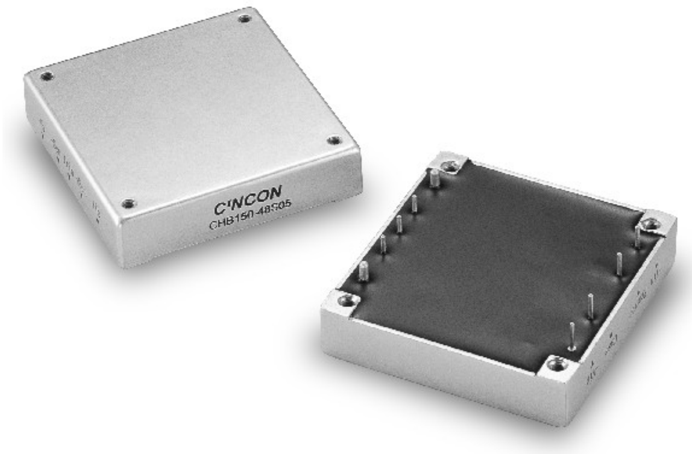
ISOLATED DC-DC CONVERTER
CHB150 SERIES
APPLICATION NOTE



Approved By:

Department	Approved By	Checked By	Written By
Research and Development Department	Jacky	Danny/Tony	Joyce
Design Quality Department	Benny	JoJo	

Contents

CHB150 Series
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1. Introduction

The CHB150 series offers 150 watts of output power with high power density in an industry standard half-brick package. The CHB150 series has wide (2:1) input voltage ranges of 36-75VDC and provides a precisely regulated output. This series has features such as high efficiency, 1500VDC isolation and a case operating temperature range of -40°C to 100°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

- 99-150W Isolated Output
- Efficiency to 89%
- 500KHz Switching Frequency
- 2:1 Input Range
- Regulated Outputs
- Continuous Short Circuit Protection
- Five-Sided Metal Case
- Half-Brick Size Meets Industrial Standard
- UL60950-1 Approval
- Without Tantalum Capacitor Inside (Except 3.3&5Vout)
- Safety Meets IEC/EN/UL 62368-1

3. Electrical Block Diagram

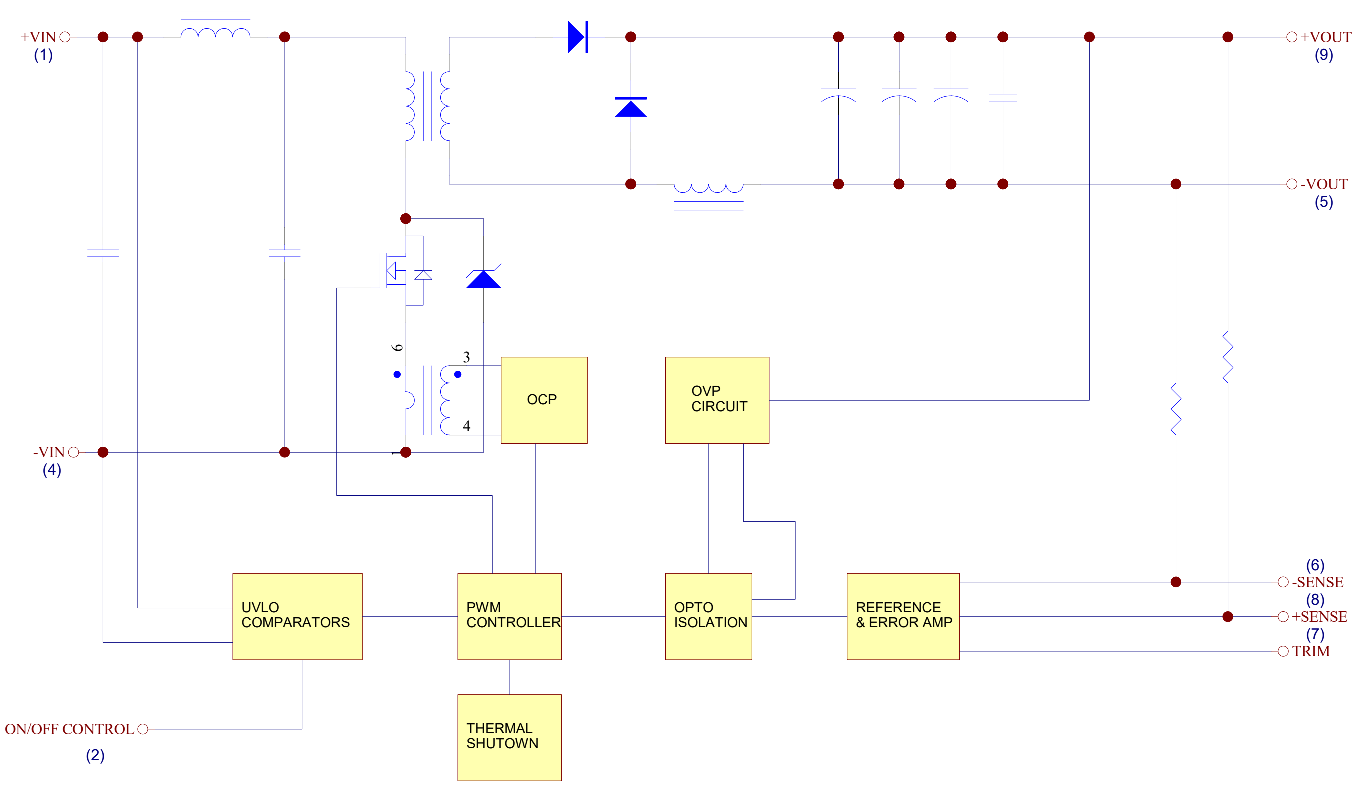


Figure 1 Electrical Block Diagram of CHB150 Series Module

4. Technical Specifications

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

ABSOLUTE MAXIMUM RATINGS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Input Voltage						
Continuous		All	-0.3		75	V_{dc}
Transient	100ms	All			100	V_{dc}
Operating Case Temperature		All	-40		100	℃
Storage Temperature		All	-40		105	℃
Isolation Voltage	1 Minute; input/output, input/case, output/case	All	1500			V_{dc}

