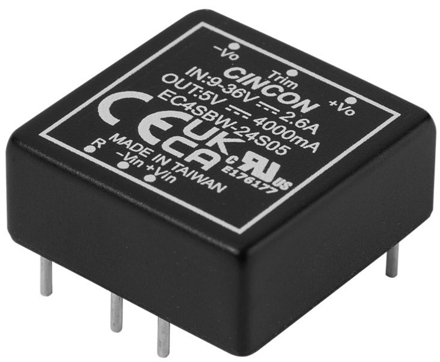
ISOLATED DC-DC CONVERTER
EC4SBW SERIES
APPLICATION NOTE



Approved By:

Department	Approved By	Checked By	Written By
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Contents

1. Introduction

The EC4SBW series of DC-DC converters offers 20 watts of output power at output voltages of 3.3, 5, 12, 15, ±12, ±15VDC with industry 1.0”x1.0”x0.4” package. It has a wide (4:1) input voltage range of 9 to 36VDC (24VDC nominal), 18 to 75VDC (48VDC nominal) and 1500VDC isolation.

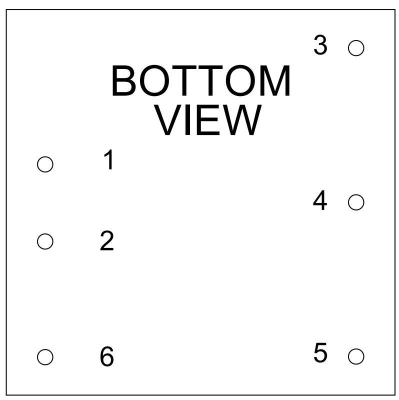
High efficiency up to 90.5%, allowing case operating temperature range of -40℃ to 105℃. Very low no load power consumption (10mA), an ideal solution for energy critical systems.

Fully protected against input UVLO (under voltage lock out), output over-current, output over-voltage and continuous short circuit conditions.

The standard control functions include remote **on/off** (positive or negative) and +10%, -10% adjustable output voltage (single output only).

EC4SBW series is designed suitable for distributed power architectures, telecommunications, battery operated equipment, industrial and mobile equipment application.

2. Pin Function Description



Single Output

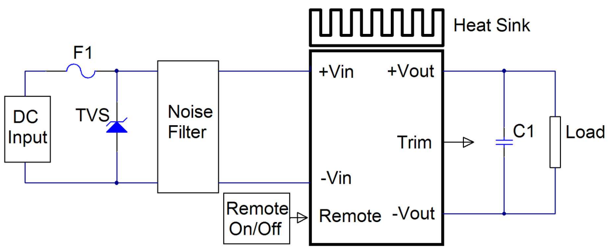
No	Label	Function	Description	Reference
1	+Vin	+V Input	Positive Supply Input	**Section 7.1**
2	-Vin	-V Input	Negative Supply Input	**Section 7.1**
3	+Vo	+V Output	Positive Power Output	**Section 7.2/7.3**
4	Trim	Trim	External Output Voltage Adjustment	**Section 6.5**
5	-Vo	-V Output	Negative Power Output	**Section 7.2/7.3**
6	R	Remote On/Off	External Remote On/Off Control	**Section 6.4**

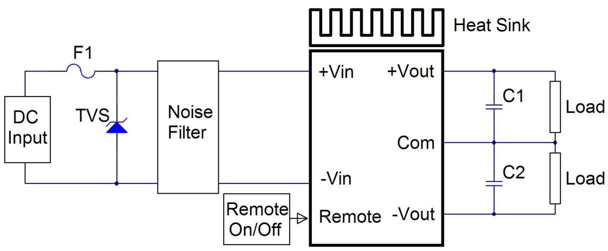
Dual Output

No	Label	Function	Description	Reference
1	+Vin	+V Input	Positive Supply Input	**Section 7.1**
2	-Vin	-V Input	Negative Supply Input	**Section 7.1**
3	+Vo	+V Output	Positive Power Output	**Section 7.2/7.3**
4	Com	Common	Common Power Output	**Section 7.2/7.3**
5	-Vo	-V Output	Negative Power Output	**Section 7.2/7.3**
6	R	Remote On/Off	External Remote On/Off Control	**Section 6.4**

3. Connection for Standard Use

The connection for standard use is shown below. External output capacitors (C1, C2) are recommended to reduce output ripple and noise, 1uF ceramic capacitor for all models.





