CQB150W-24(48)SXX Series
Application Note V11 April 2019

ISOLATED DC-DC CONVERTER
CQB150W-24(48)SXX SERIES
APPLICATION NOTE

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CQB150W-24(48)SXX Series Application Note V11 April 2019

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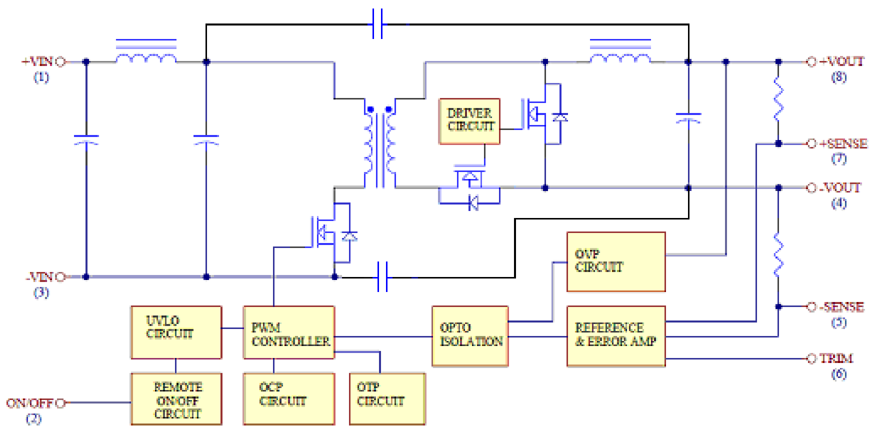
1. Introduction

The CQB150W series offers 150 watts of output power with high power density in an industry standard quarter-brick package. The CQB150W series has wide (4:1) input voltage ranges of 9-36 and 18-75VDC and provides a precisely regulated output. This series has features such as high efficiency, 2250VDC isolation and a case operating temperature range of –40°C to 105°C. The modules are fully protected against input UVLO (under voltage lock out), output short circuit, output over voltage and over temperature conditions. Furthermore, the standard control functions include remote on/off and output voltage trimming. All models are highly suited to telecommunications, distributed power architectures, battery operated equipment, industrial, and mobile equipment applications.

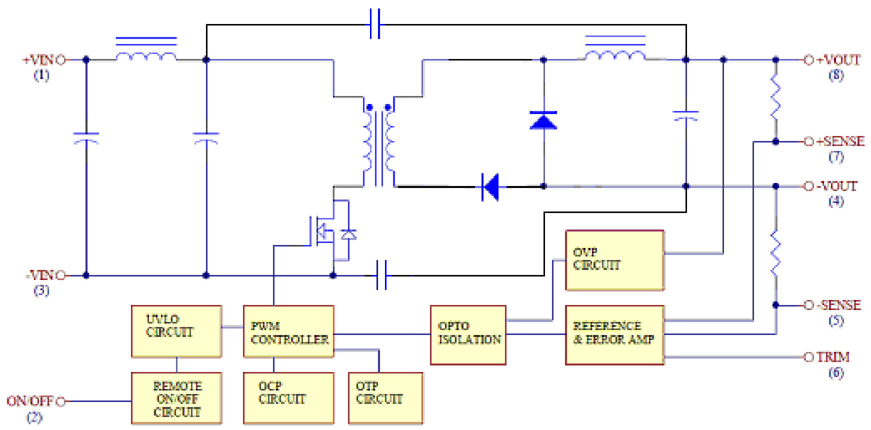
2. DC-DC Converter Features

- 150W Isolated Output
- Efficiency up to 92%
- Fixed Switching Frequency
- 4:1 Input Range
- Regulated Outputs
- Remote On/Off
- Low No Load Power Consumption
- Over Temperature Protection
- Over Voltage/Current Protection
- Continuous Short Circuit Protection
- Quarter Brick Size meet industrial standard
- UL60950-1 2nd Approval
- CB Test Certificate IEC60950-1
- Meets EN50155 with External Circuits
- Shock & Vibration Meets EN50155 (EN61373)
- Fire & Smoke Meets EN45545-2
- 3000m Operating Altitude

3. Electrical Block Diagram



Electrical Block Diagram for 5Vout and 12Vout



Electrical Block Diagram for other modules

4. Technical Specifications

(All specifications are typical at nominal input, full load at 25°C unless otherwise noted.)

ABSOLUTE MAXIMUM RATINGS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Input Voltage						
Continuous		24SXX 48SXX	-0.3 -0.3		36 75	V_{dc}
Transient	100ms	24SXX 48SXX			50 100	V_{dc}
Operating Case Temperature		All	-40		105	°C
Storage Temperature		All	-55		125	°C
Isolation Voltage	1 minute; input/output, input/case, output/case	All			2250	V_{dc}

INPUT CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Operating Input Voltage		24SXX 48SXX	9 18	24 48	36 75	V_{dc}
Input Under Voltage Lockout						
Turn-On Voltage Threshold		24SXX 48SXX	8 16.5	8.5 17	8.8 17.5	V_{dc}
Turn-Off Voltage Threshold		24SXX 48SXX	7.7 15.5	8 16	8.3 16.5	V_{dc}
Lockout Hysteresis Voltage		24SXX 48SXX		0.6 0.9		V_{dc}
Maximum Input Current	100% Load, V_{in}=9V for 24SXX	24SXX		20		A
	100% Load, V_{in} =18V for 48SXX	48SXX		10		
No-Load Input Current		24S05 24S12 24S24 24S28 24S48 48S05 48S12 48S24 48S28 48S48		10 10 10 10 10 8 8 8 8 8		mA
Input Filter	Pi filter.	All				
Inrush Current (I^2t)	As per ETS300 132-2.	All			0.1	A^2s
Input Reflected Ripple Current	P-P thru 12uH inductor, 5Hz to 20MHz, **See 6.5**	All		30		mA

OUTPUT CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Output Voltage Set Point	V_{in}=Nominal V_{in}, I_o = I_{o_max}, Tc=25°C	Vo=5.0V	4.95	5	5.05	V_{dc}
		Vo=12V	11.88	12	12.12	
		Vo=24V	23.76	24	24.24	
		Vo=28V	27.72	28	28.28	
		Vo=48V	47.52	48	48.48	
Output Voltage Regulation						
Load Regulation	I_o=I_{o_min} to I_{o_max}	All			±0.2	%
Line Regulation	V_{in}=low line to high line	All			±0.2	%
Temperature Coefficient	Tc=-40°C to 105°C	All			±0.02	%/°C
Output Voltage Ripple and Noise	5Hz to 20MHz bandwidth					
Peak-to-Peak	Full load, 10uF tantalum and 1.0uF ceramic capacitors (for Vo: 48V: Full Load 10uF aluminum and 1uF ceramic). **See 6.12**	Vo=5.0V			100	mV
		Vo=12V			150	
		Vo=24V			280	
		Vo=28V			280	
		Vo=48V			480	
RMS.		Vo=5.0V			40	mV
		Vo=12V			60	
		Vo=24V			100	
		Vo=28V			200	
Operating Output Current Range		Vo=5.0V	0		30	A
		Vo=12V	0		12.5	
		Vo=24V	0		6.3	
		Vo=28V	0		5.4	
		Vo=48V	0		3.2	
Output DC Current Limit Inception	Hiccup Mode. Auto Recovery. **See 5.3**	All	110	125	160	%
Maximum Output Capacitance	Full load (resistive)	24S05	0		30000	uF
		24S12	0		12500	
		24S24	0		6300	
		24S28	0		5400	
		24S48	0		1000	
		48S05	0		30000	
		48S12	0		12500	
		48S24	0		6300	
		48S28	0		5400	
		48S48	0		1000	
Output Voltage Trim Range	P_{out}=max rated power, **See 6.10**	All	-10		+10	%
Output Over Voltage Protection	Limited Voltage, **See 5.4**	All	115	125	140	%

DYNAMIC CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Output Voltage Current Transient						
Error Band	75% to 100% of I_{o_max} step load change d_i/d_t=0.1A/us (within 1% Vout nominal)	All			±5	%
Recovery Time		All			250	us
Turn-On Delay and Rise Time	Full load (Constant resistive load)					
Turn-On Delay Time, From On/Off Control	$V_{on/off}$ to 10%V_{o_set}	All		30		ms
Turn-On Delay Time, From Input	V_{in_min} to 10%V_{o_set}	All		30		ms
Output Voltage Rise Time	10%V_{o_set} to 90%V_{o_set}	All		30		ms

EFFICIENCY

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
100% Load	Vin=12V **See 6.8**	24S05		91		%
		24S12		91		
		24S24		89.5		
		24S28		90		
		24S48		90.5		
	Vin=24V **See 6.8**	48S05		92		
		48S12		92		
		48S24		91		
		48S28		91.5		
		48S48		92		
100% Load	Vin=24V **See 6.8**	24S05		92		%
		24S12		92		
		24S24		89.5		
		24S28		90		
		24S48		90.5		
	Vin=48V **See 6.8**	48S05		92		
		48S12		91		
		48S24		90.5		
		48S28		90.5		
		48S48		91.5		

ISOLATION CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Isolation Voltage	1 minute; input/output	All			2250	V_{dc}
	1 minute; input/case,				2250	
	1 minute; output/case				2250	
Isolation Resistance	Input/Output	All	10			MΩ
Isolation Capacitance	Input/Output	All		1500		pF
	Input/Case			NC		
	Output/Case			NC		

FEATURE CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Switching Frequency	Pulse wide modulation (PWM), Fixed	48S12	260	285	320	KHz
		Others	270	300	330	
On/Off Control, Positive Remote On/Off logic, Refer to –Vin pin.						
Logic Low (Module Off)	$V_{on/off}$ at $I_{on/off}$=1.0mA	All	0		1.2	V
Logic High (Module On)	$V_{on/off}$ at $I_{on/off}$=0.0uA	All	3.5 or Open Circuit		75	V
On/Off Control, Negative Remote On/Off logic, Refer to –Vin pin						
Logic High (Module Off)	$V_{on/off}$ at $I_{on/off}$=0.0uA	All	3.5 or Open Circuit		75	V
Logic Low (Module On)	$V_{on/off}$ at $I_{on/off}$=1.0mA	All	0		1.2	V
On/Off Current (for both remote on/off logic)	$I_{on/off}$ at $V_{on/off}$=0.0V	All		0.3	1	mA
Leakage Current (for both remote on/off logic)	Logic High, $V_{on/off}$=15V	All			30	uA
Off Converter Input Current	Shutdown input idle current	All		5	10	mA
Output Voltage Trim Range	P_{out}=max rated power	All	-10		+10	%
Output Over Voltage Protection		All	115	125	140	%
Over Temperature Shutdown	Aluminum baseplate temperature	All		110		°C
Over Temperature Recovery		All		100		°C