INPUT CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Operating Input Voltage		All	36	48	75	V_{dc}
Input Under Voltage Lockout						
Turn-On Voltage Threshold		All		34		V_{dc}
Turn-Off Voltage Threshold		All		32.5		V_{dc}
Lockout Hysteresis Voltage		All		1.5		V_{dc}
Maximum Input Current	100% Load, V_{in}=36V	All		4.9		A
No-Load Input Current		All		25		mA
Inrush Current (I^2t)		All			0.1	A^2s
Input Reflected Ripple Current	P-P thru 12uH inductor, 5Hz to 20MHz	All		14		mA

OUTPUT CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Output Voltage Set Point	V_{in}=Nominal V_{in}, I_o=$I_{o\_max.}$, T_c=25℃	48S33	3.267	3.3	3.333	V_{dc}
		48S05	4.95	5	5.05	
		48S12	11.88	12	12.12	
		48S15	14.85	15	15.15	
		48S24	23.76	24	24.24	
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	T_c=-40℃ to 100℃	All			±0.03	%/℃
Output Voltage Ripple and Noise						
Peak-to-Peak	5Hz to 20MHz bandwidth, Full load 10uF solid tantalum and 1.0uF ceramic capacitors	Vo= 3.3&5.0V			100	mV
		Vo=12&15V			150	
		Vo=24V			240	
RMS		Vo= 3.3&5.0V			40	mV
		Vo=12&15V			60	
		Vo=24V			100	

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Operating Output Current Range		48S33	0		30	A
		48S05	0		30	
		48S12	0		12.5	
		48S15	0		10	
		48S24	0		6.25	
Output DC Current Limit Inception	Output voltage=90% nominal output voltage	All	110		140	%
Maximum Output Capacitance	Full load (resistive)	48S33	0		30000	uF
		48S05	0		30000	
		48S12	0		12500	
		48S15	0		10000	
		48S24	0		6250	

DYNAMIC CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Output Voltage Current Transient						
Step Change in Output Current	75% to 100% of $I_{o\_max.}$	All			±5	%
Setting Time (within 1% Vout nominal)	d_i/d_t=0.1A/us	All			500	us
Turn-On Delay and Rise Time						
Turn-On Delay Time, From On/Off Control	$V_{on/off}$ to 10%V_{o_set}	All		8		ms
Turn-On Delay Time, From Input	$V_{in\_min.}$ to 10%V_{o_set}	All		5		ms
Output Voltage Rise Time	10%V_{o_set} to 90%V_{o_set}	All		2		ms

EFFICIENCY

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
100% Load	V_{in}=Nominal V_{in}	48S33		82		%
		48S05		86		
		48S12		89		
		48S15		89		
		48S24		89		

ISOLATION CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Isolation Voltage	1 Minute; input/output, input/case, output/case	All			1500	V_{dc}
Isolation Resistance		All	10			MΩ
Isolation Capacitance		All		1000		pF

FEATURE CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Switching Frequency		All		500		KHz
On/Off Control, Positive Remote On/Off Logic						
Logic Low (Module Off)	$V_{on/off}$ at $I_{on/off}$=1.0mA	All	0		0.8	V
Logic High (Module On)	$V_{on/off}$ at $I_{on/off}$=0.0uA	All	Open Circuit		75	V

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
On/Off Control, Negative Remote On/Off Logic						
Logic High (Module Off)	$V_{on/off}$ at $I_{on/off}$=0.0uA	All	Open Circuit		75	V
Logic Low (Module On)	$V_{on/off}$ at $I_{on/off}$=1.0mA	All	0		0.8	V
Off Converter Input Current	Shutdown input idle current	All			10	mA
Output Voltage Trim Range	P_{out}=max. rated power	All	-10		+10	%
Output Over Voltage Protection		All	115	125	140	%
Over-Temperature Protection	Shutdown case temperature	All		100		℃
	Restart threshold case temperature	All		70		℃

GENERAL SPECIFICATIONS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
MTBF	I_o=100% of $I_{o\_max.}$; T_a=25℃ per MIL-HDBK-217F	All		900		K hours
Weight		All		100		grams

5. Main Features and Functions

5.1 Operating Temperature Range

The CHB150 series converters can be operated within a wide case temperature range of -40 ℃ to 100 ℃. Consideration must be given to the derating curves when ascertaining maximum power that can be drawn from the converter. The maximum power drawn from half brick models is influenced by usual factors, such as:

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

5.2 Output Voltage Adjustment

Section 6.8 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

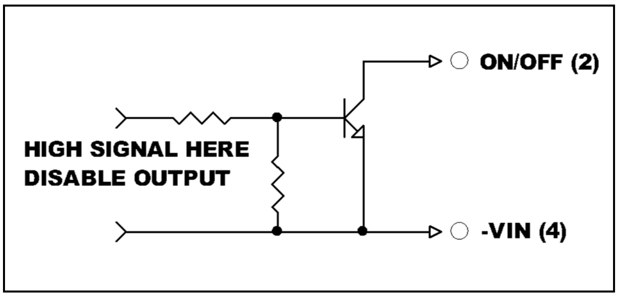
All different voltage models have full continuous short-circuit protection. To provide protection in a fault condition, the unit is equipped with internal over-current protection. The unit operates normally once the fault condition is removed. At the point of current-limit inception, the converter will go into over current 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.

