{nom}} \times 100$$

and

$V_{nom}$  = Nominal Output Voltage

$V_{adj}$  = Adjusted Output Voltage

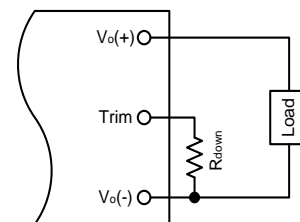
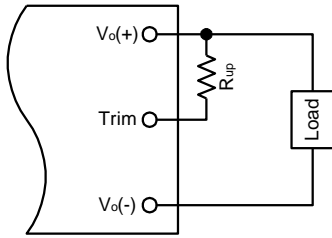


Figure 16: Circuit to Decrease Output Voltage Set Point

The circuit configuration for trim up operation is shown in Figure 17. To increase the output voltage, the value of the resistor should be

$$R_{up} = \left\{ \frac{5.11V_{nom}(100 + \Delta)}{1.225\Delta} - \frac{511}{\Delta} - 10.22 \right\} (\text{k}\Omega)$$



**Figure 17.** Circuit to Increase Output Voltage Set Point

When using the trim up function, the output power goes up for the same output current. It is important not to exceed the maximum power rating of the converter as given in the Specifications table.

### Input Under-Voltage Lockout

This feature prevents the converter from starting until the input voltage reaches the turn-on voltage threshold, and keeps the converter running until the input voltage falls below the turn-off voltage threshold. Both turn-on and turn-off voltage thresholds are defined in the Input Specifications table. The hysteresis prevents oscillations.

### Output Over-Current Protection (OCP)

This converter can be ordered in either latch-off or auto-restart version upon OCP, OVP, and OTP.

With the latch-off version, the converter will latch off when the load current exceeds the limit. The converter can be restarted by toggling the ON/OFF switch or recycling the input voltage.

With the auto-restart version, the converter will operate in a hiccup mode (repeatedly try to restart) until the cause of the over-current condition is cleared.

### Output Over-Voltage Protection (OVP)

With the latch-off version, the converter will latch off when the output voltage exceeds the limit. The converter can be restarted by toggling the ON/OFF switch or recycling the input voltage.

With the auto-restart version, the converter will operate in a hiccup mode (repeatedly try to restart) until the cause of the over-voltage condition is cleared.

### Over Temperature Protection (OTP)

With the latch-off version, the converter will shut down and latch off if an over-temperature condition is detected. The converter has a temperature sensor located at a carefully selected position in the converter circuit board, which represents the thermal condition of key components of the converter. The thermal shutdown circuit is designed to turn the converter off when the temperature at the sensor reaches 120°C. The module can be restarted by toggling the ON/OFF switch or recycling the input voltage.

With the auto-restart version, the converter will resume operation after the converter cools down.

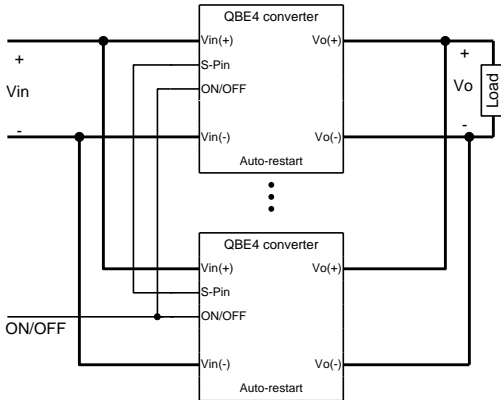
### Current Sharing Operation (optional)

QBE4 converter can be ordered as parallel version for output power expansion and/or N+1 redundancy application. When parallel feature is selected trim function is disabled and the trim pin must be left "No-connection".

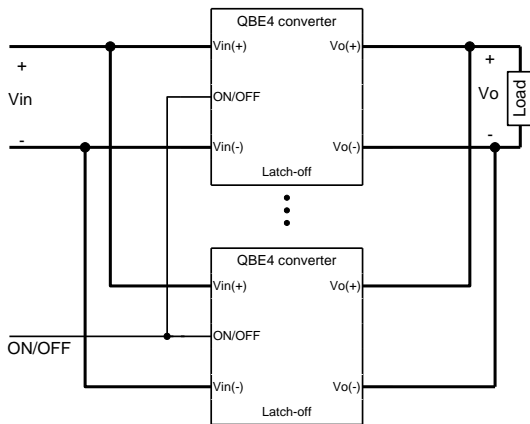
At no load condition, the converter output voltage is set to 12.5V. With the load current increasing, the output voltage is linearly decreasing. At full load, the output voltage reaches 11.6V. Such droop characteristics allow two or more converters operating in parallel to share the load current.