GENERAL SPECIFICATIONS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
MTBF	I_o=100% of I_{o_max}; MIL - HDBK - 217F_Notice 1, GB, 25°C	XXS05		309		K hours
		XXS12		331		
		XXS24		563		
		XXS28		560		
		XXS48		667		
Weight		All		68		grams
Case Material	Plastic, DAP					
Baseplate Material	Aluminum					
Potting Material	UL 94V-0					
Pin Material	Base: Copper Plating: Nickel with Matte Tin					
Shock/Vibration	MIL-STD-810F / EN61373					
Humidity	95% RH max. Non Condensing					
Altitude	3000m Operating Altitude, 12000m Transport Altitude					
Thermal Shock	MIL-STD-810F					
EMI	Meets EN55032 with external input filter, see 7.2					Class A
ESD	Meets EN61000-4-2 Air ± 8 Kv, Contanct ± 6 kV					Perf. Criteria A
Radiated immunity	Meets EN61000-4-3 20 V/m					Perf. Criteria A
Fast Transient	Meets EN61000-4-4 ± 2 kV , external input capacitor required, see 7.1					Perf. Criteria A
Surge	Meets EN61000-4-5 EN55024: ± 2 kV , external input capacitor required, see 7.1					Perf. Criteria A
Conducted immunity	Meets EN61000-4-6 10Vrms					Perf. Criteria A

5. Main Features and Functions

5.1 Operating Temperature Range

The CQB150W series converters can be operated within a wide case temperature range of -40°C to 105°C. Consideration must be given to the derating curves when ascertaining maximum power that can be drawn from the converter. The maximum power drawn from open quarter brick models is influenced by usual factors, such as:

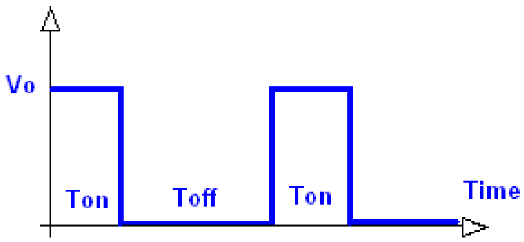
- Input voltage range
- Output load current
- Forced air or natural convection
- Heat sink optional

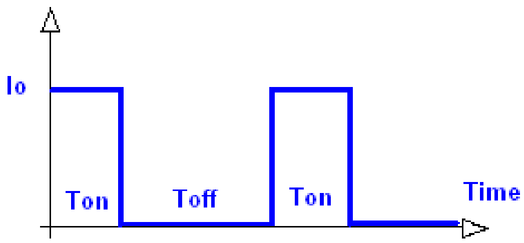
5.2 Output Voltage Adjustment

Section 6.10 describes in detail how to trim the output voltage with respect to its set point. The output voltage on all models is adjustable within the range of +10% to –10%.

5.3 Over Current Protection

All models have internal over current and continuous short circuit protection. The unit operates normally once the fault condition is removed. At the point of current limit inception, the converter will go into hiccup mode protection.





5.4 Output Over Voltage Protection

The output over voltage protection consists of circuitry that internally limits the output voltage. If more accurate output over voltage protection is required then an external circuit can be used via the remote on/off pin.

Note: Please note that device inside the power supply might fail when voltage more than rate output voltage is applied to output pin. This could happen when the customer tests the over voltage protection of unit.

5.5 Remote On/Off

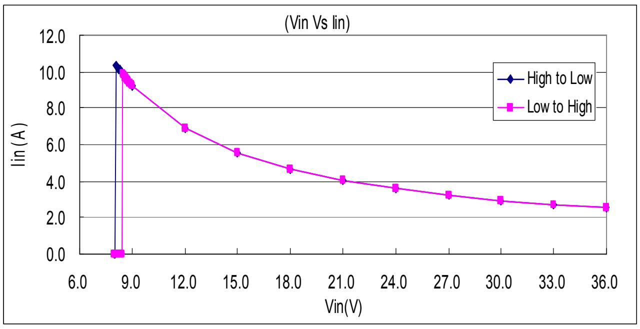
The CQB150W series allows the user to switch the module on and off electronically with the remote on/off feature. All models are available in “positive logic” and “negative logic” (optional) versions. The converter turns on if the remote On/Off pin is high (>3.5Vdc or open circuit). Setting the pin low (0 to <1.2Vdc) will turn the converter off. The signal level of the remote on/off input is defined with respect to ground. If not using the remote on/off pin, leave the pin open (converter will be on). Models with part number suffix “N” are the “negative logic” remote On/Off version. The unit turns off if the remote On/Off pin is high (>3.5Vdc or open circuit). The converter turns on if the On/Off pin input is low (0 to <1.2Vdc). Note that the converter is off by default. **See 6.14**

Logic State (Pin 2)	Negative Logic	Positive Logic
Logic Low – Switch Closed	Module on	Module off
Logic High – Switch Open	Module off	Module on

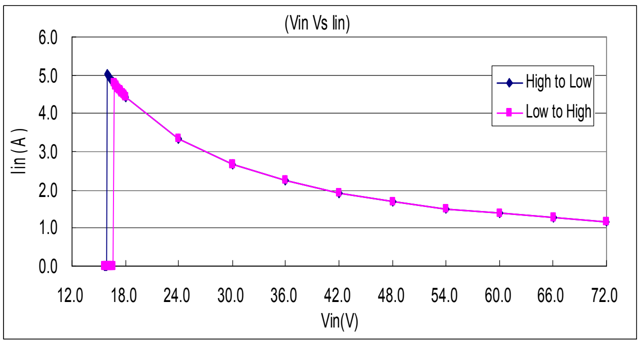
5.6 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the CQB150W unit. The unit will shut down when the input voltage drops below a threshold, and the unit will operate when the input voltage goes above the upper threshold.

CQB150W-24SXX
Iin Vs Vin

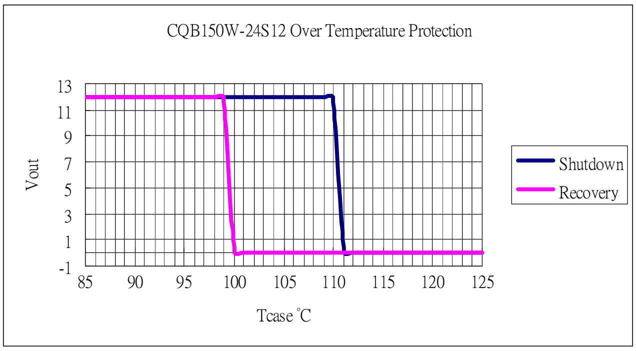


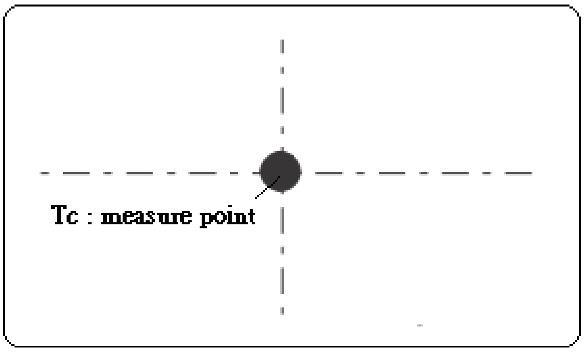
CQB150W-48SXX
Iin Vs Vin

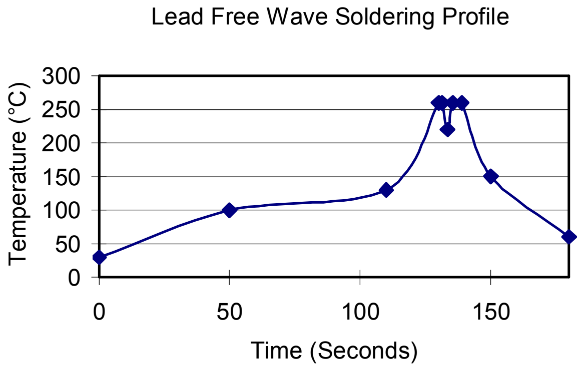


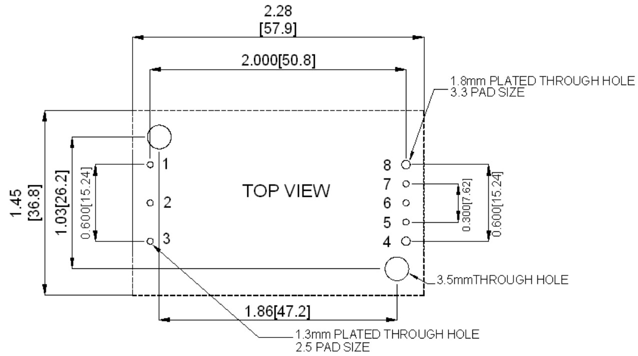
5.7 Over Temperature Protection

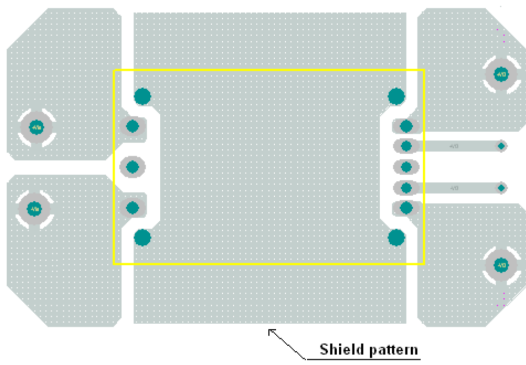
These modules have an over temperature protection circuit to safeguard against thermal damage. Shutdown occurs with the maximum case reference temperature is exceeded. The module will restart when the case temperature falls below over temperature recovery threshold. Please measure case temperature of the center part of aluminum baseplate.











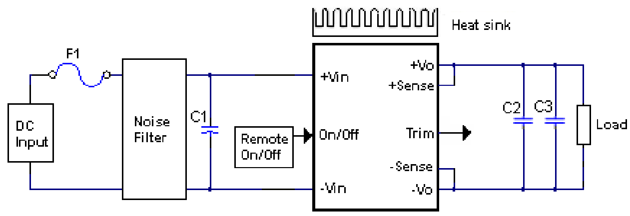
6. Applications

6.1 Recommend Layout, PCB Footprint and Soldering Information

The system designer or end user must ensure that metal and other components in the vicinity of the converter meet the spacing requirements for which the system is approved. Low resistance and inductance PCB layout traces are the norm and should be used where possible. Due consideration must also be given to proper low impedance tracks between power module, input and output grounds. The recommended soldering profile and PCB layout are shown below.

6.2 Connection for standard use

The connection for standard use is shown below. An external input capacitor (C1) 220uF for all models is recommended to reduce input ripple voltage. External output capacitors (C2, C3) are recommended to reduce output ripple and noise, 10uF aluminum and 1uF ceramic capacitor for 48Vout, and 10uF tantalum and 1uF ceramic capacitor for other models.

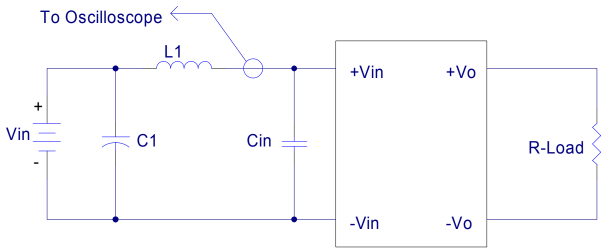


Symbol	Component	Reference
F1	Input fuse	**Section 7.1**
C1	External capacitor on input side	**Note**
C2,C3	External capacitor on the output side	**Section 6.12/6.13**
Noise Filter	External input noise filter	**Section 7.2**
Remote On/Off	External Remote On/Off control	**Section 6.16**
Trim	External output voltage adjustment	**Section 6.10**
Heat sink	External heat sink	**Section 6.4/6.5/6.6/6.7**
+Sense/-Sense	--	**Section 6.11**

Note:
If the impedance of input line is high, C1 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20 ℃.