5.6 Remote On/Off

The CHB150 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 (open circuit). Setting the pin low (0 to <0.8Vdc) 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” remoteon/off**f** version. The unit turns off if the remote **on/off** pin is high (open circuit). The converter turns on if the on/off pin input is low (0 to <0.8Vdc). Note that the converter is off by default.



5.7 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the CHB150 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.

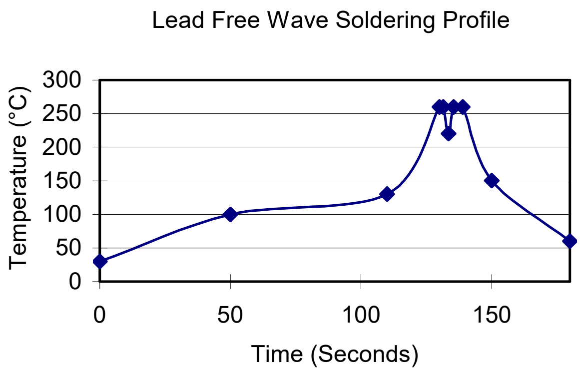
5.8 Over Temperature Protection

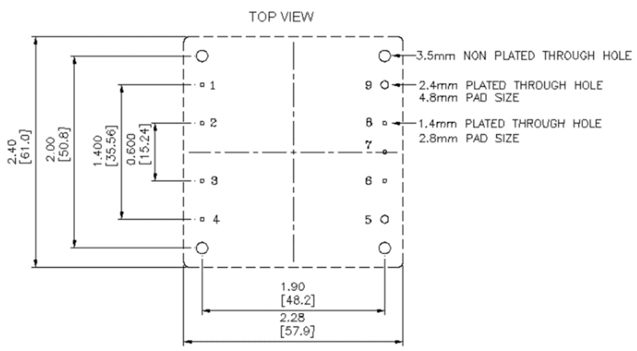
These modules have an over temperature protection circuit to safeguard against thermal damage. The module shuts down and latches off when the maximum case reference temperature is exceeded. The module will restart when the case temperature falls below restart threshold.

6. Applications

6.1 Recommended 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 Convection Requirements for Cooling

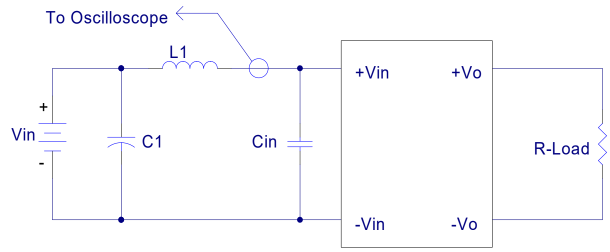
To predict the approximate cooling needed for the half brick module, refer to the power derating curves in section 6.4. These derating curves are approximations of the ambient temperatures and airflows required to keep the power module temperature below its maximum rating. Once the module is assembled in the actual system, the module's temperature should be monitored to ensure it does not exceed 100°C as measured at the center of the top of the case (thus verifying proper cooling).

6.3 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 6.4. The power output of the module should not be allowed to exceed rated power (V_{o_set} x I_{o_max}.).

6.4 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).

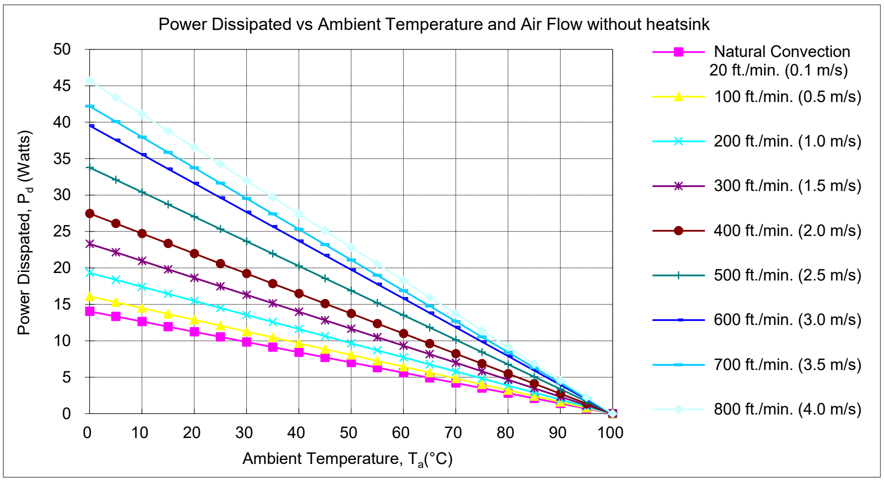


L1: Short
C1: NC
Cin: NC

Input Reflected-Ripple Test Setup

6.5 Power Derating

The operating case temperature range of CHB150 series is -40℃ to +100℃. When operating the CHB150 series, proper derating or cooling is needed. The maximum case temperature under any operating condition should not exceed 100℃.



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

Example:

What is the minimum airflow necessary for a CHB150-48S12 operating at nominal line voltage, an output current of 12.5A, and a maximum ambient temperature of 40℃.

Solution:

Given:

V_{in}=48Vdc, V_o=12Vdc, I_o=12.5A

Determine power dissipation (P_d):

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

$P_d=12\times12.5\times(1-0.89)/0.89=18.54$Watts

Determine airflow:

Given: P_d=18.54W and T_a=40℃

Check above power derating curve:

Minimum airflow= 500ft./min.