Symbol	Component	Reference
F1, TVS	Input fuse, TVS	**Section 9.1**
C1, C2	External capacitor on the output side	**Section 7.3**
Noise Filter	External input noise filter	**Section 9.2**
Remote On/Off	External remote **on/off** control	**Section 6.4**
Trim	External output voltage adjustment	**Section 6.5**
Heat Sink	External heat sink	**Section 8.1/8.2/8.3/8.4/8.5**

4. 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:

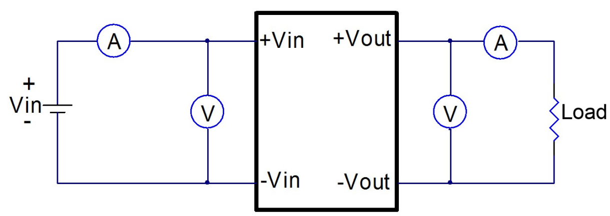
V_{FL} is the output voltage at full load
V_{NL} is the output voltage at no load

The value of line regulation is defined as:

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

Where:

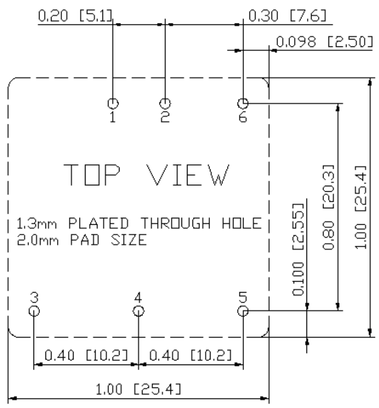
V_{HL} is the output voltage of maximum input voltage at full load
V_{LL} is the output voltage of minimum input voltage at full load



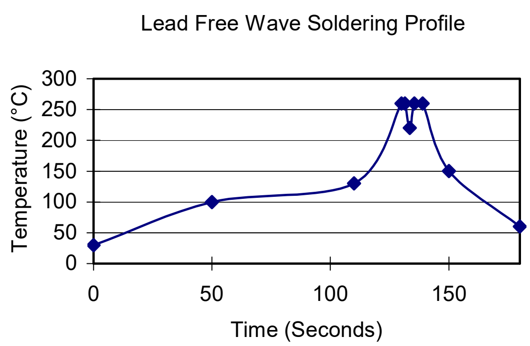
EC4SBW Series Test Setup

5. 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 footprints and soldering profiles are shown below.



Note: Dimensions are in inches (millimeters)



Hand Soldering Information:

Hand soldering is the least preferred method because the amount of solder applied, the time the soldering iron is held on the joint, the temperature of the iron, and the temperature of the solder joint are variable. The recommended hand soldering guideline is listed in following table.

Hand-Soldering Guideline

Parameter	Single-side Circuit board	Double-side Circuit board	Multi-layers Circuit board
Soldering Iron Wattage Tip Temp.	90W 385+/-10°C	90W 420+/-10°C	90W 420+/-10°C
Soldering Time	2~6 Seconds	4~10 Seconds	4~10 Seconds

The suggested soldering process must keep the power module's internal temperature below the critical temperature of 217°C continuously.

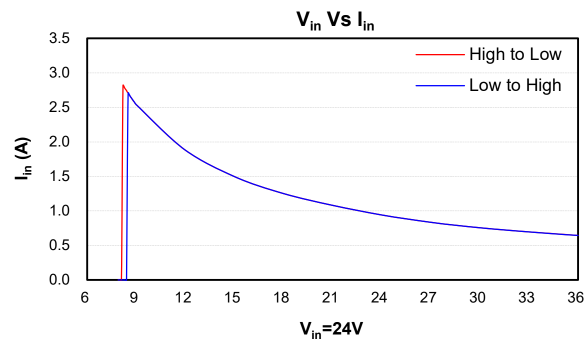
Clean the soldered side of the module with a brush, prevent liquid from getting into the module. Do not clean by soaking the module into liquid. Do not allow solvent to come in contact with product labels or resin case as this may changed the color of the resin case or cause deletion of the letters printed on the product label. After cleaning, dry the modules well.

