High Density - Board Mounted Power

APPLICATION NOTE

QBS and QES Series

QBS and QES Power Converters

POWER ONE HIGH DENSITY BOARD MOUNTED POWER

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QBS-QES Application Note Rev. 1d June 8, 2000

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Introduction:

The QBS and QES series of Power Converters continue the Power-One story of innovation in the world of high density power conversion: **OPEN FRAME CONSTRUCTION WITH EXTREMELY HIGH POWER DENSITY!**

The QBS series provides up to 150 watts of isolated output power, in a novel **1.45 BY 2.28 inch ONE-QUARTER BRICK SIZE**, from wide range inputs of 24 or 48 Volts DC. It is available with output voltages factory set to 12 or 15.0 Volts DC.

The QES series provides up to 100 watts of isolated output power, in the same **1.45 BY 2.28 inch ONE-QUARTER BRICK SIZE**, from wide range inputs of 24 or 48 Volts DC. It is available with output voltages factory set to 2.5, 3.3 or 5.0 Volts DC.

A trim feature on both models allows the user to fine tune the output for specific needs. High operating efficiency permits the very high output power densities of 90.7 Watts (QBS) and 60.5 Watts (QES) per cubic inch.

The design features of the QBS/QES series set a new standard for high density power converters, and establish Power-One as the forerunner in high reliability telecommunications power control. The units employ a multi-layer IMS substrate to carry all of the power components, and conduct the dissipated heat to the ambient. A conventional, multi-layer printed circuit board, over the top of the power substrate, contains all of the small signal control circuitry. Both are constructed with automated SMD technology.

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Open Frame Construction:

The OPEN FRAME CONSTRUCTION provides several major advantages over conventional encapsulated power modules:

- All of the control components are significantly cooler, since they are not thermally linked to the hot power components.
- All the components enjoy superior cooling in a forced air environment, since the air stream can flow through the entire unit.
- The unit is truly water washable. There are no "secret" places which entrap water or other contaminants. All of the magnetic windings are sealed.
- The weight is much less than that of an encapsulated unit of the same volume.
- The reduced component temperature of the control board, and all of the integrated circuits, results in a much superior MTBF under identical conditions.
- The real component quality, and construction quality, is readily visible. There is nothing hidden or concealed.
- There is no degradation in radiated EMI compared to an identical unit encapsulated in a plastic box.

Design Features:

The DESIGN FEATURES show state-of-the-art technology at its finest:

- Planar magnetics run cooler, and give higher operating efficiency.
- The isolated outputs of the QES series use synchronous rectification, and feature 82 to 88 per-cent conversion efficiency, depending upon model.
- Trim capability on the output permits customized output voltages, or margining in production tests.
- The size is a smaller than a standard "half-brick".
- The output power (QBS) is equal to that from a standard "half-brick".
- The output is over-voltage protected with a unique circuit which implements a separate voltage control detector. If the voltage at the output reaches the protection level the unit will turn completely off and latch. But the latch can be reset by either the normal method or removing the input voltage, or by turning the unit off with the control pin and then restarting.
- The output is over-load and short circuit protected with a unique circuit which uses a separate output voltage detector. If the voltage at the output reaches the under-voltage threshold level as a result of an overload on the unit, it will operate for a fixed time and then turn completely off and latch. This latch, also, can be reset by either the normal method or removing the input voltage, or by turning the unit off with the control pin and then restarting.
- Thermal design using infrared thermal imaging allows "hot spots" to be engineered out of the product.

QBS to QES Model Distinction:

- The QBS series offers output voltages from 2.50 to 15.0 Volts. Other output voltages, both higher and lower are available as customs.

- The QBS series features high operating efficiencies ranging from 76 to 86 %, depending upon the output voltage, input voltage and output power.

- The QBS series features standard rectification and can be directly paralleled, without combining diodes, for a higher output power. Using external current sharing, up to 300 watts of output power can be obtained from the module board area of a standard “half-brick”.

- The QBS series, because of the extremely high output power densities which are obtained, requires careful attention to external thermal management.

- The QES series offers output voltages of 1.80, 2.10, 2.50 and 3.30 Volts. Other output voltages, lower than 5.0 VDC, are available as customs.

- The QES series features extremely high, state of the art, operating efficiencies ranging from 80 to 86 %, depending upon the output voltage, input voltage and output power.

- The QES series features synchronous rectification to obtain the high operating efficiency. This topology cannot directly paralleled. Combining diodes are required for a higher output power.

- The QES series requires less careful attention to external thermal management than the QBS series, and can operate to higher ambient temperatures with the same volume of heat sink.

- All of the other features of the QBS and QES series, including the control (shutdown or ON/OFF), the trim capability the output over-voltage, under-voltage and short circuit protection and the input under-voltage lockout features are identical.

Models in the QBS Series:

There are presently fourteen models in the QBS series, all with either an 18 to 36 or a 36 to 75 VDC operating input voltage range. They differ by output voltage and output current capability.

Vout VDC	Iout ADC	Model	Vin VDC	Pout Watts	Effic, Typ.
2.50	15.00	QBS038YD-A	18-36	38.0	76%
3.30	15.00	QBS050YE-A	18-36	50.0	80%
5.00	15.00	QBS075YG-A	18-36	75.0	84%
12.00	8.33	QBS100YH-A	18-36	100.0	85%
15.00	6.67	QBS100YJ-A	18-36	100.0	85%
12.00	10.00	QBS120YH-A	18-36	150.0	83%
15.00	10.00	QBS150YJ-A	18-36	150.0	83%
2.50	15.00	QBS038ZD-A	36-75	38.0	77%
3.30	15.00	QBS050ZE-A	36-75	50.0	81%
5.00	15.00	QBS075ZG-A	36-75	75.0	83%
12.00	8.33	QBS100ZH-A	36-75	100.0	86%
15.00	6.67	QBS100ZJ-A	36-75	100.0	86%
12.00	10.00	QBS120ZH-A	36-75	120.0	84%
15.00	10.00	QBS150ZJ-A	36-75	150.0	84%

QBS Model Numbering Convention:

QBS - XXX - Y - Z - A - NT

Series	Output Power (38, 50, 75, 100, 120, 150 Watts)	Vin (Y = 24 Vin) (Z = 48 Vin)	Vout (D = 2.50 Vout) (E = 3.30 Vout) (G = 5.00 Vout) (H = 12.0 Vout) (J = 15.0 Vout)	Open Frame Unit	Logic/Trim Options (Blank = Standard) (-N = Neg. Logic (-NT = Neg. Logic, Positive Trim)

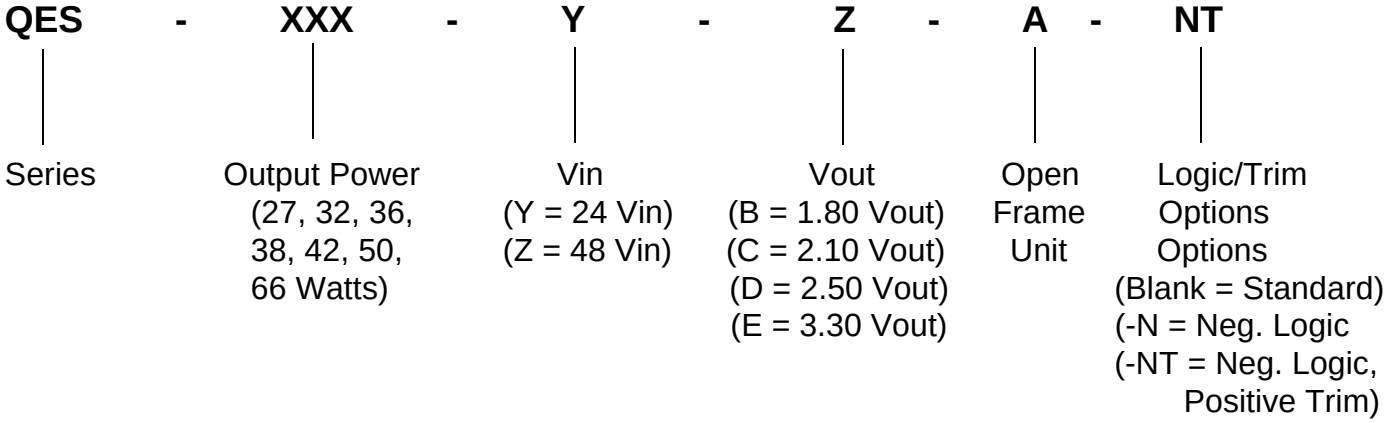
Custom QBS models with alternate input voltage, or input voltage range, or different output voltages are available. Consult the Power-One factory.

Models in the QES Series:

There are presently sixteen models in the QES series, all with either an 18 to 36 or a 36 to 75 VDC operating input voltage range. They differ by output voltage and output current capability.

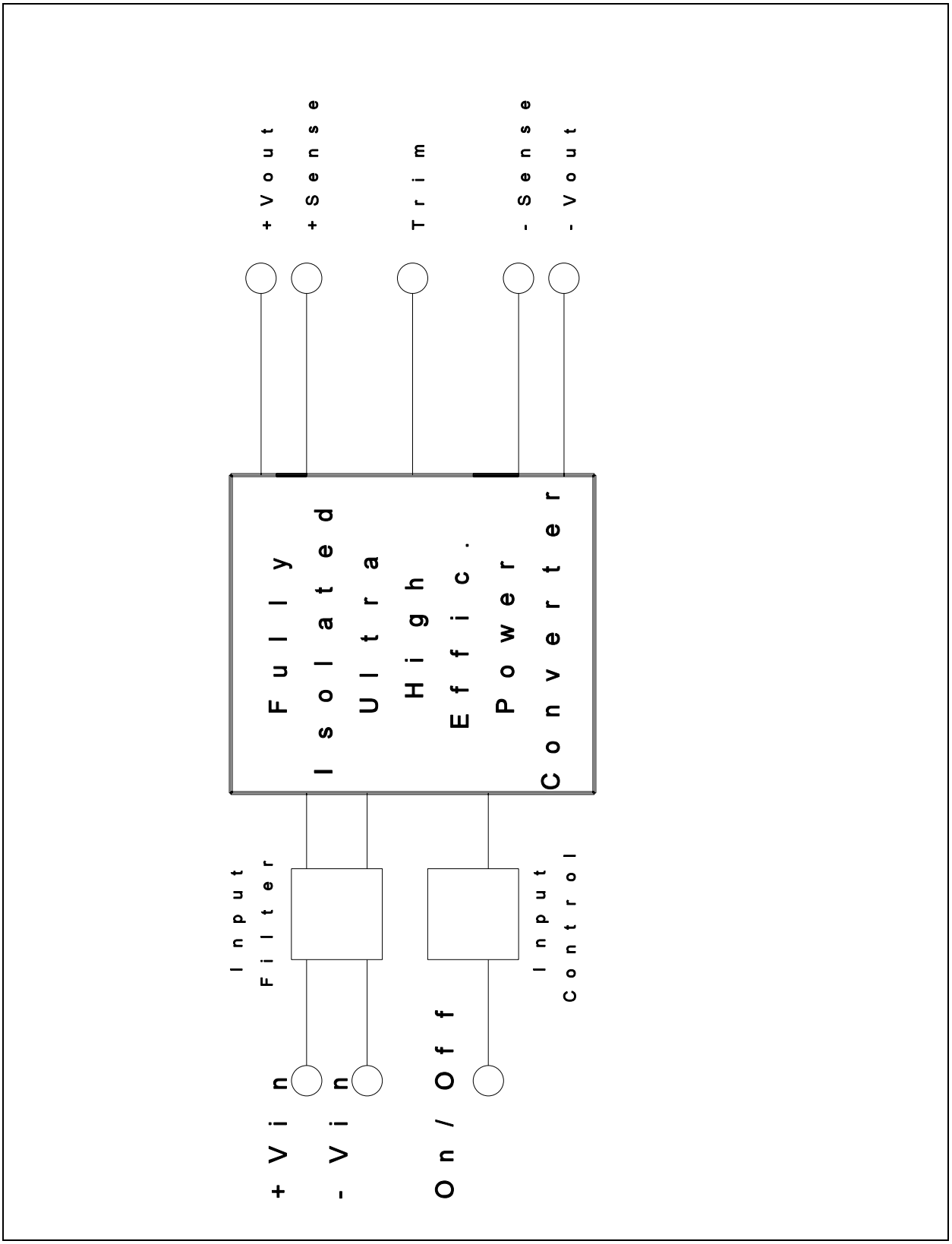
Vout VDC	Iout ADC	Model	Vin VDC	Pout Watts	Effic, Typ.
1.80	15.0	QES027YB-A	18-36	27.0	TBD%
2.10	15.0	QES032YC-A	18-36	31.5	TBD%
2.50	15.0	QES038YD-A	18-36	38.0	80%
3.30	15.0	QES050YE-A	18-36	50.0	85%
1.80	20.0	QES036YB-A	18-36	36.0	TBD%
2.10	20.0	QES042YC-A	18-36	42.0	TBD%
2.50	20.0	QES050YD-A	18-36	50.0	80%
3.30	20.0	QES066YE-A	18-36	66.0	85%
1.80	15.0	QES027ZB-A	36-75	27.0	TBD%
2.10	15.0	QES032ZC-A	36-75	31.5	TBD%
2.50	15.0	QES038ZD-A	36-75	38.0	83%
3.30	15.0	QES050ZE-A	36-75	50.0	86%
1.80	20.0	QES036ZB-A	36-75	36.0	TBD%
2.10	20.0	QES042ZC-A	36-75	42.0	TBD%
2.50	20.0	QES050ZD-A	36-75	50.0	82%
3.30	20.0	QES066ZE-A	36-75	66.0	86%

QES Model Numbering Convention:



Custom QES with alternate input voltage, or input voltage range, or different output voltages are available. Consult the Power-One factory.

QBS and QES Block Diagram:



Design Considerations:

The QBS and QES series power module, and indeed any constant efficiency power module, must be connected to a low AC impedance source of DC voltage.

A constant efficiency power module exhibits an input voltage versus current characteristic which electrically resembles a negative resistor in the normal operating range of the module. Constant efficiency means that if the output power is held constant, the input power will remain constant across the operating input voltage range. If the source voltage rises, the current drawn from the source will fall, to maintain a constant product of voltage and current, hence, constant input power. This characteristic is that of a negative resistor. When a negative resistance is fed from a positive source impedance which has a greater magnitude than that of the negative resistance, either the system crashes or it becomes unstable. A good general rule is that the magnitude of the source impedance must be lower than the magnitude of the input impedance of the module, at all frequencies up to the switching frequency of the module. (The classic reference is Middlebrook and Cuk, “Input Filter Considerations in Design and Application of Switching Regulators,” Advances in Switched-Mode Power Conversion, pp 91-107, TeslaCo, 1981.) This rule is especially important, and harder to follow, with higher power modules, such as the QBS, because the magnitude of the negative input impedance is lower.

The normal solution is to place a low impedance capacitor directly across the input terminals of the module. 100 µF is recommended for 48 Volt inputs at the power level of the QBS converter, and 220 µF for 24 Volt inputs. 100 µF will also be adequate for the QES 48 Volt inputs, and 220 µF for the 24 Volt inputs. This capacitor insures that the magnitude of the source impedance is lower than that of the module input impedance. Note: this assumes that the DC source resistance is sufficiently low; nothing can correct this problem. Too high a DC source resistance means that the necessary energy required by the input of the module is not available, and this system will not work.

Use of the capacitor complicates the system design. There must be some consideration of the surge current required to charge the capacitor when power is first applied. A surge limiting mechanism may be required. The capacitor may form a resonant circuit with the inductance of an EMI filter. If this happens, the resonance will require damping. The capacitor must be rated to handle all of the reflected ripple current of the module. Adding damping in the form of a resistor in series with the capacitor may reduce the ripple current in the capacitor. A small value, high ripple current capacitor may then be required in parallel with the damped electrolytic in order to meet the EMI requirements. The system designer must evaluate all of these requirements and make the correct choices for the application.

Application of input capacitors:

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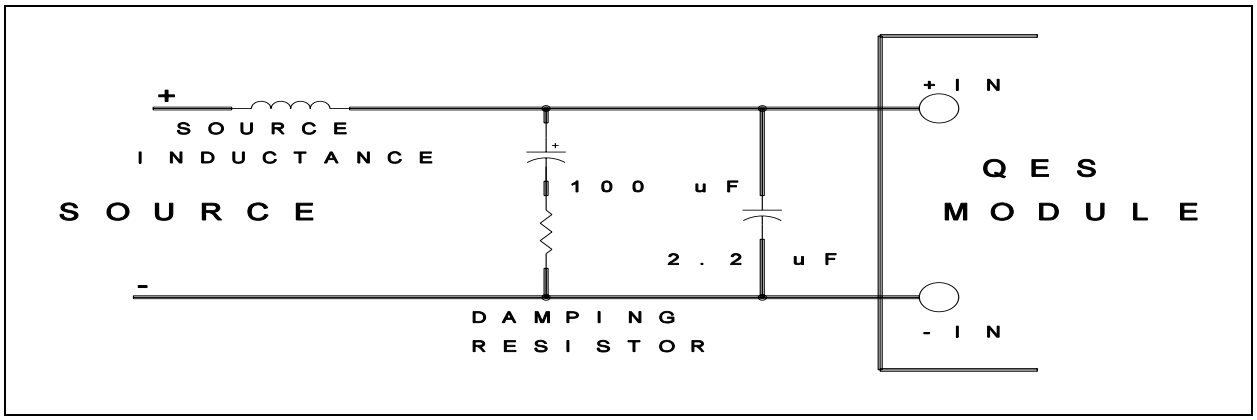


Safety Considerations:

Isolation:

The QBS and QES power modules feature 1500 Volt DC isolation from input to output and 1050 Volt DC isolation from input to baseplate and output to baseplate. The input to output resistance is greater than 10 megohms. Nevertheless, if the system using the power module needs to receive safety agency approval, certain rules must be followed in the design of the system using the module. In particular, all of the creepage and clearance requirements of the end-use safety requirement must be observed. These documents include UL-1950, EN60950 and CSA 22.2-960, although specific applications may have other or additional requirements.

Fusing:

These power modules have NO INTERNAL FUSE. **AN EXTERNAL FUSE MUST ALWAYS BE EMPLOYED!** In general, a 250 Volt rated fuse must be used to meet international safety requirements. The fuse value should be selected to be greater than the maximum input current of the module, which occurs at the minimum input voltage. Both input traces and the chassis ground trace (if used) must be capable of conducting a current of 1.5 times the value of the fuse without opening. If one of the input lines is connected to chassis ground, then the fuse must be in the other input line.

SELV Output Criteria:

In order for the output of the module to be considered as SELV (Safety Extra Low Voltage), one of the following requirements must be met in the system design:

A. The voltage source feeding the module must be SELV and ungrounded. The output of the module must be ungrounded.

B. The voltage source feeding the module must be SELV and grounded. The output of the module must be grounded.

C. A non-SELV voltage source feeding the module must be provided with “reinforced insulation” between the source to the module and any hazardous voltages (such as the input to the non-SELV voltage source) and the system, including the QBS or QES module, must pass a dielectric withstand test. This type of system requires expert engineering and understanding of the overall safety requirements.

When the QBS or QES module is powered from a voltage source which is considered to be in the category of ELV (Extra Low Voltage: a source which meets the voltage level requirements but not the insulation requirements for SELV), the output of the module is also considered to be ELV, and must be appropriately protected so that human contact cannot happen.

Case Grounding:

The baseplate of the module does not require a connection to a chassis ground for proper operation of the module. The final decision of whether to ground the case must come from safety considerations, and is entirely determined by the end application. Power-One suggests consulting a safety expert.

Leaving the case floating can help to reduce magnetic field radiation from common mode noise currents. If the case must be grounded for safety reasons, it may be accomplished through an inductor, which will connect it to chassis at DC and AC line frequencies, but leave it floating at switching frequencies. This can provide the best of both; the safety requirements are met and the emissions are minimized. In general, this inductor must be able to conduct safely all the available input current and maintain a DC resistance from the case to chassis ground of no more than 0.1 Ω. All of the available current means the value of the input fuse to the module. IEC 950 requires testing the DC resistance at 1.5 times that value. Specific safety requirements may dictate something different.

Where a system using the module is not in a metallic enclosure, it may be advisable to directly ground the case to reduce electric field emissions.

Minimum Load Requirements:

Output: Ten per-cent (10%) of Full Load required.

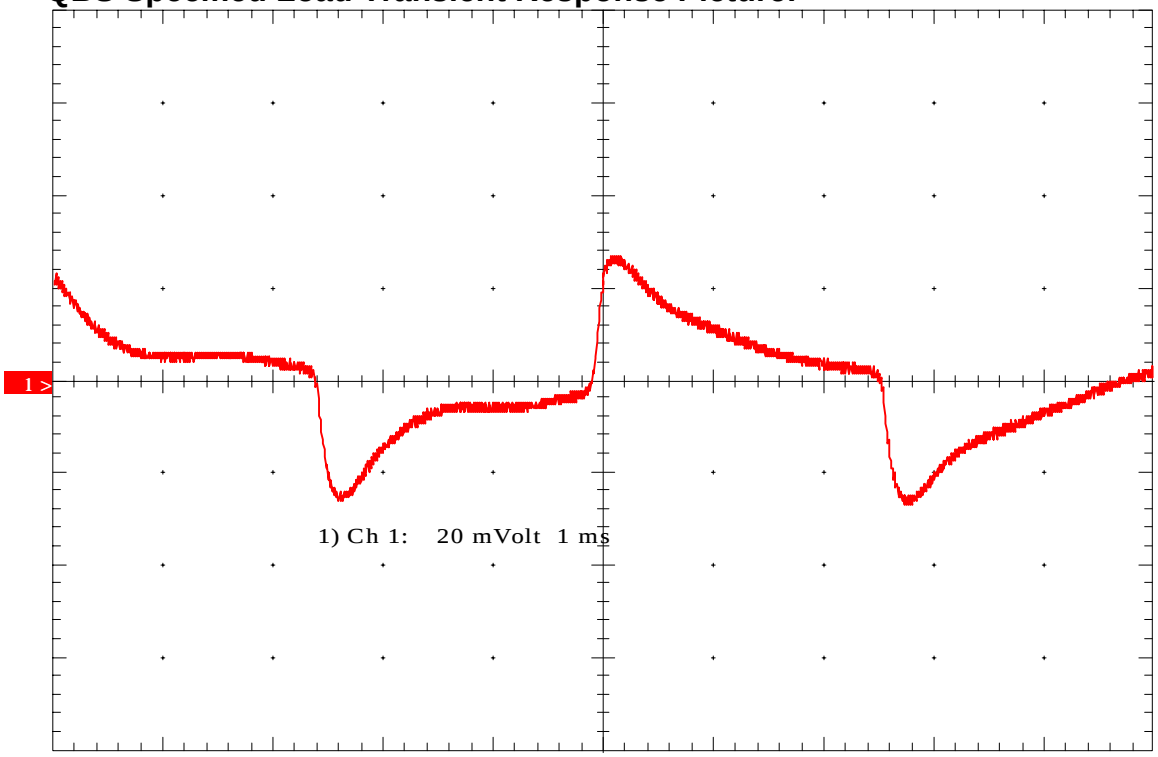
The output load current MUST be maintained at or above the 10% requirement. Both the QBS and the QES series will not maintain regulation with output currents below 10% of full load.

There is a warning required here. Although the QES operates at a light load, it should never be back driven at its output with a higher output voltage. If this is done, the control loop will turn the power conversion stage off. This turns both output synchronous rectifiers on and causes a short circuit to appear at the output of the unit. Never back drive the QES in an attempt to test the output over-voltage protection, and never use the QES in parallel with another power source without output blocking diodes. These warnings do not apply to the QBS series, because of its different topology.

Transient Response:

The following oscilloscope pictures show the stepped load characteristics of the QBS and QES series:

QBS Specified Load Transient Response Picture:

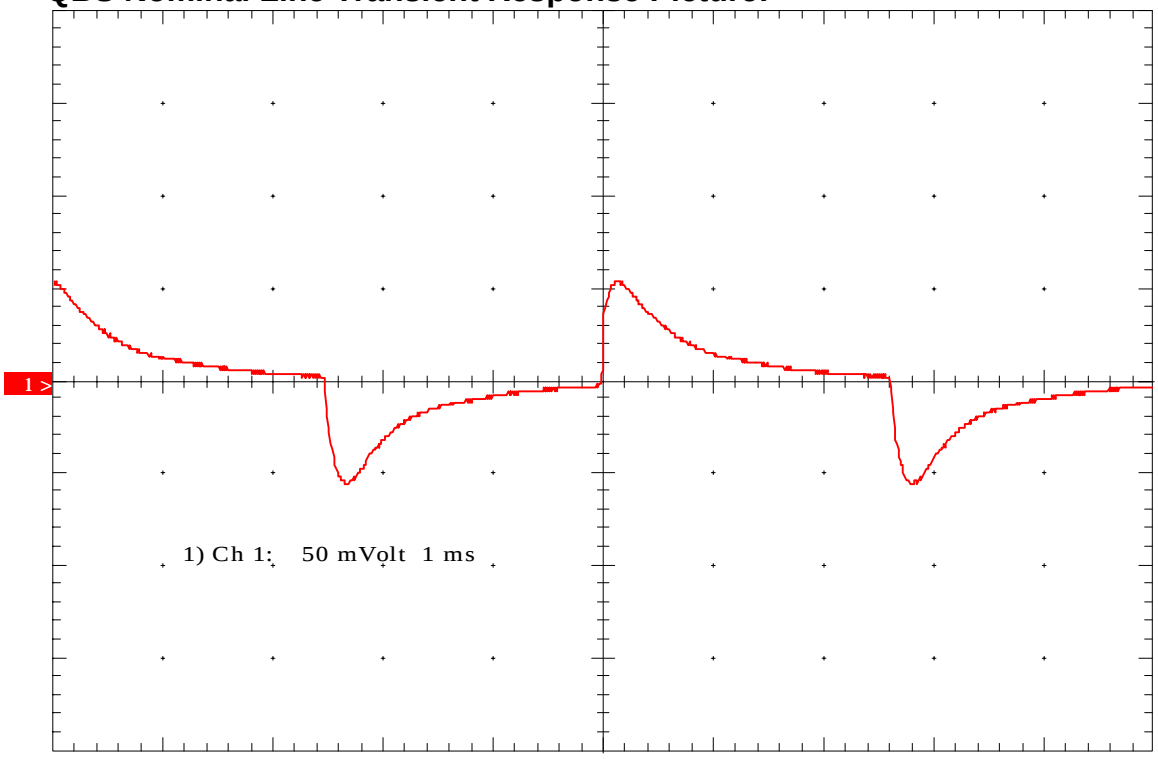


Load transient, QBS033ZE, 5.0 Amps to 7.5 Amps to 5.0 Amps, 48 VDC in.
Trace: Output Voltage, 20 mv per division, AC coupled.
Horizontal: 1.0 milliseconds per division.

The specified transient amplitude is ±2% (66 mv) for a load step of ±25% (2.5A). The specified recovery time to ±1% (33 mv) is 250 microseconds.

Note that the transient amplitude is about 25 mv, never departing the 1% recovery band.

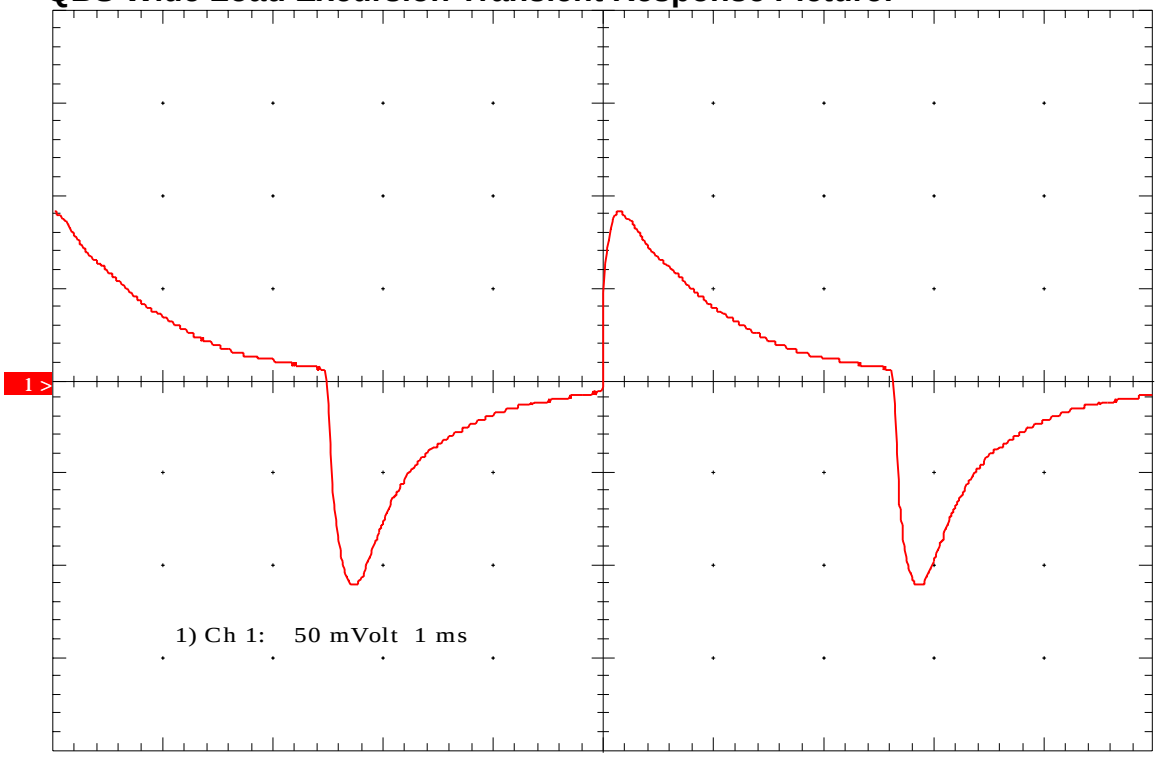
QBS Nominal Line Transient Response Picture:



Load transient, QBS066ZE, 5.0 Amps to 10.0 Amps to 5.0 Amps, 48 VDC in.

Trace:	Output Voltage, 50 mv per division, AC coupled.
Horizontal:	1.0 milliseconds per division.

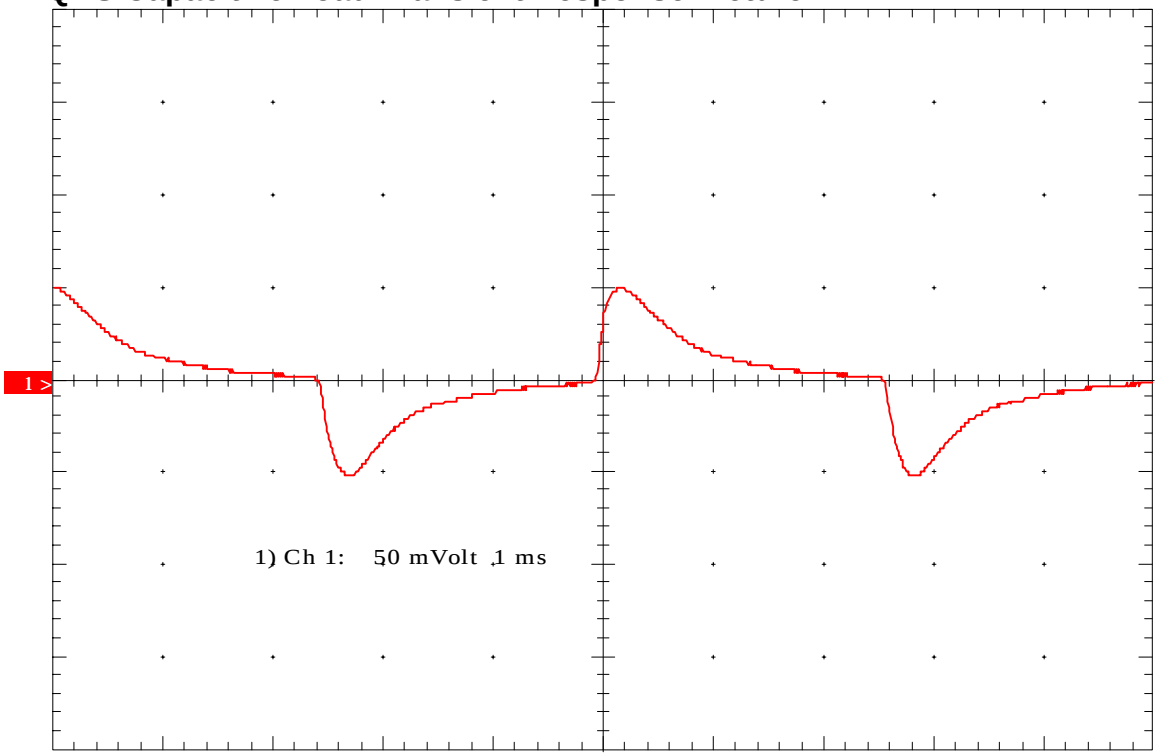
QBS Wide Load Excursion Transient Response Picture:



Load transient, QBS066ZE, 1.0 Amps to 10.0 Amps to 1.0 Amps, 48 VDC in.
Trace: Output Voltage, 50 mv per division, AC coupled.
Horizontal: 1.0 milliseconds per division.

Here, the load is stepped from 10% to 100% of full load. As expected, the transient amplitude is higher and the recovery takes longer, but the recovery is still fast and clean.