Verify:

The maximum temperature rise

$\triangle T=P_d\times R_{ca}=18.54\times2.96=54.88$℃

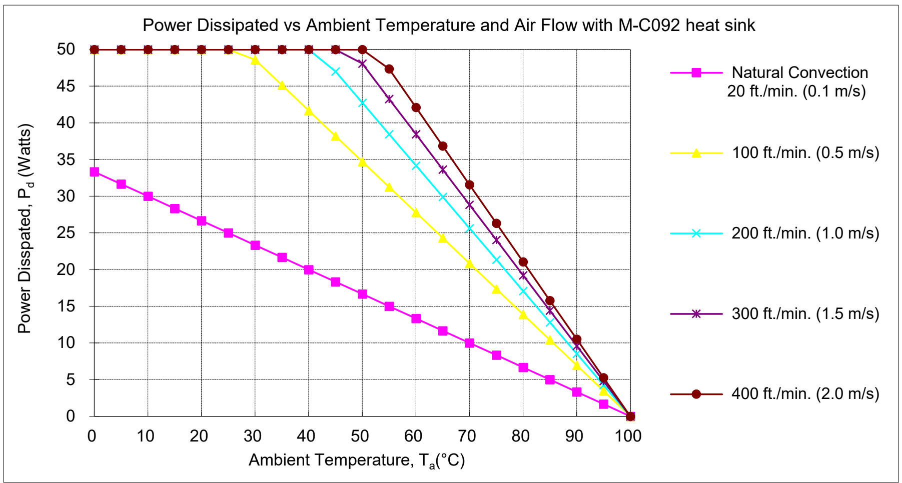
The maximum case temperature

$T_c=T_a+\triangle T=94.88$℃<100℃

Where:

The R_{ca} is thermal resistance from case to ambience

The T_a is ambient temperature and the T_c is case temperature



AIR FLOW RATE	TYPICAL R_{ca}
Natural Convection 20ft./min. (0.1m/s)	3 ℃/W
100 ft./min. (0.5m/s)	1.44 ℃/W
200 ft./min. (1.0m/s)	1.17 ℃/W
300 ft./min. (1.5m/s)	1.04 ℃/W
400 ft./min. (2.0m/s)	0.95 ℃/W

Example with heatsink HBT254 (M-C092):
What is the minimum airflow necessary for a CHB150-48S12 operating at nominal line voltage, an output current of 12.5A, and a maximum ambient temperature of 40℃.

Solution:

Given:

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

Determine power dissipation (Pd):

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

P_d=12×12.5×(1-0.89)/0.89=18.54Watts

Determine airflow:

Given: P_d=18.54W and T_a=40℃

Check above power de-rating curve:

P_d<20W, Natural Convection

Verify:

Maximum temperature rise is △T=Pd×Rca=18.54×3=55.62℃

Maximum case temperature is $T_c=T_a$+△T=95.62℃<100℃

Where:

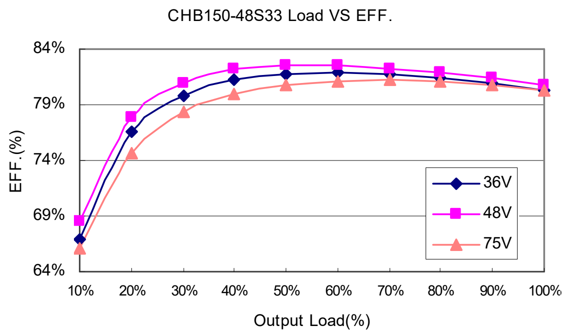
The R_{ca} is thermal resistance from case to ambient environment

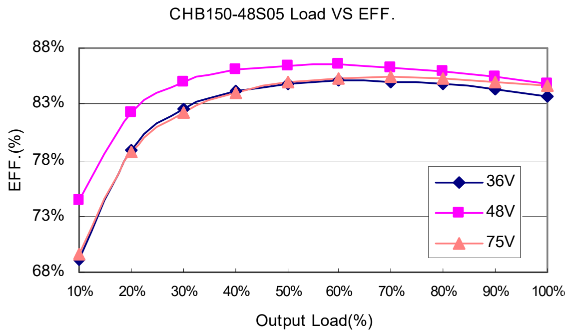
T_a is ambient temperature and T_c is case temperature

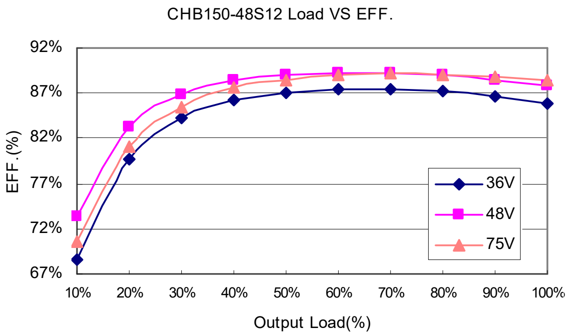
6.6 Half Brick Heat Sinks

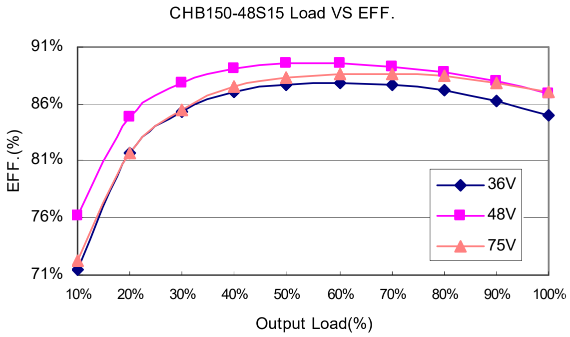
Heat sinks assembly **refer to Datasheet-Thermal**