6. Features and Functions

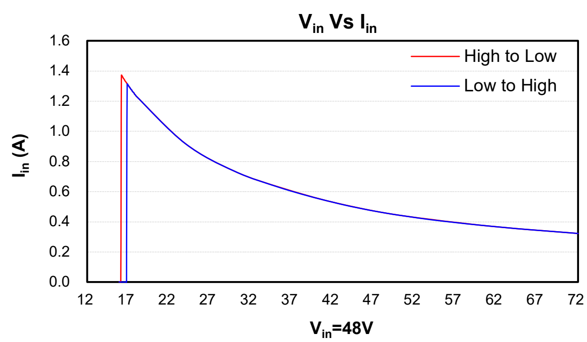
6.1 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the EC4SBW series 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.

EC4SBW-24SXX

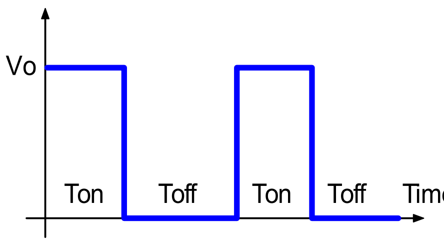


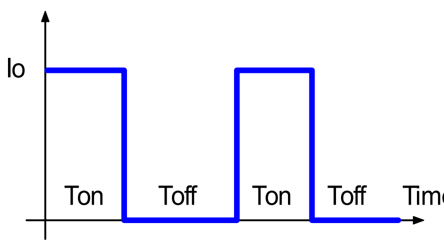
EC4SBW-48SXX



6.2 Over Current / Short Circuit 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.





6.3 Output Over Voltage Protection

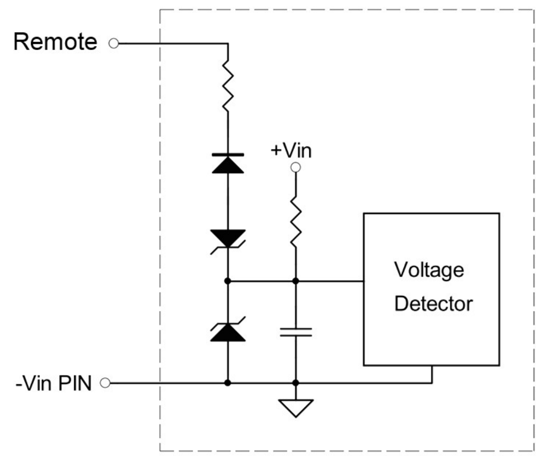
The over-voltage protection consists of a zener diode to limiting the out voltage.

6.4 Remote On/Off

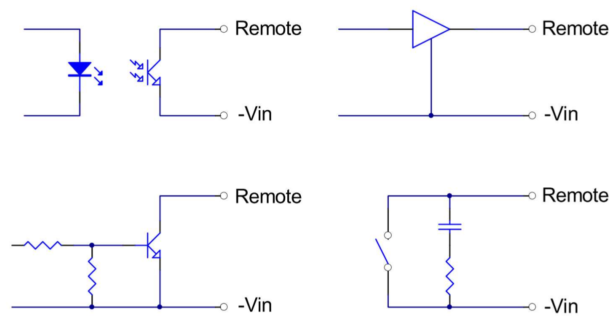
The EC4SBW series allows the user to switch the module on and off electronically with the remote **on/off** feature. All models are available in “positive logic” and “negative logic” (optional) versions. The converter turns on if the remote **on/off** pin is high (>3.5V_{dc} to 75V_{dc} or open circuit). Setting the pin low (0 to<1.2V_{dc}) 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). Converter will be turn on in positive mode.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 (>3.5V_{dc} to 75V_{dc} or open circuit). The converter turns on if the **on/off** pin input is low (0 to<1.2V_{dc}). Note that the converter is off by default.

Logic State (Pin 6)	Negative Logic	Positive Logic
Logic Low	Module on	Module off
Logic High	Module off	Module on

The converter remote **on/off** circuit built-in on input side. The ground pin of input side remote **on/off** circuit is -V_{in} pin. Inside connection sees below.



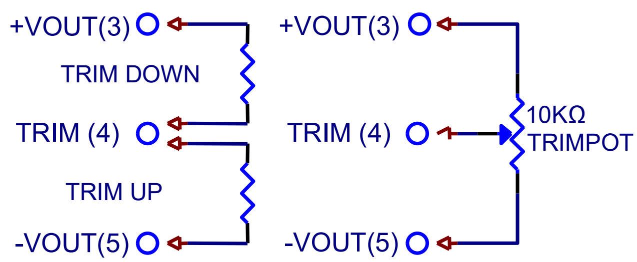
Connection examples see below.