6.3 Input Capacitance at the Power Module

The converters must be connected to low AC source impedance. To avoid problems with loop stability source inductance should be low. Also, the input capacitors (Cin) should be placed close to the converter input pins to de-couple distribution inductance. However, the external input capacitors are chosen for suitable ripple handling capability. Low ESR capacitors are good choice. Circuit as shown as below represents typical measurement methods for reflected ripple current. C1 and L1 simulate a typical DC source impedance. The input reflected-ripple current is measured by current probe to oscilloscope with a simulated source Inductance (L1).



L1: 12uH
C1: 470uF ESR<0.1ohm @100KHz
Cin: 470uF ESR<0.7ohm @100KHz

6.4 Convection Requirements for Cooling

To predict the approximate cooling needed for the quarter brick module, refer to the power derating curves in **section 6.6**. These derating curves are approximations of the ambient temperatures and airflows required to keep the power module temperature below its maximum rating. Once the module is assembled in the actual system, the module's temperature should be monitored to ensure it does not exceed 105°C as measured at the center of the top of the case (thus verifying proper cooling).

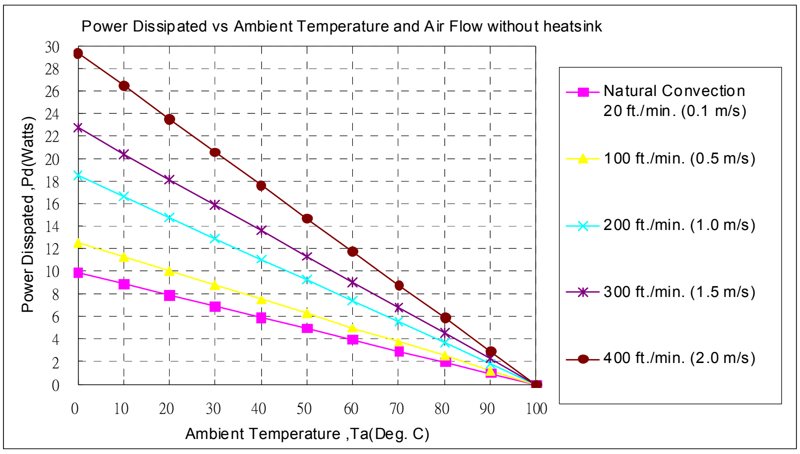
6.5 Thermal Considerations

The power module operates in a variety of thermal environments; however, sufficient cooling should be provided to help ensure reliable operation of the unit. Heat is removed by conduction, convection, and radiation to the surrounding environment. The example is presented in **section 6.6**. The power output of the module should not be allowed to exceed rated power (V_{o_set} x I_{o_max}).

6.6 Power Derating

The operating case temperature range of CQB150W series is -40°C to +105°C. When operating the CQB150W series, proper derating or cooling is needed. The maximum case temperature under any operating condition should not exceed 105°C.

The following curve is the de-rating curve of CQB150W series without heat sink.



AIR FLOW RATE	TYPICAL R_{ca}
Natural Convection 20ft./min. (0.1m/s)	10.1 ℃/W
100 ft./min. (0.5m/s)	8.0 ℃/W
200 ft./min. (1.0m/s)	5.4 ℃/W
300 ft./min. (1.5m/s)	4.4 ℃/W
400 ft./min. (2.0m/s)	3.4 ℃/W

Example:

What is the minimum airflow necessary for a CQB150W-48S12 operating at nominal line voltage, an output current of 12.5A, and a maximum ambient temperature of 40°C?

Solution:
Given:

V_{in}=48V_{dc}, Vo=12V_{dc}, I_o=12.5A

Determine Power dissipation (P_d):

$P_d = P_i - P_o = P_o(1-\eta)/\eta$

P_d =12V×12.5A×(1-0.9)/0.9=16.67Watts

Determine airflow:

Given: P_d =16.67W and T_a=40°C

Check *Power Derating* curve:

Minimum airflow= 400 ft./min.

Verify:

Maximum temperature rise is

ΔT = Pd × Rca=16.67W×3.4=56.68°C.

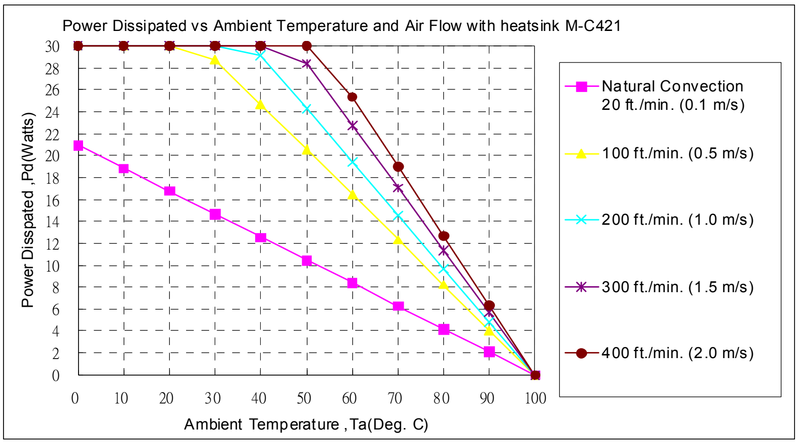
Maximum case temperature is

Tc=Ta+ΔT=96.68°C <105°C.

Where:

The Rca is thermal resistance from case to ambient environment.

Ta is ambient temperature and Tc is case temperature.



AIR FLOW RATE	TYPICAL R_{ca}
Natural Convection 20ft./min. (0.1m/s)	4.78 ℃/W
100 ft./min. (0.5m/s)	2.44 ℃/W
200 ft./min. (1.0m/s)	2.06 ℃/W
300 ft./min. (1.5m/s)	1.76 ℃/W
400 ft./min. (2.0m/s)	1.58 ℃/W

Example with heat sink QBT210 (M-C421):

What is the minimum airflow necessary for a CQB150W-24S05 operating at nominal line voltage, an output current of 30A, and a maximum ambient temperature of 40℃?

Solution:

Given:

Vin=24Vdc, Vo=5Vdc, Io=30A

Determine Power dissipation (P_d):

Pd=Pi-Po=Po(1-η)/η

Pd=5.0×30×(1-0.89)/0.89=18.54Watts

Determine airflow:

Given: Pd=18.54W and Ta=40℃

Check above Power de-rating curve:

Minimum airflow= 100 ft./min

Verify:

Maximum temperature rise is $\triangle T = P_d \times R_{ca}$=18.54×2.44=45.24℃

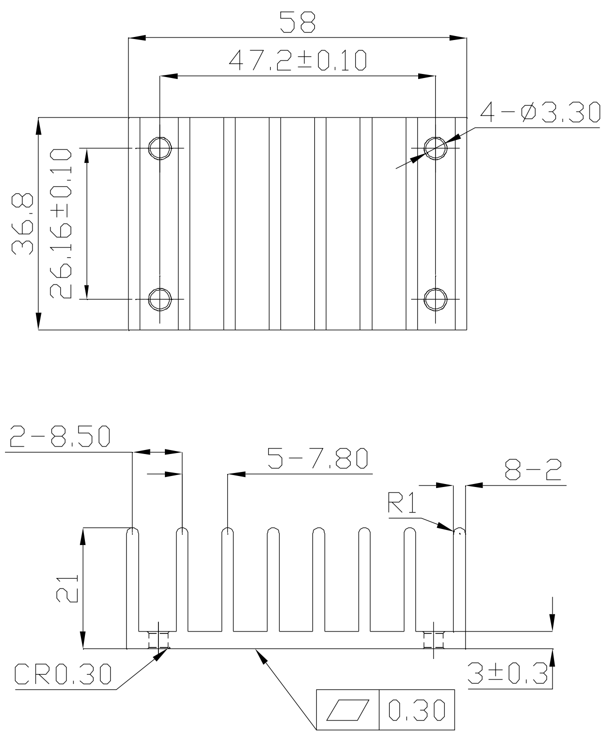
Maximum case temperature is Tc=Ta+△T=84.24℃ <105℃

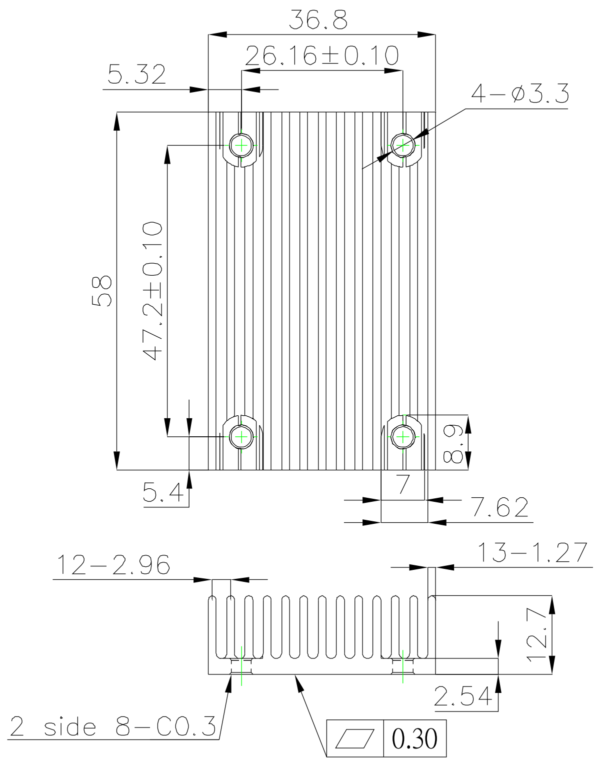
Where:

The Rca is thermal resistance from case to ambient environment.

Ta is ambient temperature and Tc is case temperature.