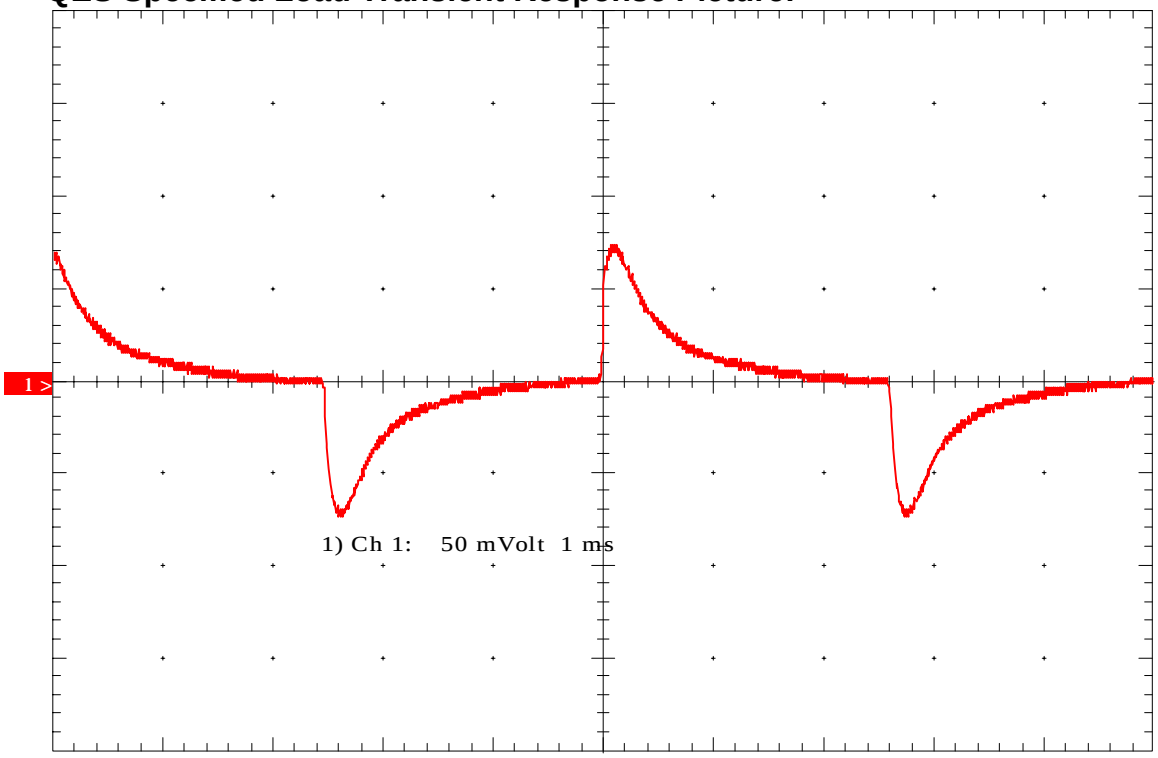
QBS Capacitive Load Transient Response Picture:



Load transient, QBS066ZE, 5.0 Amps to 10.0 Amps to 5.0 Amps, 48 VDC in.
Trace: Output Voltage, 50 mv per division, AC coupled.
Horizontal: 1.0 milliseconds per division.

Here 3300 µF has been added across the output of the QBS. Note that the transient amplitude is reduced and the recovery time increased, but there is no evidence of any ringing or excessive overshoots, or of any loss of phase margin..

QES Specified Load Transient Response Picture:



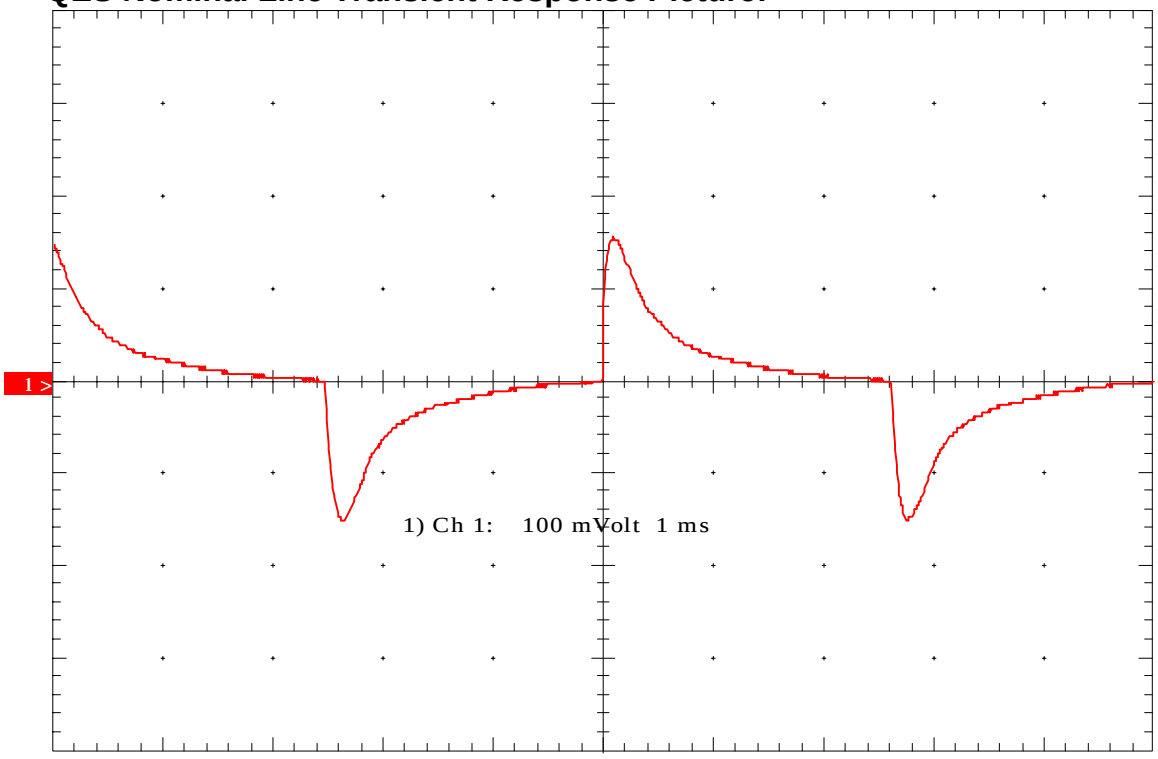
Load transient, QES066ZE, 10.0 Amps to 15.0 Amps to 10.0 Amps, 48 VDC in.

Trace:	Output Voltage, 50 mv per division, AC coupled.
Horizontal:	1.0 milliseconds per division.

The specified transient amplitude is ±2% (66 mv) for a load step of ±25% (5.0A). The specified recovery time to ±1% (33 mv) is 250 microseconds.

Note that the transient amplitude is about 60 mv and the recovery to within 1% is about 250 microseconds.

QES Nominal Line Transient Response Picture:

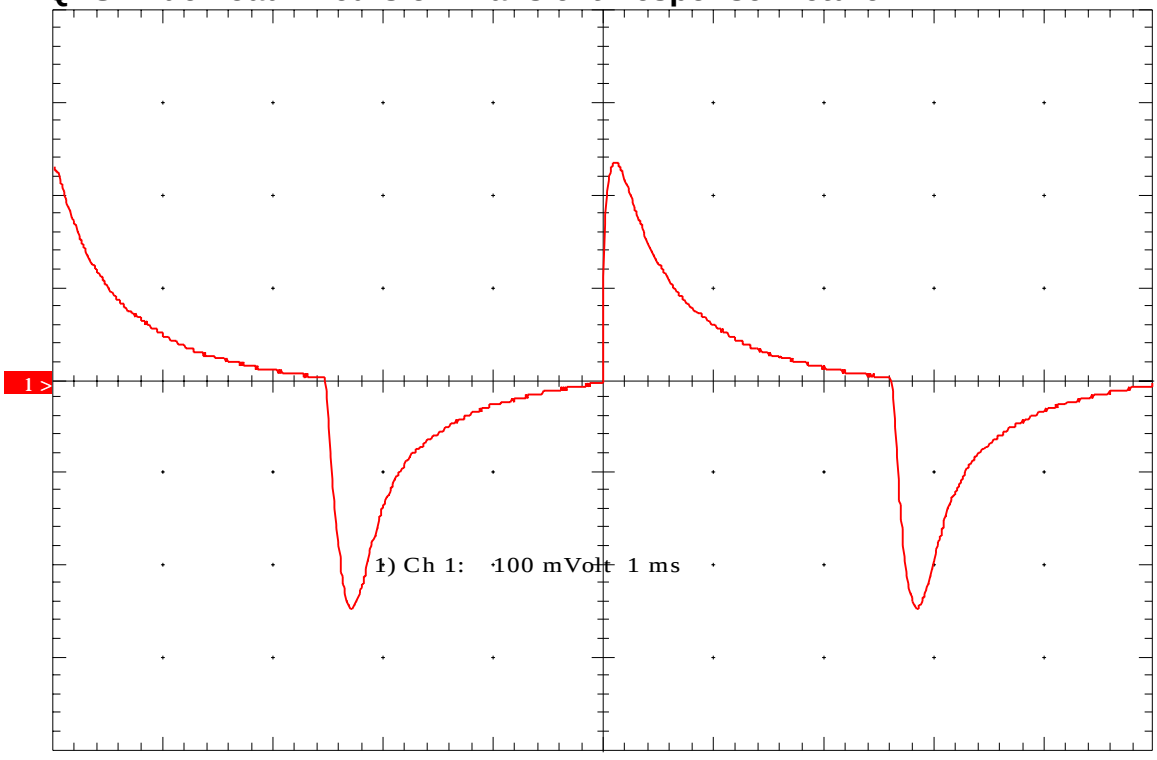


Load transient, QES066ZE, 10.0 Amps to 20.0 Amps to 10.0 Amps, 48 VDC in.

Trace:	Output Voltage, 100 mv per division, AC coupled.
Horizontal:	1.0 milliseconds per division.

Note the recovery in both directions in less than 500 microseconds.

QES Wide Load Excursion Transient Response Picture:



Load transient, QES066ZE, 2.0 Amps to 20.0 Amps to 2.0 Amps, 48 VDC in.
Trace: Output Voltage, 100 mv per division, AC coupled.
Horizontal: 1.0 milliseconds per division.

Here, the load is stepped from 10% to 100% of full load. As expected, the transient amplitude is higher and the recovery takes longer, but the recovery is still fast and clean.

Efficiency vs. Output Loading:

The typical full load efficiency of the various models in the QES and QBS series is a function of the output voltage and power rating. The efficiency of any model varies with input voltage and output power.

The following chart shows the typical full load efficiency for the various models in the series.

Efficiency Chart for QBS Series:

MODEL	Vout	Iout	Efficiency	Vin Range	Iin @ Min Vin
QBS038YD-A	2.50	15.00	76%	18 - 36	2.90
QBS050YE-A	3.30	15.00	80%	18 - 36	3.50
QBS075YG-A	5.00	15.00	84%	18 - 36	5.20
QBS100YH-A	12.00	8.33	85%	18 - 36	6.80
QBS100YJ-A	15.00	6.67	85%	18 - 36	6.80
QBS120YH-A	12.00	10.00	83%	18 - 36	8.10
QBS150YJ-A	15.00	10.00	83%	18 - 36	10.0
QBS038ZD-A	2.50	15.00	77%	36 - 75	1.40
QBS050ZE-A	3.30	15.00	81%	36 - 75	1.70
QBS075ZG-A	5.00	15.00	83%	36 - 75	2.50
QBS100ZH-A	12.00	8.33	86%	36 - 75	3.30
QBS100ZJ-A	15.00	6.67	86%	36 - 75	3.30

MODEL	Vout	Iout	Efficiency	Vin Range	Iin @ Min Vin
QBS120ZH-A	12.00	10.00	84%	36 - 75	4.00
QBS150ZJ-A	15.00	10.00	84%	36 - 75	5.10

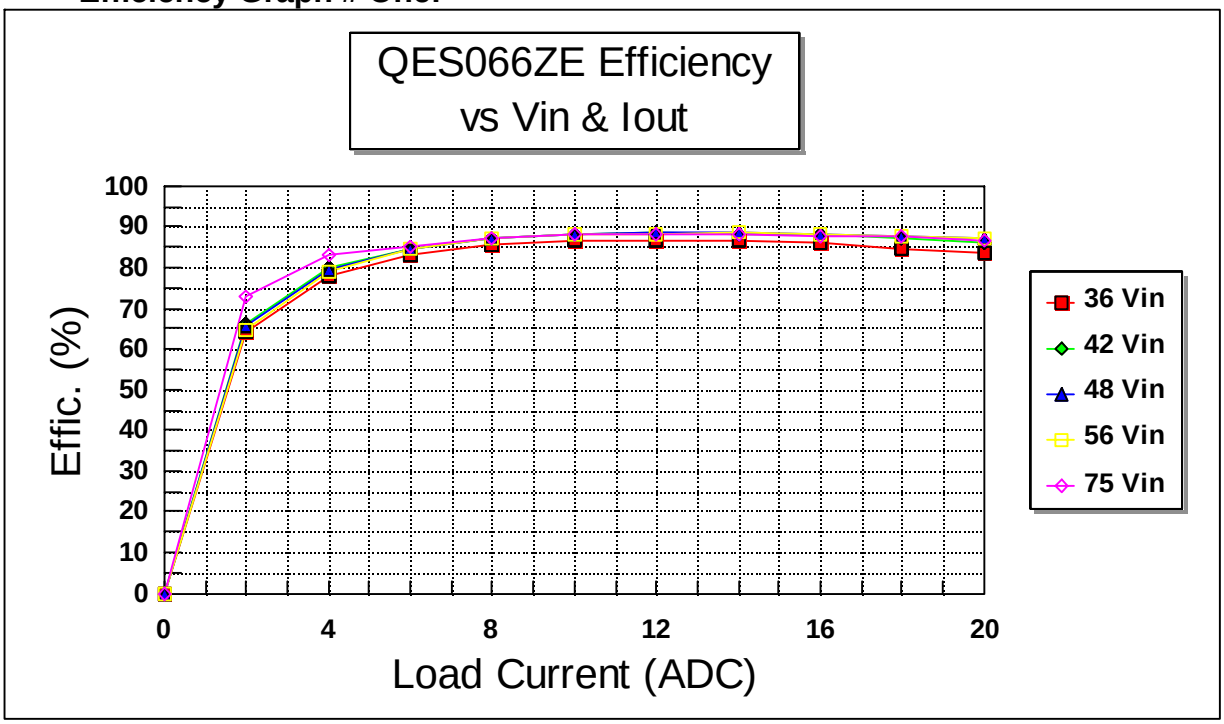
The power dissipated can be calculated by dividing the output power by the efficiency (to obtain the total input power) and then subtracting the output power.

Typical Efficiency Data for model QES066ZE, 3.30 Vout @ 20.0 Aout:

Iout	% F.L.	(36 Vin)	(42 Vin)	(48 Vin)	(56 Vin)	(75 Vin)
2.0 A	10.0	64.02	66.46	65.83	64.87	72.75
4.0 A	20.0	77.79	79.74	79.60	79.07	82.87
6.0 A	30.0	82.97	84.83	84.87	84.68	85.19
8.0 A	40.0	85.40	87.20	87.32	87.20	87.36
10.0 A	50.0	86.43	88.31	88.40	88.31	88.01
12.0 A	60.0	86.74	88.62	88.75	88.20	88.21
14.0 A	70.0	86.56	88.40	88.75	88.59	88.11
16.0 A	80.0	85.95	88.00	88.34	88.28	87.84
18.0 A	90.0	84.87	87.26	87.82	87.87	87.49
20.0 A	100	83.73	86.34	87.00	87.22	86.90

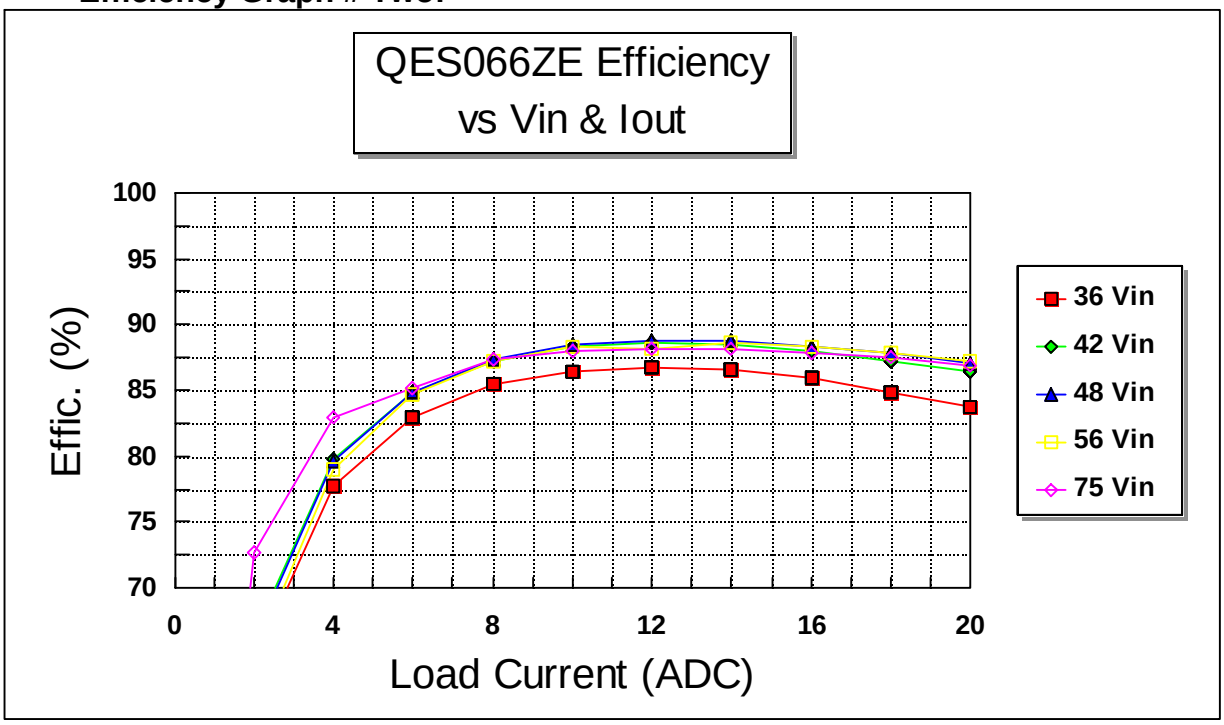
Efficiencies are expressed in per-cent (%). This data is TYPICAL ONLY, and the guaranteed efficiency should be used in all thermal calculations.

Efficiency Graph # One:



Typical data, measured on one sample.

Efficiency Graph # Two:



Typical data, measured on one sample.

These graphs show that the efficiency of the QES remains relatively constant over a wide range of a load, and over the entire nominal input voltage range of 42 to 75 VDC. The 36 volt input efficiency is slightly lower. Although these graphs are from a particular model, the shape of the curves for other models is similar. We advise making an initial efficiency estimate by scaling the 48 Vin end point of the graph to match the full load efficiency listed at nominal input voltage in the chart above. This will produce a conservative efficiency estimate. Contact Power-One if additional efficiency information is required for specific models.

The QBS efficiency curve is similar, but does not exhibit the slight reduction in efficiency at 36 Vin. A QBS efficiency curve is presently not available.

Cooling:

The QES and QBS are designed for either natural or forced convection cooling, although comparatively little power can be obtained with only natural convection. The best cooling can be achieved by cooling the unit with forced air. Both the QBS and the QES exhibit the same thermal characteristics.

The operating temperature range of the QBS and QES is -40° to +100° C. This is the baseplate temperature range. The ambient air temperature range is -40° to +85° C. When operating these modules with an external forced air, the flow rate must be maintained in order keep the module baseplate at or below +100° C. at the maximum ambient air temperature and the maximum power dissipation (in the module).

The power dissipation can be estimated from the equation or graph in the discussion of efficiency. Since every natural convection application is different, Power-One suggests that the user always verify the theoretical results with measurements.

Optimum cooling is obtained with forced convection. Some typical thermal resistance numbers are tabulated below:

Chart of Thermal Resistance vs. Air Flow:

AIR FLOW RATE	TYPICAL θca
Natural Convection	10.1°C/W
100 LFM	8.0°C/W
200 LFM	5.4°C/W
300 LFM	4.4°C/W
400 LFM	3.4°C/W

These numbers are typical only. The natural convection data was recorded with the baseplate of the unit vertically oriented, with the longer dimension going up. The forced convection data was recorded with the air flow parallel to the long dimension (longitudinal air flow). The data was recorded at roughly sea level (Boston, MA).

These numbers must be considered as the initial point for any design, only. There are a great many factors which influence thermal resistance. Air density (altitude) and temperature, distance from the fan blades, relative humidity and others. In addition, back pressure causes fans to slow down and generate less CFM of air than the maximum rating. Air must often be ducted to flow where the cooling is needed, rather than around it. In any application, the temperature rise MUST be measured and controlled.

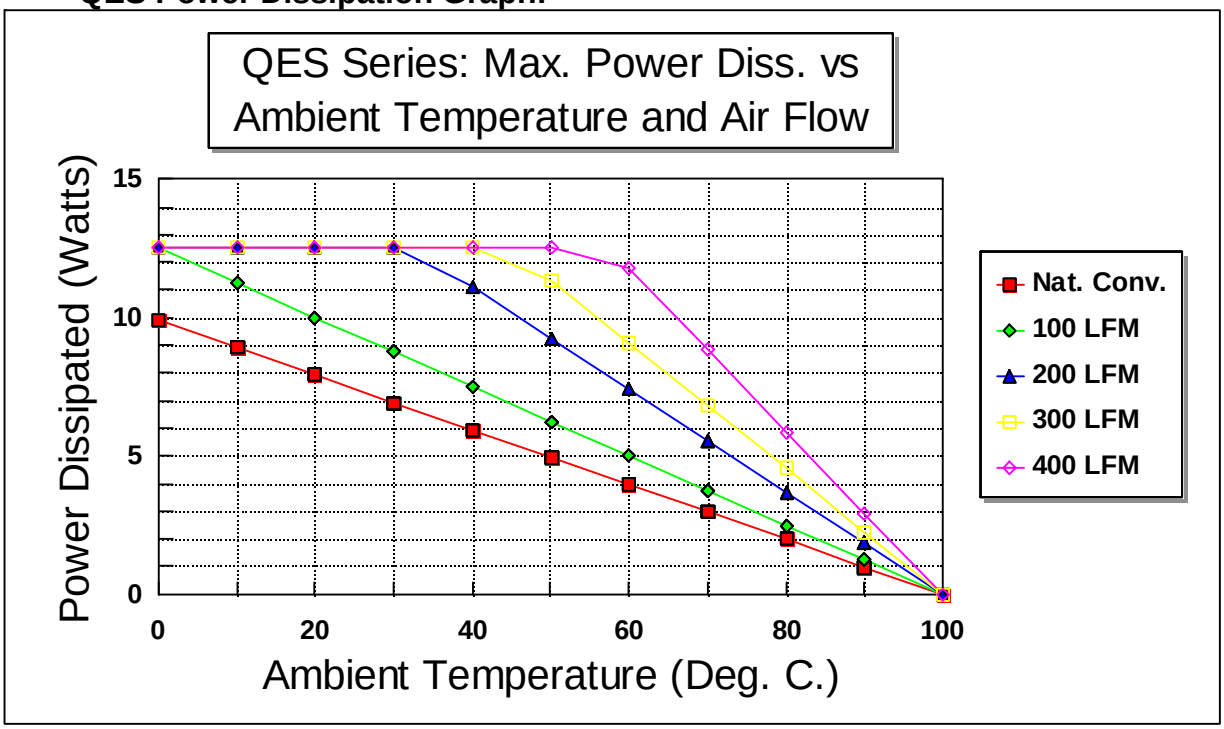
For a given application, the maximum ambient operating temperature is derived as follows: Using the maximum output power, divide it by the efficiency estimated from the graphs, at the input voltage extreme which produces the lowest efficiency. Use the lowest value of efficiency which is within the actual operating conditions. This result is the input power. From it, subtract the output power. This is the power dissipated in the unit. Although not all of the power goes through the base, assuming that it does gives a worst case result. Then, multiply the power dissipated by the thermal resistance, using the lowest value of air flow anticipated. This gives the base temperature rise.

Subtracting this value from the maximum allowable base temperature of +100° C. gives the highest allowable ambient temperature.

Naturally, a prudent engineer would not wish to operate the QBS, QES, or any other power converter, at or near its rated maximum base temperature. Power-One heartily recommends a good measure of engineering conservatism.

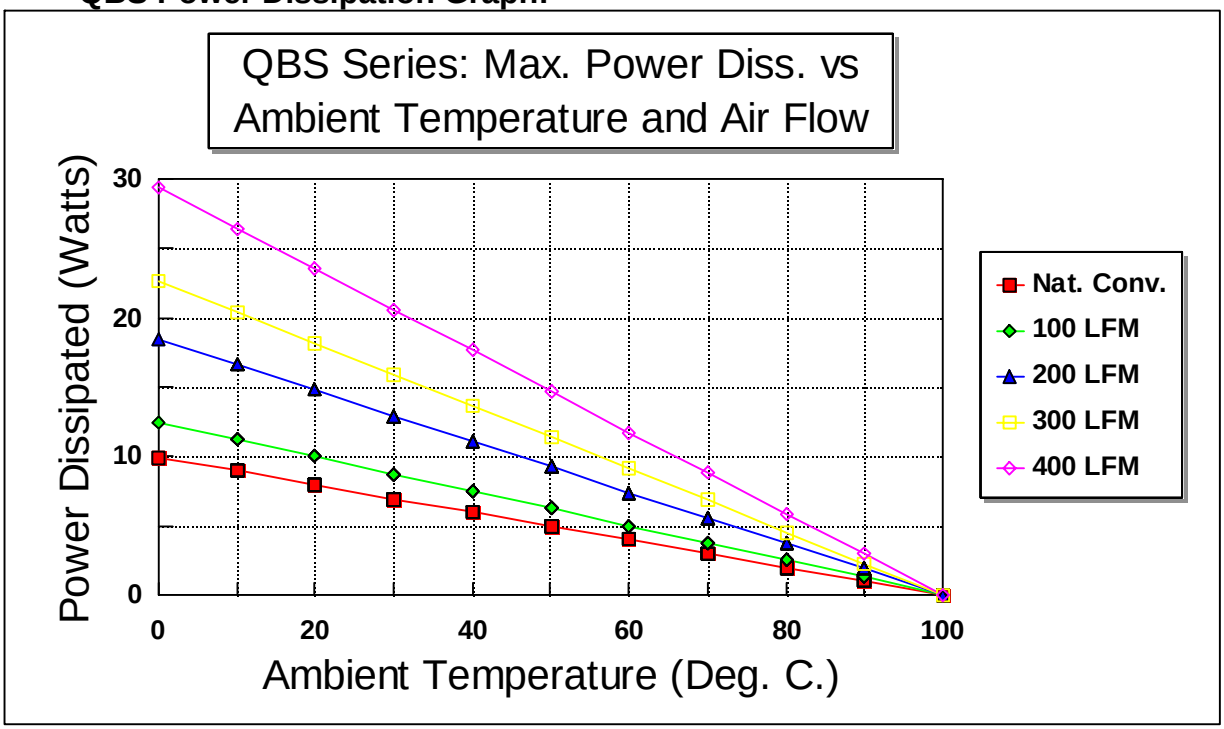
The graphs below will assist in estimating the maximum permissible power dissipation with both natural convection and forced air cooling at sea level.

QES Power Dissipation Graph:



The air flow shown above is longitudinal.

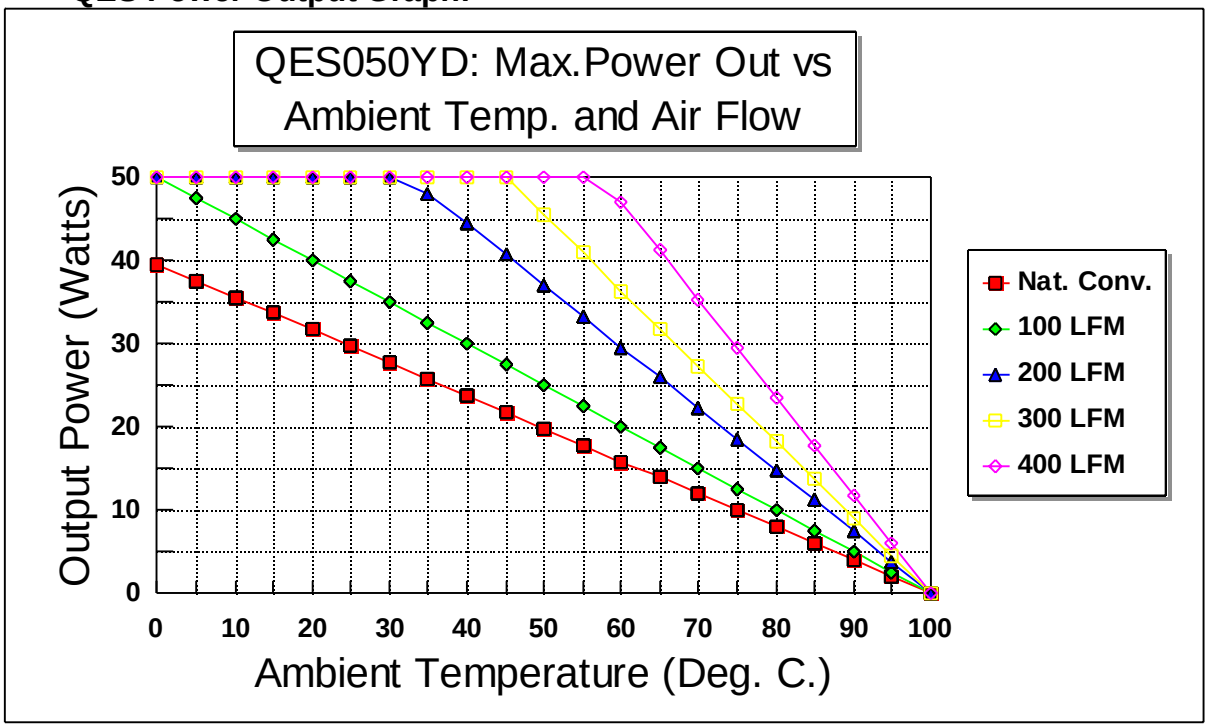
QBS Power Dissipation Graph:



The air flow shown above is longitudinal.

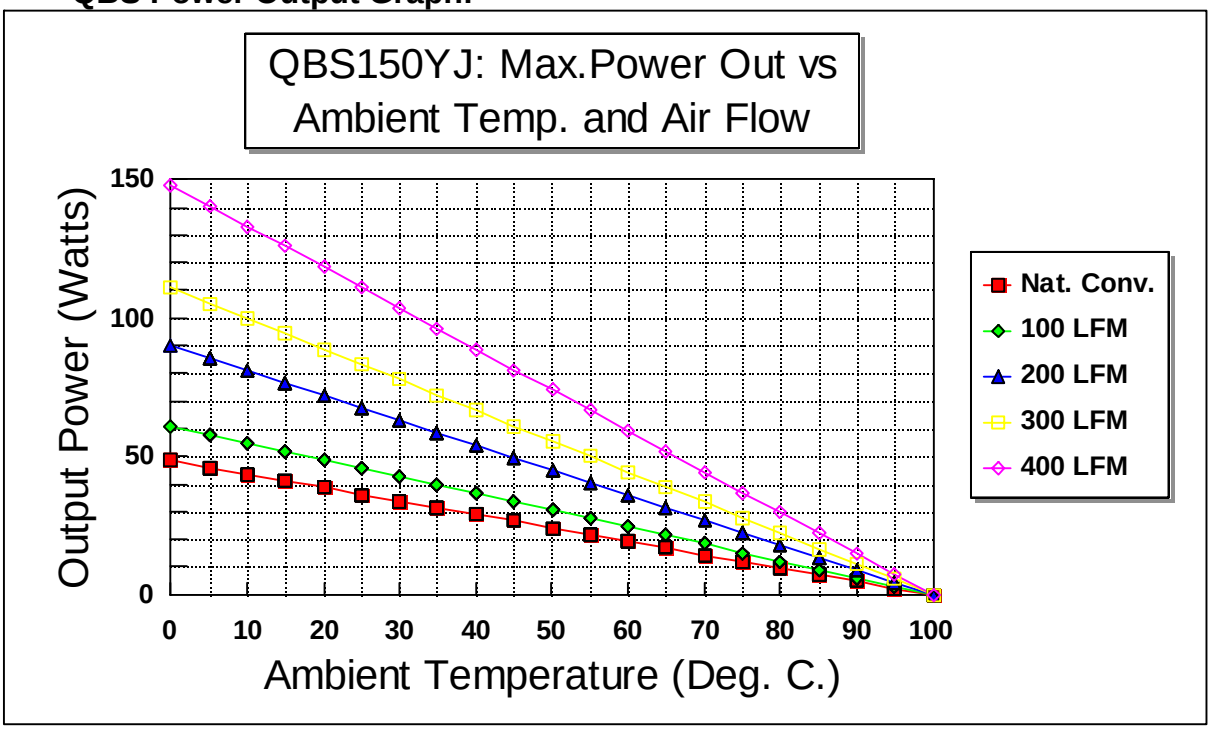
The graphs below will assist in estimating the maximum output power with both natural convection and forced air cooling at sea level.

QES Power Output Graph:



This graph (immediately above) is based upon the typical efficiency of the QES050YD, the model with the highest dissipation in the QES series.

QBS Power Output Graph:



This graph (immediately above) is based upon the typical efficiency of the QBS150YJ, the model with the highest dissipation in the QBS series.

Once again, employing a large dose of engineering conservatism will result in a better product. In addition, all of the information presented above is only for the purposes of selecting an initial air flow. The final results MUST be verified in the actual application by measuring the real temperature rise. Keep in mind that the local ambient temperature for the module may be elevated from the external ambient by the dissipation in other elements.