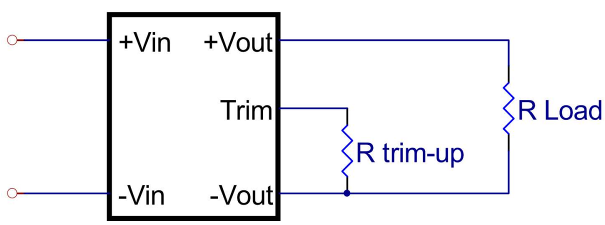
Remote On/Off Connection Examples

6.5 Output Voltage Adjustment

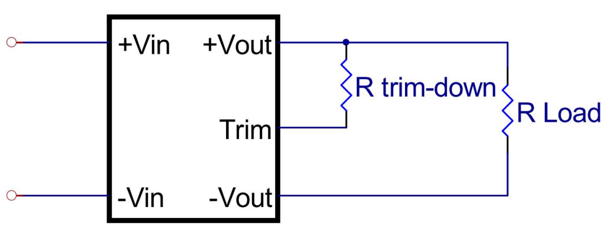
Output may be externally trimmed -10% to +10% (single output models only) with a fixed resistor or an external trim pot as shown (optional). Model specific formulas for calculating trim resistors are available upon request as a separate document.



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



Trim-up Voltage Setup



Trim-down Voltage Setup

1. The value of Rtrim-up defined as:

$$R_{trim-up} = (\frac{Vr \times R1 \times (R2 + R3)}{(V_o - V_{o,nom}) \times R2}) - Rt \ \ (K\Omega)$$

Where

$R_{\text{trim-up}}$ is the external resistor in Kohm

$V_{o,\,nom}$ is the nominal output voltage

V_o is the desired output voltage

R1, Rt, R2, R3 and V_r are internal to the unit and are defined in Table 1.

Table 1 – Trim up and Trim down Resistor Values

Model Number	Output Voltage(V)	R1 (KΩ)	R2 (KΩ)	R3 (KΩ)	Rt (KΩ)	Vr (V)
EC4SBW-24S33 EC4SBW-48S33	3.3	2.74	1.8	0.27	9.1	1.24
EC4SBW-24S05 EC4SBW-48S05	5.0	2.32	2.32	0	8.2	2.5
EC4SBW-24S12 EC4SBW-48S12	12.0	6.8	2.4	2.32	22	2.5
EC4SBW-24S15 EC4SBW-48S15	15.0	8.06	2.4	3.9	27	2.5

For example, to trim-up the output voltage of 5.0V module (EC4SBW-24S05) by 10% to 5.5V, R trim-up is calculated as follows:

$V_o - V_{o,\,nom} = 5.5 - 5.0 = 0.5V$

R1 = 2.32 KΩ

R2 = 2.32 KΩ

R3 = 0 KΩ

Rt = 8.2 KΩ

V_r= 2.5 V

$$R_{trim\ -\ up} = (\frac{2.5 \times 2.32 \times (2.32 + 0)}{0.5 \times 2.32}) - 8.2 = 3.4(K\Omega)$$

The typical value of R_{trim_up}

Trim up %	3.3V	5V	12V	15V
	R_{trim_up} (KΩ)			
1%	109.301	107.800	256.611	325.625
2%	50.101	49.800	117.306	149.313
3%	30.367	30.467	70.870	90.542
4%	20.500	20.800	47.653	61.156
5%	14.580	15.000	33.722	43.525
6%	10.634	11.133	24.435	31.771
7%	7.814	8.371	17.802	23.375
8%	5.700	6.300	12.826	17.078
9%	4.056	4.689	8.957	12.181
10%	2.740	3.400	5.861	8.263

2.The value of R trim-down defined as:

$$R_{trim-down} = R1 \times (\frac{Vr \times R1}{(V_{o,nom} - V_o) \times R2} - 1) - Rt\ (K\Omega)$$

Where

$R_{\text{trim-down}}$ is the external resistor in Kohm

$V_{o,\,nom}$ is the nominal output voltage

V_o is the desired output voltage

R1, Rt, R2, R3 and V_r are internal to the unit and are defined in Table 1.