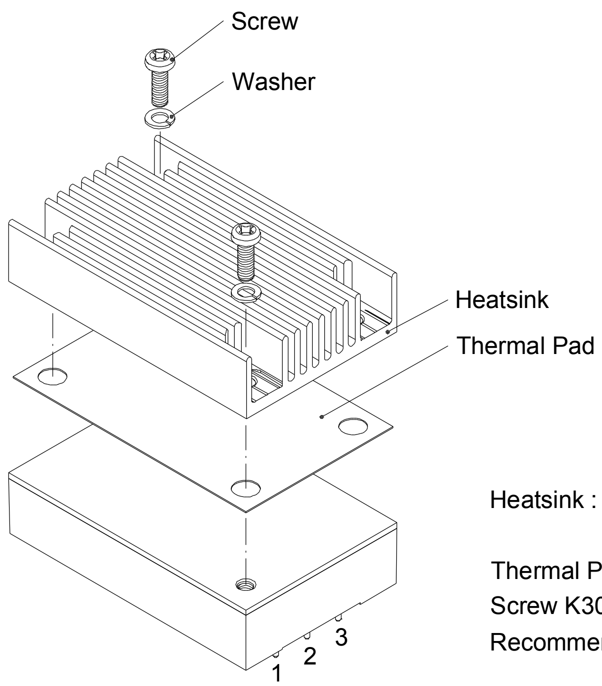
6.7 Quarter Brick Heat Sinks:





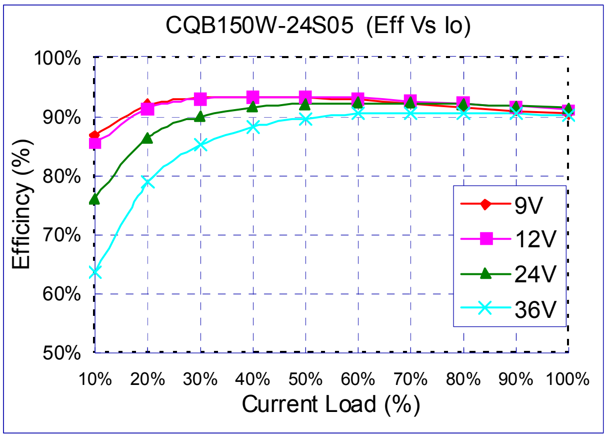
All Dimensions in mm

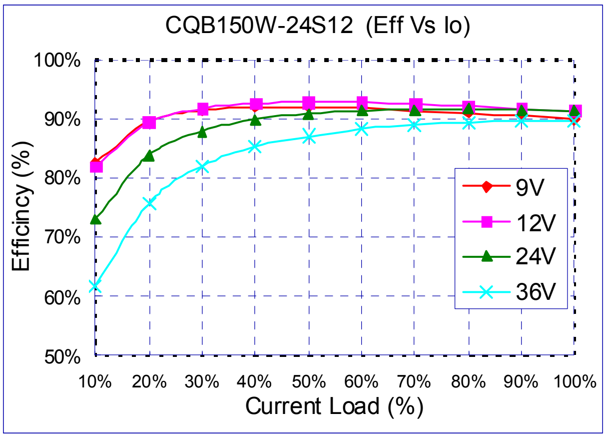
QBT210 (M-C421): G6620510201 Transverse Heat Sink	QBL127 (M-C448): G6620570202 Longitudinal Heat Sink
Rca: 4.78°C/W (typ.), At natural convection	Rca: 5.61°C/W (typ.), At natural convection
2.44°C/W (typ.), At 100LFM	4.01°C/W (typ.), At 100LFM
2.06°C/W (typ.), At 200LFM	3.39°C/W (typ.), At 200LFM
1.76°C/W (typ.), At 300LFM	2.86°C/W (typ.), At 300LFM
1.58°C/W (typ.), At 400LFM	2.49°C/W (typ.), At 400LFM

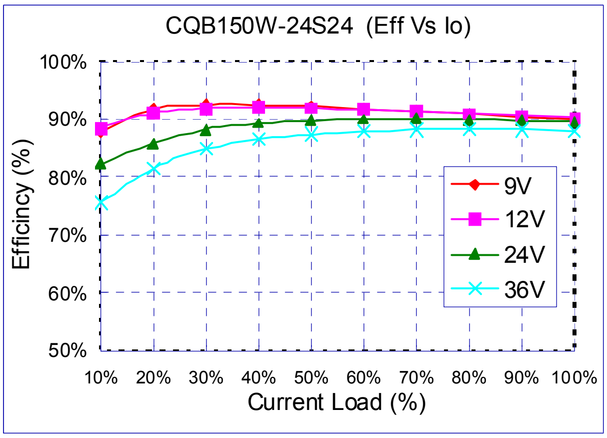


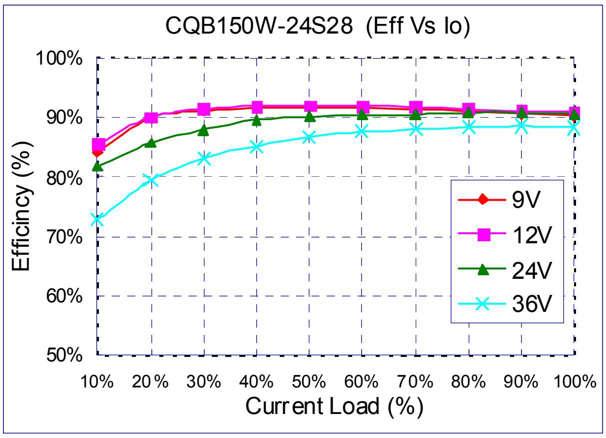
Heatsink : QBL127 (M-C448)
QBT210 (M-C421)
Thermal Pad PQ01: SZ35.8x56.9x0.25mm
Screw K308W: SMP+SW M3x8L
Recommended torque 3 Kgf-cm

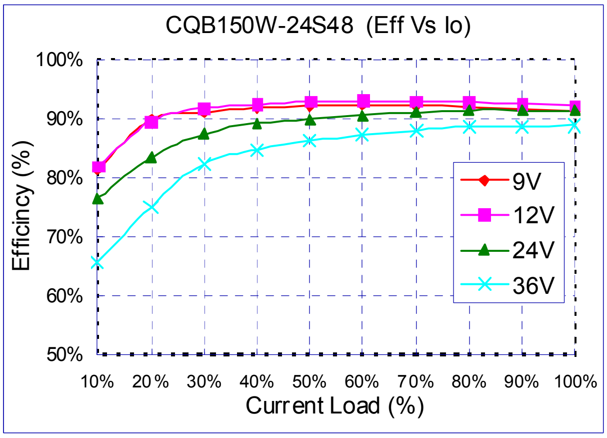
6.8 Efficiency VS. Load

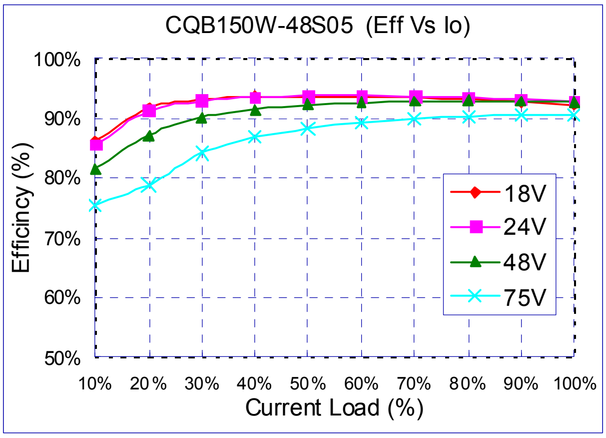


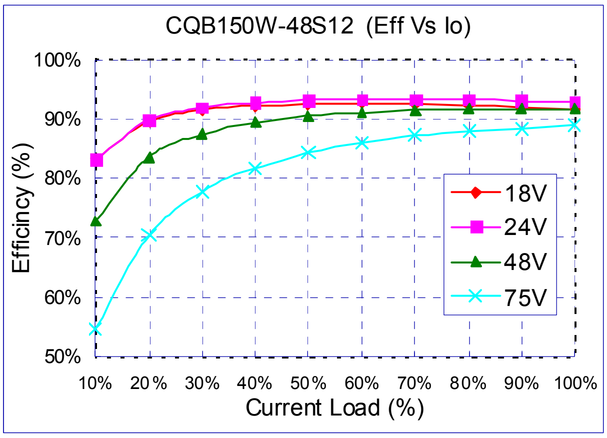


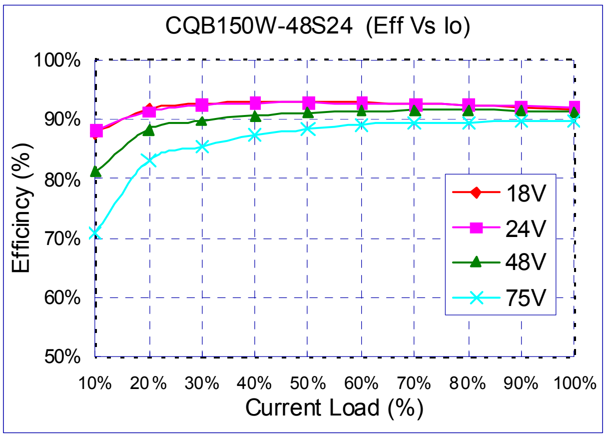


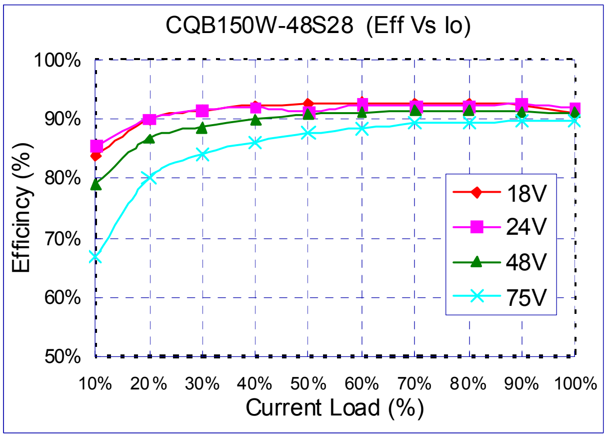


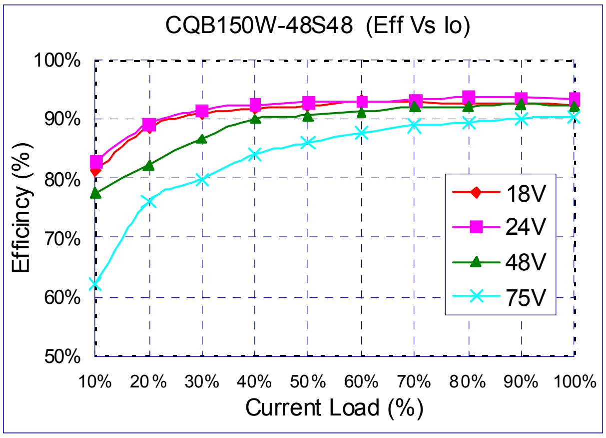





CQB150W-48S12 (Eff Vs Io)
100%
90%
80%
70%
60%
50%
Efficincy (%)
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
18V
24V
48V
75V


CQB150W-48S24 (Eff Vs Io)
100%
90%
80%
70%
60%
50%
Efficincy (%)
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
18V
24V
48V
75V


CQB150W-48S28 (Eff Vs Io)
100%
90%
80%
70%
60%
50%
Efficincy (%)
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
18V
24V
48V
75V


CQB150W-48S48 (Eff Vs Io)
100%
90%
80%
70%
60%
50%
Efficincy (%)
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
18V
24V
48V
75V

6.9 Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown below. When testing the modules under any transient conditions please ensure that the transient response of the source is sufficient to power the equipment under test. We can calculate:

- Efficiency
- Load regulation and line regulation.

The value of efficiency is defined as:

$$\eta = \frac{Vo \times Io}{Vin \times Iin} \times 100\%$$

Where:

V_o is output voltage,
I_o is output current,
V_{in} is input voltage,
I_{in} is input current.