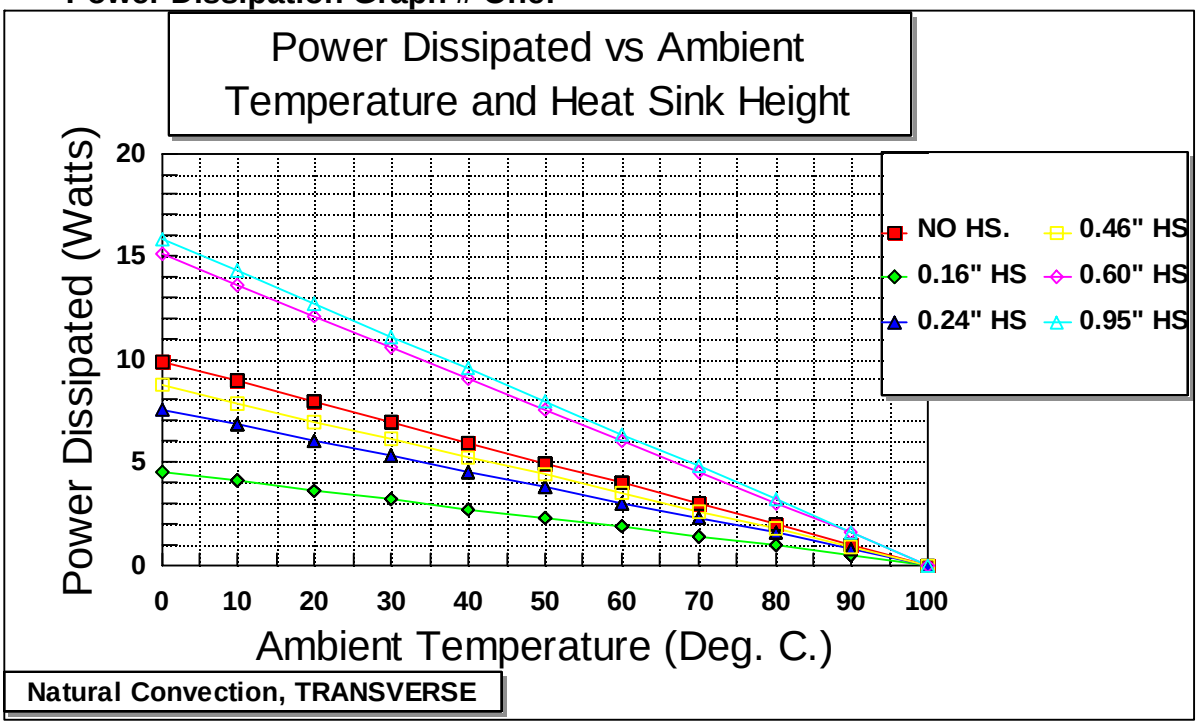
Cooling with Attached Heatsinks:

Cooling with Natural Convection:

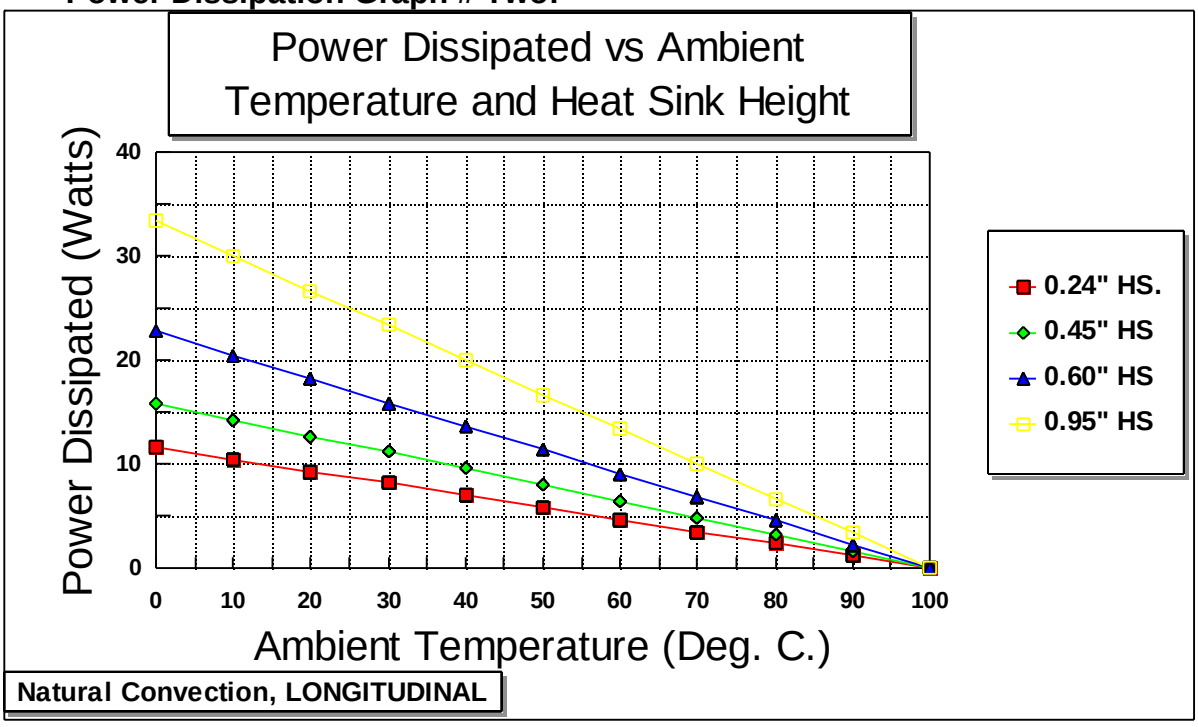
Attaching a heatsink to the module will permit higher output power with lower case temperatures. Once again, the designer must know the maximum amount of power being dissipated by the unit and the maximum local ambient temperature. The size of the heatsink can be traded for the case temperature of the module. Power-One has several stock heat sinks available for this quarter brick size. The graphs shown below are based upon these.

The graphs below show the APPROXIMATE power dissipation of these heat sinks.

Power Dissipation Graph # One:



Power Dissipation Graph # Two:



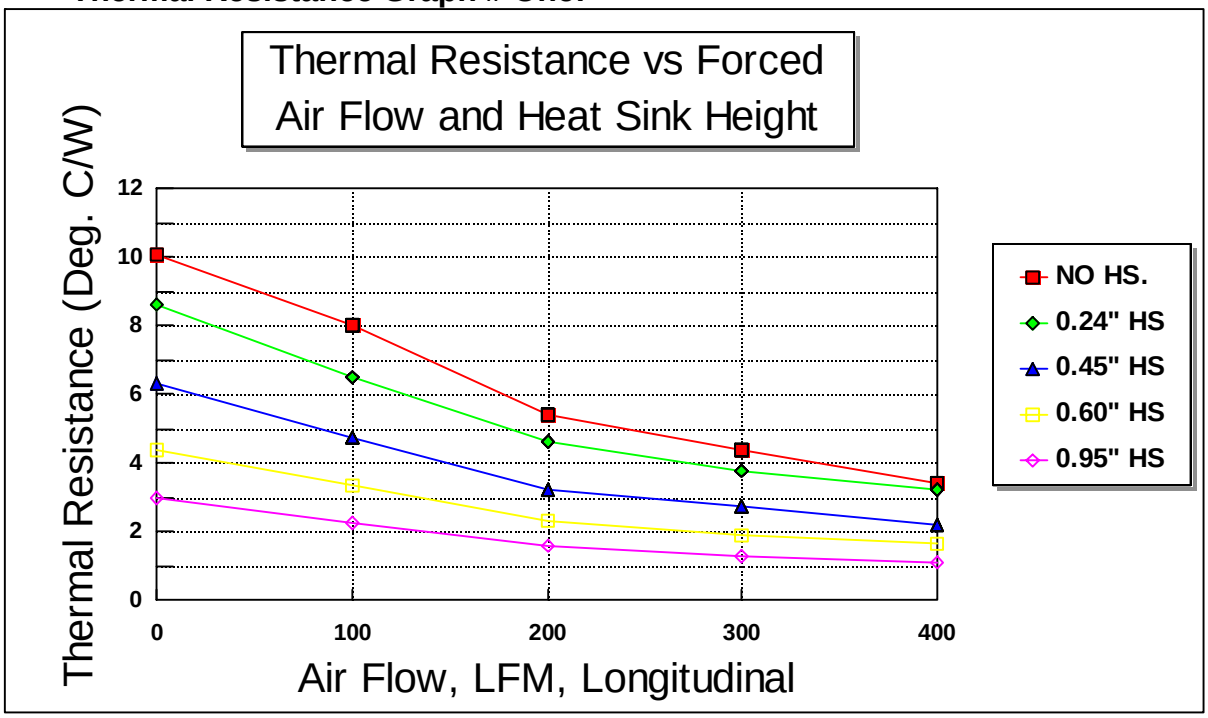
Cooling with Forced Convection:

The graphs below show the APPROXIMATE thermal resistance of a module and same size attached heat sink in a forced air environment. The module temperature is:

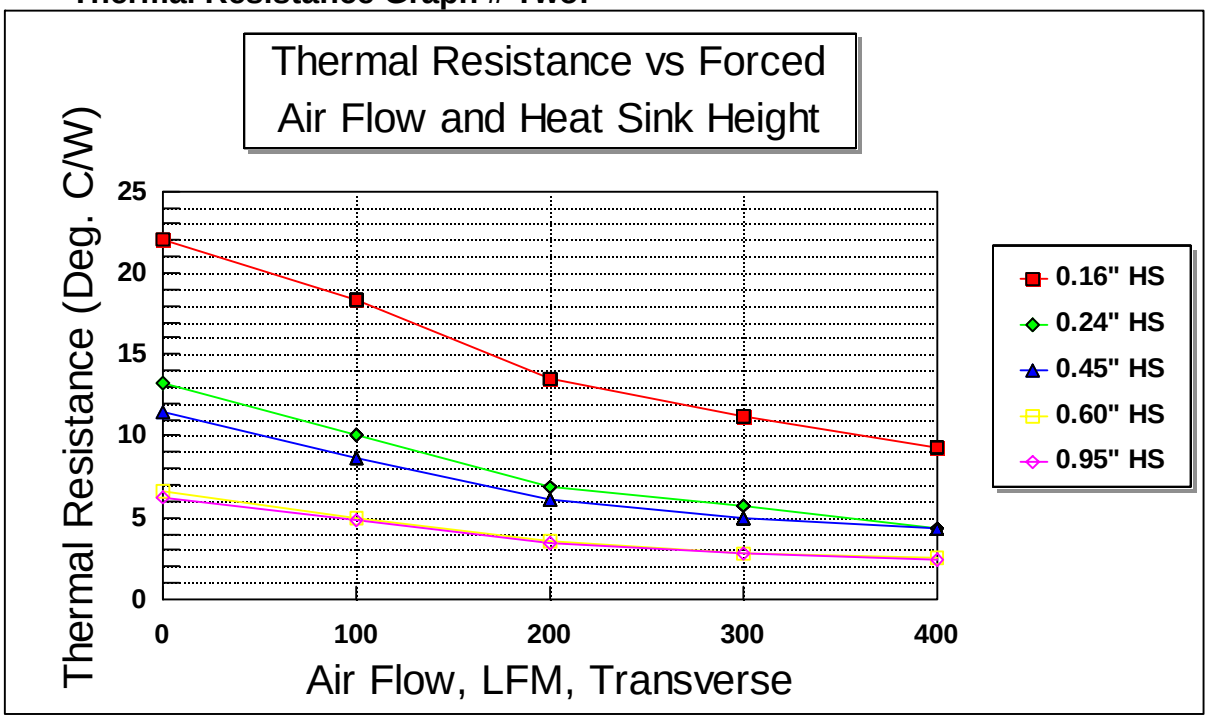
$$T_c = T_a + (P_d * \theta)$$

where T_c is the module case temperature,
T_a is the local ambient temperature,
P_d is the power dissipated in Watts, and
θ is the thermal resistance from the graphs below.

Thermal Resistance Graph # One:



Thermal Resistance Graph # Two:



Once again, employing a large dose of engineering conservatism will result in a better product. In addition, all of the information presented above is only for the purposes of selecting an initial heat sink and air flow. The final results MUST be verified in the actual application by measuring the real temperature rise. Keep in mind that the local ambient temperature for the module may be elevated from the external ambient by the dissipation in other elements.

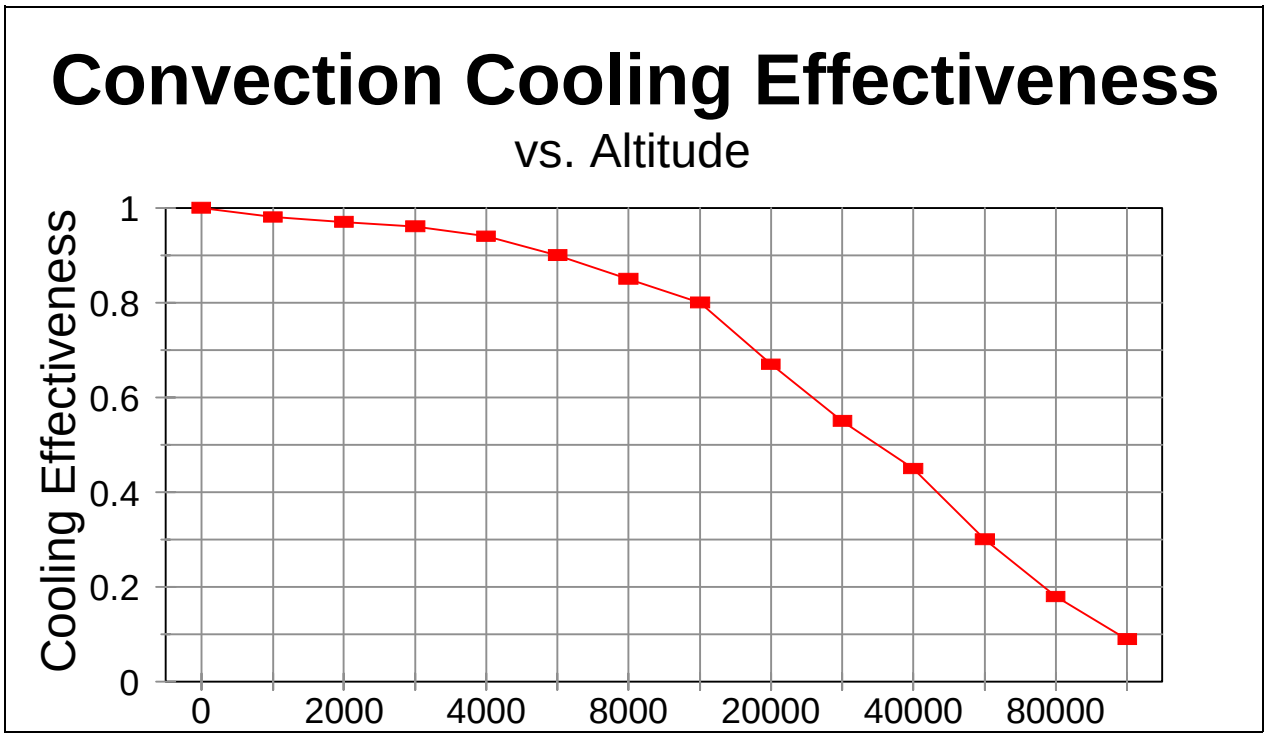
In order to achieve the listed thermal resistance numbers, there must be either a Grafoil (Registered trademark of Union Carbide company, US Patent # 3,404,061) pad or other suitable thermal interface material between the module and the heat sink, and the mounting screws must have sufficient torque, typically 4 to 6 in-lbs. Note that the interface thermal resistance, typically 0.1 to 0.3°C/W, between the module and heatsink contributes significantly to the result.

Improved performance in a forced convection environment can be obtained with oversized heat sinks: they overhang the module. One of these must be individually designed to match the application. An extremely useful tool is the program called “Cool Cat,” by Aavid Engineering. It can be used to evaluate the thermal performance of different sizes of Aavid standard extrusions. This program can be down loaded from the Aavid Engineering web site at “http://www.aavid.com.

Derating for altitude:

At altitudes above sea level, there are fewer molecules of air in each area of volume. Since the air molecules perform the actual convection heat transfer, there is reduced effectiveness as the altitude of use increases.

Effect of Altitude Graph:



To use this curve, divide the sea level thermal resistance by the cooling effectiveness at the applicable altitude. This produces the effective value of thermal resistance at the altitude. Use this number in the calculations above. Again, engineering conservatism will produce successful projects.

Thermal Calculation Example:

As an example, we wish to run a model QBS150ZJ at a full 150 watts of output power at up to 45° C. and up to 10,000 feet altitude. For reliability, we wish to maintain the case temperature at or below +85° C.

1. Power dissipated = (150/.84) - 150 = 28.57 Watts.

2. Thermal Resistance required at sea level = (85-45)/28.57 = 1.400°C/W.

3. Derating for 10,000 feet: 1.400 * 0.8 = 1.120°C/W actual required.

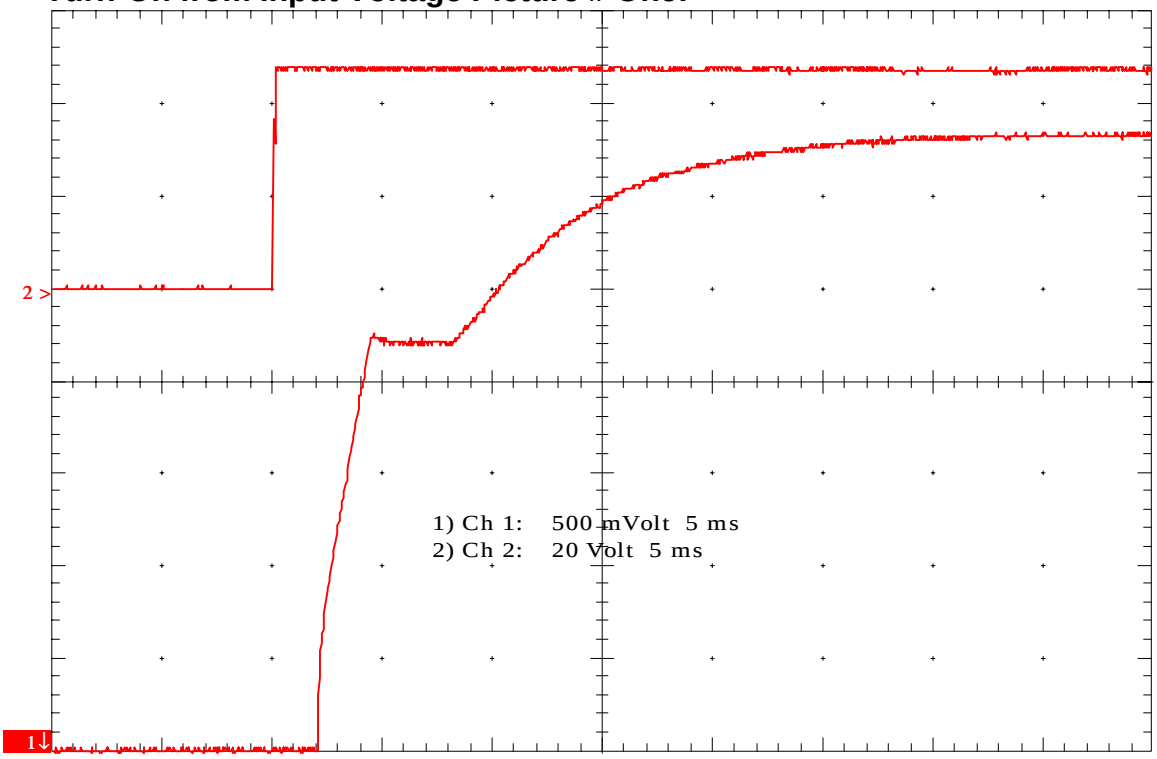
4. From the charts of thermal resistance we see that we need at least 400 LFM of forced air with a 0.95" high heat sink to even approach the thermal resistance value required. Either more air, or a lower thermal resistance heat sink would be advisable.

Turn-On Time:

Turn-On from Input Voltage:

The QBS and QES have under-voltage lockout (UVLO) which uses a comparator to measure the input voltage. Once the threshold is achieved, at approximately 32 VDC in, the units turn on very rapidly. The photograph below shows the response of the QBS033ZE-AN to the rapid application of 48 VDC.

Turn-On from Input Voltage Picture # One:

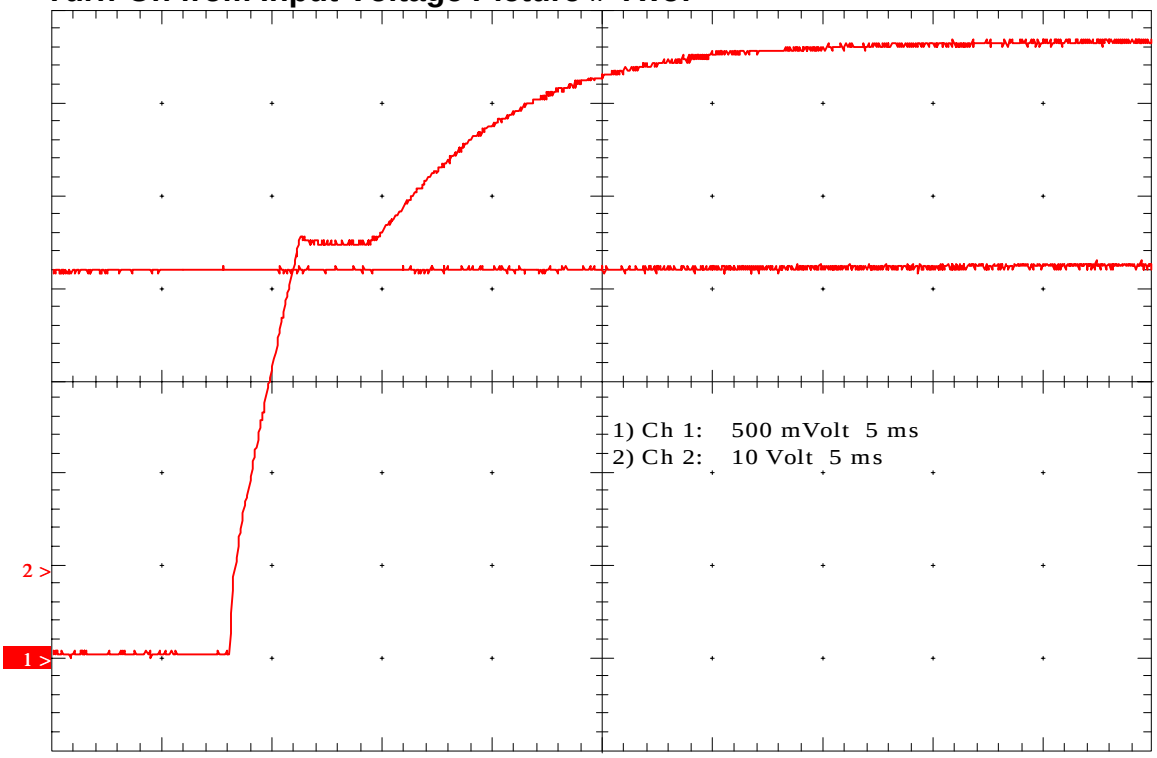


Input and Output voltages, QBS033ZE-AN, 48 VDC in, 10.0 Amps out.

Trace #1:	Output Voltage, 0.50 V per division, DC coupled.
Trace #2:	Input Voltage, 20 V per division, DC coupled.
Horizontal:	5.00 milliseconds per division.

The photograph below shows the response of the QBS033ZE to the slow application of 48 VDC.

Turn-On from Input Voltage Picture # Two:

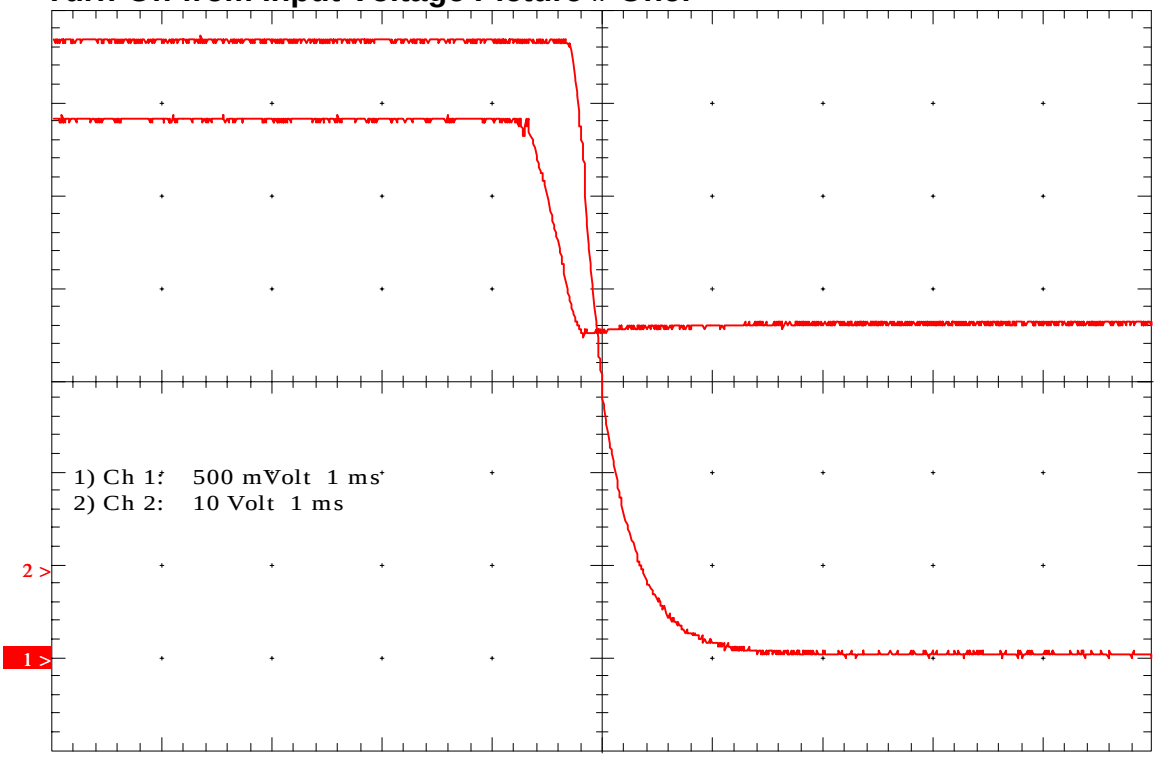


Input and Output voltages, QBS033ZE-AN, 48 VDC in, 10.0 Amps out.
Trace #1: Output Voltage, 0.50 V per division, DC coupled.
Trace #2: Input Voltage, 10 V per division, DC coupled.
Horizontal: 5.00 milliseconds per division.

Turn-Off from Input Voltage:

The under-voltage lockout (UVLO) comparator of the QBS and QES turns the unit off at approximately 30 VDC in. The photograph below shows the response of the QBS033ZE to the rapid removal of 48 VDC.

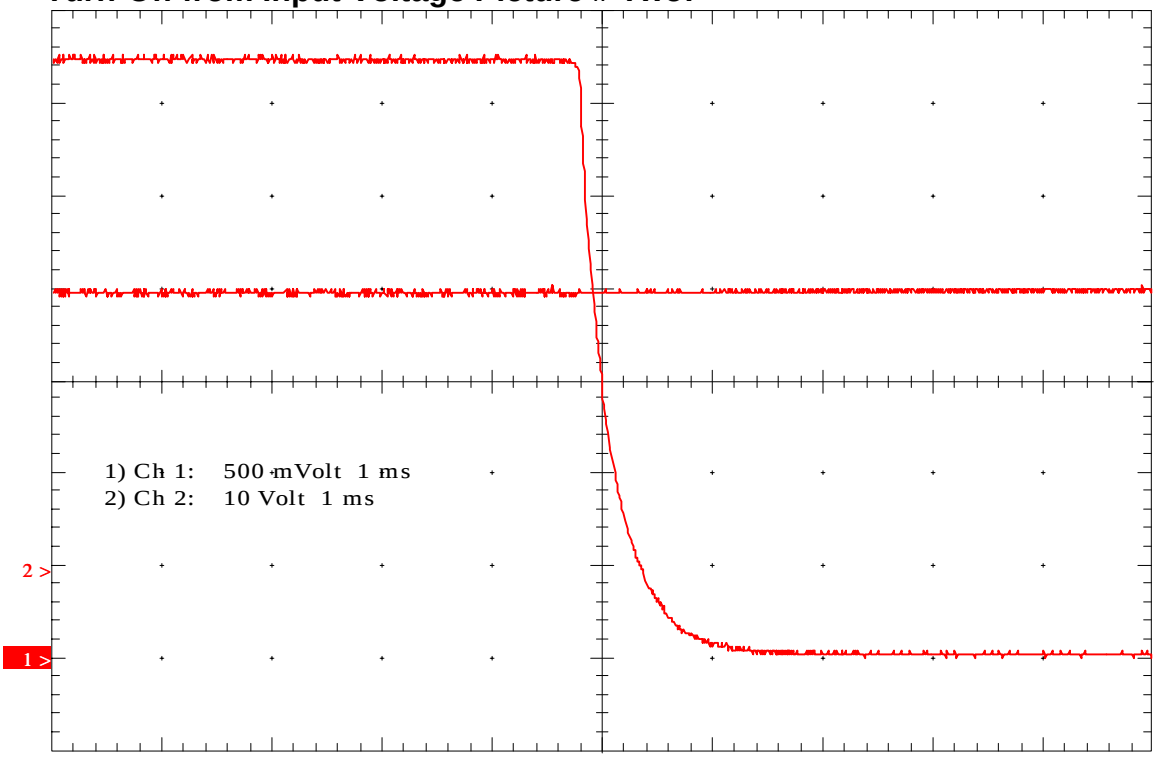
Turn-Off from Input Voltage Picture # One:



Input and Output voltages, QBS033ZE-AN, 48 VDC in, 10.0 Amps out.
Trace #1: Output Voltage, 0.50 V per division, DC coupled.
Trace #2: Input Voltage, 10 V per division, DC coupled.
Horizontal: 1.00 milliseconds per division.

The photograph below shows the response of the QBS033ZE to the slow removal of 48 VDC.

Turn-Off from Input Voltage Picture # Two:

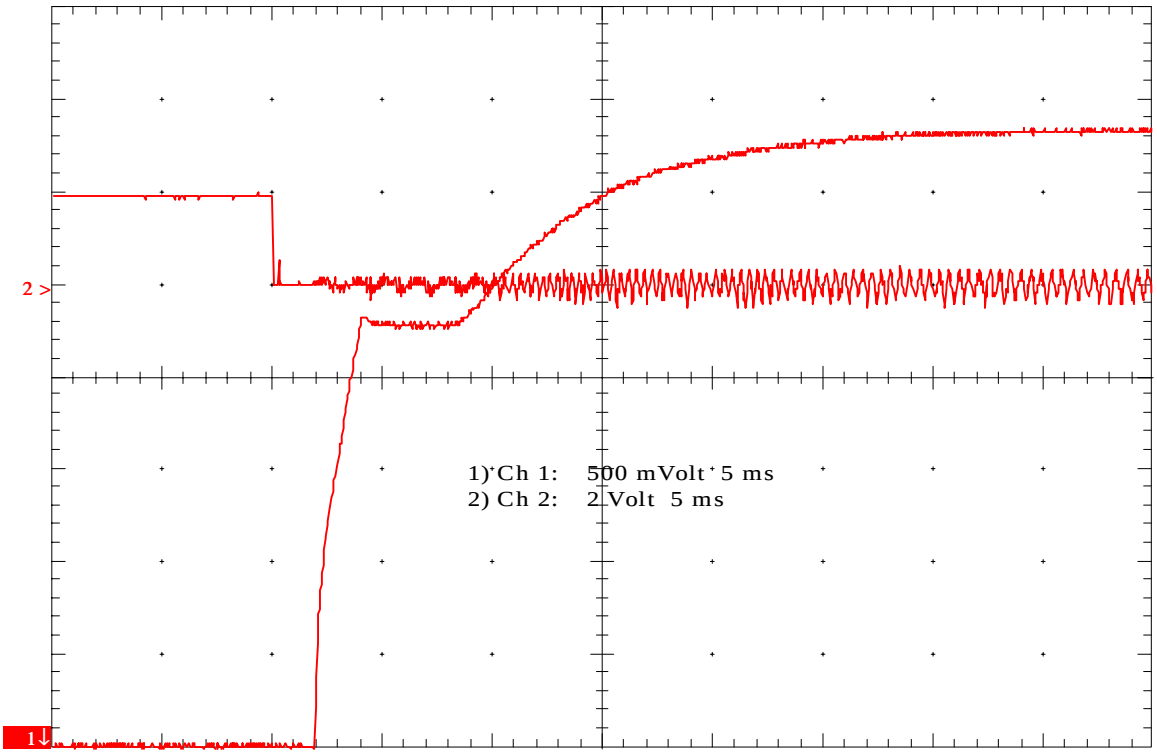


Input and Output voltages, QBS033ZE-AN, 48 VDC in, 10.0 Amps out.
Trace #1: Output Voltage, 0.50 V per division, DC coupled.
Trace #2: Input Voltage, 10 V per division, DC coupled.
Horizontal: 1.00 milliseconds per division.

Turn-On from Control:

Turn-on time from control is similar to the application of input voltage, except there is less than 1.0 millisecond from the release of the shutdown to the initiation of the rise of output voltage.

Turn-On from Control Picture:

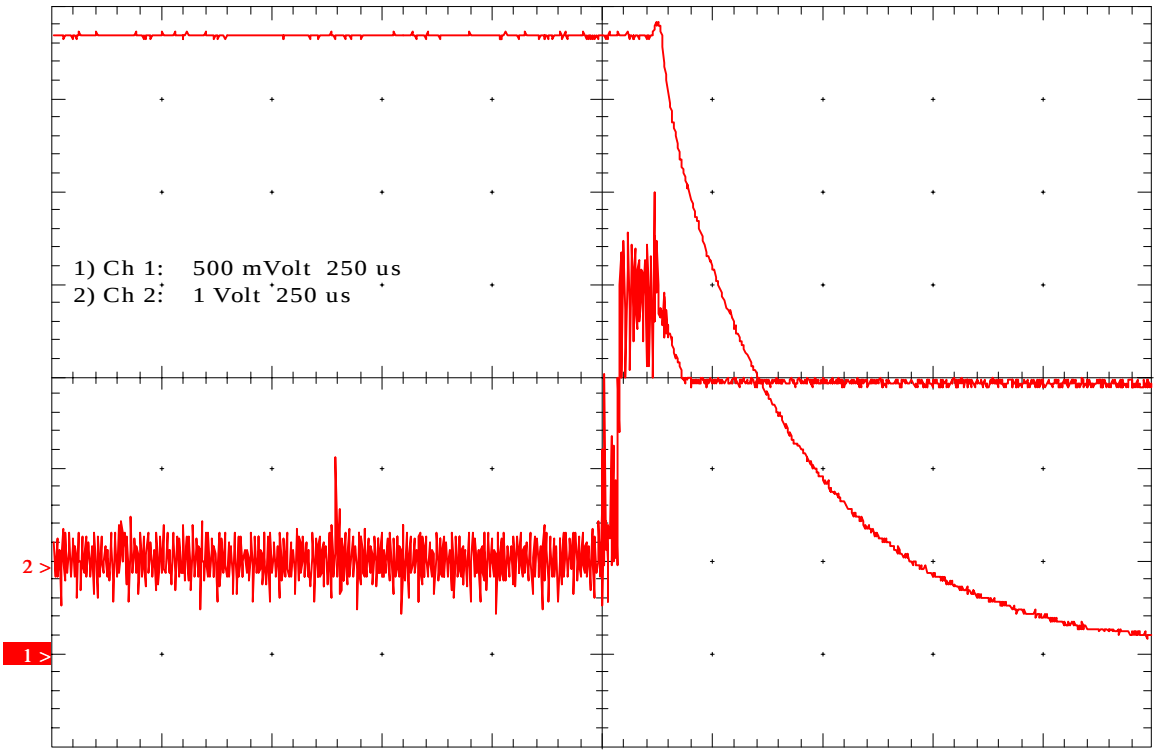


Output and Control voltages, QBS033ZE-AN, 48 VDC in, 10.0 Amps out.
Trace #1: Output Voltage, 0.50 V per division, DC coupled.
Trace #2: Control Pin Voltage, 2.0 V per division, DC coupled.
Horizontal: 5.0 milliseconds per division.