NetPower's QBE4 converters can operate in parallel without using ORing devices. Figure 18 shows the connection diagram of auto-restart converters without ORing devices for parallel operation. The converter is designed with synchronous startup feature, which is mandatory for auto-restart protection converters to operate in parallel without using ORing devices. By connecting the "S" pins of the converters together, these paralleled converters will start up and shut down at the same time. This connection diagram is not suitable for N+1 redundancy application.

If converters with latch-off protection are used, the synchronous startup feature is not needed (the "S" pin is not available for latch-off version). In the event of a fault protection, the faulty converter will be latched off. The paralleled converters can be restarted by toggling the ON/OFF signal. Figure 19 shows the connection diagram of latch-off converters in parallel without ORing devices.

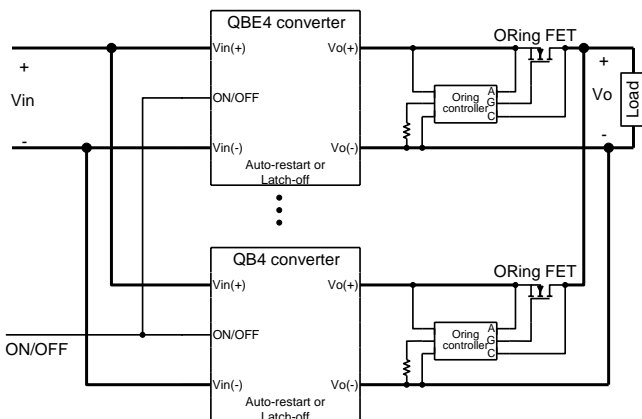


**Figure 18.** The connection diagram of parallel version auto-restart QBE4 converters without ORing devices for power expansion



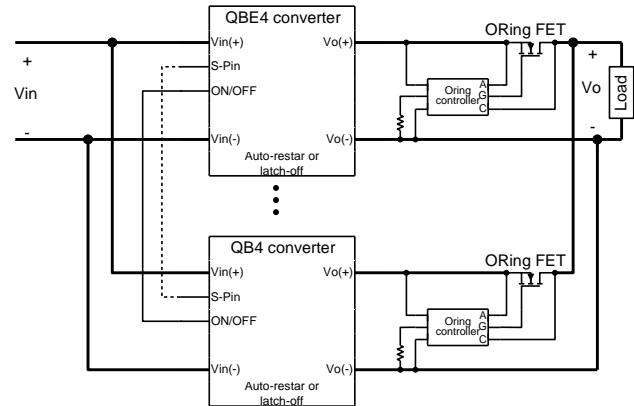
**Figure 19.** The connection diagram of parallel version latch-off QBE4 converters without ORing devices for power expansion

However, for N+1 application, an ORing device at the output of each QBE4 converter is needed and the synchronous startup/shutdown feature should not be used. The “S” pin should be left open if the part number is with “S” pin option. Figure 20 shows the connection diagram for N+1 application.



**Figure 20.** The connection diagram of QBE4 converters for N+1 application and/or power expansion

If ORing devices are used in the paralleled converters only for power expansion purpose, QBE4 converter with synchronous startup feature is recommended but not mandatory (A part number without “S” pin can be used). Figure 21 shows the connection diagram of auto-restart/latch-off converters in parallel with ORing devices for power expansion.



**Figure 21.** The connection diagram of parallel version auto-restart/latch-off QBE4 converters with ORing devices

## Design Considerations

As with any DC/DC converter, the stability of the QBE4 converters may be compromised if the source impedance is too high or inductive. It's desirable to keep the input source ac-impedance as low as possible. Although the converters are designed to be stable without adding external input capacitors for typical source impedance, it is recommended to add 100  $\mu$ F low ESR electrolytic capacitors at the input of the converter for each 100W output power, which reduces the potential negative impact of the source impedance on the converter stability. These electrolytic capacitors should have sufficient RMS current rating over the operating temperature range.