The value of load regulation is defined as:

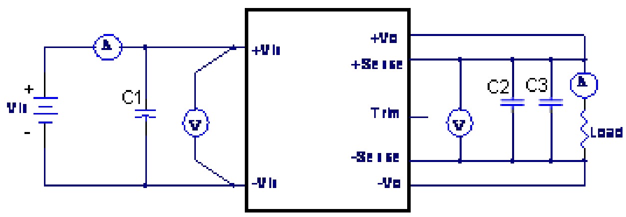
$$Load.reg = \frac{V_{FL} - V_{NL}}{V_{NL}} \times 100\%$$

Where:
V_{FL} is the output voltage at full load
V_{NL} is the output voltage at no load

The value of line regulation is defined as:

$$Line.reg = \frac{V_{HL} - V_{LL}}{V_{LL}} \times 100\%$$

Where: V_{HL} is the output voltage of maximum input voltage at full load. V_{LL} is the output voltage of minimum input voltage at full load.

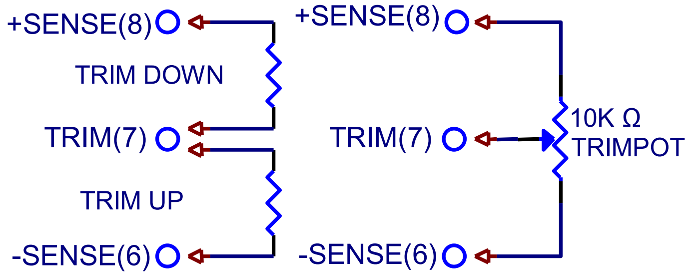


CQB150W Series Test Setup

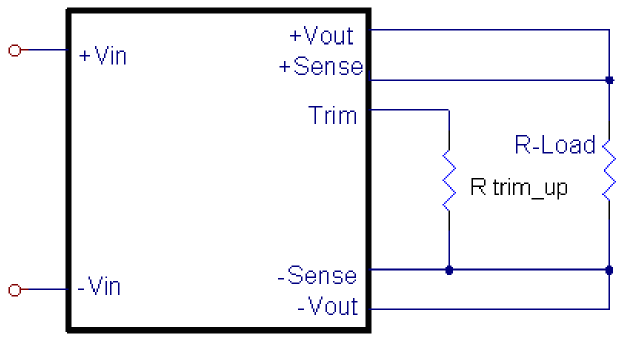
C1: 220uF/100V ESR<0.035Ω
C2: 1uF/ 1210 ceramic capacitor
C3: 10uF aluminum capacitor for 48Vout.
10uF tantalum capacitor for others.

6.10 Output Voltage Adjustment

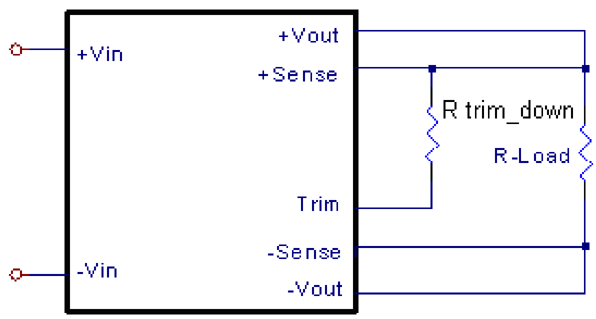
Output may be externally trimmed (±10%) with a fixed resistor or an external trim pot as shown (optional). Model specific formulas for calculating trim resistors are available upon request as a separate document.



In order to trim the voltage up or down, one needs to connect the trim resistor either between the trim pin and -Sense for trim-up or between trim pin and +Sense for trim-down. The output voltage trim range is ±10%. This is shown:



Trim-up Voltage Setup



Trim-down Voltage Setup

V_{out} (V)	R1 (KΩ)	R2 (KΩ)	R3 (KΩ)	V_r (V)	V_f (V)
5V	2.32	3.3	0	2.5	0
12V	9.1	51	5.1	2.5	0.46
24V	20	100	7.5	2.5	0.46
28V	23.7	150	6.2	2.6	0.64
48V	36	270	5.1	2.5	0.46

Trim Resistor Values

The value of R_{trim_up} defined as:

For Vo=5V Rtrim_up decision:

$$R_{trim\_up} = \frac{R_1 V_r}{Vo - V_{o\_nom}} - R_2 \quad (K\Omega)$$

For others Rtrim_up decision:

$$R_{trim\_up} = \left(\frac{R_1\left(V_r - V_f\left(\frac{R_2}{R_2 + R_3}\right)\right)}{Vo - V_{o\_nom}}\right) - \frac{R_2 R_3}{R_2 + R_3} \quad (\mathrm{K}\Omega)$$

Where:

R_{trim_up} is the external resistor in KΩ.

V_{o_nom} is the nominal output voltage.

V_o is the desired output voltage.

R1, R2, R3 and V_r are internal components.

For example, to trim-up the output voltage of 12V module (CQB150W-48S12) by 5% to 12.6V, R_{trim_up} is calculated as follows:

$V_o - V_{o\_nom} = 12.6 - 12 = 0.6V$
R1 = 9.1 KΩ, R2 = 51 KΩ, R3 = 5.1KΩ,
V_r= 2.5 V, V_f=0.46 V

$$R_{trim\_up} = \frac{18.944}{0.6} - 4.636 = 26.94\ (\mathrm{K}\Omega)$$

The value of R_{trim_down} defined as:

$$R_{trim\_down} = \frac{R_1 \times (V_o - V_r)}{V_{o\_nom} - V_o} - R_2 \quad (\mathrm{K}\Omega)$$

Where:

R_{trim_down} is the external resistor in KΩ.

V_{o_nom} is the nominal output voltage.

V_o is the desired output voltage.

R1, R2, R3 and V_r are internal components.

For example: to trim-down the output voltage of 12V module (CQB150W-48S12) by 5% to 11.4V, R_{trim_down} is calculated as follows:

$V_{o\_nom} - V_o = 12 - 11.4 = 0.6$ V
R1 = 9.1 KΩ, R2 = 51 KΩ, V_r = 2.5 V

$$R_{trim\_down} = \frac{9.1 \times (11.4 - 2.5)}{0.6} - 51 = 83.98\ \ (\mathrm{K}\Omega)$$

The typical value of R_{trim_up}

Trim up %	5V	12V	24V	28V	48V
	R_{trim_up} (KΩ)				
1%	112.7	153.2	165.7	168.3	148.6
2%	54.70	74.30	79.36	81.16	71.81
3%	35.37	47.99	50.58	52.12	46.21
4%	25.70	34.83	36.19	37.60	33.40
5%	19.90	26.94	27.56	28.86	25.72
6%	16.03	21.68	21.80	23.08	20.60
7%	13.27	17.92	17.69	18.93	16.94
8%	11.20	15.10	14.61	15.82	14.20
9%	9.589	12.91	12.21	13.40	12.07
10%	8.300	11.15	10.29	11.47	10.36

The typical value of R_{trim_down}

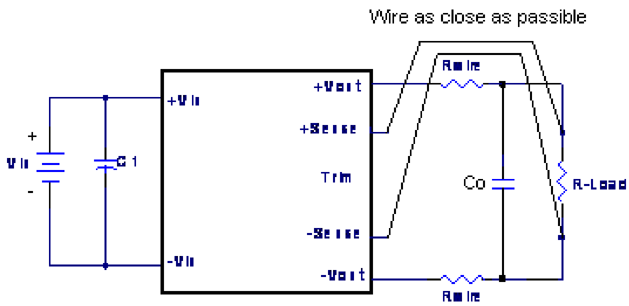
Trim down %	5V	12V	24V	28V	48V
	R_{trim_down} (KΩ)				
1%	110.4	660.3	1671	1984	3106
2%	52.38	300.1	775.8	905.5	1400
3%	33.05	180.0	477.2	545.8	831.5
4%	23.38	120.0	327.9	365.9	547.1
5%	17.58	83.99	238.3	258.0	376.5
6%	13.71	59.97	178.6	186.0	262.8
7%	10.95	42.82	136.0	134.6	181.5
8%	8.880	29.95	104.0	96.10	120.6
9%	7.269	19.95	79.07	66.12	73.17
10%	5.980	11.94	59.17	42.14	35.25

6.11 Output Remote Sensing

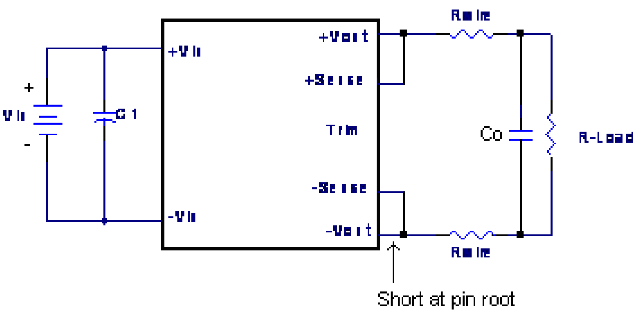
The CQB150W series converter has the capability to remotely sense both lines of its output. This feature moves the effective output voltage regulation point from the output of the unit to the point of connection of the remote sense pins. This feature automatically adjusts the real output voltage of the CQB150W series in order to compensate for voltage drops in distribution and maintain a regulated voltage at the point of load. The remote-sense voltage range is:

$[(+V_{out}) - (-V_{out})] - [(+\text{Sense}) - (-\text{Sense})] \leqq 10\%$ of $V_{o\_nominal}$

When remote sense is in use, the sense should be connected by twisted-pair wire or shield wire. If the sensing patterns short, heave current flows and the pattern may be damaged. Output voltage might become unstable because of impedance of wiring and load condition when length of wire is exceeding 400mm. This is shown in the schematic below.

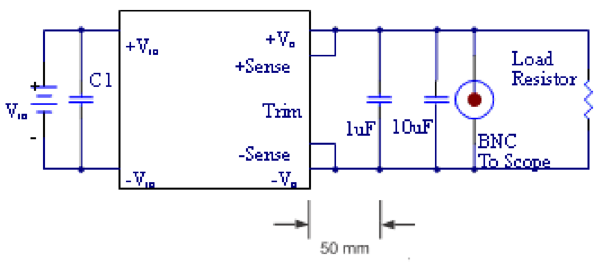


If the remote sense feature is not to be used, the sense pins should be connected locally. The +Sense pin should be connected to the +Vout pin at the module and the -Sense pin should be connected to the -Vout pin at the module. Wire between +Sense and +Vout and between -Sense and –Vout as short as possible. Loop wiring should be avoided. The converter might become unstable by noise coming from poor wiring. This is shown in the schematic below.



Note: Although the output voltage can be varied (increased or decreased) by both remote sense and trim, the maximum variation for the output voltage is the larger of the two values not the sum of the values. The output power delivered by the module is defined as the voltage at the output terminals multiplied by the output current. Using remote sense and trim can cause the output voltage to increase and consequently increase the power output of the module if output current remains unchanged. Always ensure that the output power of the module remains at or below the maximum rated power. Also be aware that if $V_{o.set}$ is below nominal value, $P_{out.max}$ will also decrease accordingly because $I_{o.max}$ is an absolute limit. Thus, $P_{out.max} = V_{o.set} \times I_{o.max}$ is also an absolute limit.