Turn-Off from Control:

Turn off from control is virtually instantaneous:

Turn Off from Control Picture:



Output and Control voltages, QBS033ZE-AN, 48 VDC in, 3.3V @ 10.0 Amps out.

Trace #1:	Output Voltage, 0.50 V per division, DC coupled.
Trace #2:	Control Pin Voltage, 1.0 V per division, DC coupled.
Horizontal:	250 microseconds per division.

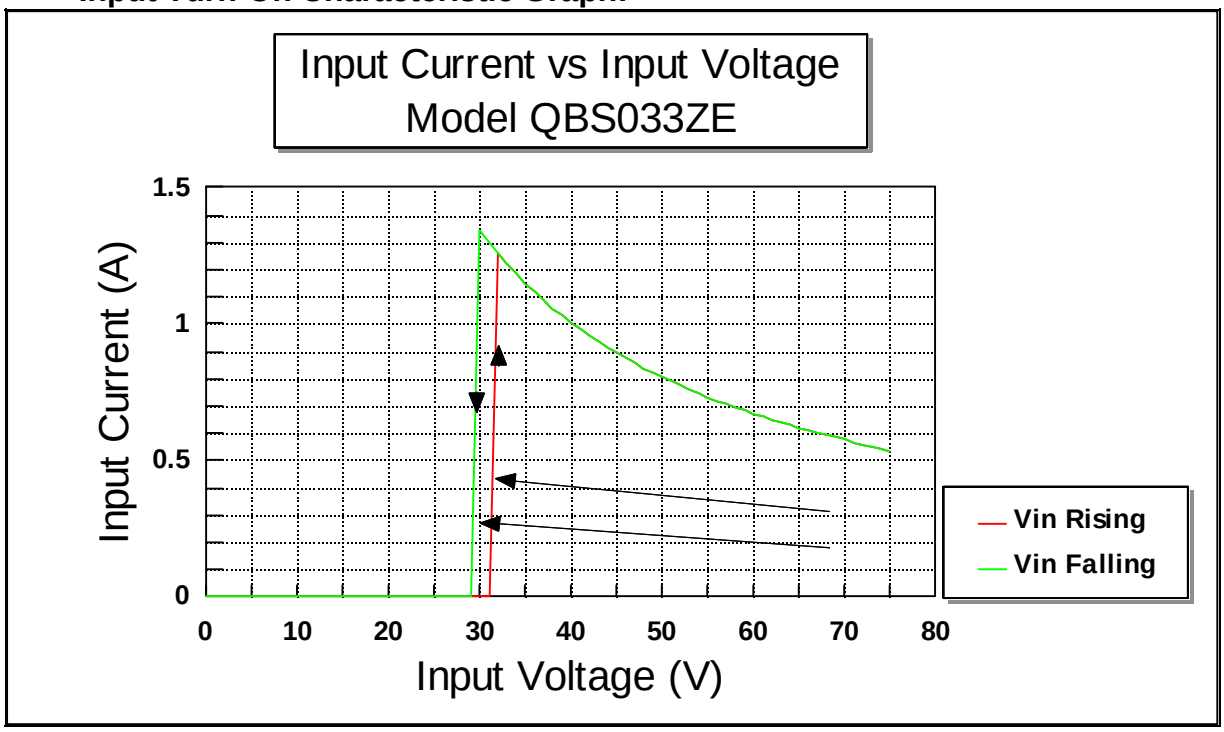
Input Inrush Current:

The input inrush current in the QES and QBS converters is not actively controlled. The input is capacitive, and the magnitude of the inrush current will largely be determined by the δv/δt at the input. In normal applications, the source impedance will limit the current peak, and spread the time duration out. The charge at 48 VDC input is approximately 480 micro coulombs. External input capacitors largely determine the effective charge and inrush current.

Input Turn On Characteristics:

The QBS and QES have under-voltage lockout, with hysteresis. A 48 volt input unit typically turns on at 32 Vin, and turns off at 30 Vin. The chart below shows one characteristic. The output load current is 10.0 amperes (resistive).

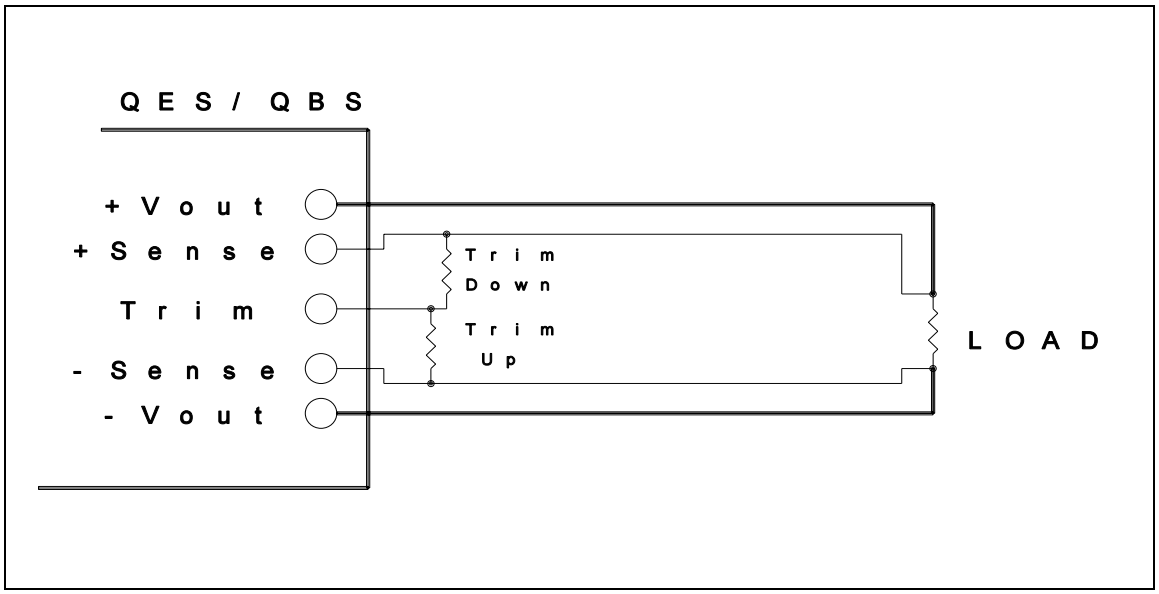
Input Turn-On Characteristic Graph:



Output Remote Sensing:

The QES and QBS converters both have the capability to remotely sense both lines of the output. This feature moves the effective output voltage regulation point from the output of the unit to the point of connection of the remote sense pins. This feature automatically adjusts the real output voltage of the module in order to compensate for voltage drops in distribution and maintain a regulated voltage at the point of load. This is shown in the schematic below.

Remote Sensing Schematic:

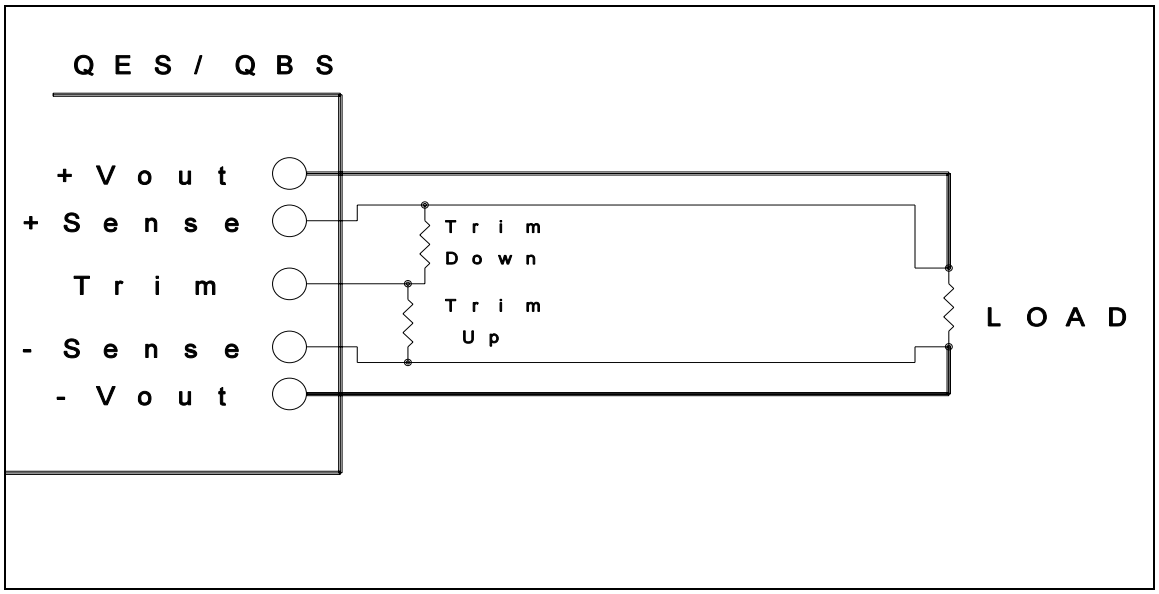


If the remote sense feature is not to be used, the sense pins should be connected locally. The +Sense pin should be connected to the +Out pin at the module and the -Sense pin should be connected to the -Out pin at the module.

Output Trimming:

The trim feature allows the user to adjust the output voltage from the nominal. This can be used to accommodate a different requirement or to do production margin testing. This can also be used with external circuitry to achieve current sharing between two units in parallel. Contact the Power-One factory for further information on this. There are two options available. The positive logic mode unit is the Power-One standard and trims with the circuit below:

Positive Logic Trim Circuit Schematic:



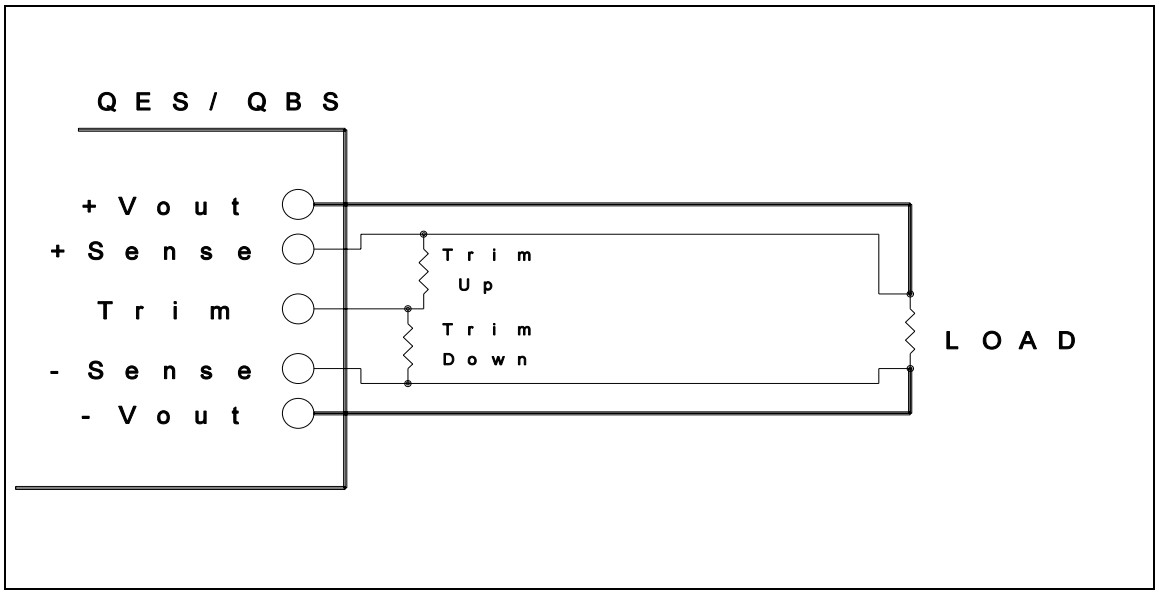
Positive Logic Trimming Up:
The QES and QBS positive logic units trim up with a resistor from the TRIM pin to the -Sense pin.

Positive Logic Trimming Down:
The QES and QBS positive logic units trim down with a resistor from the TRIM pin to the +Sense pin.

Negative Logic Trimming:

The -N option trims exactly like Lucent Technologies modules:

Negative Logic Trim Schematic:



Negative Logic Trimming Up:
The QES and QBS negative logic units trim up with a resistor from the TRIM pin to the +Sense pin.

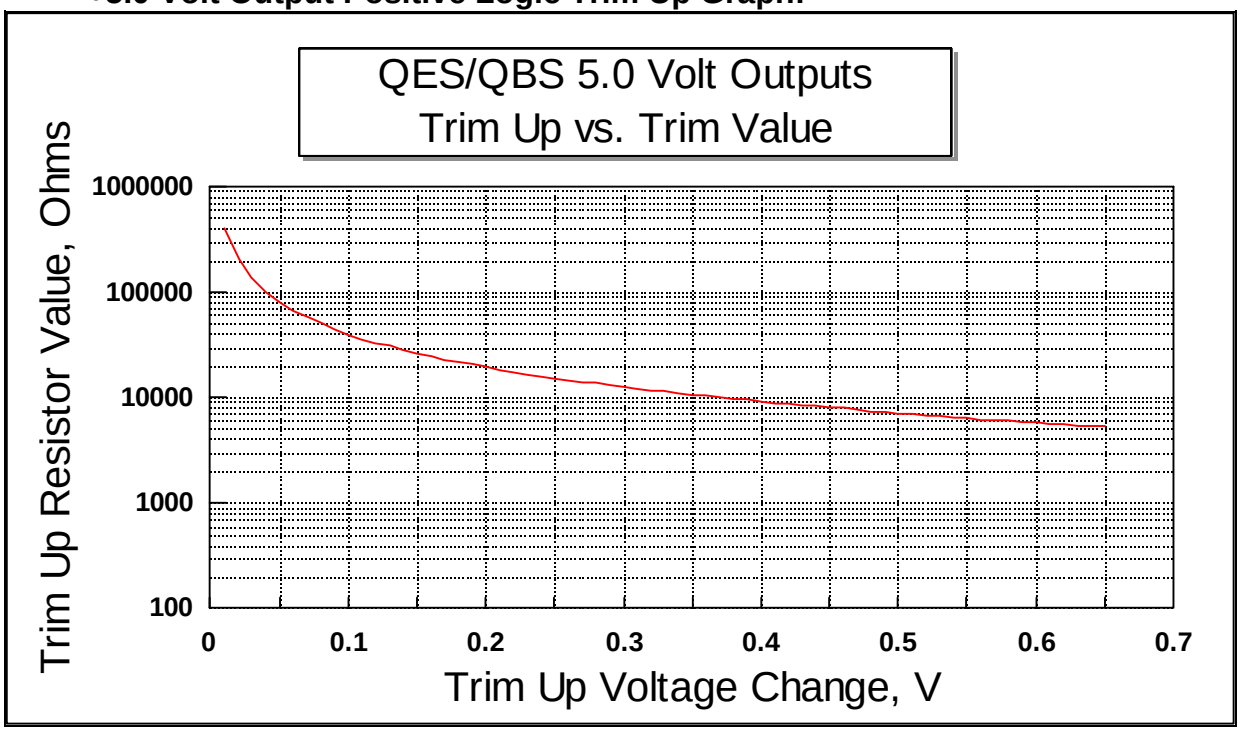
Negative Logic Trimming Down:
The QES and QBS negative logic units trim down with a resistor from the TRIM pin to the -Sense pin.

Important Trim Instructions, both Positive and Negative Logic:
In order to avoid creating apparent load regulation degradation, it is important that the trim resistors connect directly to the pin, and not to the load or to traces going to the load. A Kelvin style connection is recommended.

Trim Equations for Positive Logic:

The general equation for changing the output voltage on the positive logic modules is invariant, but the internal values are different for different output voltages, so the constants in the equation change. The graph of output voltage change versus trim resistor value and the specific equation for each output voltage is shown below:

+5.0 Volt Output Positive Logic Trim Up Graph:



+5.0 Volt Output Positive Logic Trim-Up Equation:

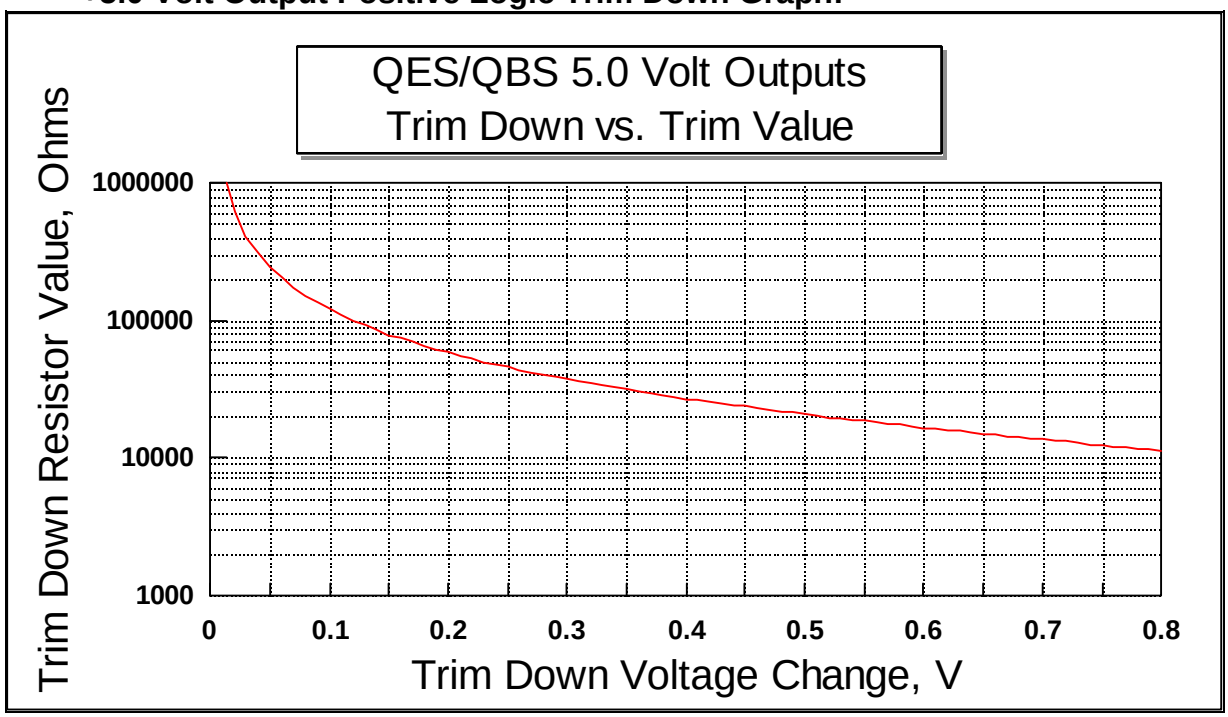
$$R_{TrimUp} = \frac{(4.067 - 1.000\Delta V_o)}{\Delta V_o} K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+5.0 Volt Output Positive Logic Trim Up Values:
(Approximate)

Resistor	Value	Effect
R-Trim up	Short	Trim +5 V up to 9.07 V (Not recommended)
R-Trim up	7.00 KΩ	Trim +5 V up to 5.51 V (Not recommended)
R-Trim up	8.00 KΩ	Trim +5 V up to 5.45 V
R-Trim up	9.00 KΩ	Trim +5 V up to 5.41 V
R-Trim up	10.0 KΩ	Trim +5 V up to 5.37 V
R-Trim up	20.0 KΩ	Trim +5 V up to 5.20 V
R-Trim up	50.0 KΩ	Trim +5 V up to 5.08 V
R-Trim up	100 KΩ	Trim +5 V up to 5.04 V
R-Trim up	250 KΩ	Trim +5 V up to 5.02 V

+5.0 Volt Output Positive Logic Trim Down Graph:



+5.0 Volt Output Positive Logic Trim-Down Equation:

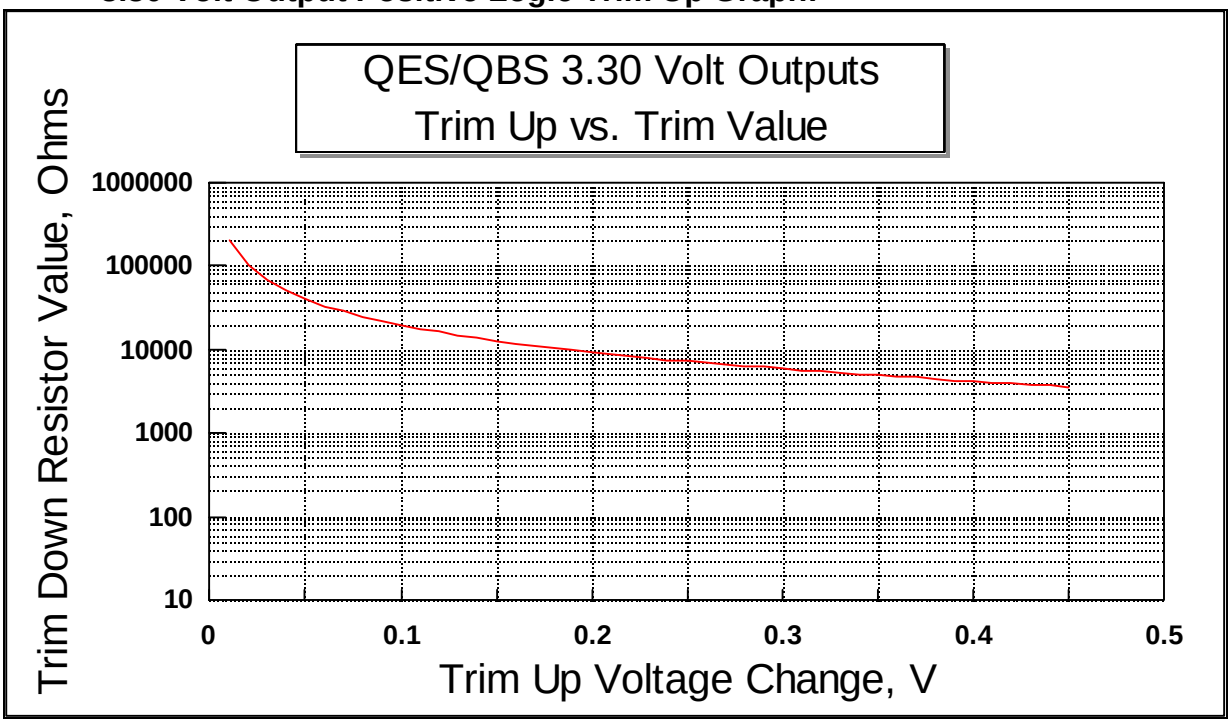
$$R_{TrimDown} = \frac{(12.533 - 4.320\Delta V_o)}{\Delta V_o} K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+5.0 Volt Output Positive Logic Trim Down Values:
(Approximate)

Resistor	Value	Effect
R-Trim down	Short	Trim +5 V down to 2.01 V (Not recommended)
R-Trim down	15.0 KΩ	Trim +5 V down to 4.35 V (Not recommended)
R-Trim down	20.0 KΩ	Trim +5 V down to 4.48 V (Not recommended)
R-Trim down	25.0 KΩ	Trim +5 V down to 4.57 V
R-Trim down	35.0 KΩ	Trim +5 V down to 4.68 V
R-Trim down	50.0 KΩ	Trim +5 V down to 4.77 V
R-Trim down	100 KΩ	Trim +5 V down to 4.88 V
R-Trim down	250 KΩ	Trim +5 V down to 4.95 V

+3.30 Volt Output Positive Logic Trim Up Graph:



+3.30 Volt Output Positive Logic Trim-Up Equation:

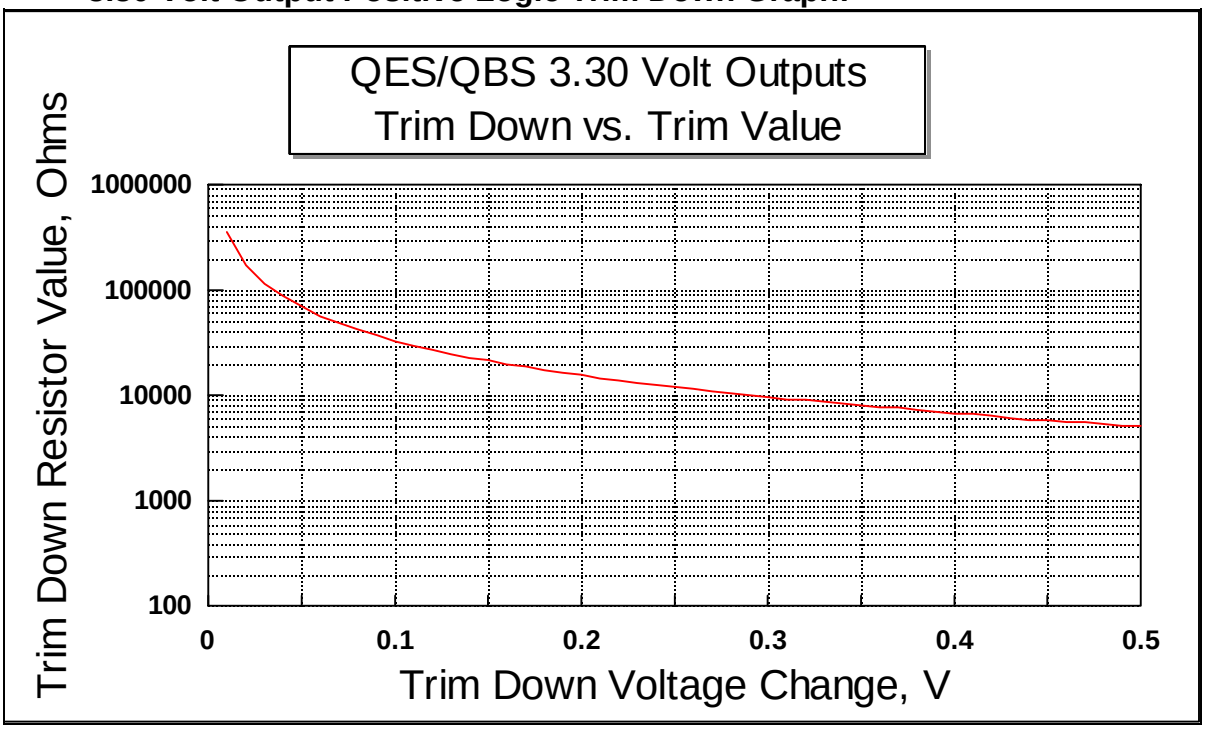
$$R_{TrimDown} = \frac{(2.0750 - 1.000\Delta V_o)}{\Delta V_o} K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+3.30 Volt Output Positive Logic Trim Up Values:
(Approximate)

Resistor	Value	Effect
R-Trim up	Short	Trim +3.3 V up to 5.38 V (Not recommended)
R-Trim up	5.00 KΩ	Trim +3.3 V up to 3.65 V (Not recommended)
R-Trim up	7.00 KΩ	Trim +3.3 V up to 3.56 V
R-Trim up	8.00 KΩ	Trim +3.3 V up to 3.54 V
R-Trim up	10.0 KΩ	Trim +3.3 V up to 3.49 V
R-Trim up	20.0 KΩ	Trim +3.3 V up to 3.40 V
R-Trim up	50.0 KΩ	Trim +3.3 V up to 3.34 V
R-Trim up	100 KΩ	Trim +3.3 V up to 3.32 V
R-Trim up	250 KΩ	Trim +3.3 V up to 3.31 V

+3.30 Volt Output Positive Logic Trim Down Graph:



+3.30 Volt Output Positive Logic Trim-Down Equation:

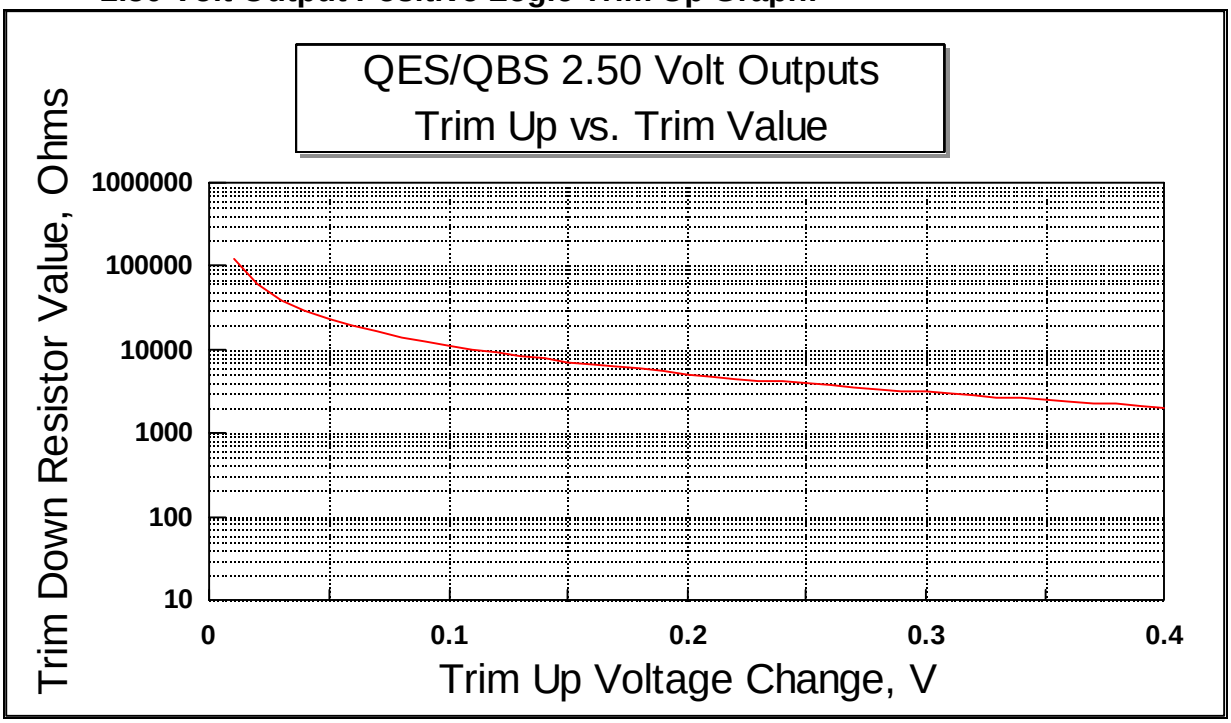
$$R_{TrimDown} = \frac{(3.5148 - 2.000\Delta V_o)}{\Delta V_o} K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+3.30 Volt Output Trim Positive Logic Down Values:
(Approximate)

Resistor	Value	Effect
R-Trim down	Short	Trim +3.3 V down to 2.00 V (Not recommended)
R-Trim down	5.00 KΩ	Trim +3.3 V down to 2.84 V (Not recommended)
R-Trim down	10.0 KΩ	Trim +3.3 V down to 3.02 V
R-Trim down	20.0 KΩ	Trim +3.3 V down to 3.15 V
R-Trim down	35.0 KΩ	Trim +3.3 V down to 3.21 V
R-Trim down	50.0 KΩ	Trim +3.3 V down to 3.23 V
R-Trim down	85.0 KΩ	Trim +3.3 V down to 3.26 V
R-Trim down	100 KΩ	Trim +3.3 V down to 3.27 V
R-Trim down	250 KΩ	Trim +3.3 V down to 3.29 V

+2.50 Volt Output Positive Logic Trim Up Graph:



+2.50 Volt Output Positive Logic Trim-Up Equation:

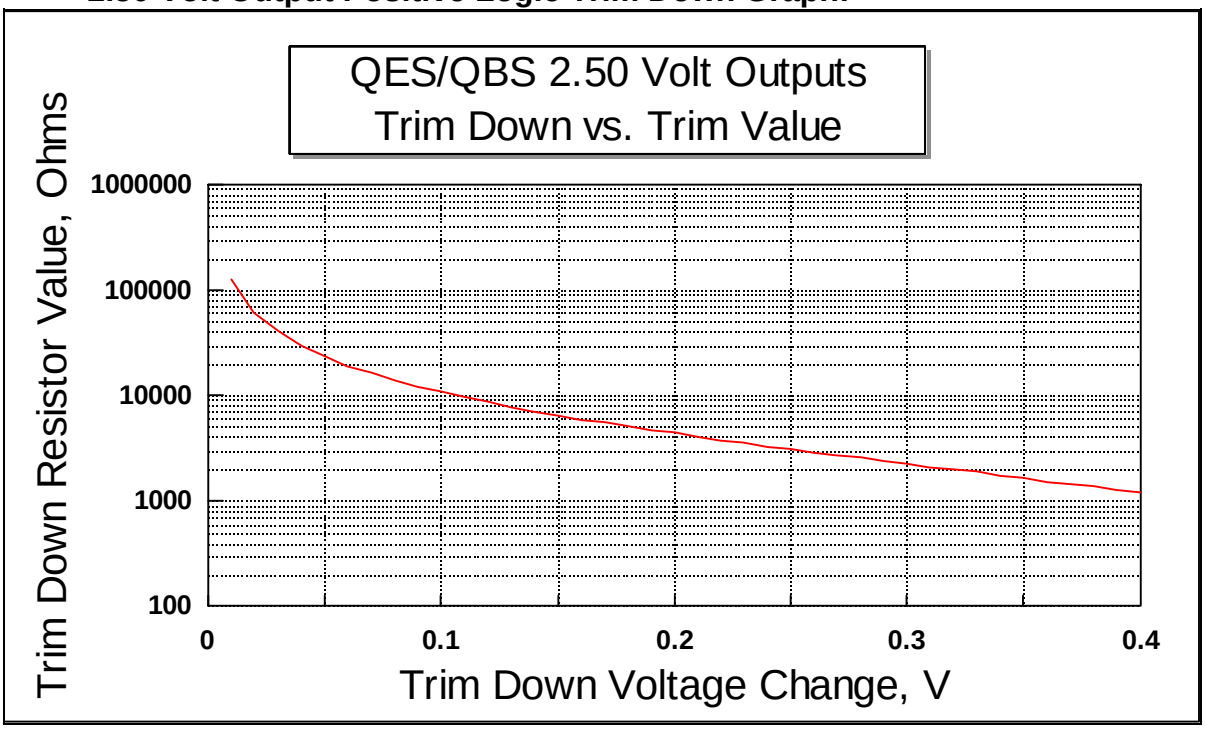
$$R_{TrimUp} = \frac{(1.2250 - 1000\Delta V_o)}{\Delta V_o} K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+2.50 Volt Output Positive Logic Trim Up Values:
(Approximate)