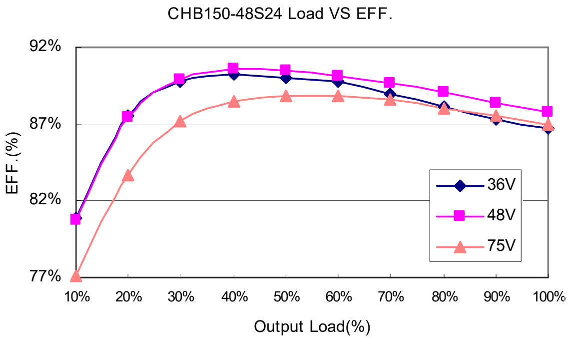
6.7 Efficiency VS. Load











6.8 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:

$$\eta = \frac{V_O \times I_o}{V_{in} \times I_{in}} \times 100\%$$

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:

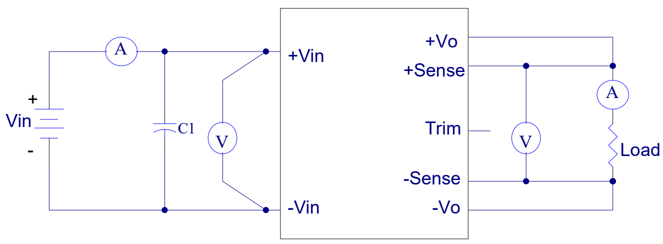
V_{FL} is the output voltage at full load
V_{NL} is the output voltage at no load

The value of line regulation is defined as:

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

Where:

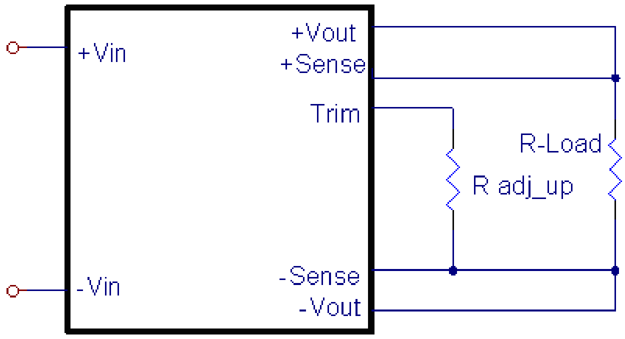
V_{HL} is the output voltage of maximum input voltage at full load
V_{LL} is the output voltage of minimum input voltage at full load



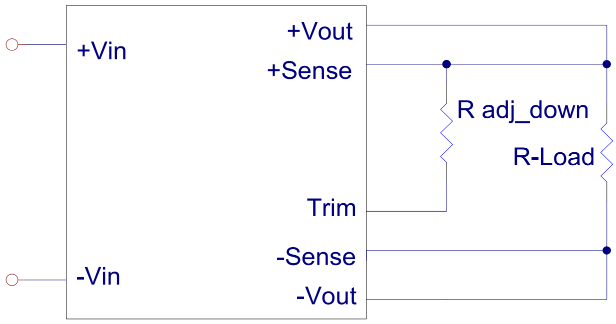
CHB150W Series Test Setup

6.9 Output Voltage Adjustment

In order to trim the voltage up or down, one needs to connect the trim resistor either between the trim pin and -Vo for trim-up or between trim pin and +Vo 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)
3.3V	3	12	4.3	1.24	0.46
5V	2.32	3.3	NC	2.5	0
12V	9.1	51	5.1	2.5	0.46
15V	12	56	8.25	2.5	0.46
24V	20	100	7.5	2.5	0.46

Table of Trim Resistor Values

The value of R_{adj_up} defined as:

For 5V output module

$$Radj\_up = \left(\frac{R1Vr}{Vo - Vo\_nom}\right) - R2\ (K\Omega)$$

For other output module

$$Radj\_up = \left(\frac{R1\left(Vr - Vf\left(\frac{R2}{R2 + R3}\right)\right)}{Vo - Vo\_nom}\right) - \frac{R2R3}{R2 + R3}\ (K\Omega)$$

Where:

R_{adj_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 and are defined in the table of trim resistor values

For example, to trim-up the output voltage of 5V module (CHB150-48S05) by 8% to 5.4V, R_{adj_up} is calculated as follows:

$V_o – V_{o\_nom}$=5.4– 5.0=0.4V

R1=2.32KΩ, R2=3.3 KΩ, V_r=2.5V

$$Radj\_up = \frac{5.8}{0.4} - 3.3 = 11.2\ (K\Omega)$$

The value of R_{adj_down} defined as:

$$Radj\_down = \frac{R1 \times (Vo - Vr)}{Vo\_nom - Vo} - R2\ (K\Omega)$$

Where:

R_{adj_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 (CHB150-48S05) by 8% to 4.6V, R_{adj_down} is calculated as follows:

$V_{o\_nom} – V_o$= 5.0–4.6=0.4V

R1 = 2.32 KΩ, R2 = 3.3 KΩ, V_r=2.5V

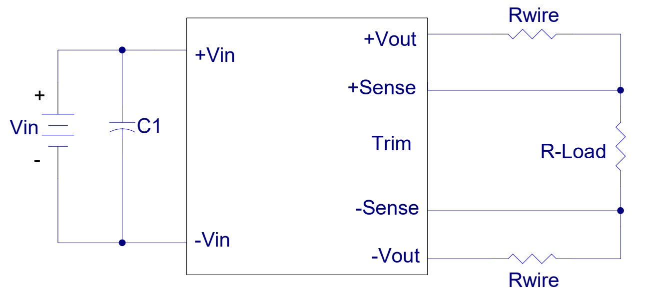
$$Radj\_down = \frac{2.32 \times (4.6 - 2.5)}{0.4} - 3.3 = 8.88\ (K\Omega)$$