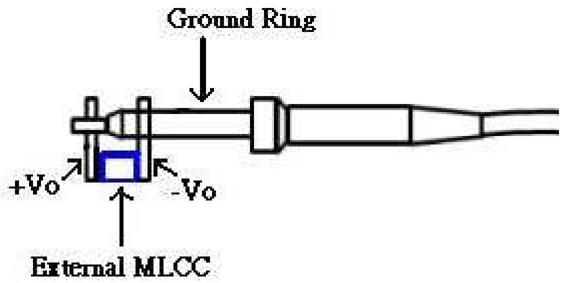
6.12 Output Ripple and Noise



Output ripple and noise measured with 10uF aluminum and 1uF ceramic capacitor across output for 48Vout and with 10uF tantalum and 1uF ceramic capacitor for others. A 20 MHz bandwidth oscilloscope is normally used for the measurement.

The conventional ground clip on an oscilloscope probe should never be used in this kind of measurement. This clip, when placed in a field of radiated high frequency energy, acts as an antenna or inductive pickup loop, creating an extraneous voltage that is not part of the output noise of the converter.

Another method is shown in below, in case of coaxial-cable/BNC is not available. The noise pickup is eliminated by pressing scope probe ground ring directly against the -Vout terminal while the tip contacts the +Vout terminal. This makes the shortest possible connection across the output terminals.

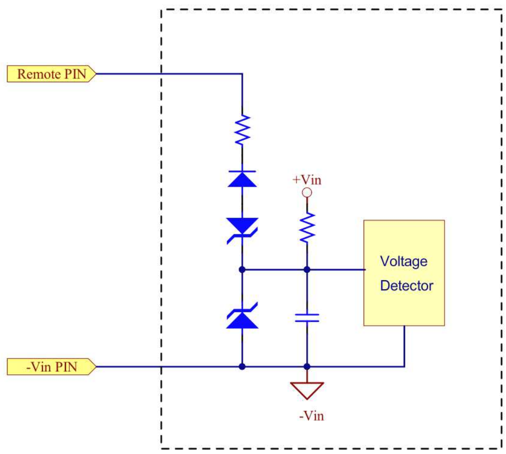


6.13 Output Capacitance

The CQB150W series converters provide unconditional stability with or without external capacitors. For good transient response, low ESR output capacitors should be located close to the point of load (<100mm). PCB design emphasizes low resistance and inductance tracks in consideration of high current applications. Output capacitors with their associated ESR values have an impact on loop stability and bandwidth. Cincon's converters are designed to work with load capacitance to see technical specifications.

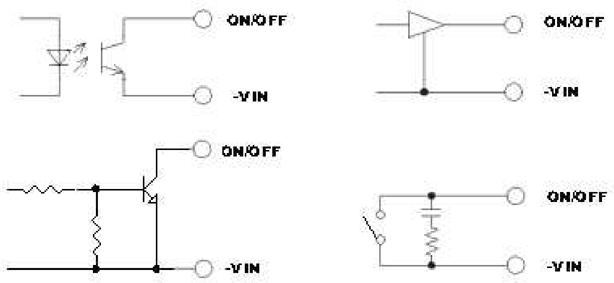
6.14 Remote On/Off Circuit

The converter remote On/Off circuit built-in on input side. The ground pin of input side Remote On/Off circuit is –Vin pin. **Refer to 5.5** for more details. Inside connection sees below.



Inside Remote On/Off Circuit Schematic

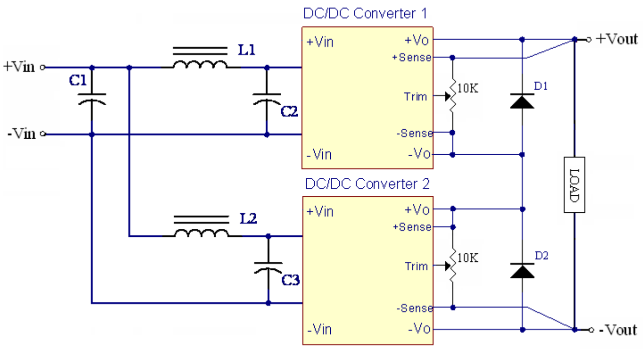
Connection examples see below.



Remote On/Off Connection Example

6.15 Series Operation

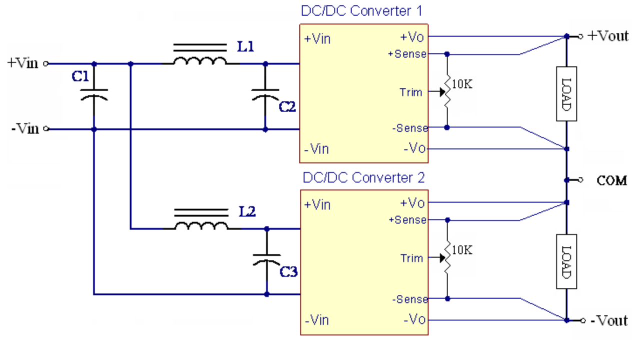
Series operation is possible by connecting the outputs two or more units. Connection is shown in below. The output current in series connection should be lower than the lowest rate current in each power module.



Simple Series Operation Connect Circuit

L1, L2: 1.0uH
C1, C2, C3: 220uF/100V ESR<0.035Ω
Note:
1. If the impedance of input line is high, C1, C2, C3 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20 ℃
2. Recommend Schottky diode (D1, D2) be connected across the output of each series connected converter, so that if one converter shuts down for any reason, then the output stage won't be thermally overstressed. Without this external diode, the output stage of the shut-down converter could carry the load current provided by the other series converters, with its MOSFETs conducting through the body diodes. The MOSFETs could then be overstressed and fail. The external diode should be capable of handling the full load current for as long as the application is expected to run with any unit shut down.

Series for ±output operation is possible by connecting the outputs two units, as shown in the schematic below.

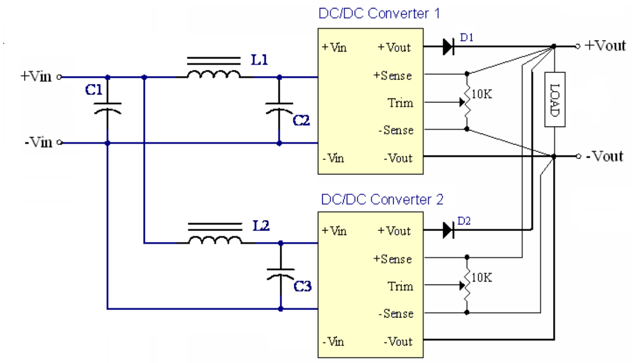


Simple ±Output Operation Connect Circuit

L1, L2: 1.0uH
C1, C2, C3: 220uF/100V ESR<0.035Ω
Note:
If the impedance of input line is high, C1, C2, C3 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20 ℃

6.16 Parallel / Redundant Operation

The CQB150W-24(48)SXX series parallel operation is **not** possible.
Parallel for redundancy operation is possible by connecting the units as shown in the schematic below. The current of each converter become unbalance by a slight difference of the output voltage. Make sure that the output voltage of units of equal value and the output current from each power supply does not exceed the rate current. Suggest use an external potentiometer to adjust output voltage from each power supply.



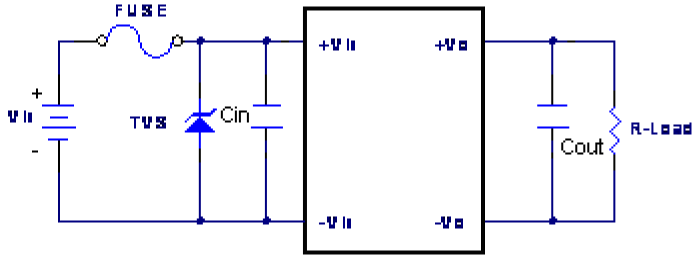
Simple Redundant Operation Connect Circuit

L1, L2: 1.0uH
C1, C2, C3: 220uF/100V ESR<0.035Ω
Note:
If the impedance of input line is high, C1, C2, C3 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20 ℃

7. Safety & EMC

7.1 Input Fusing and Safety Considerations

The CQB150W series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a 30A time delay fuse for 24V_{in} models, and 15A for 48V_{in} models. It is recommended that the circuit have a transient voltage suppressor diode (TVS) across the input terminal to protect the unit against surge or spike voltage and input reverse voltage (as shown).



The external input capacitor (Cin) and transient voltage suppressor diode (TVS) is required if CQB150W series has to meet EN61000-4-4, EN61000-4-5.
The Cin recommended a 470uF/100V (Nippon Chemi-Con KY series) aluminum capacitor. And the TVS recommended SMDJ40CA for 24V_{in} models, and SMDJ78A for 48V_{in} models.

7.2 EMC Considerations

EMI Test standard: EN55022 / EN55032 Class A Conducted Emission
Test Condition: Input Voltage: Nominal, Output Load: Full Load

(1) EMI and conducted noise meet EN55032 Class A:

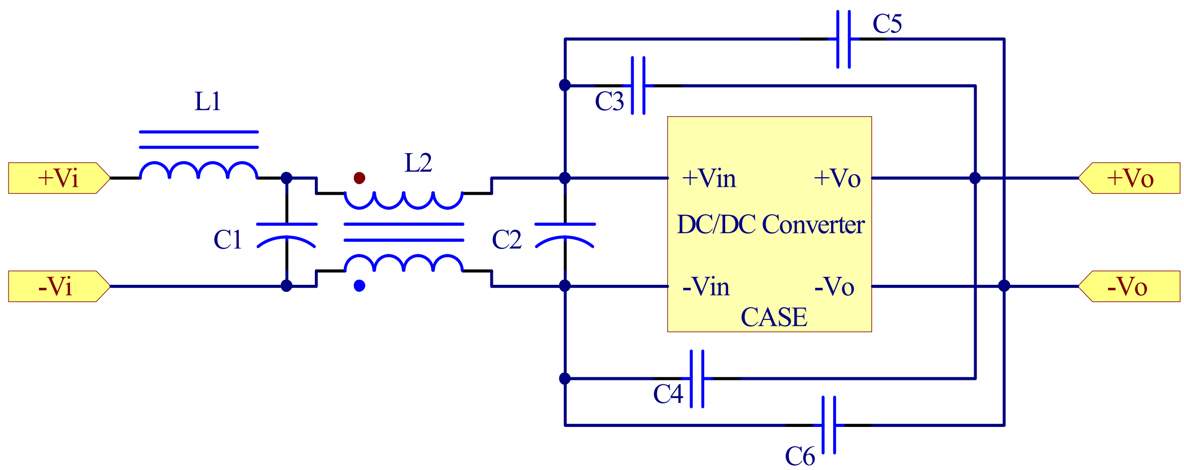
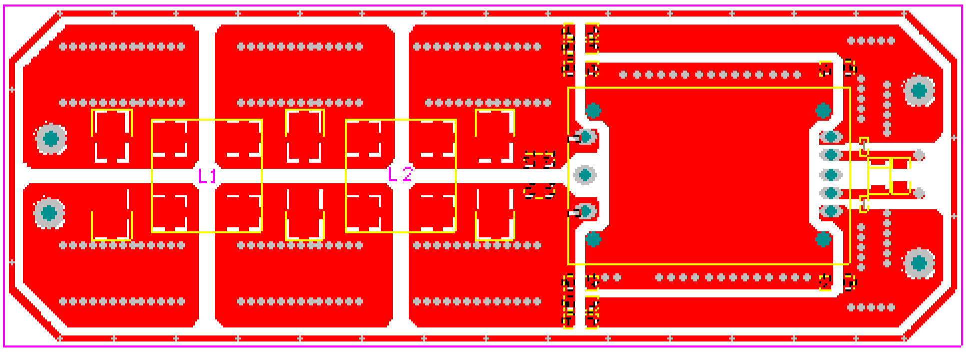