The converter is designed to be stable without additional output capacitors. To further reduce the output voltage ripple or improve the transient response, additional output capacitors are often used in applications. When additional output capacitors are used, a combination of ceramic capacitors and tantalum/polymer capacitors shall be used to provide good filtering while assuring the stability of the converter.



## Safety Considerations

The QBE4 Series of converters is designed in accordance with EN 62368 Safety of Information Technology Equipment Including Electrical Equipment. The converters meet the requirements in UL 62368, Safety of Information Technology Equipment and applicable Canadian Safety Requirement, and ULc 62368. Flammability ratings of the PWB and plastic components in the converter meet 94V-0.

To protect the converter and the system, an input line fuse is highly recommended on the un-grounded input end.

## Thermal Considerations

The QBE4 Series of converters can operate in various thermal environments. Due to the high efficiency and optimal heat distribution, these converters exhibit excellent thermal performance.

The maximum allowable output power of any power converter is usually determined by the electrical design and the maximum operating temperature of its components. The QBE4 Series of converters have been tested comprehensively under various conditions to generate the derating curves with the consideration for long term reliability.

The thermal derating curves are highly influenced by the test conditions. One of the critical variables is the interface method between the converter and the test fixture board. There is no industry standard to define the method for the derating tests. Common test methods are using sockets to plug in the converter, or soldering the converter into the fixture board. It should be noticed that these two methods produce significantly different results for a given converter. When the converter is soldered into the fixture board, the thermal performance of the converter is significantly improved compared with the method using sockets due to the reduction of the contact loss and the thermal impedance from the pins to the fixture board. Other factors affecting the results include the board spacing, construction (especially copper weight, holes and openings) of the fixture board and the spacing board, temperature measurement method and ambient temperature measurement point. The thermal derating curves in this datasheet are obtained using a PWB fixture board and a PWB spacing board with no opening, a board-to-board spacing of 1", and the converter is soldered to the test board with thermal relieves.

Note that the natural convection condition was measured at 0.05 m/s to 0.15 m/s (10ft. /min. to 30 ft. /min).

### Heat Transfer without a Baseplate

With single-board DC/DC converter designs, convection heat transfer is the primary cooling means for converters without a baseplate. Therefore, airflow speed should be checked carefully for the intended operating environment. Increasing the airflow over the converter enhances the heat transfer via convection.

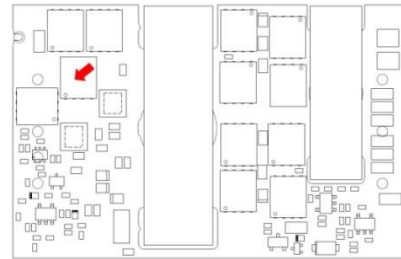


Figure 22. Temperature Monitoring Location (top side)

Figure 22 shows a recommended temperature monitoring point for open frame modules. For reliable operation, the temperature at this location should not continuously exceed 120 °C.

### Heat Transfer with a Baseplate

The QBE4 Series of converters have the options of using a baseplate for enhanced thermal performance.

The typical height of the converter with the baseplate option is 0.50". The use of an additional heatsink or cold-plate can further improve the thermal performance of the converter. With the baseplate option, a standard quarter-brick heatsink can be attached to the converter using M3 screws.

For reliable operation, the baseplate temperature should not continuously exceed 100 °C.