6.10 Output Remote Sensing

The CHB150 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 CHB150 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:

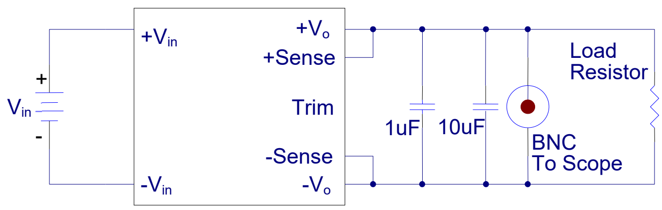
$[(+V_{out}) - (-V_{out})] – [(+Sense) – (-Sense)] \leqq 10\%$ of $V_{o\_nominal}$

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.
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.

6.11 Output Ripple and Noise



Output ripple and noise is measured with 1.0uF ceramic and 10uF solid tantalum capacitors across the output.

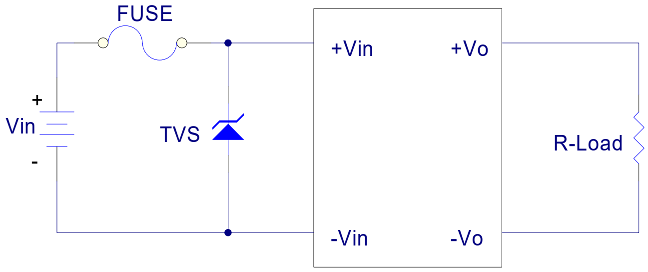
6.12 Output Capacitance

The CHB150 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. 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.

7. Safety & EMC

7.1 Input Fusing and Safety Considerations

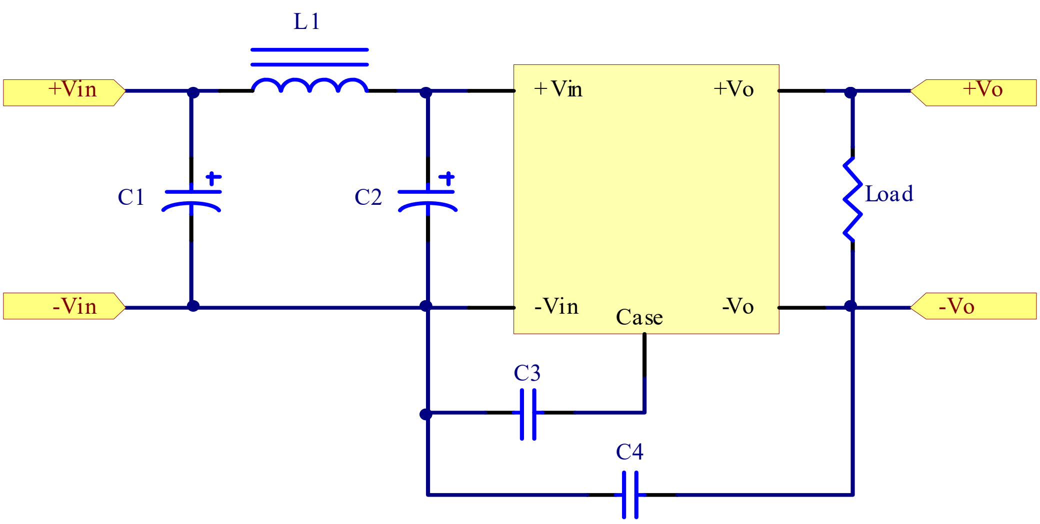
The CHB150 series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a 6.3A fast acting fuse. It is recommended that the circuit have a transient voltage suppressor diode (TVS) across the input terminal to protect the unit against surge or spike voltage and input reverse voltage (as shown).



7.2 EMC Considerations

Suggested Circuits for Conducted EMI Class A & Class B

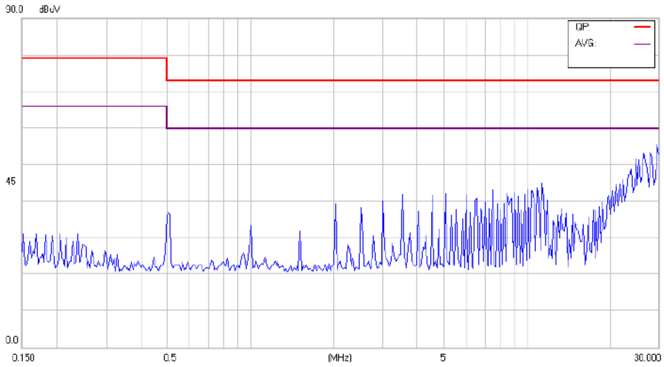
(1) EMI and Conducted Noise Meet EN 55032 Class A Specifications:



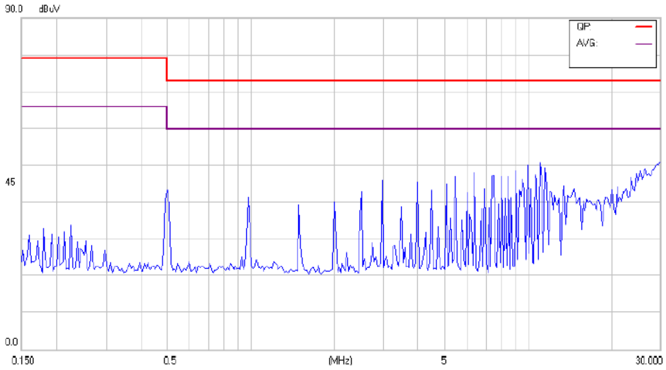
Model No.	C1	C2	C3	C4	L1
CHB150-48S33	47uF/100V	47uF/100V	1000pF	1000pF	3.4uH
CHB150-48S05	47uF/100V	47uF/100V	1000pF	1000pF	3.4uH
CHB150-48S12	47uF/100V	47uF/100V	1000pF	1000pF	3.4uH
CHB150-48S15	47uF/100V	47uF/100V	1000pF	1000pF	3.4uH
CHB150-48S24	47uF/100V	47uF/100V	1000pF	1000pF	3.4uH

Note:

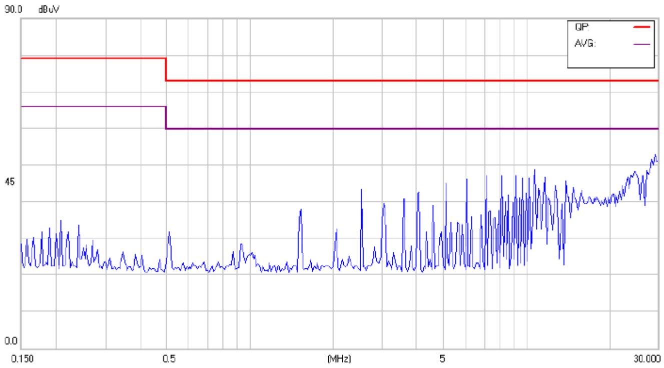
47uF/100V aluminum capacitors, C3, C4 is ceramic capacitors.



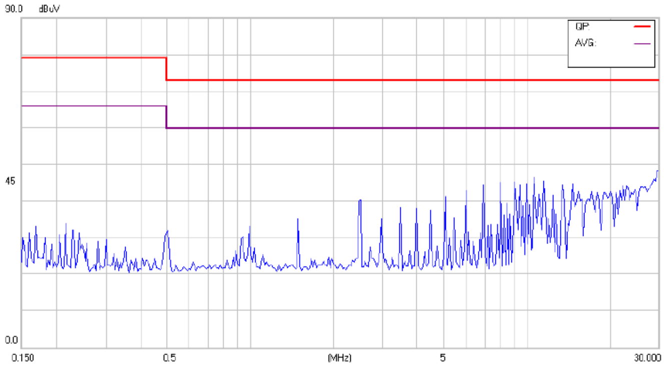
Conducted Class A of CHB150-48S33



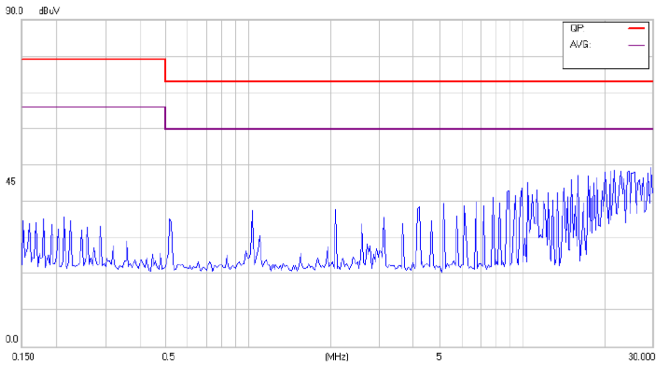
Conducted Class A of CHB150-48S05



Conducted Class A of CHB150-48S12

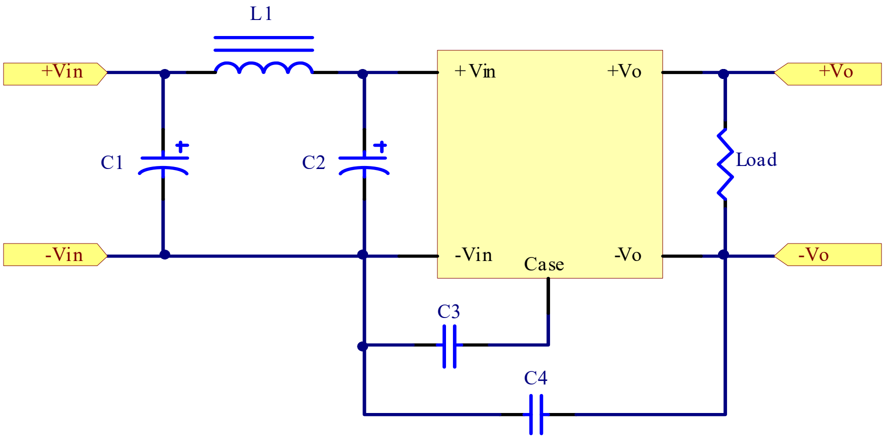


Conducted Class A of CHB150-48S15



Conducted Class A of CHB150-48S24

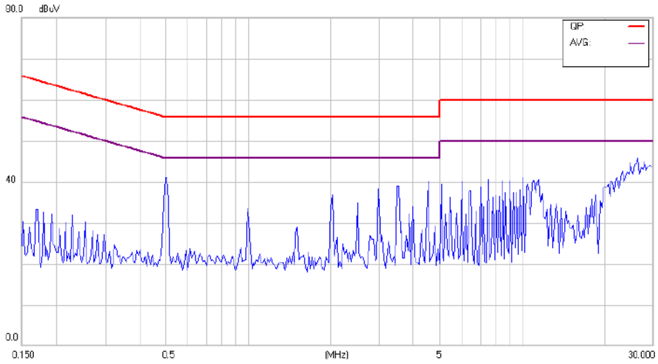
(2) EMI and Conducted Noise Meet EN 55032 Class B Specifications:



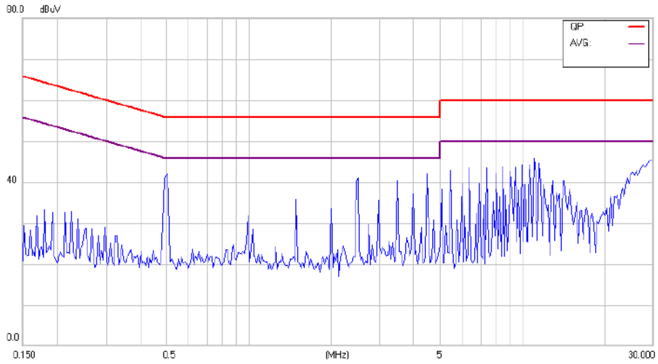
Model No.	C1	C2	C3	C4	L1
CHB150-48S33	82uF/100V	82uF/100V	1500pF	1500pF	3.4uH
CHB150-48S05	82uF/100V	82uF/100V	1500pF	1500pF	3.4uH
CHB150-48S12	82uF/100V	82uF/100V	1500pF	1500pF	3.4uH
CHB150-48S15	82uF/100V	82uF/100V	1500pF	1500pF	3.4uH
CHB150-48S24	82uF/100V	82uF/100V	1500pF	1500pF	3.4uH

Note:

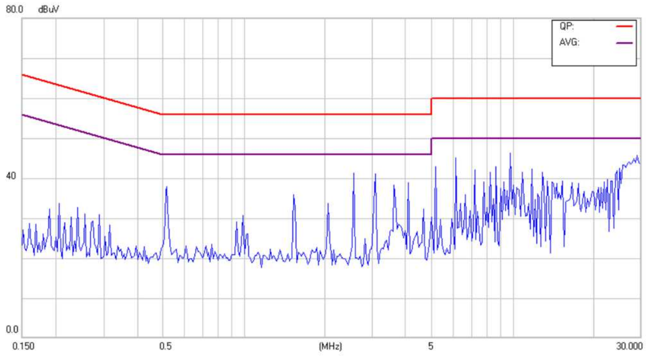
82uF/100V aluminum capacitors, C3, C4 is ceramic capacitors.



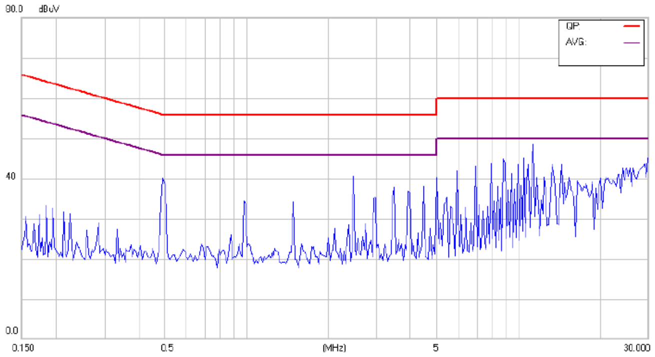
Conducted Class B of CHB150-48S33



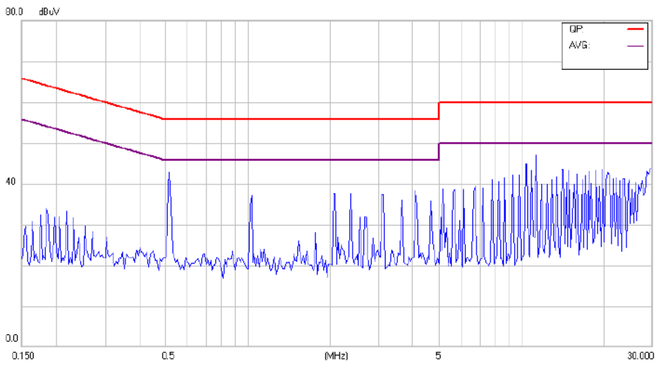
Conducted Class B of CHB150-48S05



Conducted Class B of CHB150-48S12



Conducted Class B of CHB150-48S15



Conducted Class B of CHB150-48S24

8. Part Number

Format: CHB150 – II X OO L Y

Parameter	Series	Nominal Input Voltage	Number of Outputs	Output Voltage	Remote On/Off Logic	Mounting Inserts
Symbol	CHB150	II	X	OO	L	Y (Option)
Value	CHB150	48 : 48 Volts	S : Single	33 : 3.3Volts 05 : 05Volts 12 : 12Volts 15 : 15Volts 24 : 24Volts	None : Positive N : Negative	-C : Clear Mounting Insert (3.2mm DIA.)

CINCON ELECTRONICS CO., LTD.

Headquarters:

14F, No.306, Sec.4, Hsin Yi Rd.
Taipei, Taiwan
Tel: 886-2-27086210
Fax: 886-2-27029852
E-mail: sales@cincon.com
Web Site: https://www.cincon.com

Factory:

No. 8-1, Fu Kung Rd.
Fu Hsing Industrial Park
Fu Hsing Hsiang,
Chang Hua Hsien, Taiwan
Tel: 886-4-7690261
Fax: 886-4-7698031

Cincon North America:

1655 Mesa Verde Ave. Ste 180
Ventura, CA 93003
Tel: 805-639-3350
Fax: 805-639-4101
E-mail: info@cincon.com