Resistor	Value	Effect
R-Trim up	Short	Trim +2.5 V up to 3.73 V (Not recommended)
R-Trim up	3.00 KΩ	Trim +2.5 V up to 2.81 V (Not recommended)
R-Trim up	5.00 KΩ	Trim +2.5 V up to 2.70 V
R-Trim up	7.00 KΩ	Trim +2.5 V up to 2.65 V
R-Trim up	10.0 KΩ	Trim +2.5 V up to 2.61 V
R-Trim up	20.0 KΩ	Trim +2.5 V up to 2.56 V
R-Trim up	50.0 KΩ	Trim +2.5 V up to 2.52 V
R-Trim up	100 KΩ	Trim +2.5 V up to 2.512 V
R-Trim up	250 KΩ	Trim +2.5 V up to 2.505 V

+2.50 Volt Output Positive Logic Trim Down Graph:



+2.50 Volt Output Positive Logic Trim-Down Equation:

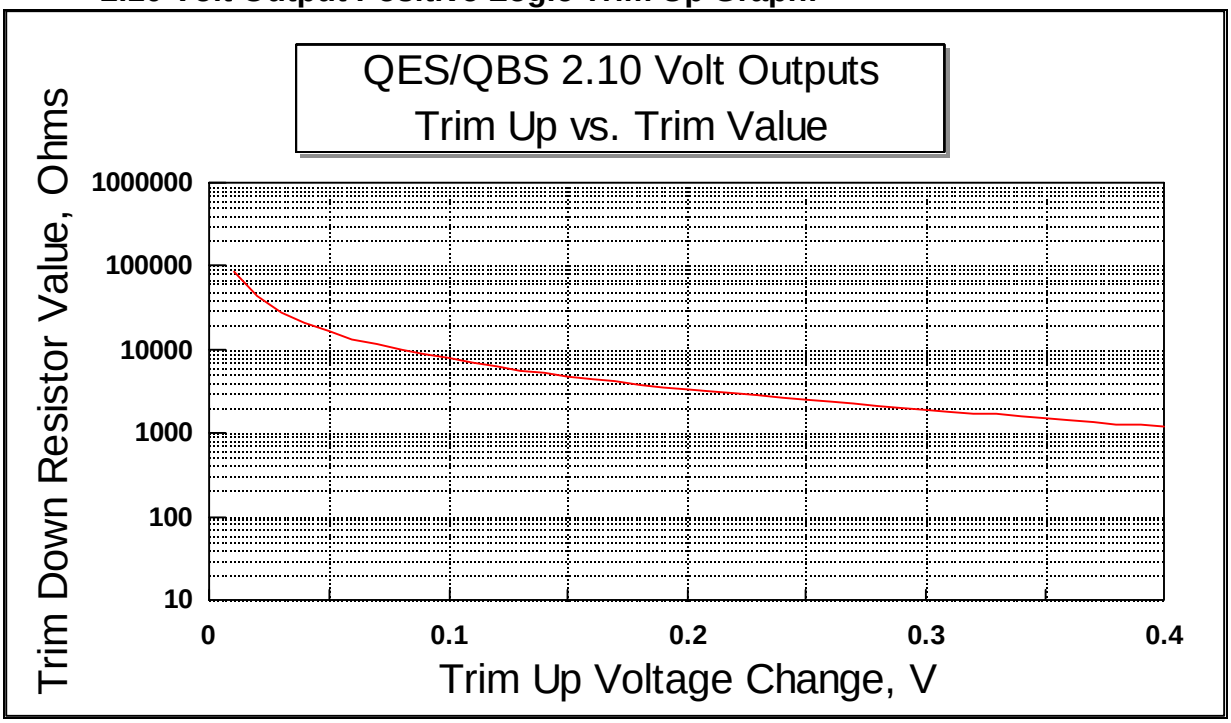
$$R_{TrimDown} = \frac{(1.2750 - 2.0000\Delta V_o)}{\Delta V_o} K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+2.50 Volt Output Positive Logic Trim Down Values:
(Approximate)

Resistor	Value	Effect
R-Trim down	Short	Trim +2.5 V down to 1.86 V (Not recommended)
R-Trim down	2.00 KΩ	Trim +2.5 V down to 2.18 V (Not recommended)
R-Trim down	3.00 KΩ	Trim +2.5 V down to 2.25 V
R-Trim down	5.00 KΩ	Trim +2.5 V down to 2.32 V
R-Trim down	10.0 KΩ	Trim +2.5 V down to 2.39 V
R-Trim down	20.0 KΩ	Trim +2.5 V down to 2.44 V
R-Trim down	50.0 KΩ	Trim +2.5 V down to 2.48 V
R-Trim down	100 KΩ	Trim +2.5 V down to 2.49 V
R-Trim down	250 KΩ	Trim +2.5 V down to 2.495 V

+2.10 Volt Output Positive Logic Trim Up Graph:



+2.10 Volt Output Positive Logic Trim-Up Equation:

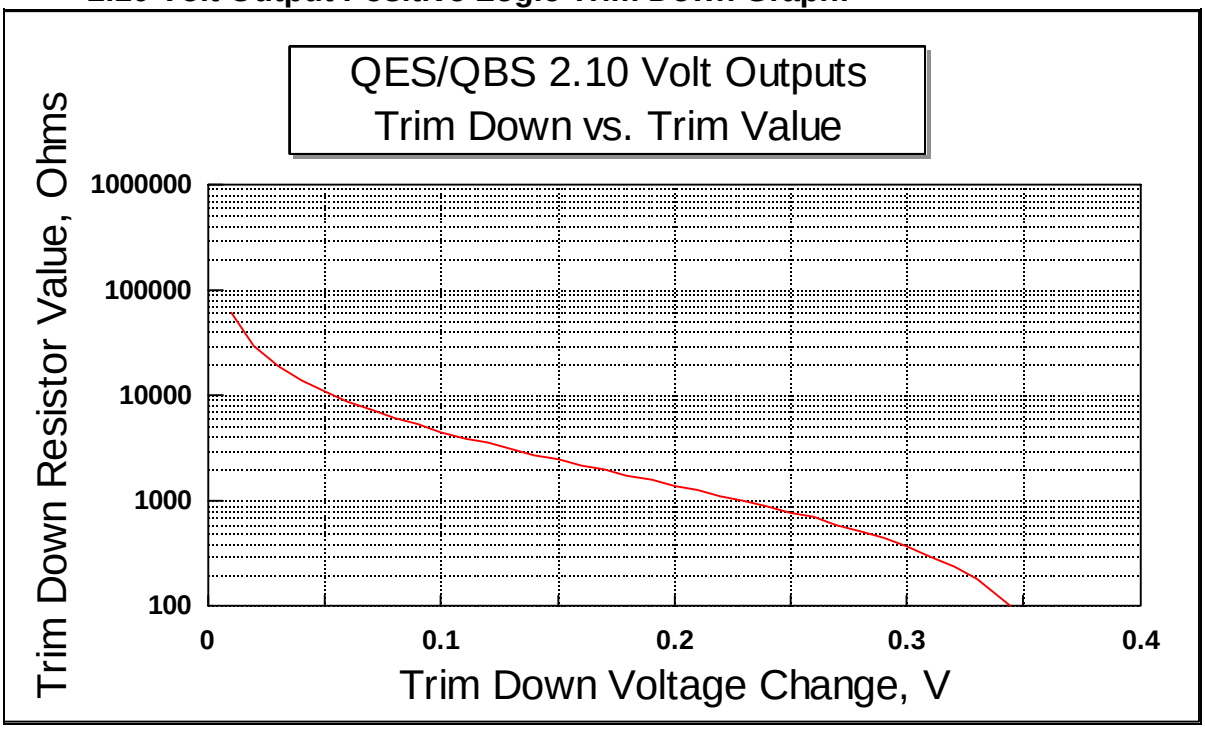
$$R_{TrimUp} = \frac{(0.8750 - 1000\Delta V_o)}{\Delta V_o} K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+2.10 Volt Output Positive Logic Trim Up Values:
(Approximate)

Resistor	Value	Effect
R-Trim up	Short	Trim +2.1 V up to 2.98 V (Not recommended)
R-Trim up	3.00 KΩ	Trim +2.1 V up to 2.32 V
R-Trim up	5.00 KΩ	Trim +2.1 V up to 2.25 V
R-Trim up	7.00 KΩ	Trim +2.1 V up to 2.21 V
R-Trim up	10.0 KΩ	Trim +2.1 V up to 2.18 V
R-Trim up	20.0 KΩ	Trim +2.1 V up to 2.14 V
R-Trim up	50.0 KΩ	Trim +2.1 V up to 2.12 V
R-Trim up	100 KΩ	Trim +2.1 V up to 2.11 V

+2.10 Volt Output Positive Logic Trim Down Graph:



+2.10 Volt Output Positive Logic Trim-Down Equation:

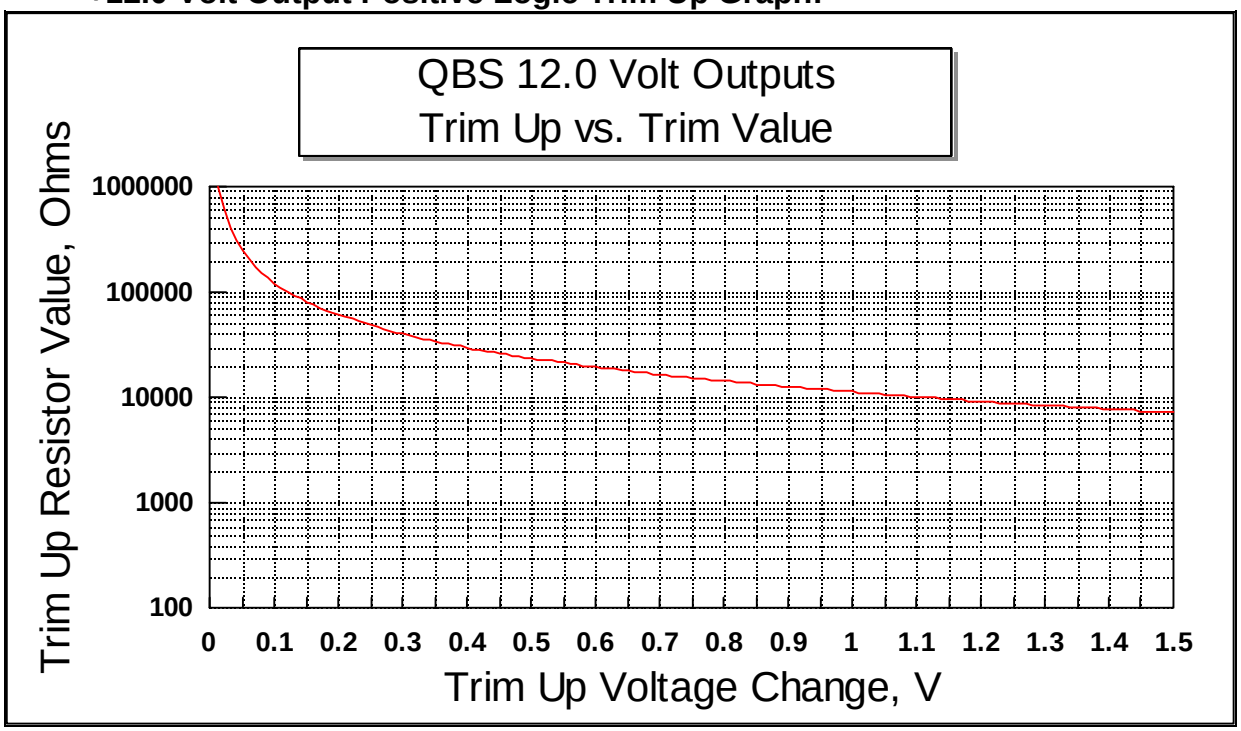
$$R_{TrimDown} = \frac{(0.6250 - 1.7143\Delta V_o)}{\Delta V_o} K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+2.10 Volt Output Positive Logic Trim Down Values:
(Approximate)

Resistor	Value	Effect
R-Trim down	Short	Trim +2.1 V down to 1.74 V (Not recommended)
R-Trim down	2.00 KΩ	Trim +2.1 V down to 1.93 V
R-Trim down	3.00 KΩ	Trim +2.1 V down to 1.97 V
R-Trim down	5.00 KΩ	Trim +2.1 V down to 2.01 V
R-Trim down	10.0 KΩ	Trim +2.1 V down to 2.05 V
R-Trim down	20.0 KΩ	Trim +2.1 V down to 2.08 V
R-Trim down	50.0 KΩ	Trim +2.1 V down to 2.09 V

+12.0 Volt Output Positive Logic Trim Up Graph:



+12.0 Volt Output Positive Logic Trim-Up Equation:

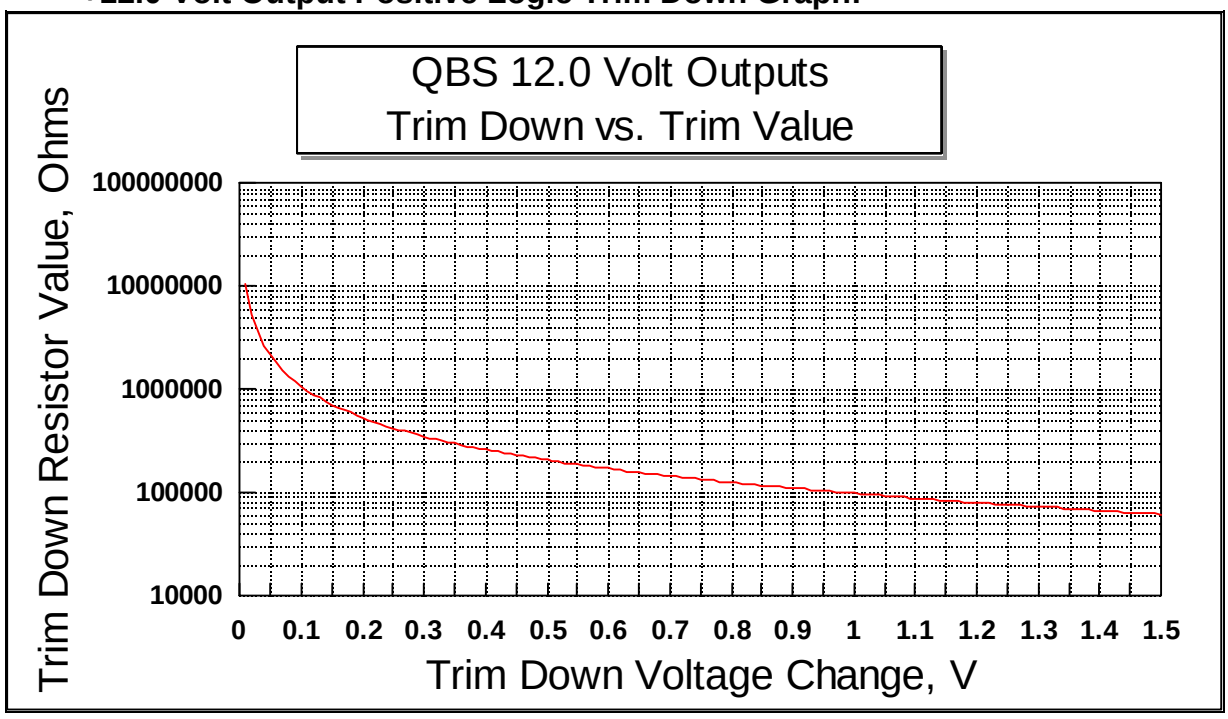
$$R_{TrimUp} = \frac{(12.250 - 1.000\Delta V_o)}{\Delta V_o} K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+12.0 Volt Output Positive Logic Trim Up Values:
(Approximate)

Resistor	Value	Effect
R-Trim up	Short	Trim +12 V up to 24.3 V (Not recommended)
R-Trim up	7.00 KΩ	Trim +12 V up to 13.5 V (Not recommended)
R-Trim up	8.00 KΩ	Trim +12 V up to 13.4 V
R-Trim up	9.00 KΩ	Trim +12 V up to 13.2 V
R-Trim up	10.0 KΩ	Trim +12 V up to 13.1 V
R-Trim up	20.0 KΩ	Trim +12 V up to 12.6 V
R-Trim up	50.0 KΩ	Trim +12 V up to 12.2 V
R-Trim up	100 KΩ	Trim +12 V up to 12.1 V
R-Trim up	250 KΩ	Trim +12 V up to 12.05 V

+12.0 Volt Output Positive Logic Trim Down Graph:



+12.0 Volt Output Positive Logic Trim-Down Equation:

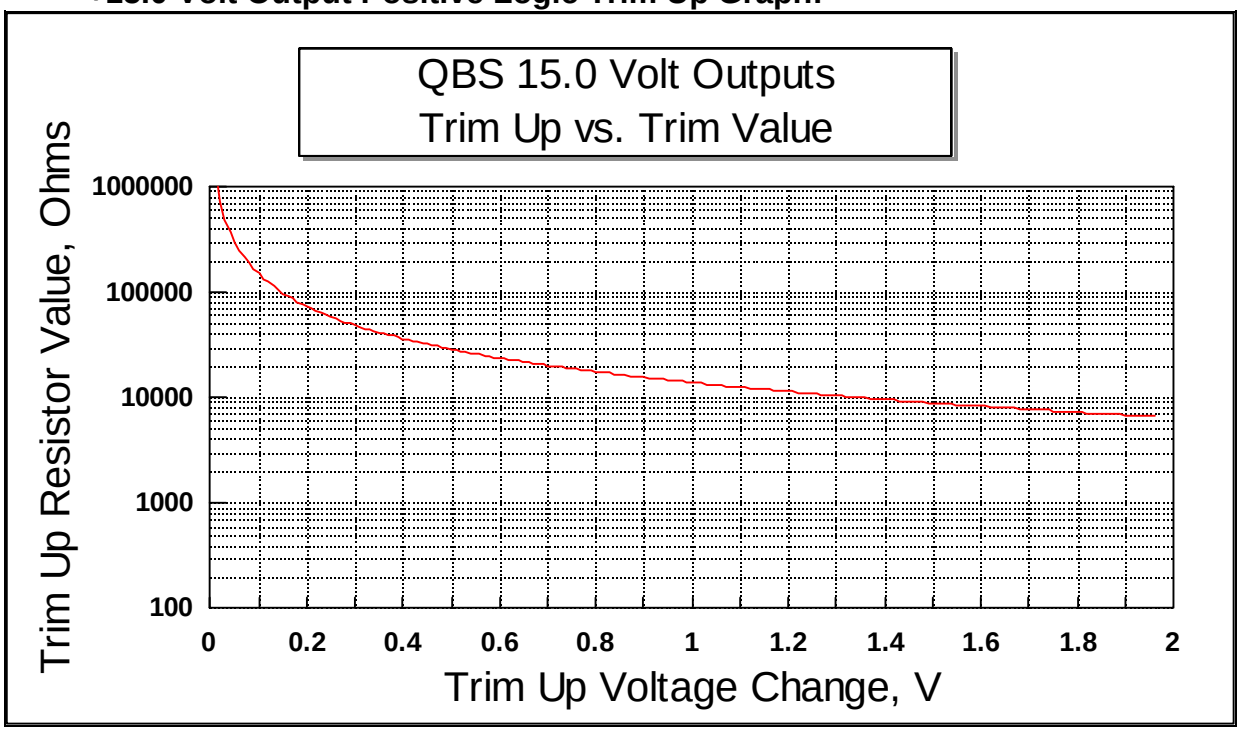
$$R_{TrimDown} = \frac{(107.750 - 11.000\Delta V_o)}{\Delta V_o} K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+12.0 Volt Output Positive Logic Trim Down Values:
(Approximate)

Resistor	Value	Effect
R-Trim down	Short	Trim +12 V down to 2.20 V (Not recommended)
R-Trim down	50.0 KΩ	Trim +12 V down to 10.2 V (Not recommended)
R-Trim down	100 KΩ	Trim +12 V down to 11.0 V
R-Trim down	200 KΩ	Trim +12 V down to 11.5 V
R-Trim down	250 KΩ	Trim +12 V down to 11.6 V
R-Trim down	500 KΩ	Trim +12 V down to 11.8 V
R-Trim down	1.00 MΩ	Trim +12 V down to 11.9 V

+15.0 Volt Output Positive Logic Trim Up Graph:



+15.0 Volt Output Positive Logic Trim-Up Equation:

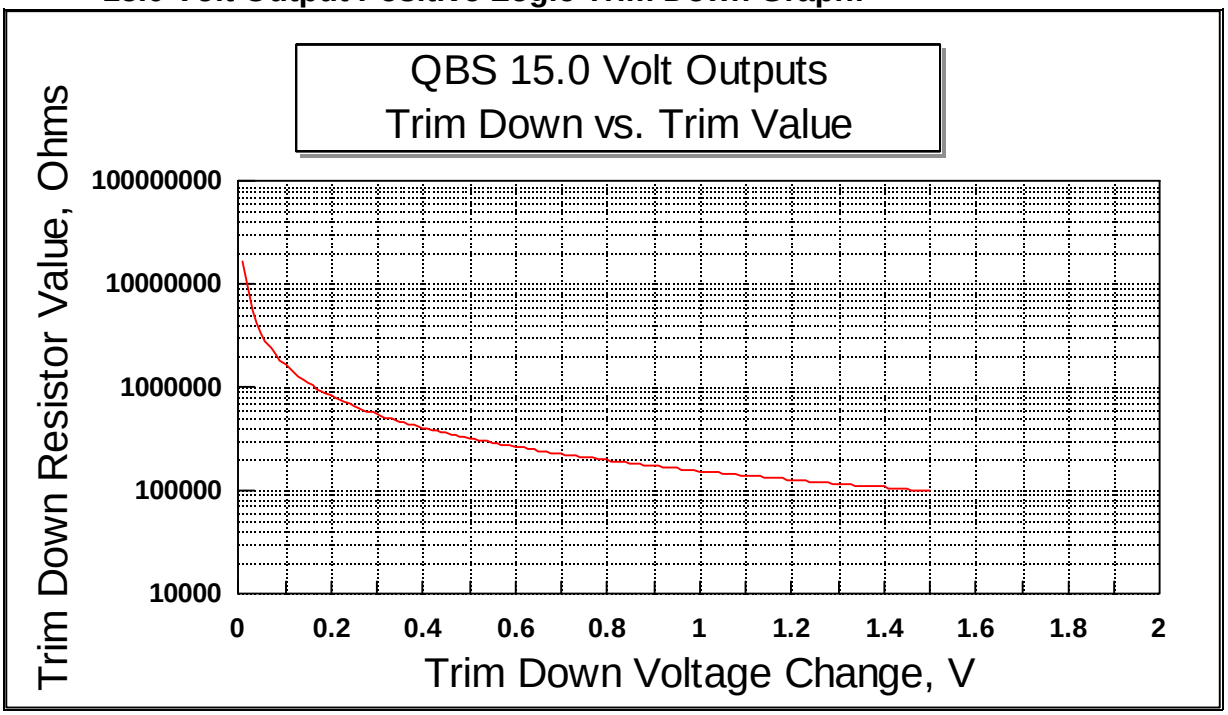
$$R_{TrimUp} = \frac{(14822.5 - 1.000\Delta V_o)}{\Delta V_o} K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+15.0 Volt Output Positive Logic Trim Up Values:
(Approximate)

Resistor	Value	Effect
R-Trim up	Short	Trim +15 V up to 29.8 V (Not recommended)
R-Trim up	7.00 KΩ	Trim +15 V up to 16.9 V (Not recommended)
R-Trim up	8.00 KΩ	Trim +15 V up to 16.6 V (Not recommended)
R-Trim up	9.00 KΩ	Trim +15 V up to 16.5 V
R-Trim up	10.0 KΩ	Trim +15 V up to 16.3 V
R-Trim up	20.0 KΩ	Trim +15 V up to 15.7 V
R-Trim up	50.0 KΩ	Trim +15 V up to 15.3 V
R-Trim up	100 KΩ	Trim +15 V up to 15.1 V

+15.0 Volt Output Positive Logic Trim Down Graph:



+15.0 Volt Output Trim-Down Equation:

$$R_{TrimDown} = \frac{(166.6775 - 13.10\Delta V_o)}{\Delta V_o} K\Omega$$

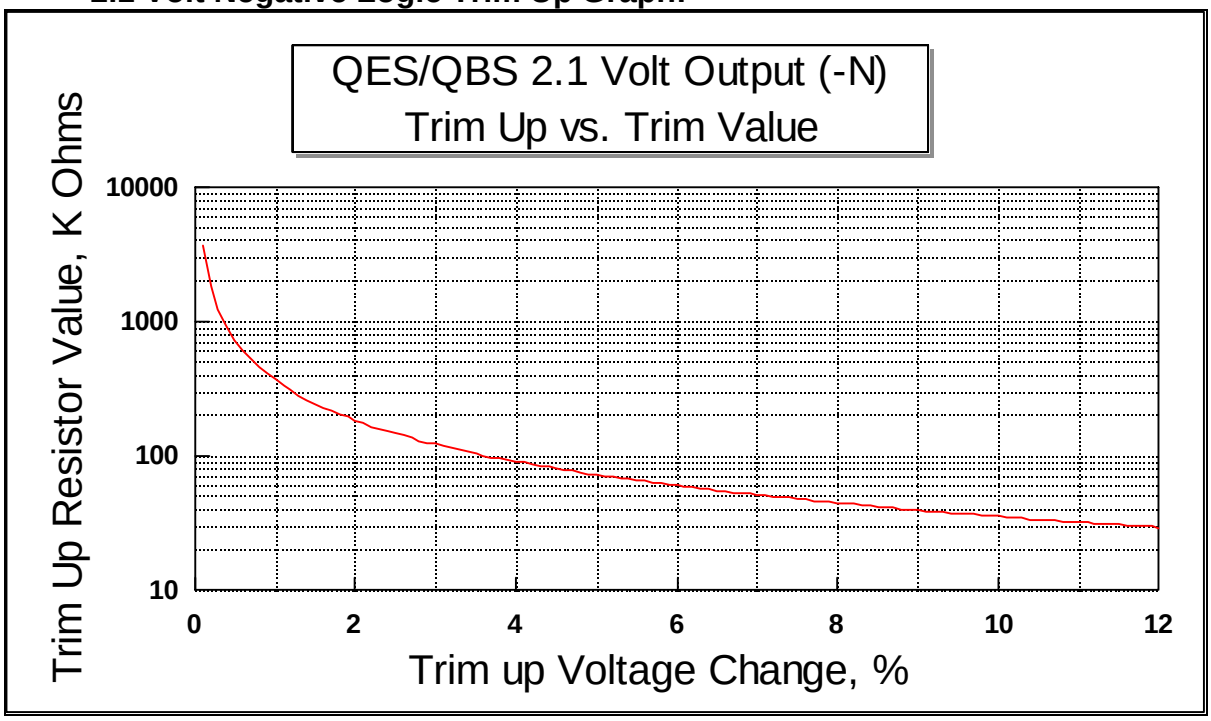
Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Positive Logic Trim Circuit Schematic, and ΔV_o is the change in the trimmed output voltage from the nominal output voltage.

+15.0 Volt Output Trim Down Values:
(Approximate)

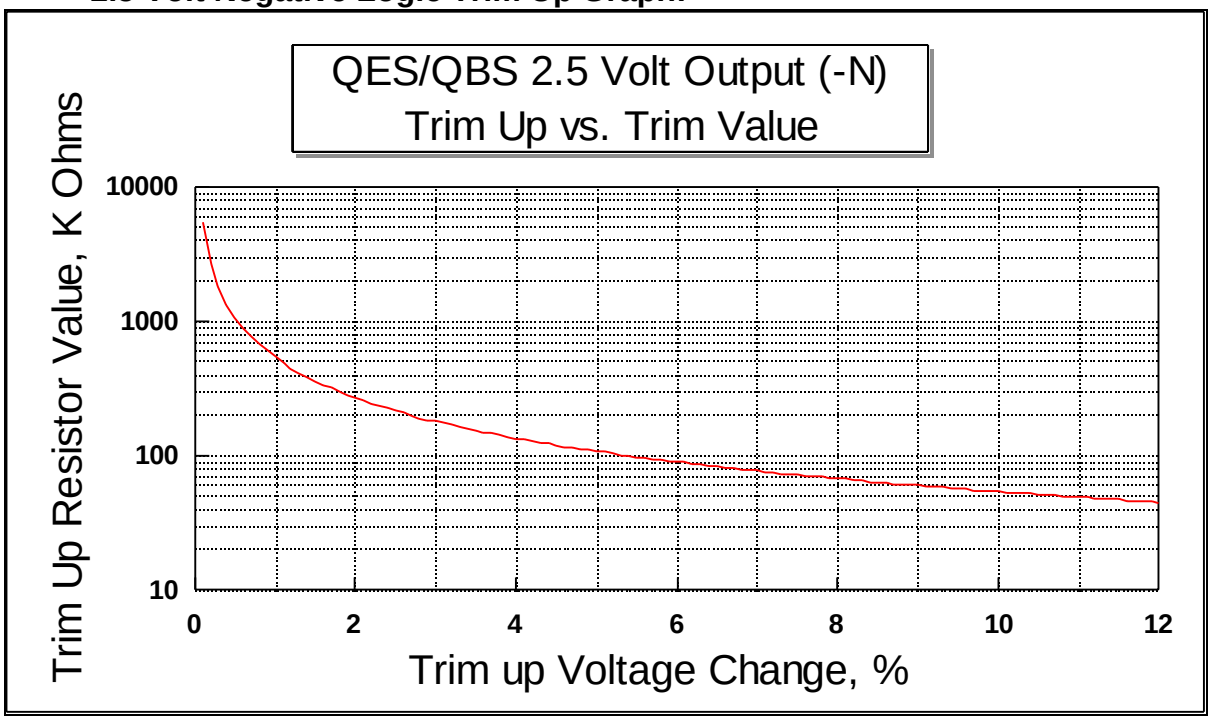
Resistor	Value	Effect
R-Trim down	Short	Trim +15 V down to 2.28 V (Not recommended)
R-Trim down	90.0 KΩ	Trim +15 V down to 13.4 V (Not recommended)
R-Trim down	100 KΩ	Trim +15 V down to 13.5 V
R-Trim down	155 KΩ	Trim +15 V down to 14.0 V
R-Trim down	200 KΩ	Trim +15 V down to 14.2 V
R-Trim down	320 KΩ	Trim +15 V down to 14.5 V
R-Trim down	545 KΩ	Trim +15 V down to 14.7 V
R-Trim down	820 KΩ	Trim +15 V down to 14.8 V
R-Trim down	1.65 MΩ	Trim +15 V down to 14.9 V

Trim Values for Negative Logic:

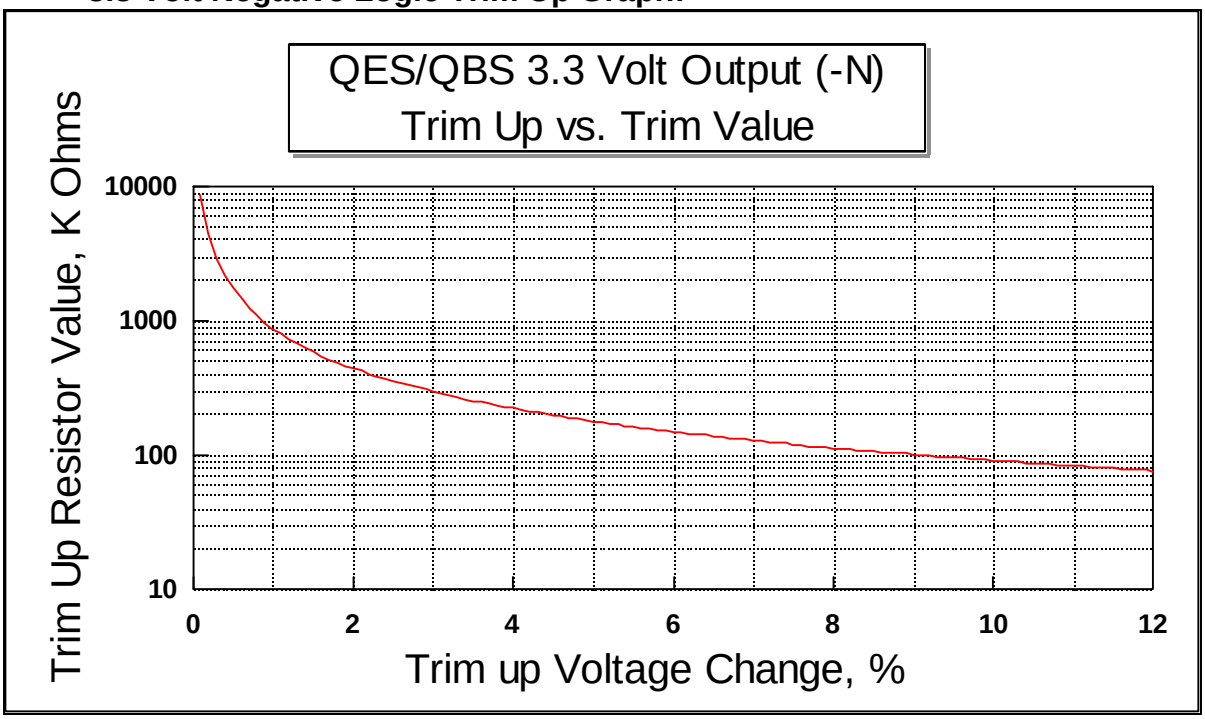
+2.1 Volt Negative Logic Trim Up Graph:



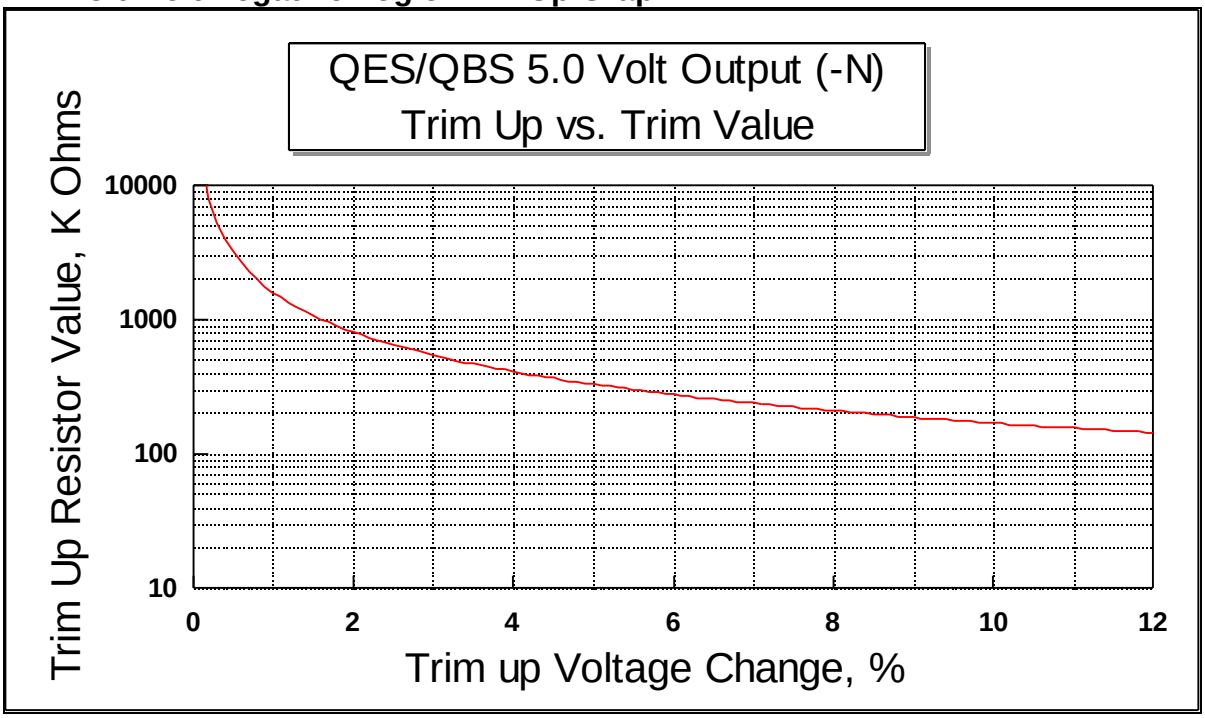
+2.5 Volt Negative Logic Trim Up Graph:



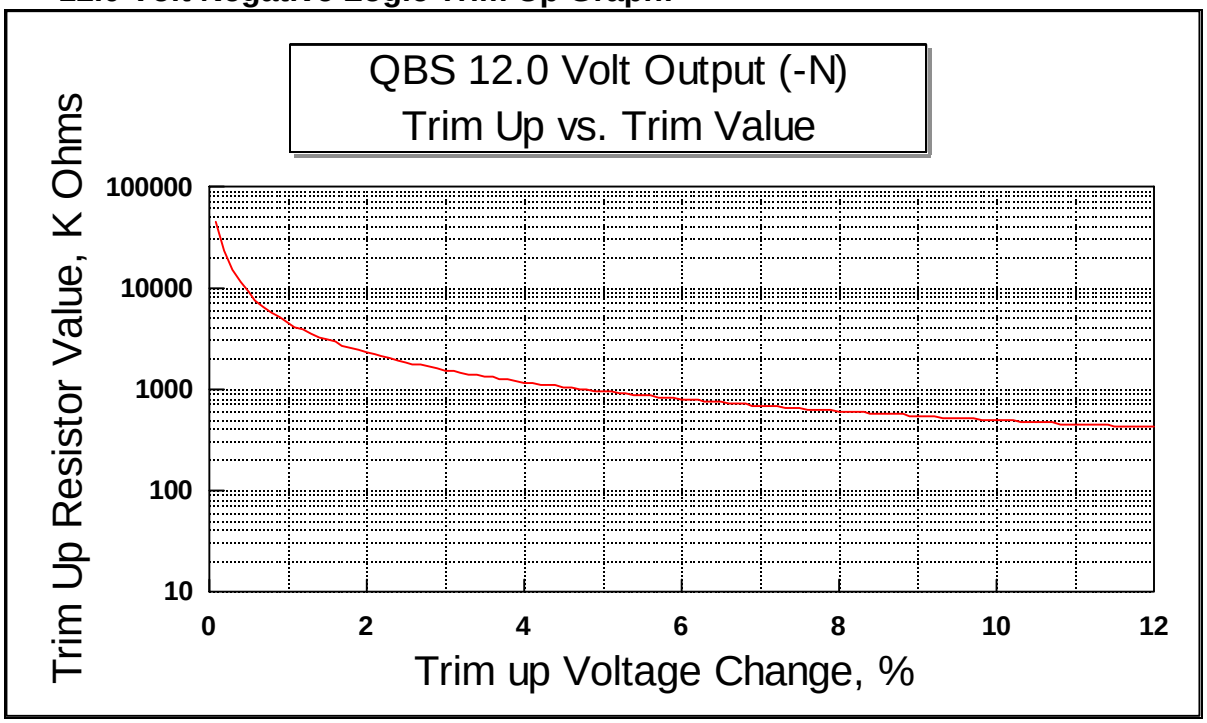
+3.3 Volt Negative Logic Trim Up Graph:



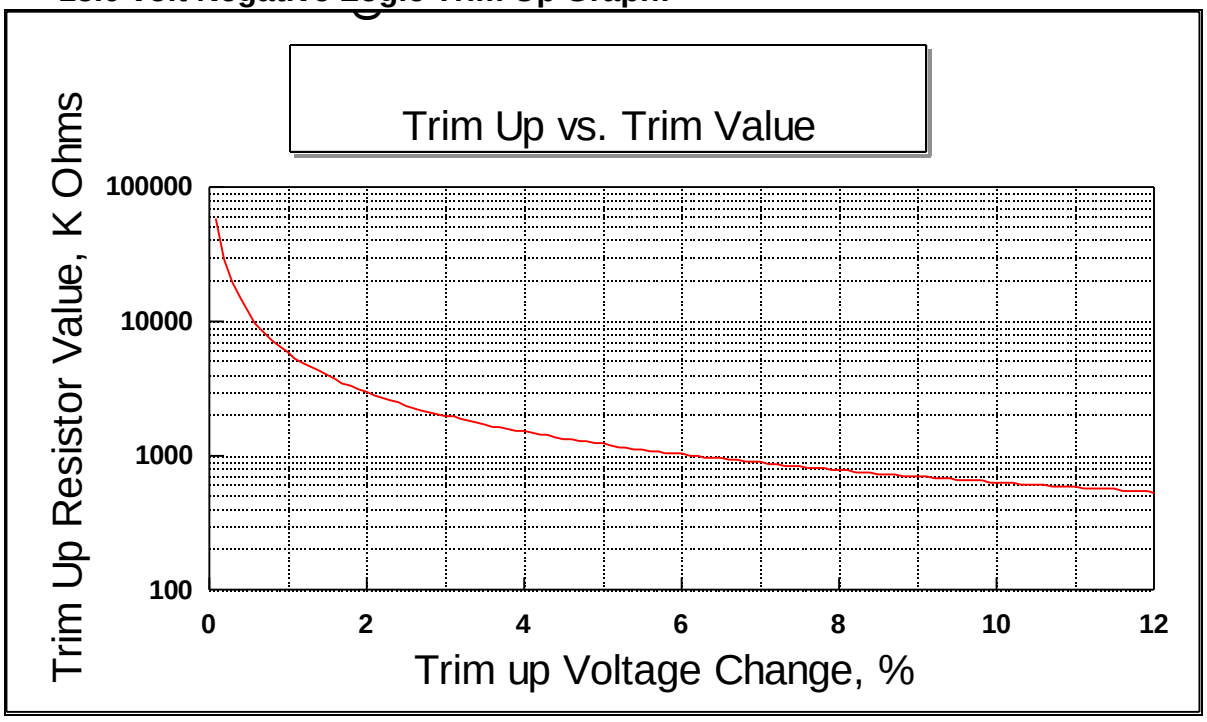
+5.0 Volt Negative Logic Trim Up Graph:



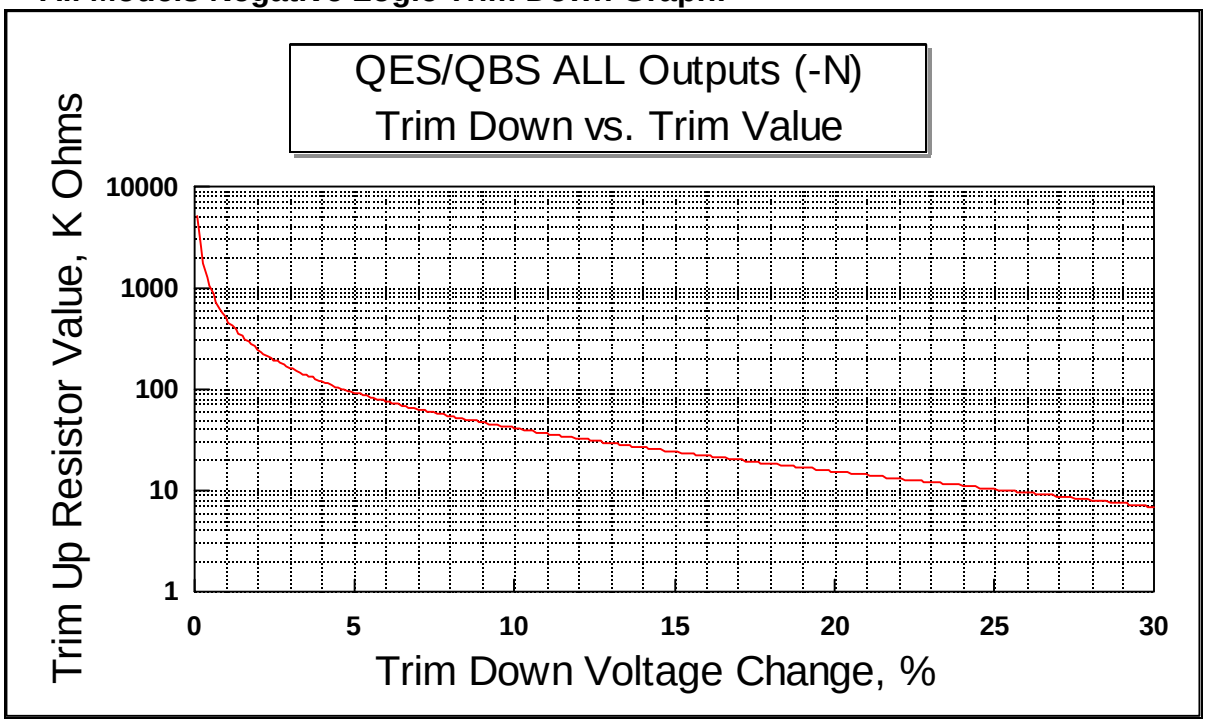
+12.0 Volt Negative Logic Trim Up Graph:



+15.0 volt Negative Logic Trim Up Graph:



All Models Negative Logic Trim Down Graph:



Trim Equations for Negative Logic:

The precise trim values for negative logic models can be determined from the following equations:

Negative Logic Trim Up Equation:

$$R_{TrimUp} = 5.11\left[\frac{Vo(100+\Delta\%)}{1.225\Delta\%} - \frac{(100+2\Delta\%)}{\Delta\%}\right] K\Omega$$

Negative Logic Trim Down Equation:

$$R_{TrimDown} = 5.11\left(\frac{100}{\Delta\%} - 2\right) K\Omega$$

Where R_{TrimUp} and $R_{TrimDown}$ are as shown in the QES/QBS Negative Logic Trim Circuit, Δ% is the change in the trimmed output voltage from the nominal output voltage, expressed in percent, and Vo is the value of the nominal output voltage of the unit.

Other Output Voltages:

For trim equations or values for other output voltages, call Power-One.

Trim and Remote Sense Limits:

There are limits to both the remote sense capability and the output trim capability:

Limit #1: The output voltage measured across the output pins of the unit must never be greater than 110% of the nominal output voltage. The QES and QBS are capable of maintaining regulation at full output power at 110% of nominal output voltage. They may not be capable of maintaining regulation at 110% of the nominal output at the minimum input voltage.

Limit #2: The output power from the unit must not exceed its maximum rating. This is determined by measuring the output voltage on the output pins, and multiplying by the output current. When using remote sensing, the output pin voltage is always greater than the load (sense pin) voltage.

Limit #3: There should never be greater than 0.25 volts of drop between any output pin and its remote sense pin. This limit can sometimes be violated if a diode is used for voltage blocking for redundancy or current sharing purposes. Consult the Power-One factory for details on specific models.

Limit #4: Models with output voltages above 2.50 volts will trim down further than the 10% limit. In general, this is permissible. The user must confirm that the results are acceptable in the application. Trimming down further than the 10% limit causes the feedback loop dynamics to change, with a reduction in the phase margin.

Output Over-Voltage Protection:

The over-voltage protection incorporates a separate feedback loop which activates at between 120% and 140% of the nominal output voltage, measured on the output pins. When it detects an over-voltage condition it sends a signal to the input side of the module which turns it off and causes it to latch off. The latch can be reset in either of two different ways. Either remove the DC input for a few seconds or pull the shutdown pin low, turning the unit off, and then release it. The output voltage will then come up under the control of the input soft start. If the over-voltage condition was externally caused and is gone, the module will then operate normally. If the over-voltage condition persists, the unit will latch off again. If a tighter control over the output voltage is required, Power-One recommends an independent output voltage monitor which shuts off the module with the control pin. Pulling the control pin low will absolutely shut the output off in any single fault condition.

Output OVP Thresholds:

The output over-voltage thresholds are factory set at 115 to 140% of the nominal output voltage, and do not change with a trim in the output voltage of the unit. These thresholds are:

2.50 Volt Outputs:	OV limit between 2.88 and 3.50 volts.
3.30 Volt Outputs:	OV limit between 3.80 and 4.62 volts.
5.00 Volt Outputs:	OV limit between 5.75 and 7.00 volts.
12.0 Volt Outputs:	OV limit between 13.8 and 16.8 volts.
15.0 Volt Outputs:	OV limit between 17.25 and 21.0 volts.

Output Under-Voltage Protection:

The QBS and QES modules also feature output under-voltage protection, which activates, after a time delay, when the output voltage is below the set point. When activated the under-voltage protection turns the module off and latches it off. This latch can be reset in the same two ways as the output over-voltage latch. Either remove the DC input for a few seconds or pull the shutdown pin low, turning the unit off, and then release it. The output voltage will then come up under the control of the input soft start. If the under-voltage condition was externally caused and is gone, the module will then operate normally. If the condition persists, the unit will latch off again. This feature provides absolute protection against output overloads or short circuits which would cause the dissipation in the module to exceed that in normal operation. This feature also helps protect against burnt traces or wires in the power distribution system from the module to the load.

Redundant and “Hot-Swap” Applications:

The QES and QBS power converters, because of their high efficiency and small board area, are ideal choices for redundant or hot swap applications. Implementing these, however, requires a careful understanding of all of the implications of the circuit. As mentioned previously, QES converters should never be connected in parallel directly on their outputs. A blocking diode must always be used (QBS units may be directly connected). In order to maintain regulation after the diode, the remote sensing must be connected there. When two units are paralleled, one unit will have a higher output. This unit will cause the other unit to be turned off, since it will see an output voltage higher than it is set for. This is always unacceptable, since the off unit will not be available to take up the load immediately should the first unit fail. The solution for this is also to implement current sharing, so both units are always operating. Even so, under light load conditions, one unit may be off. Since a redundant unit should always be

monitored ahead of its combining diode to insure that it is capable of operation, this may create an alarm. It is thus also a good idea to incorporate a “catch” circuit on the remote sensing. This simple circuit “catches” the output if it attempts to go low, and holds it there. Contact Power-One for details.

Hot swap power converters are designed to be plugged into racks while the power is applied. In order to avoid burning the input connector pins with the inrush current, there is usually some type of active inrush limiting used. This is especially true if there is local EMI filtering, since the capacitors in this filter can also cause high current spikes, so the inrush limiting must be ahead of the EMI filter. Since these units will turn on almost immediately once input voltage is applied, it should be actively held off with the control pin until the inrush limiting is completed, and there is a low resistance between the source and the converter.

There are several more tricks involved with redundant or hot-swap applications. Power-One recommends conversations with the factory about any of these applications.

Input Shutdown Pin:

Positive Logic Shutdown:

The shutdown pin in the QES and QBS functions as a normal soft shutdown. It is referenced to the negative input pin. With the normal positive logic, when the shutdown pin is pulled low, the output is turned off and the unit goes into a very low input power mode. The externally applied low must be capable of pulling at least 1.0 ma down to below 1.8 volts. To turn the unit on again, either the low can be released or the pin can be driven high. The open circuit voltage of the pin is about 5 volts. There is an internal blocking diode, so a driven high can go up to 15 volts. The unit input current in shutdown is just over the same 1.0 ma which the control circuit must sink, and less than 5.0 ma. The shutdown pin is also used to reset the latch off which results from either an output over-voltage condition or an output overload condition. Pulling the pin low, as would be done to turn off, will both turn it off and reset the latch. Releasing the pin will then permit a normal start, provided that the problem which created the latch has been cleared.

Negative Logic Shutdown:

With negative logic, when the pin is forced high or left open the unit is off. When the pin is pulled low, the unit is turned on. The externally applied low must be capable of pulling at least 1.0 ma down to below 1.2 volts. To turn the unit off again, either the low can be released or the pin can be driven high. The open circuit voltage of the pin is about 5 volts. There is an internal blocking diode, so a driven high can go up to 15 volts. The shutdown pin is also used to reset the latch off which results from either an output over-voltage condition or an output overload condition. Pushing the pin high or releasing a pull-down, as would be done to turn off, will both turn it off and reset the

latch. Pulling the pin low again will then permit a normal start, provided that the problem which created the latch has been cleared.

When the shutdown pin is used to achieve remote control, the user must take care to insure that the pin reference for the control is really the -IN pin. The shutdown cannot be referenced ahead of EMI filtering, or remotely from the unit. Optically coupling the shutdown information, and locating the optical coupler directly at the module, will solve any of these problems.

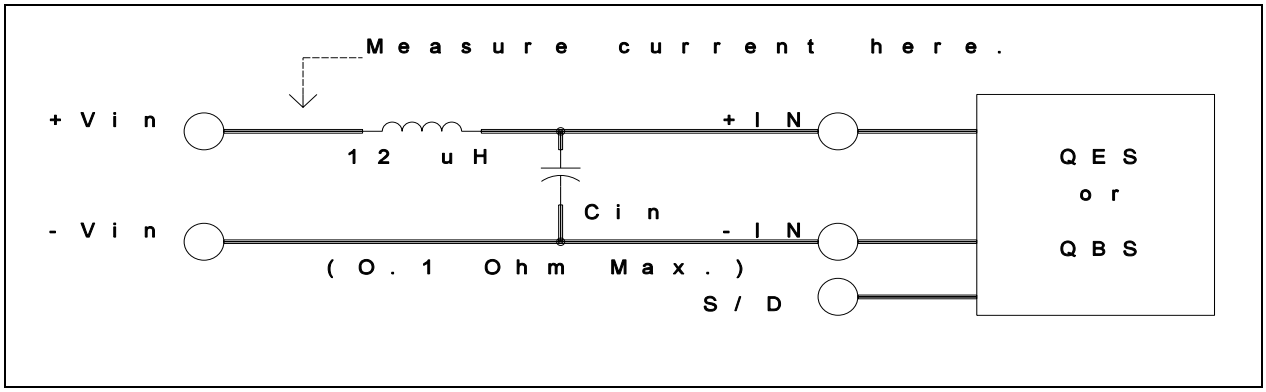
Optional Control Features:

The QES or QBS can be produced with control pins labeled “gate-in” and “gate-out,” providing functional equivalence with other high density power converters. The gate-in pin functions as a control, and also as a synchronization input. The gate-out pin functions as an output with which to synchronize other units. Contact the factory for further details and specifications.

Reflected Input Current:

The input reflected current can be reduced with the following circuit external to the modules:

Reflected Ripple Current Measurement Circuit:

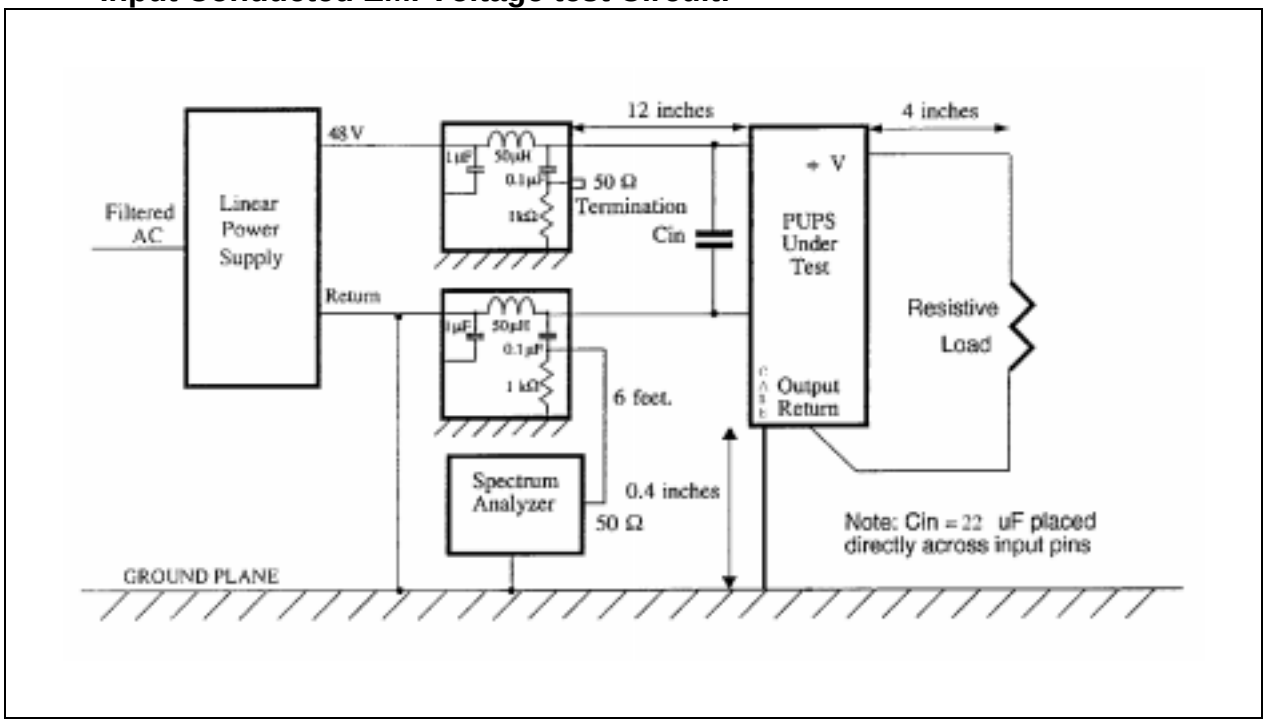


Input EMI Characteristics:

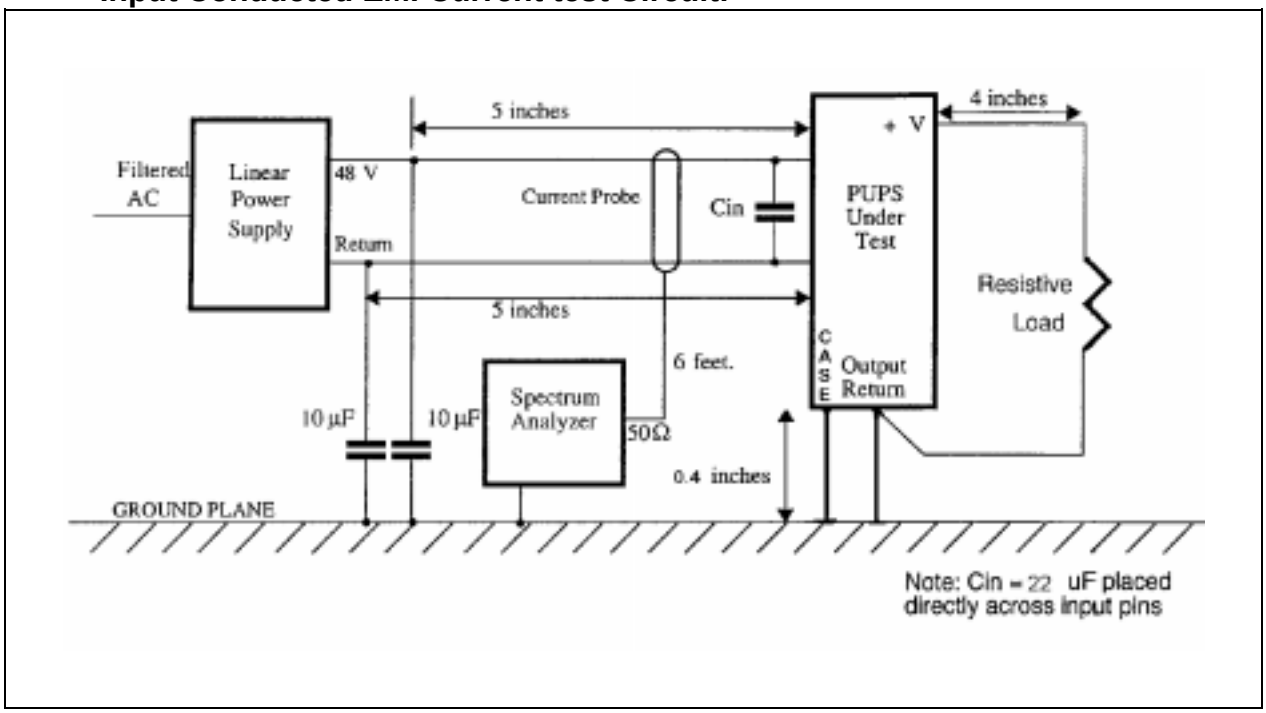
The QES uses a constant switching frequency of about 300 kHz. The QBS uses a constant switching frequency of about 360 kHz. The input conducted spectrum contains the fundamental frequency, and all of its harmonics. The switching frequency is constant, and does not change with line or load. There are no lower frequencies contained below the fundamental, unless there is a low frequency (below 10 kHz.) component to the output load current. In this case, some of this will be present in the input current spectrum.

There are two methods of measurement for input conducted EMI: voltage measurements and current measurements. The voltage data presented uses a 50Ω LISN (Line Impedance Stabilization Network) and measures the input voltage spectrum from each input line of the converter to ground, using FCC and CISPR measurement techniques. The current data uses a 10 microfarad capacitor from each input line to ground, and measures the current in both lines simultaneously using the measurement technique defined in section 3.4.5, part B3 of the Bellcore document GR-1089-CORE. In each case, there was no external input filter. There was only a single 22µF aluminum capacitor across the input lines. The output common of the unit was grounded to the reference ground plane, as was the case of the unit. All spectra presented were taken with the unit under test operating from 48 VDC at its full load output load current.

Input Conducted EMI Voltage test Circuit:



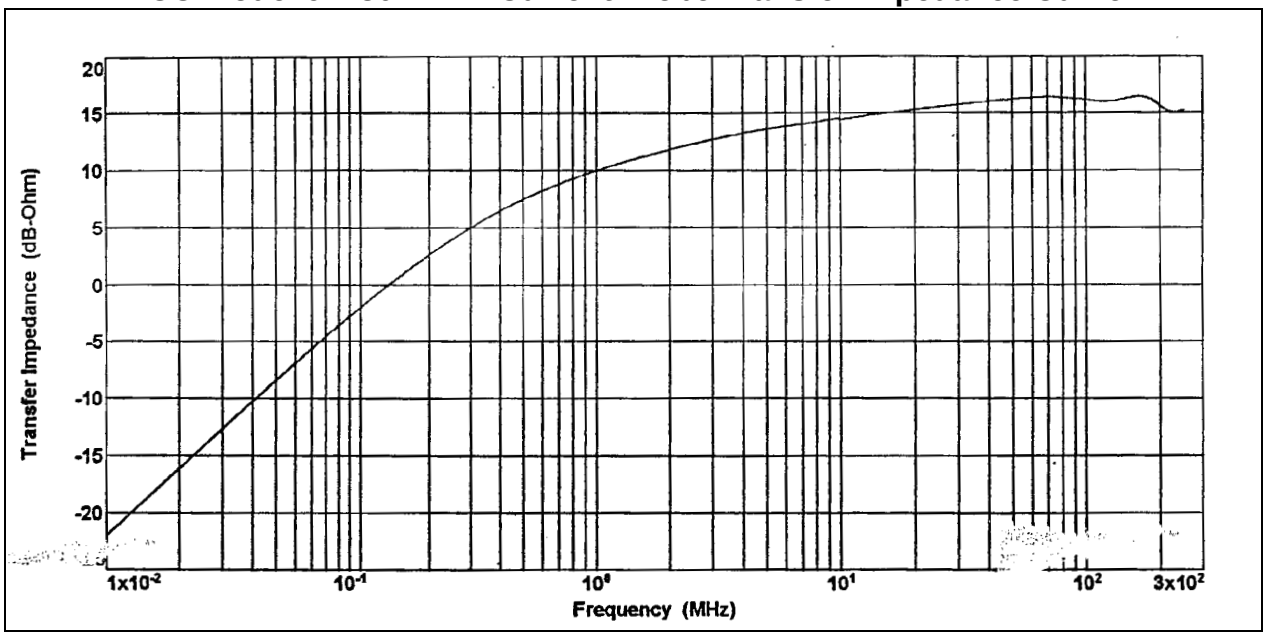
Input Conducted EMI Current test Circuit:



Power-One uses the EMCO model 94430-1 current probe in this test circuit. The probe has a transfer impedance which is not constant with frequency. The transfer impedance, expressed in dBΩ, must be subtracted from the reading as measured on the spectrum analyzer in dBµV, in order to obtain the true current, measured in dBµA.

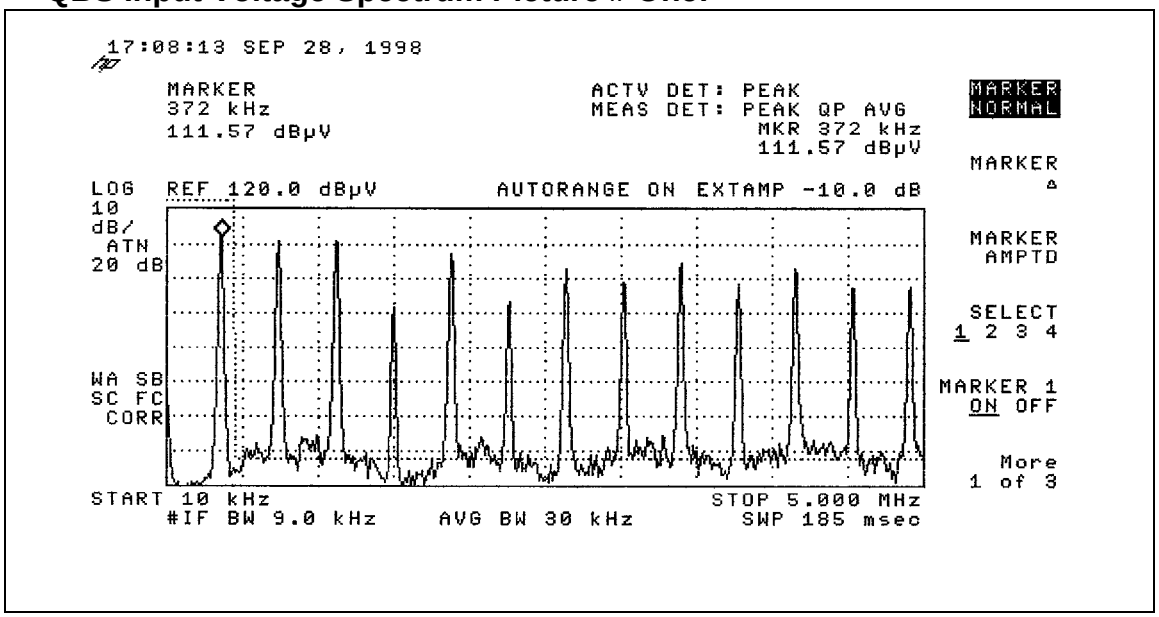
Note that this is a common-mode current measurement, where both input lines to the unit under test are measured simultaneously.

EMCO Model 94430-1 EMI Current Probe Transfer Impedance Curve:



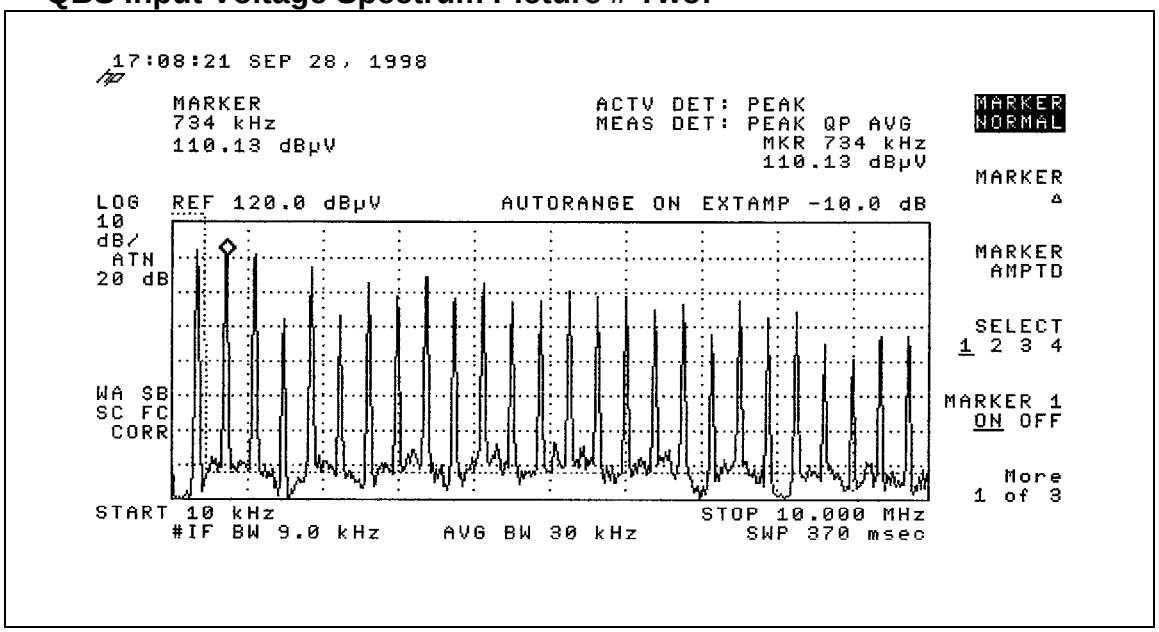
QBS Input Voltage Spectra:

QBS Input Voltage Spectrum Picture # One:



Model: QBS033ZE-AN, 48 VDC input, 3.3V @ 10.0A output.
Input Conducted voltage spectrum, 10 kHz. to 5.0 MHz.
Reference 120 dBµV.
Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar within 2 dB.