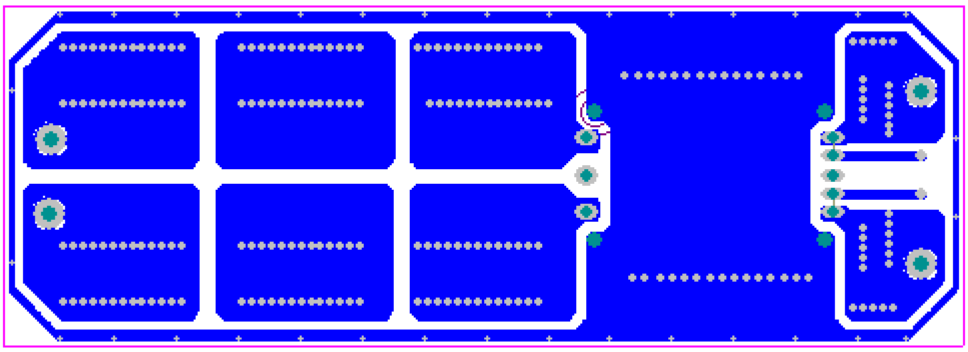
Figure1 Connection circuit for conducted EMI Class A testing

Model No.	C1	C2	C3	C4	C5	C6	L1	L2
CQB150W-24S05	470uF/50V	470uF/50V	2200pF	N.C.	N.C.	2200pF	Short	0.5mH
CQB150W-24S12	470uF/50V	470uF/50V	2200pF	N.C.	N.C.	2200pF	Short	0.5mH
CQB150W-24S24	470uF/50V	470uF/50V	2200pF	N.C.	N.C.	2200pF	Short	0.5mH
CQB150W-24S28	470uF/50V	470uF/50V	2200pF	N.C.	N.C.	2200pF	Short	0.5mH
CQB150W-24S48	470uF/50V	470uF/50V	4700pF	N.C.	N.C.	4700pF	Short	0.5mH
CQB150W-48S05	220uF/100V	220uF/100V	2200pF	N.C.	N.C.	2200pF	Short	0.5mH
CQB150W-48S12	220uF/100V	220uF/100V	2200pF	N.C.	N.C.	2200pF	Short	0.5mH
CQB150W-48S24	220uF/100V	220uF/100V	2200pF	N.C.	N.C.	2200pF	Short	0.5mH
CQB150W-48S28	220uF/100V	220uF/100V	2200pF	N.C.	N.C.	2200pF	Short	0.5mH
CQB150W-48S48	220uF/100V	220uF/100V	4700pF	N.C.	N.C.	4700pF	Short	0.5mH

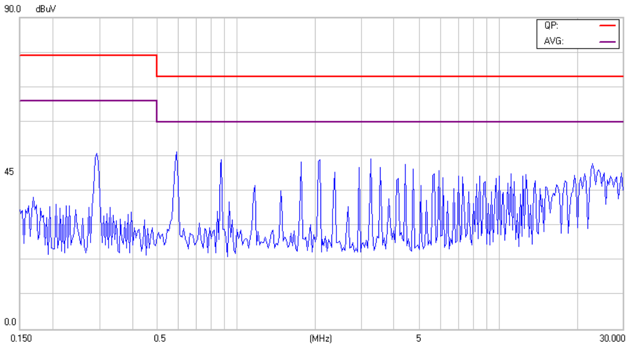
Note: C1, C2 NIPPON CHEMI-CON KY series aluminum capacitors, C3, C4, C5, C6 is ceramic capacitors.
C1, C2: 470uF/50V (NIPPON CHEMI-CON EKY-500E□□471MK20S) or equivalent.
220uF/100V (NIPPON CHEMI-CON EKY-101E□□221MK25S)or equivalent.
C3, C6: 2200pF (MURATA KX Series DC1E3KX222MA4BN01F)or equivalent.
4700pF (MURATA KX Series DC1E3KX472MA4BN01F)or equivalent.
L2: SC-15-05J (TOKIN) or equivalent.



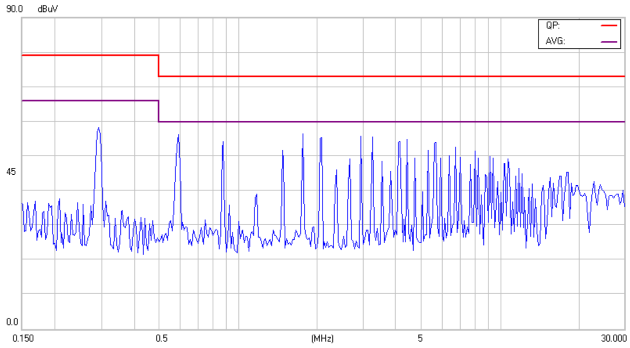
EMI test board top side



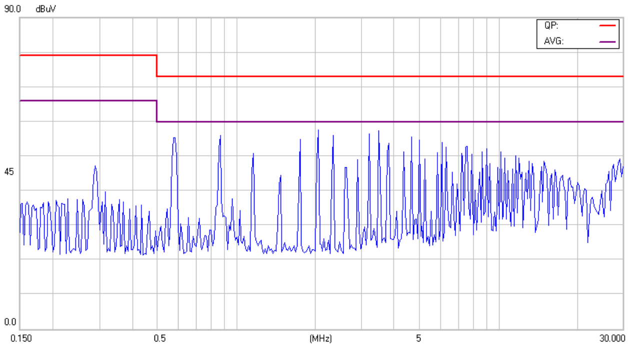
EMI test board bottom side



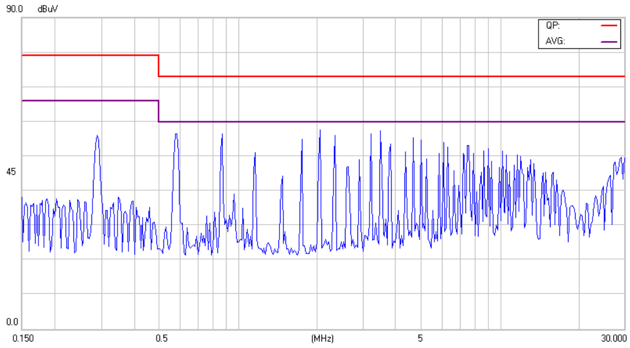
Conducted Class A of CQB150W-24S05 Line



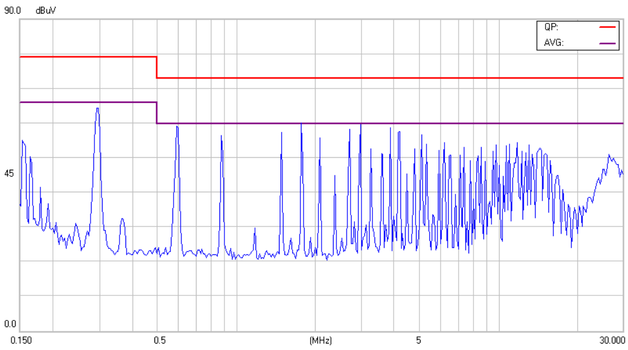
Conducted Class A of CQB150W-24S05 Nature



Conducted Class A of CQB150W-24S12 Line



Conducted Class A of CQB150W-24S12 Nature



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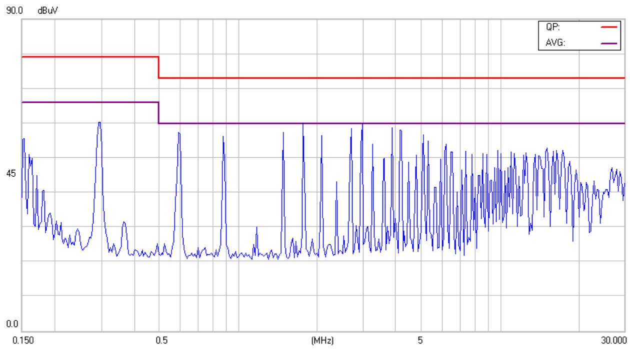

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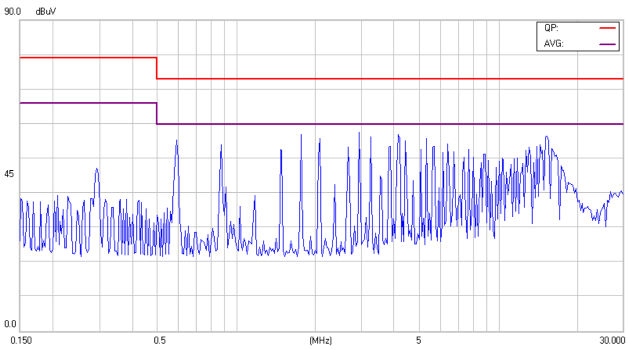
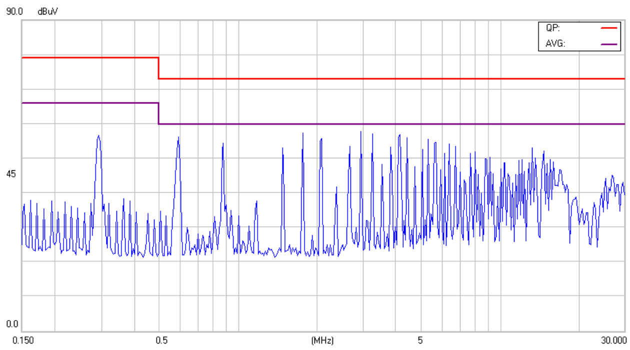


Conducted Class A of CQB150W-24S28 Line



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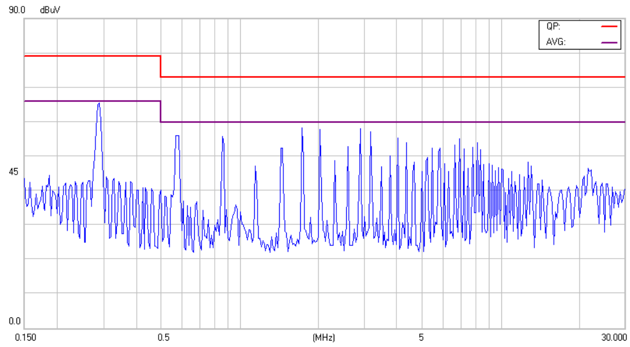
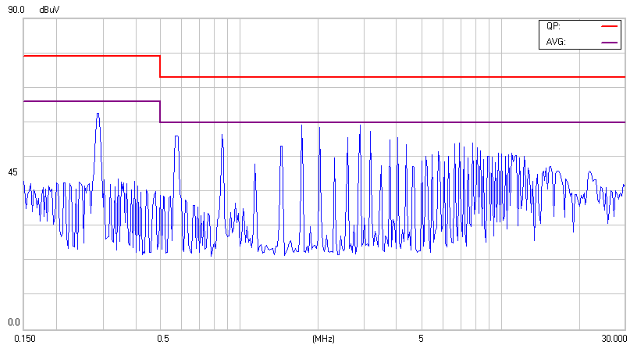