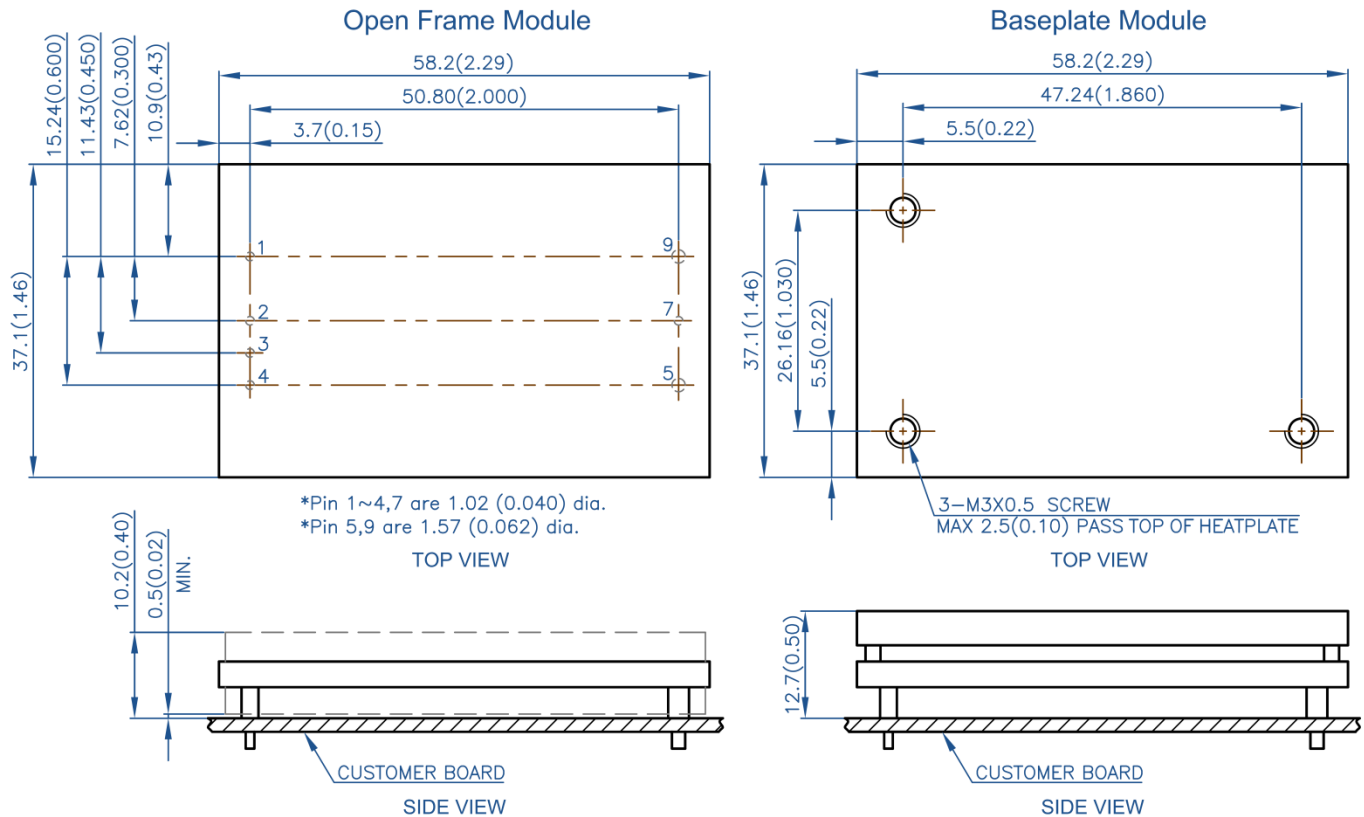
## EMC Considerations

The EMC performance of the converter is related to the layout and filtering design of the customer board.

Careful layout and adequate filtering around the converter are important to confine noise generated by the switching actions in the converter and to optimize system EMC performance.



## Mechanical Drawing



Pin	Name	Function
1	Vin(+)	Positive input voltage
2	ON/OFF	Remote control
3	CASE/S-Pin	Case ground pin / Synchronous startup (optional)
4	Vin(-)	Negative input voltage
5	Vout(-)	Negative output voltage
7	TRIM	Output voltage adjustment (optional)
9	Vout(+)	Positive output voltage

## Notes

- All dimensions in mm (inches)  
Tolerances: .x ± .5 (.xx ± 0.02)  
.xx ± .25 (.xxx ± 0.010)
- Input and function pins are 1.02mm (0.040") dia. with +/- 0.10mm (0.004") tolerance. The recommended diameter of the receiving hole is 1.42mm (0.056").
- Output pins are 1.57 mm (0.062") dia. with +/- 0.10mm (0.004") tolerance. The recommended diameter of the receiving hole is 1.98mm (0.078").
- All pins are coated with 90%/10% solder, Gold, or Matte Tin finish with Nickel under plating.
- Weight: 45 g open frame converter  
65 g baseplate converter
- Workmanship meets or exceeds IPC-A-610 Class II.
- Torque applied on screw should not exceed 6in-lb. (0.7 Nm).
- Baseplate flatness tolerance is 0.10mm (0.004") TIR for surface.
- If M3 screws are used to attach a heatsink to the baseplate, the screw length from the top surface of baseplate going down should not exceed 2.5mm (0.10") max.