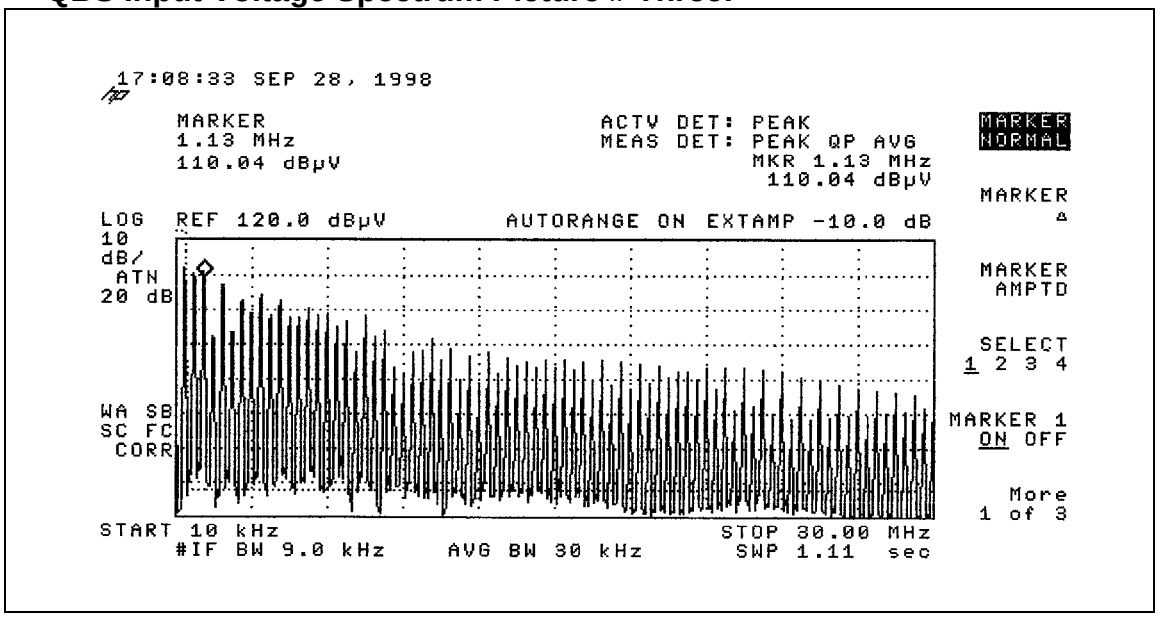
QBS Input Voltage Spectrum Picture # Two:



Model: QBS033ZE-AN, 48 VDC input, 3.3V @ 10.0A output.
Input Conducted voltage spectrum, 10 kHz. to 10 MHz.

Reference 120 dBµV.
Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar within 2 dB.

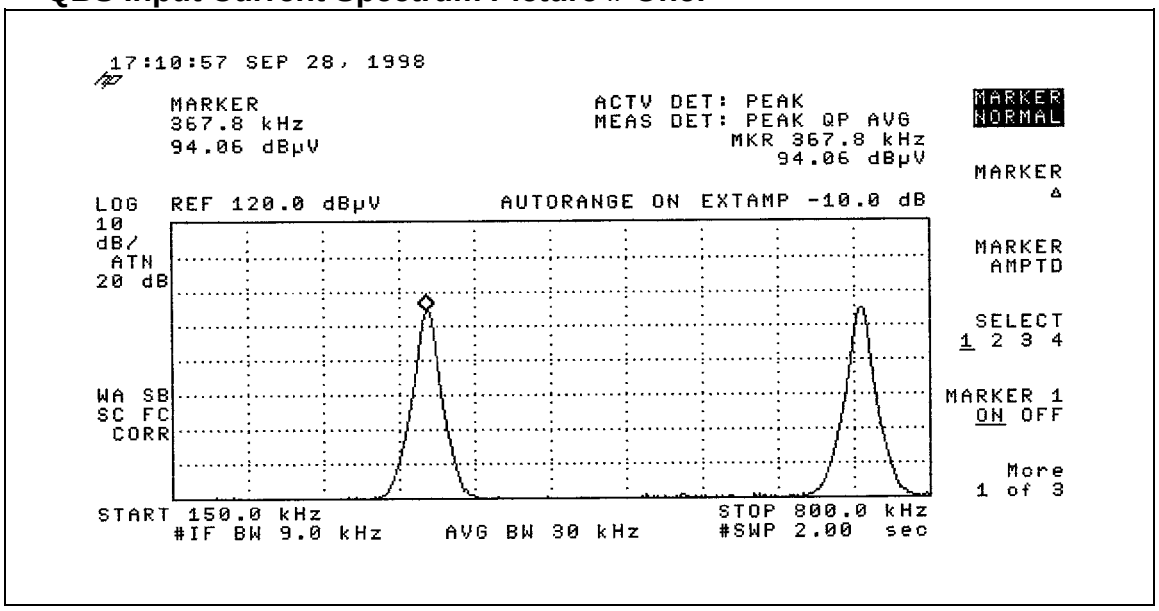
QBS Input Voltage Spectrum Picture # Three:



Model: QBS033ZE-AN, 48 VDC input, 3.3V @ 10.0A output.
Input Conducted voltage spectrum, 10 kHz. to 30 MHz.
Reference 120 dBµV.
Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar within 2 dB.

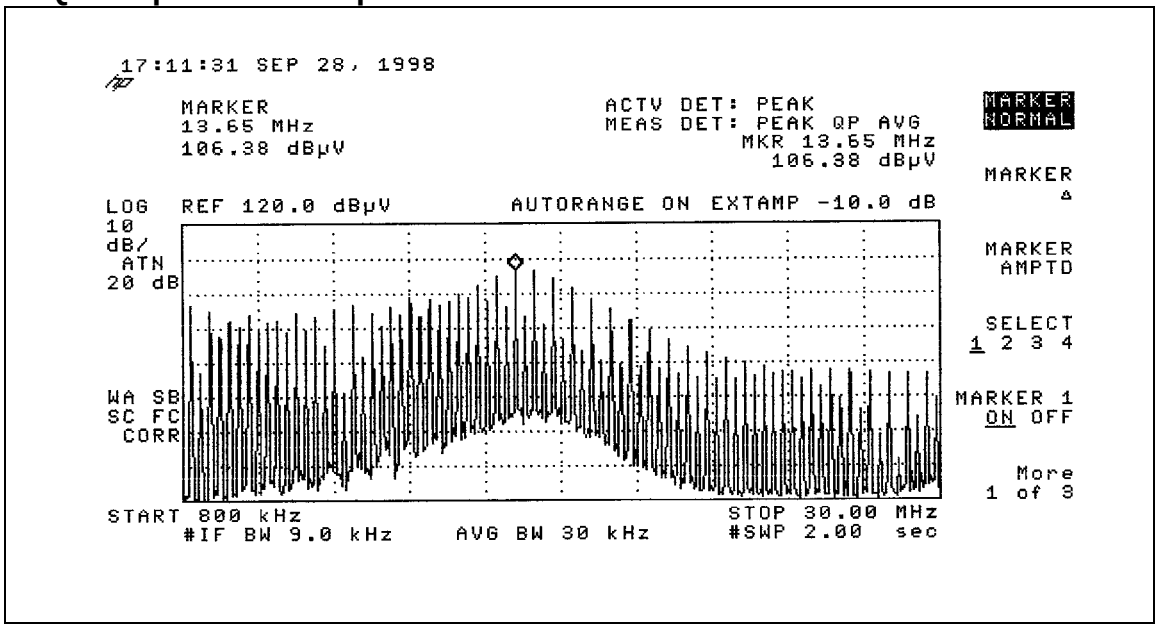
QBS Input Current Spectra:

QBS Input Current Spectrum Picture # One:



Model: QBS033ZE-AN, 48 VDC input, 3.3V @ 10.0A output.
Input Conducted current spectrum, 150 to 800 kHz.
GR-1089 current measurement, using an EMCO model 94430-1 probe.
Reference 110.8 dBµA at 800 kHz. (Use correction curve at other frequencies.).
Bandwidth: 9.0 kHz.
Start Frequency: 150 kHz Stop Frequency: 800 kHz.
Line: Both input lines together measured.

QBS Input Current Spectrum Picture # Two:

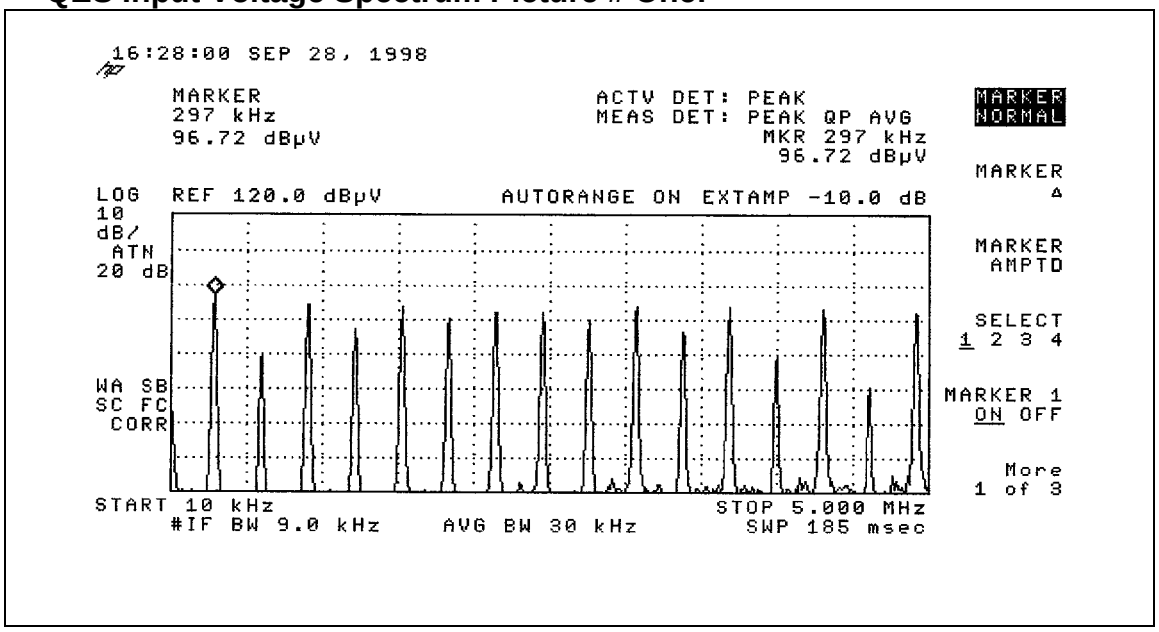


Model: QBS033ZE-AN, 48 VDC input, 3.3V @ 10.0A output.
Input Conducted current spectrum, 800 kHz to 30 MHz.
GR-1089 current measurement, using an EMCO model 94430-1 probe.

Reference 110 dBµA at 1.0 MHz. (Use correction curve at other frequencies.).
Bandwidth: 9.0 kHz.
Start Frequency: 800 kHz Stop Frequency: 30.0 MHz.
Line: Both input lines together measured.

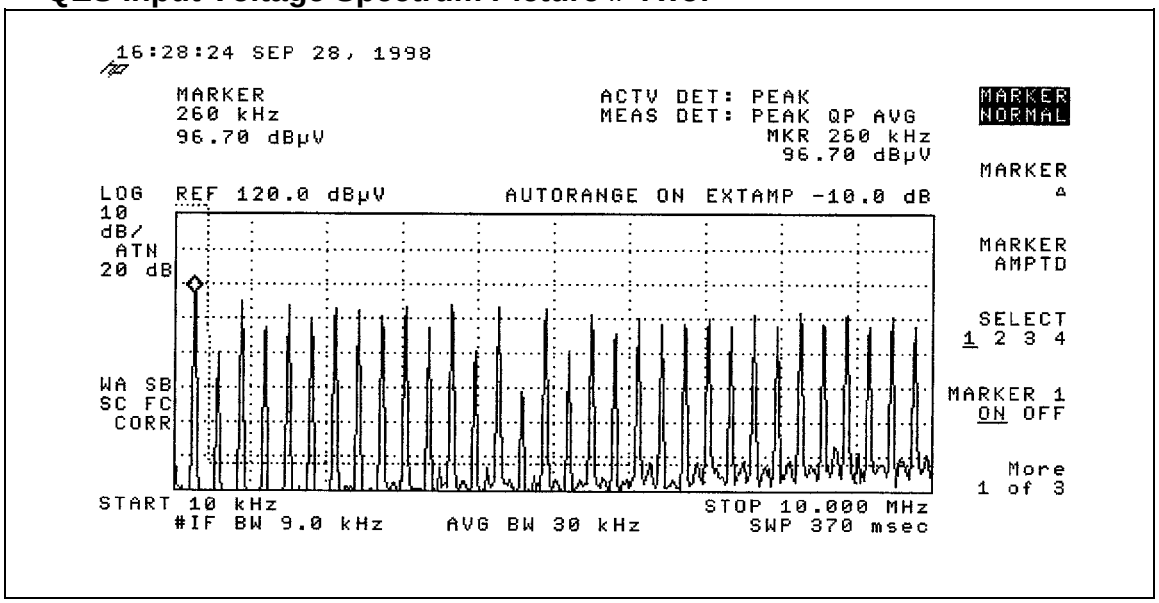
QES Input Voltage Spectra:

QES Input Voltage Spectrum Picture # One:



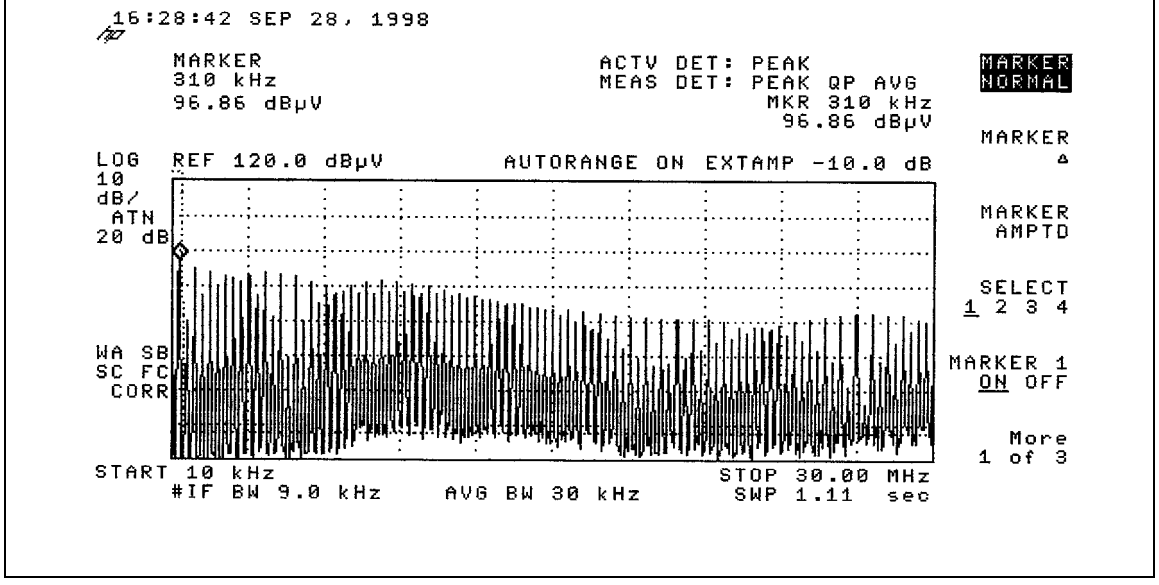
Model: QES066ZE-AN, 48 VDC input, 3.3V @ 20.0A output.
Input Conducted voltage spectrum, 10 kHz. to 5.0 MHz.
Reference 120 dBµV.
Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar within 2 dB.

QES Input Voltage Spectrum Picture # Two:



Model: QES066ZE-AN, 48 VDC input, 3.3V @ 20.0A output.
Input Conducted voltage spectrum, 10 kHz. to 10 MHz.
Reference 120 dBµV.
Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar within 2 dB.

QES Input Voltage Spectrum Picture # Three:

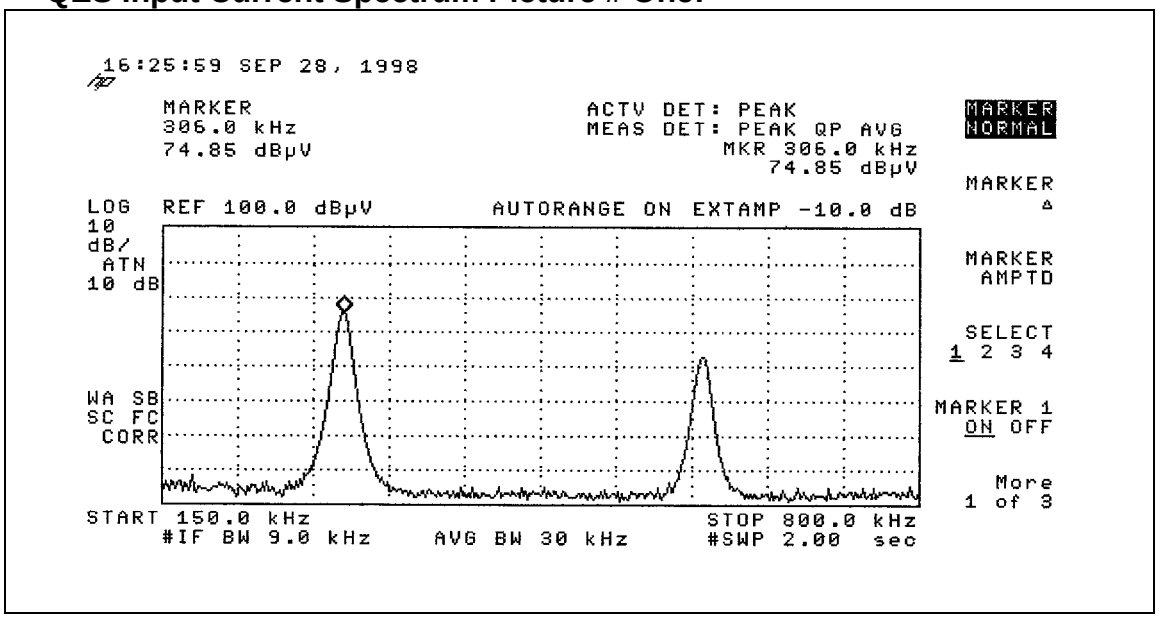


Model: QES066ZE-AN, 48 VDC input, 3.3V @ 20.0A output.
Input Conducted voltage spectrum, 10 kHz. to 30 MHz.
Reference 120 dBµV.

Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar within 2 dB.

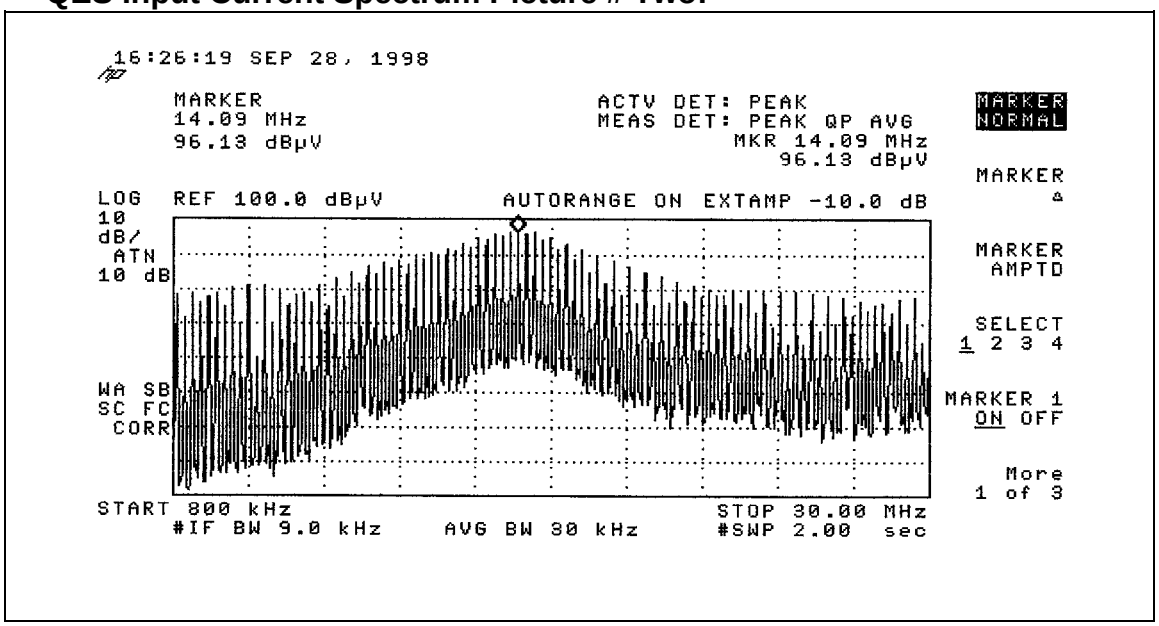
QES Input Current Spectra:

QES Input Current Spectrum Picture # One:



Model: QES066ZE-AN, 48 VDC input, 3.3V @ 20.0A output.
Input Conducted current spectrum, 150 to 800 kHz.
GR-1089 current measurement, using an EMCO model 94430-1 probe.
Reference 90.8 dBµA at 800 kHz. (Use correction curve at other frequencies.).
Bandwidth: 9.0 kHz.
Start Frequency: 150 kHz Stop Frequency: 800 kHz.
Line: Both input lines together measured.

QES Input Current Spectrum Picture # Two:



Model: QES066ZE-AN, 48 VDC input, 3.3V @ 20.0A output.
Input Conducted current spectrum, 800 kHz to 30 MHz.
GR-1089 current measurement, using an EMCO model 94430-1 probe.
Reference 90 dBµA at 1.0 MHz. (Use correction curve at other frequencies.).
Bandwidth: 9.0 kHz.
Start Frequency: 800 kHz Stop Frequency: 30.0 MHz.
Line: Both input lines together measured.

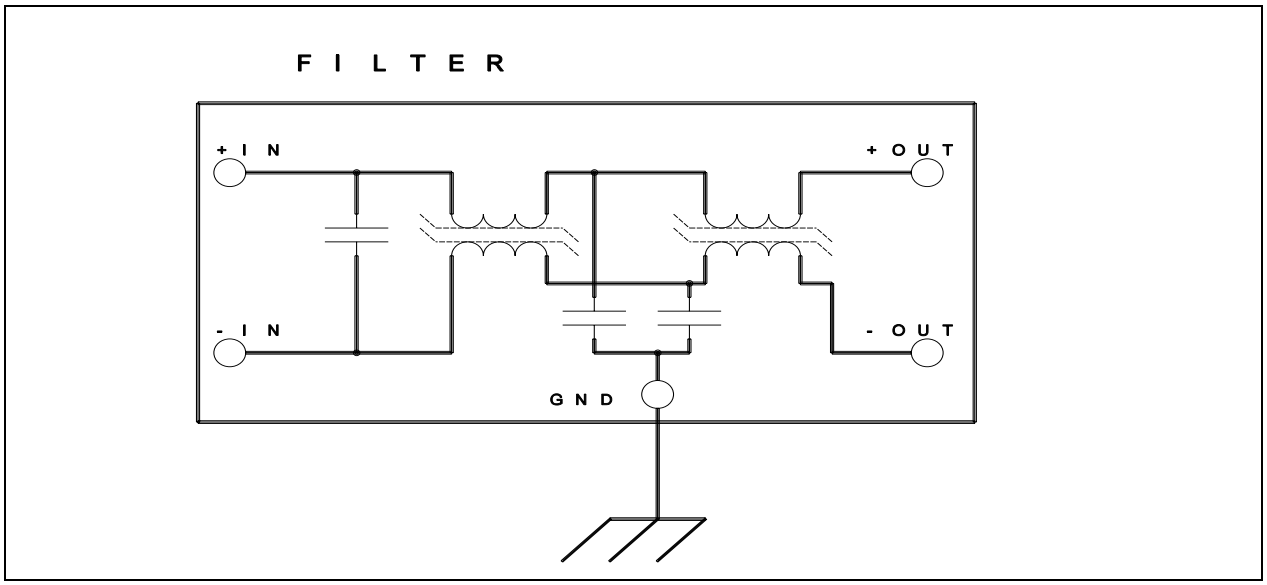
Common Mode Noise and EMI Control:

Common mode noise is generated by all power converters. The QES/QBS series uses state of the art planar magnetics, with optimum coupling between primary and secondary, to achieve both high isolation and high efficiency. Like the rest of the real world, these advantages do not come without a certain disadvantage. Planar magnetics generate more common mode noise. The spectra above illustrate the magnitude of the noise generated by a typical converter. Without attempting to present a set of spectra for each model, the user can assume that the spectra of the other models in the series is similar to the one presented.

Fortunately, the high switching frequency makes this noise easy to control with small components. The following circuit is implemented in a miniature module, 1.0" by 1.0", the Power-One model number FC100V5A, which combines both a normal mode filter and a common mode filter. The module must be employed properly to achieve these results. The input leads to the module must not pass under the converter, or go closer to the

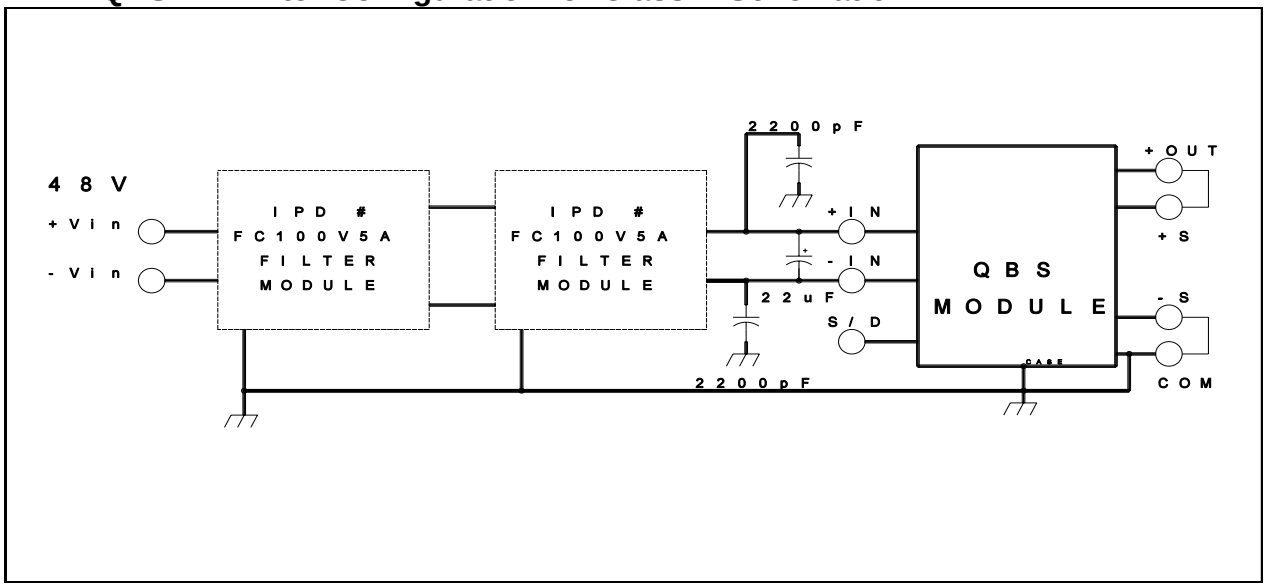
converter than the length of the module. Radiation from either the leads from the filter to the converter, or from the converter itself, must be kept out of the input leads of the filter module. Normally, this is simply a matter of placing the converter and filter correctly, and running the traces to them correctly. Be sure that the fuse is ahead of the filter, not between the filter and the converter.

Power-One # FC100V5A EMI Filter Schematic:

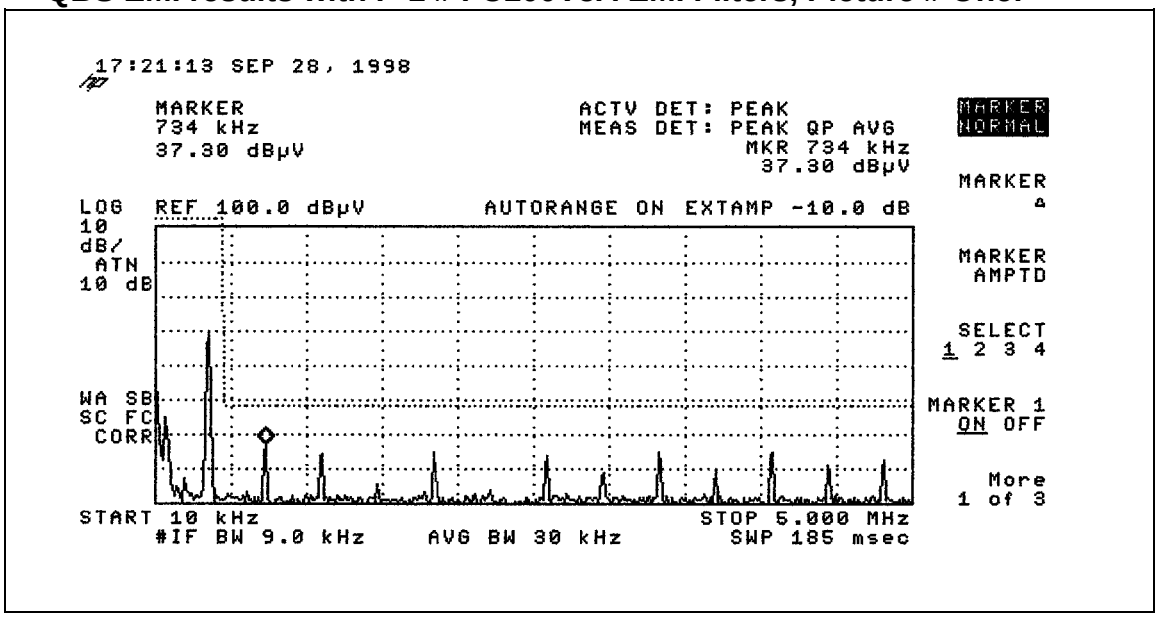


The purpose of the baluns (common mode inductors) is to place a high impedance (to common mode noise) between the converter and the source. The purpose of the capacitors to ground is to provide a low impedance path to ground for these signals. In many applications, this circuit can reduce input conducted EMI voltages to levels below the FCC class B levels. With the QBS converter, the optimum filter configuration to meet Class B involves two FC100V5A filters with external capacitors to ground.

QBS EMI Filter Configuration for Class B Schematic:

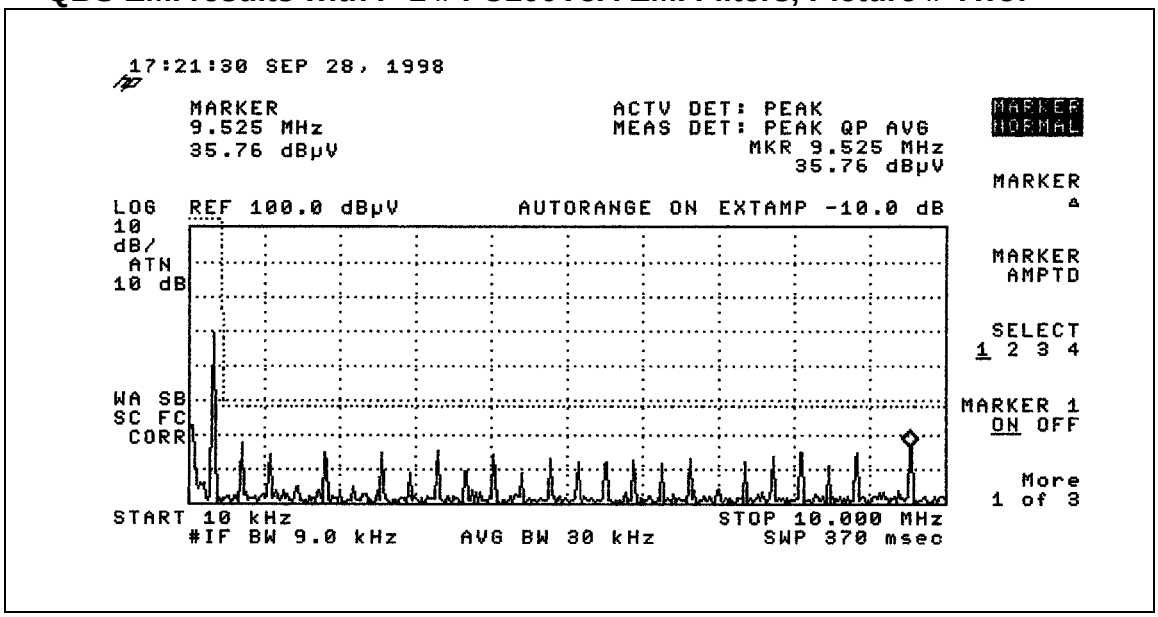


QBS EMI results with P-1 # FC100V5A EMI Filters, Picture # One:



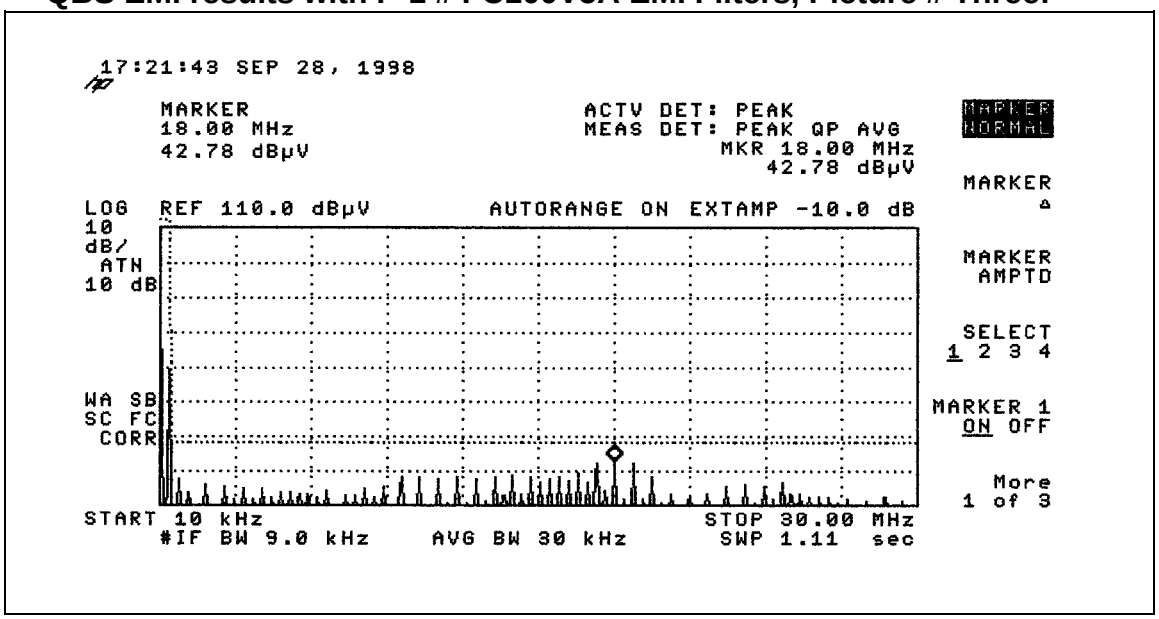
Model: QBS033ZE-AN, 48 VDC input, 3.3V @ 10.0A output.
Input Conducted voltage spectrum, 10 kHz. to 5.0 MHz.
Reference: 100 dBµV.
Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar.