Conducted Class A of CQB150W-24S48 Line



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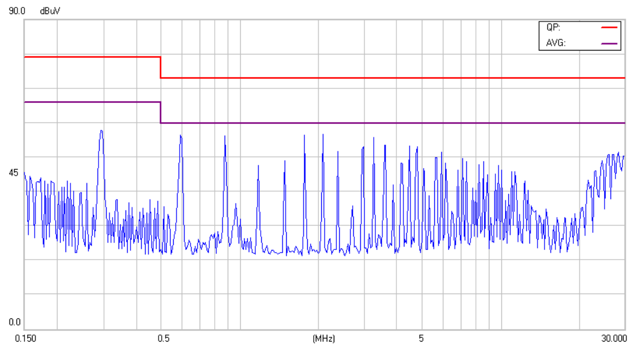
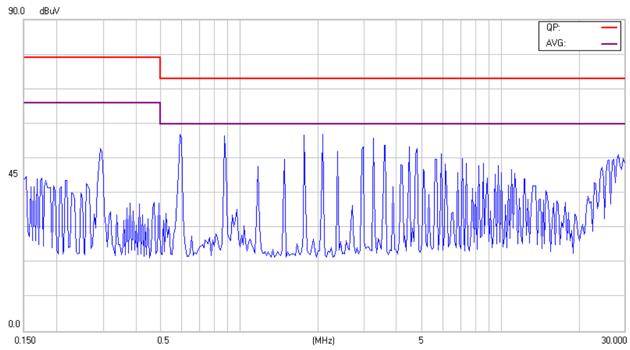


Conducted Class A of CQB150W-48S05 Line



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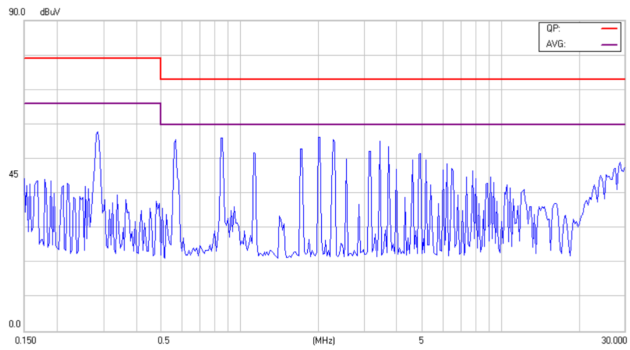

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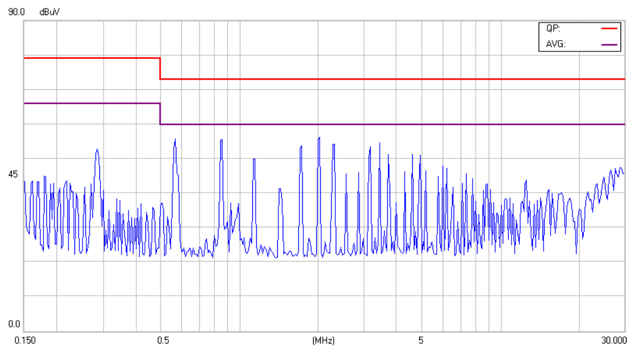

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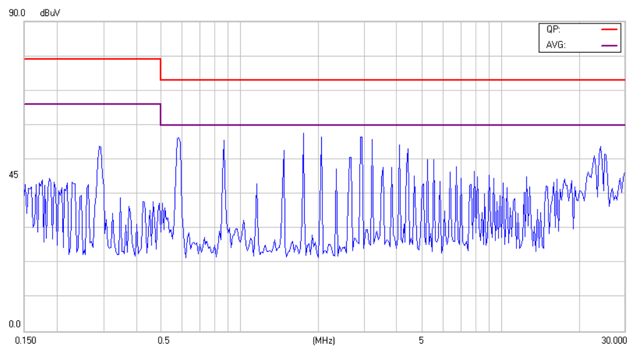

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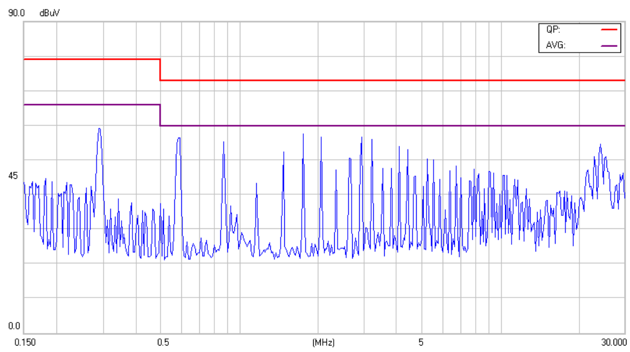

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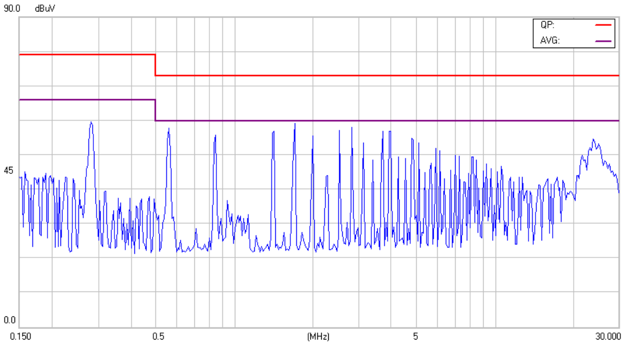
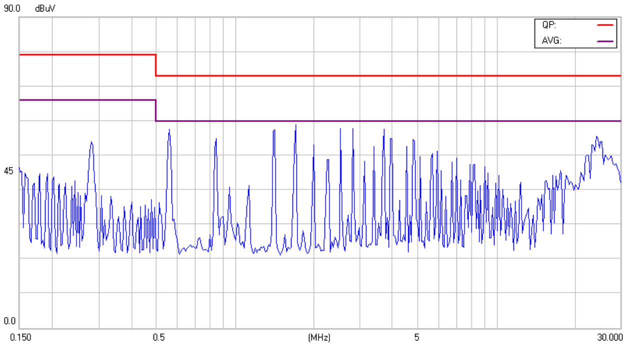
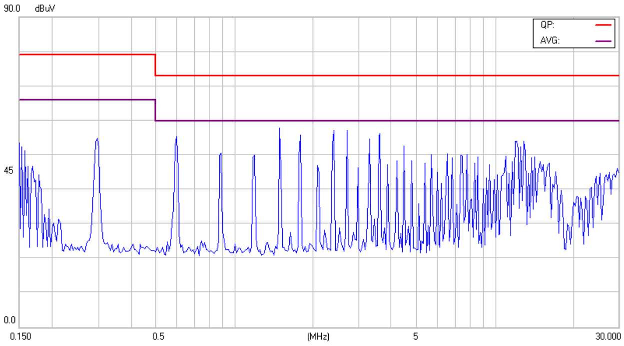


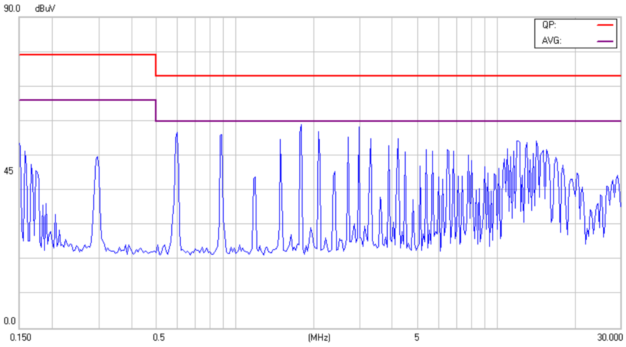
Conducted Class A of CQB150W-48S28 Line



Conducted Class A of CQB150W-48S28 Nature



Conducted Class A of CQB150W-48S48 Line



Conducted Class A of CQB150W-48S48 Nature

8. Part Number

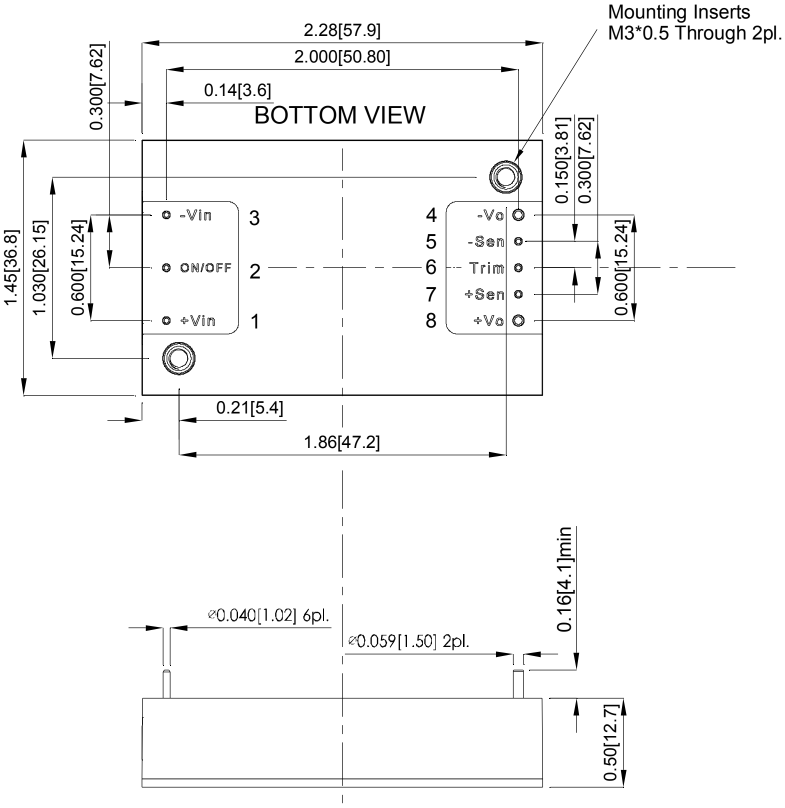
Format: CQB150W – II O XX L-Y

Parameter	Series	Nominal Input Voltage	Number of Outputs	Output Voltage	Remote On/Off Logic	Mounting Inserts
Symbol	CQB150W	II	O	XX	L	Y (Option)
Value	CQB150W	24: 24 Volts 48: 48 Volts	S: Single	05: 5.0 Volts 12: 12 Volts 24: 24 Volts 28: 28 Volts 48: 48 Volts	None: Positive N: Negative	C: Clear Mounting Insert (3.2mm DIA.)

9. Mechanical Specifications

9.1 Mechanical Outline Diagrams

All Dimensions In Inches(mm)
Tolerances Inches: X.XX= ±0.02 , X.XXX= ±0.010
Millimeters: X.X= ±0.5 , X.XX=±0.25



PIN CONNECTION	
PIN	Function
1	+V Input
2	On/Off
3	-V Input
4	-V Output
5	-Sense
6	Trim
7	+Sense
8	+V Output

CQB150W Mechanical Outline Diagram

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