QBS EMI results with P-1 # FC100V5A EMI Filters, Picture # Two:



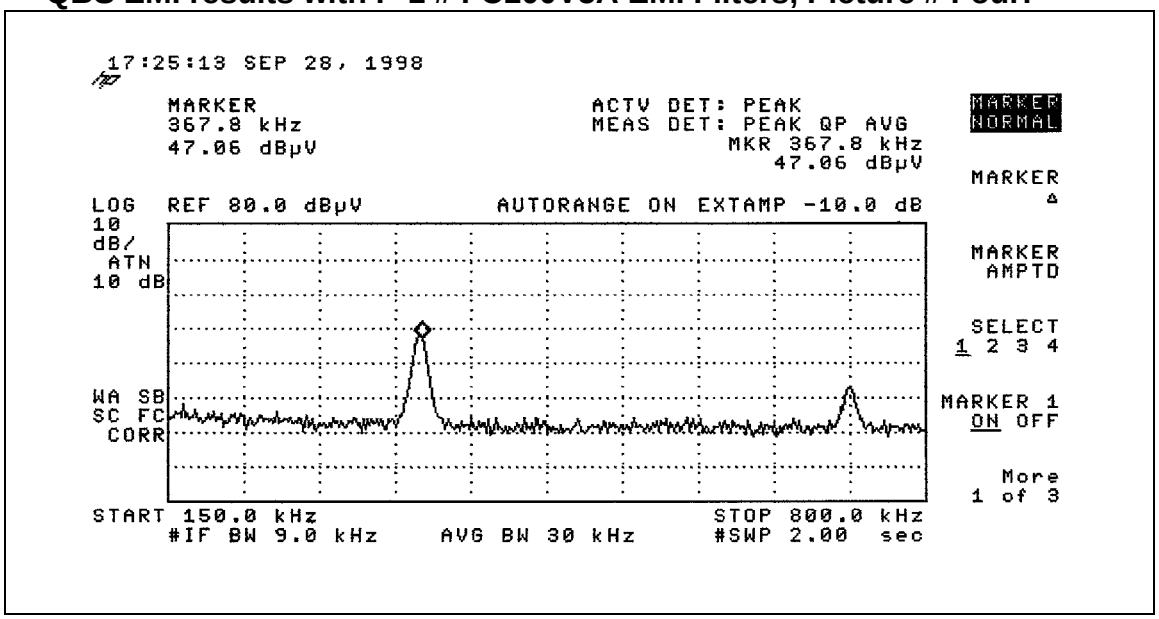
Model: QBS033ZE-AN, 48 VDC input, 3.3V @ 10.0A output.
Input Conducted voltage spectrum, 10 kHz. to 10.0 MHz.
Reference: 100 dBµV.
Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar.

QBS EMI results with P-1 # FC100V5A EMI Filters, Picture # Three:



Model: QBS033ZE-AN, 48 VDC input, 3.3V @ 10.0A output.
Input Conducted voltage spectrum, 10 kHz. to 30.0 MHz.
Reference: 110 dBµV.
Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar.

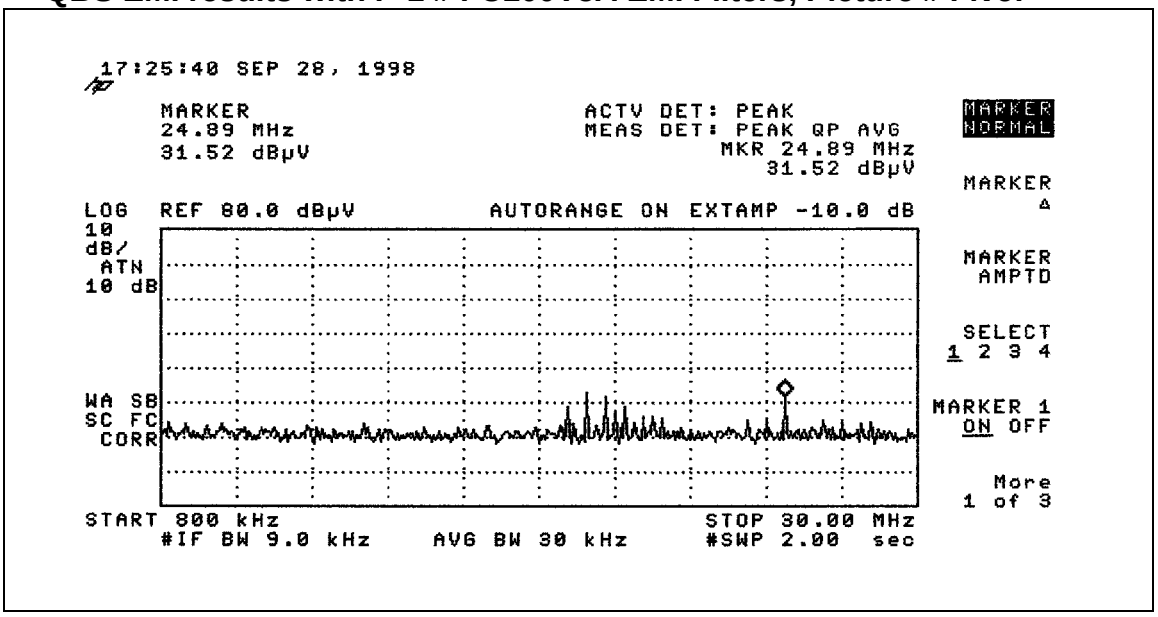
QBS EMI results with P-1 # FC100V5A EMI Filters, Picture # Four:



Model: QBS033ZE-AN, 48 VDC input, 3.3V @ 10.0A output.
Input Conducted current spectrum, 150 to 800 kHz.
GR-1089 current measurement, using an EMCO model 94430-1 probe.
Reference 70.8 dBµA at 800 kHz. (Use correction curve at other frequencies.).
Bandwidth: 9.0 kHz.

Start Frequency: 150 kHz Stop Frequency: 800 kHz.
Line: Both input lines together measured.

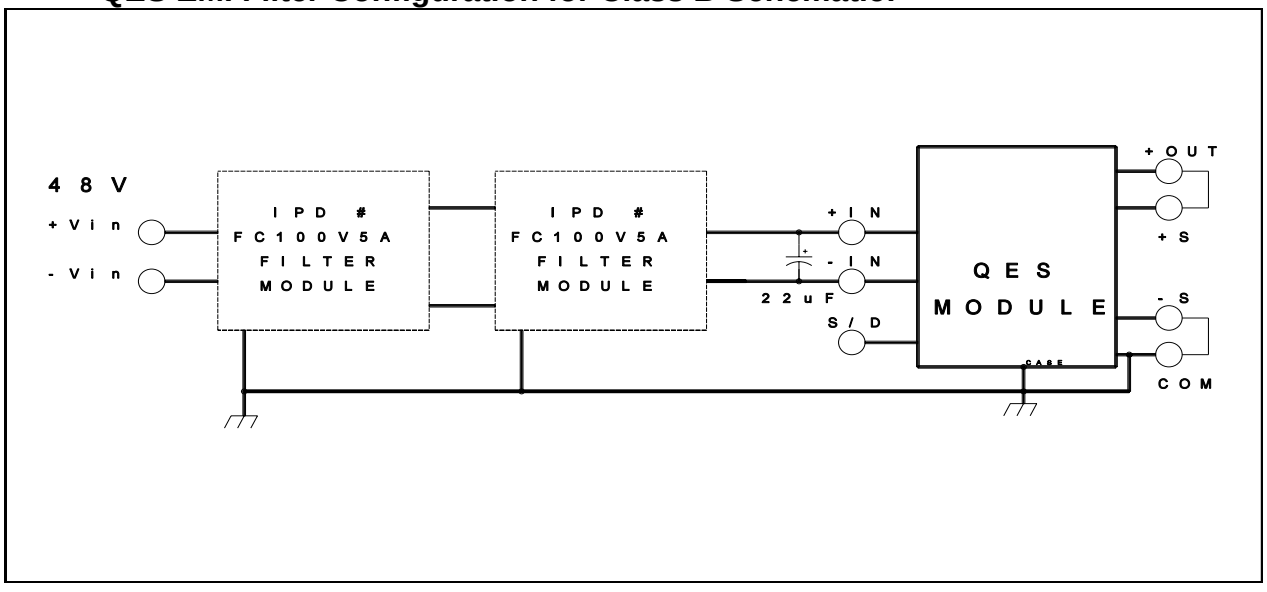
QBS EMI results with P-1 # FC100V5A EMI Filters, Picture # Five:



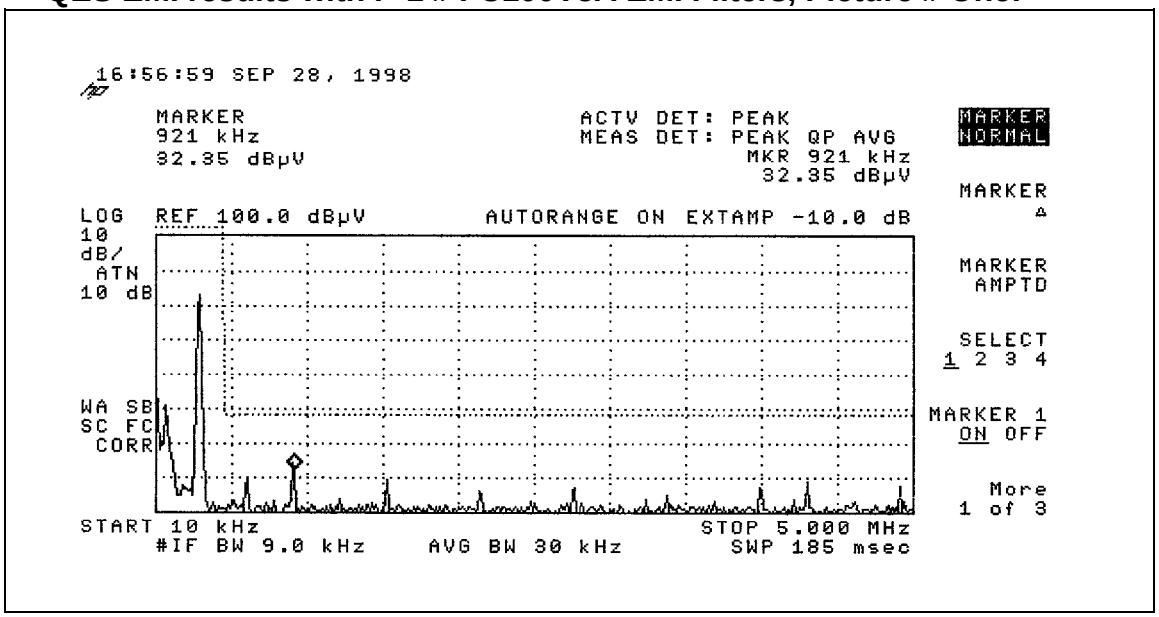
Model: QBS033ZE-AN, 48 VDC input, 3.3V @ 10.0A output.
Input Conducted current spectrum, 800 kHz to 30 MHz.
GR-1089 current measurement, using an EMCO model 94430-1 probe.
Reference 70.0 dBµA at 800 kHz. (Use correction curve at other frequencies.).
Bandwidth: 9.0 kHz.
Start Frequency: 800 kHz Stop Frequency: 30.0 MHz.
Line: Both input lines together measured.

With the QES converter, the optimum filter configuration to meet Class B involves two FC100V5A filters.

QES EMI Filter Configuration for Class B Schematic:

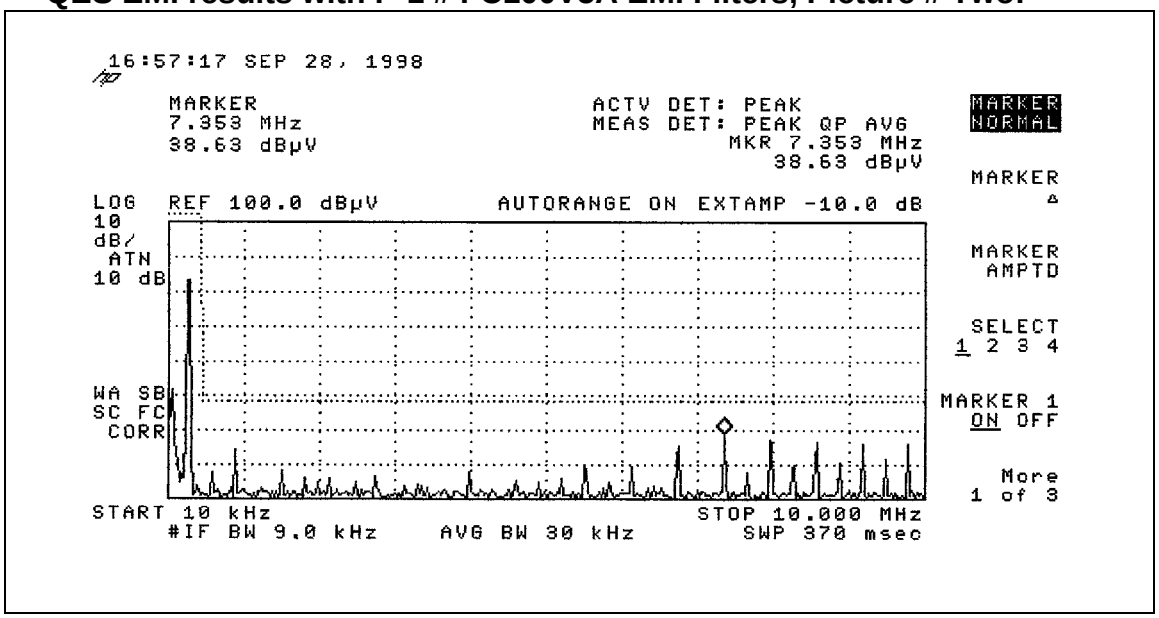


QES EMI results with P-1 # FC100V5A EMI Filters, Picture # One:



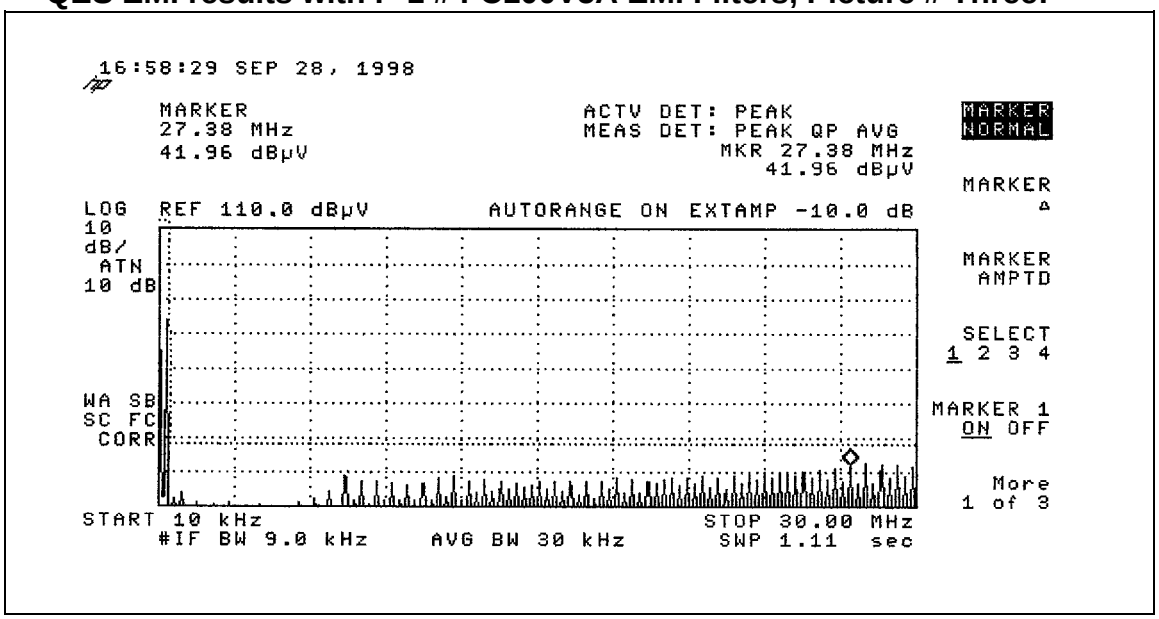
Model: QES066ZE-AN, 48 VDC input, 3.3V @ 20.0A output.
Input Conducted voltage spectrum, 10 kHz. to 5.0 MHz.
Reference: 100 dBµV.
Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar.

QES EMI results with P-1 # FC100V5A EMI Filters, Picture # Two:



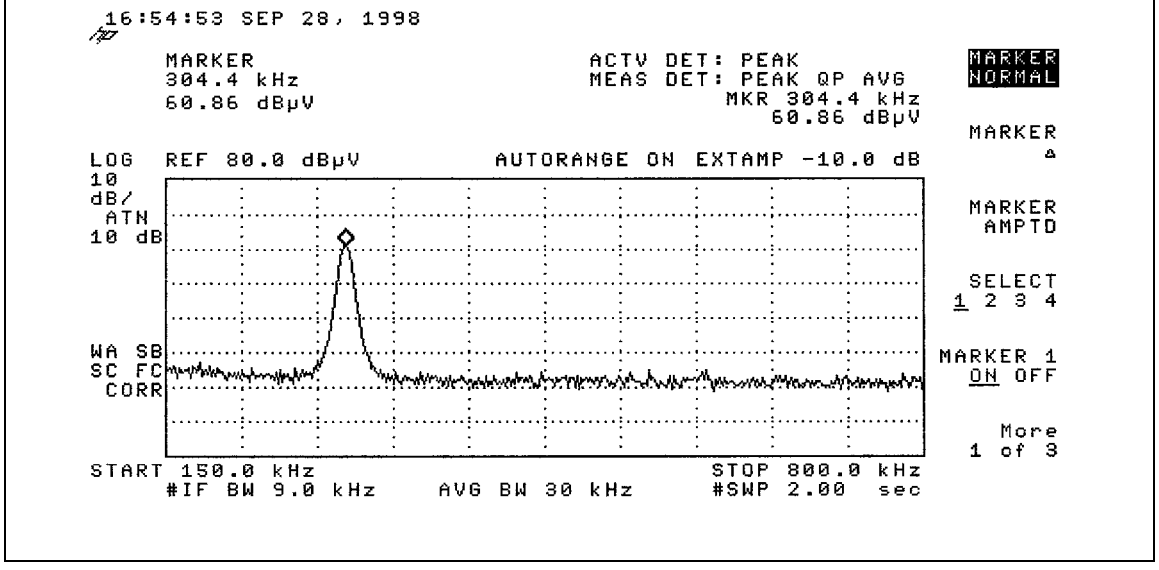
Model: QES066ZE-AN, 48 VDC input, 3.3V @ 20.0A output.
Input Conducted voltage spectrum, 10 kHz. to 10.0 MHz.
Reference: 100 dBµV.
Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar.

QES EMI results with P-1 # FC100V5A EMI Filters, Picture # Three:



Model: QES066ZE-AN, 48 VDC input, 3.3V @ 20.0A output.
Input Conducted voltage spectrum, 10 kHz. to 5.0 MHz.
Reference: 110 dBµV.
Bandwidth: 9.0 kHz.
Limits: FCC Class B superimposed.
Line: Positive input line displayed. Both lines similar.

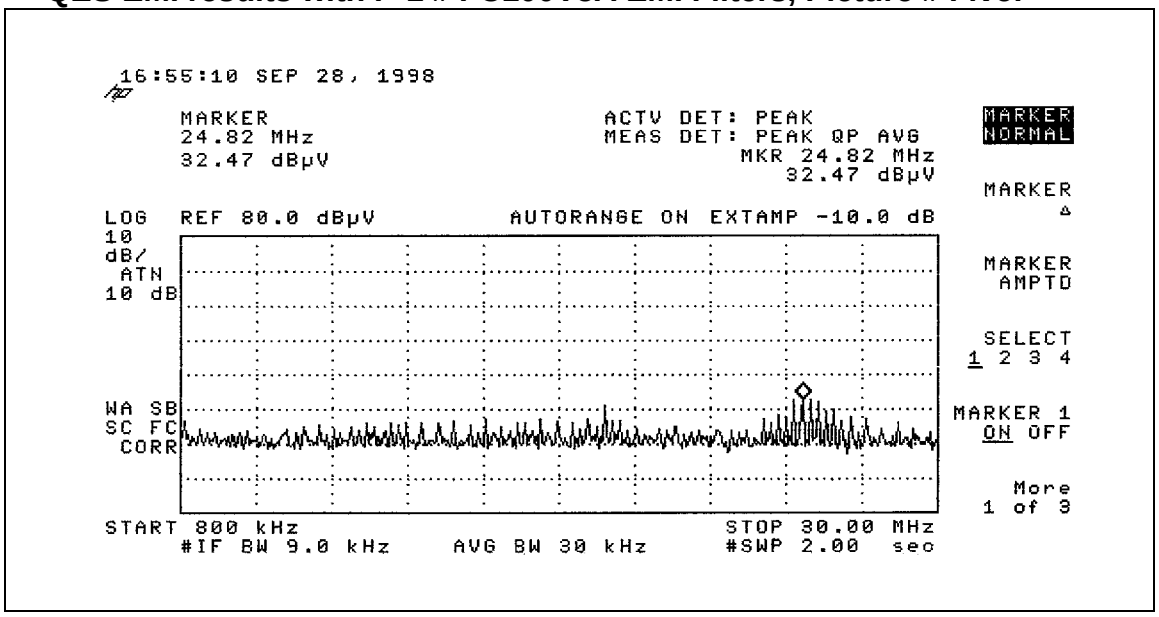
QES EMI results with P-1 # FC100V5A EMI Filters, Picture # Four:



Model: QES066ZE-AN, 48 VDC input, 3.3V @ 20.0A output.
Input Conducted current spectrum, 150 to 800 kHz.
GR-1089 current measurement, using an EMCO model 94430-1 probe.
Reference 70.8 dBµA at 800 kHz. (Use correction curve at other frequencies.).
Bandwidth: 9.0 kHz.

Start Frequency: 150 kHz Stop Frequency: 800 kHz.
Line: Both input lines together measured.

QES EMI results with P-1 # FC100V5A EMI Filters, Picture # Five:



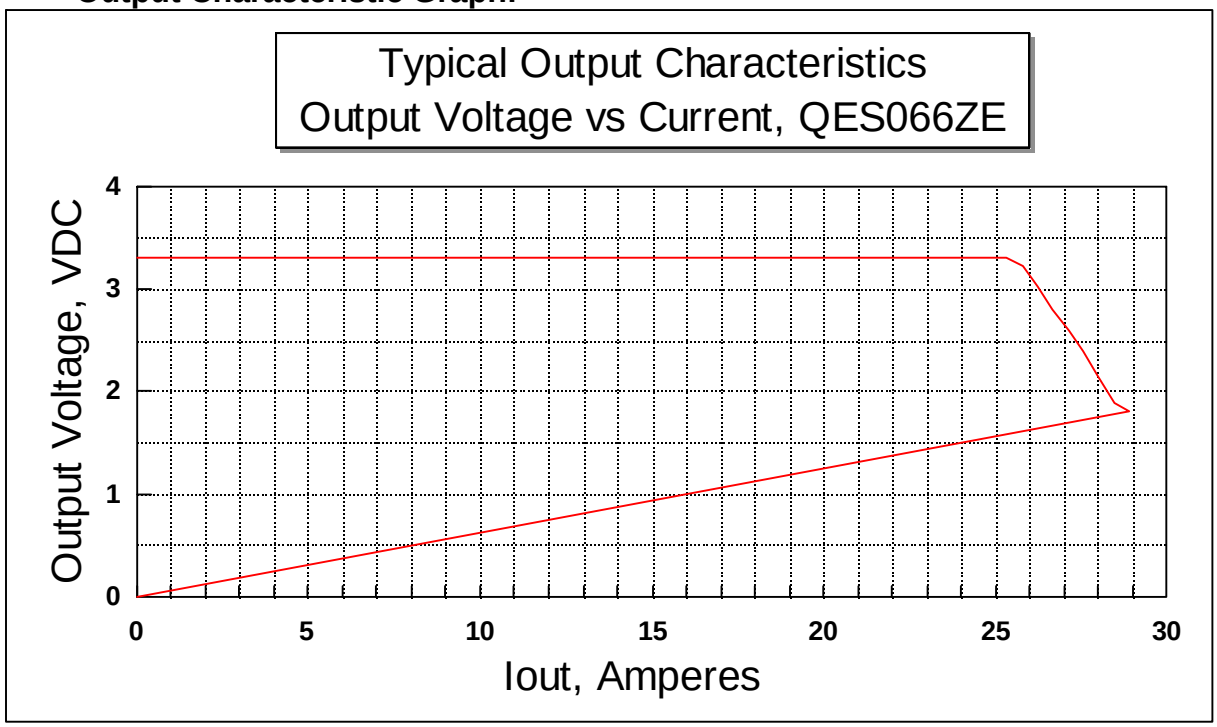
Model: QES066ZE-AN, 48 VDC input, 3.3V @ 20.0A output.
Input Conducted current spectrum, 800 kHz to 30 MHz.
GR-1089 current measurement, using an EMCO model 94430-1 probe.
Reference 70.0 dBµA at 800 kHz. (Use correction curve at other frequencies.).
Bandwidth: 9.0 kHz.
Start Frequency: 800 kHz Stop Frequency: 30.0 MHz.
Line: Both input lines together measured.

Output Characteristics:

The QES and QBS use primary side current limiting with a latching mode of short circuit protection. When an overload or short circuit is applied to the output of the module, it will provide its maximum current for a defined time, and then will latch off. The latch can be reset by either removing the DC input voltage or pulling the shutdown pin low. Pulling the pin low, as would be done to turn the unit off, will both turn it off and reset the latch. Releasing the pin will then permit a normal start, provided that the problem which created the latch has been cleared.

The graph below shows the typical output voltage versus current characteristic for a QBS or QES converter.

Output Characteristic Graph:



Other converters with different output voltages or full load currents will have a curve with a similar shape. The knee current point where the output voltage drops out of regulation will be at about 130% of full load, and the maximum current point will be at about 140% of full load.

Notice that this model QES operates into an overload up to about 29 amperes, where it latches off. The latch can be reset either by removing the input voltage or by pulling the shutdown pin low and then releasing it.

Overload Characteristics:

The QBS and QES will regulate properly up to approximately 110% of full load output current if there is negligible voltage drop between the output pins and the remote sense pins. Using the remote sensing to regulate at the load while having a voltage drop of up to 0.25 V in each leg will cause the overcurrent knee to move in towards the full load current point. When a short or overload exceeding the threshold is applied to the unit it will provide its overload current for a defined time, and then latch off completely.

The input power into a converter operating at short circuit is much less than when it is operating at full output power and voltage. Nevertheless, the dissipation in the converter is higher than when it is operating at normal full output. In this condition, the QBS and QES will self protect by latching off, as described above.

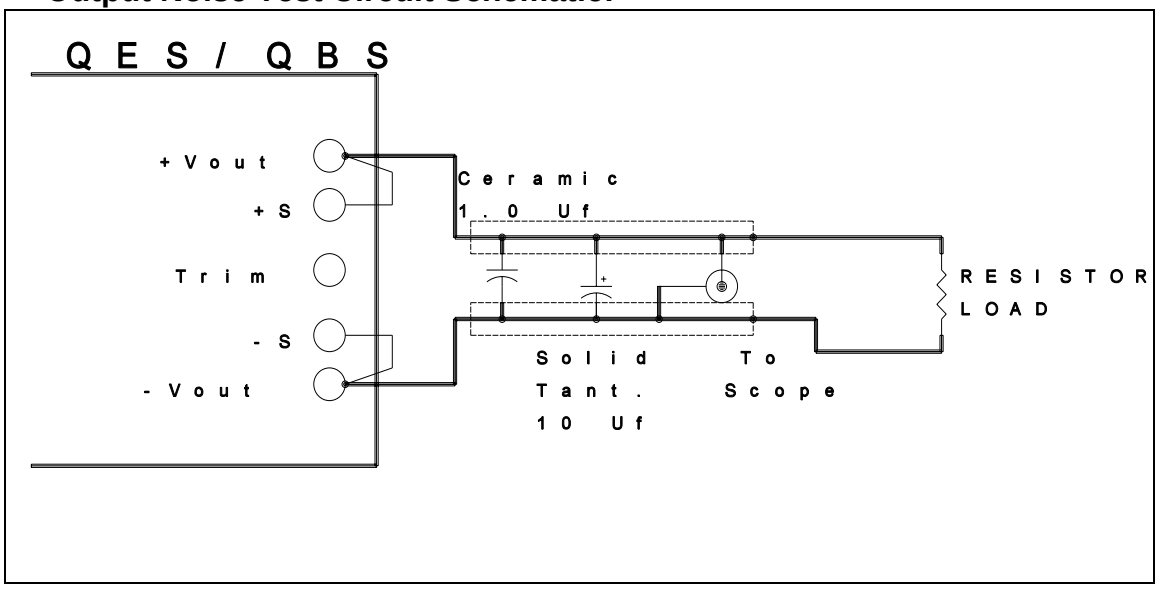
Thermal Shutdown:

The QBS and QES have an internal thermal shutdown which will activate and turn the converter off when the baseplate temperature reaches from +105° to +115° C. The unit will automatically restore to normal operation when the baseplate temperature drops back into a normal range, at or below +100° C.

Output Noise:

The output noise is measured with an input filter, using the following test circuit. The input to the oscilloscope is AC terminated with 50 Ohms.

Output Noise Test Circuit Schematic:



The user must use great care to obtain accurate measurements. In particular, modern digital oscilloscopes use sampling techniques to obtain readings. In most of them, the sampling rate is inversely proportional to the sweep rate selected. These power converters contain spectral content into the region above 100 MHz. The Nyquist criteria states that the sampling rate must be at least twice that of the highest frequency component being measured. If it is not, aliasing will occur and the measured waveform will not be a true representation of the real output noise. Power-One recommends using an analog oscilloscope. If using a digital oscilloscope, a 20 MHz. filter bandwidth should be used along with a sampling rate of at least 100 MS/s.

MTBF and Reliability:

The single most important factor to obtaining the inherent reliability of the QBS and QES power converters lies entirely in the hands of the user: CONTROL OF TEMPERATURE RISE!

The MTBF for both models, calculated in accordance with Bellcore TR-NWT-000332 is 2,500,000 hours. This represents an average failure rate of just 0.4000 failures per million unit hours of operation. The assumptions are 50% parts stress and a +40° C. device temperature.

Obtaining this MTBF in practice is entirely possible. It means providing sufficient forced air cooling to maintain the base temperature at or below +40° C., or at least 400 LFM for operation at +25° C. ambient.

COMPONENT TEMPERATURES DETERMINE THEIR RELIABILITY!

Designing the cooling so as to provide the **best possible cooling** will give the greatest field MTBF.

Printed Circuit Board Design:

Unlike some high density modules, the shutdown pin on the QBS and QES is decoupled, and relatively insensitive to noise. Nevertheless, we advise referencing any transistors or gates used to pull the shutdown pin low directly to the negative input pin of the unit. If a balun is used in the input of the module for common mode noise control, then an optical coupler is the ideal interface to the shutdown pin. Wire the emitter of the opto transistor directly to -Vin, and the collector directly to the shutdown pin. There are no other components required.

For optimum filtering, all shunt capacitors which are used in either the input or output circuits must be wired with "Four- Terminal" techniques. Traces enter the node of the capacitor on one side of its pad (surface mount or discrete) and depart from the other side. Capacitors are never "Tee'd" from other traces. The traces feeding the capacitors should be close together and parallel. Never leave large loops in input (or output) and return traces in the printed circuit board designs for power converters. Large loops form large antennas; large antennas create the most radiated EMI.

Power-One also recommends that one layer of the board which carries the converter be dedicated as a ground plane. Preferably, this is the layer directly under the converter. It should extend out beyond the edges of the converter. The ground plane should be connected to earth ground, or to +Vin.

Manufacturing Issues:

Processing of Completed Power-One Power Converters:

The incorporation of completed Power-One power converters into assemblies, or installation into mother boards, can be handled by the conventional industry methods. The stanchions which are fabricated of PPS plastic, along with all the other component parts used by Power-One, will withstand normal preheat temperatures associated with standard soldering operations. The most common method for mass soldering of the power supply to a mother board is “wave soldering” and should be profiled approximately as follows:

1. The solder pot should be set at 500° F and the conveyor should have a speed preset to insure that each section of the bottom side of the assembly dwells in the molten solder wave for 3 to 4 seconds. It is imperative that a correct temperature profile be used, not only to reduce solder defects but to eliminate any chance of thermal shock on the components.

2. The mother board should attain a top side preheat temperature of 220° to 240° F before it enters the solder wave. The temperature change between the preheat and the soldering zones should be minimized.

3. The cooling rate after the solder wave should be similar in drop in temperature to the preheat rise.

Notes on Processing of Completed Power-One Power Converters:

- The Power-One through hole pins are tin/lead plated and are easily soldered if all process parameters are met. However, in fluxing, the flux density, the activity and the ratio of flux foam to wave height must be closely monitored and controlled to maintain minimum solder defects.’

- In controlling the solder profile, preheating of the assembly in two or three stages minimizes the thermal shock damage and increases the end life of the unit.

- If the power converters are to be hand soldered into the mother board, a temperature controlled iron of 700° F (MAX) is recommended.

- While the Power-One power converters generally spend about 3 seconds in the wave, they are designed to withstand soldering temperatures of 500° F for up to 10 seconds.

- If non-conventional methods are to be used to solder the Power-One power supplies to the mother board, contact Power-One Processing Engineering before proceeding.

Cross References and Replacements:

Power-One can supply replacements for converters from other manufacturers, or offer custom solutions. Please contact the Power-One factory for details.

How to Contact Power-One:

From within the USA please call:	**1-888-473-2668**
From outside the USA please call:	**617-782-3331**
To send P1 HD-BMP a fax:	**617-782-7416**
To connect to the P1 website:	**www.power-one.com**
To send an e-mail message:	**sales@power-one.com**