For example, to trim-down the output voltage of 5.0V module (EC4SBW-24S05) by 10% to 4.5V, R trim-down is calculated as follows:

$V_{o,nom} - V_o = 5.0 - 4.5 = 0.5V$
R1 = 2.32 KΩ
R2 = 2.32 KΩ
R3 = 0 KΩ
Rt = 8.2 KΩ
V_r= 2.5 V

$$R_{trim-down} = 2.32 \times \left(\frac{(2.5 \times 2.32)}{0.5 \times 2.32} - 1\right) - 8.2 = 1.08\ (K\Omega)$$

The typical value of R_{trim_down}

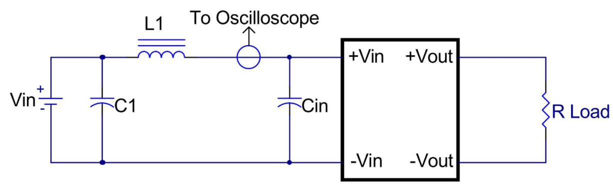
Trim down %	3.3V	5V	12V	15V
	R_{trim_down} (KΩ)			
1%	144.884	105.480	372.589	416.076
2%	66.522	47.480	171.894	190.508
3%	40.401	28.147	104.996	115.319
4%	27.341	18.480	71.547	77.724
5%	19.505	12.680	51.478	55.167
6%	14.281	8.813	38.098	40.129
7%	10.549	6.051	28.541	29.388
8%	7.751	3.980	21.374	21.332
9%	5.574	2.369	15.799	15.066
10%	3.832	1.080	11.339	10.054

The EC4SBW series models is adjustable within the range of ±10%, see input & output trim curves for trim up and trim down ranges.

7. Input / Output Considerations

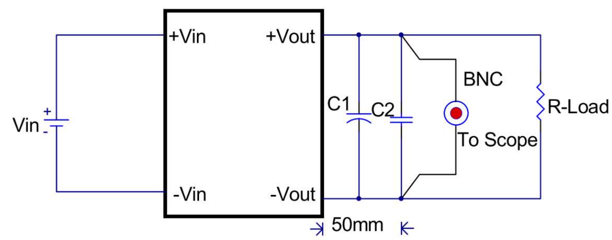
7.1 Input Capacitance at the Power Module

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).



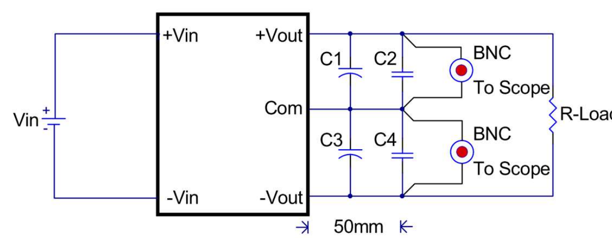
L1: 12uH
C1: NC
Cin: 47uF ESR<0.17ohm @100KHz

7.2 Output Ripple and Noise



Note:
C1: 10uF tantalum capacitor
C2: 1uF ceramic capacitor

EC4SBW Single Output Module

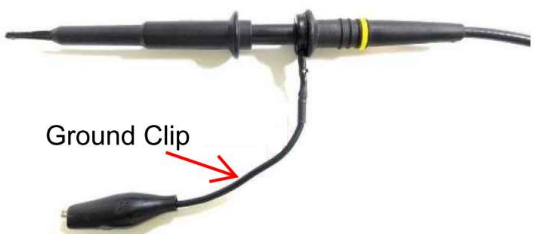


Note:
C1 & C3: 10uF tantalum capacitor
C2 & C4: 1uF ceramic capacitor.

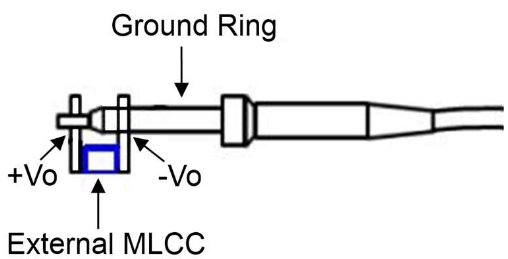
EC4SBW Dual Output Module

Output ripple and noise measured with 10uF tantalum capacitor and 1uF ceramic capacitor across output, 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 -V_{out} terminal while the tip contacts the +V_{out} terminal. This makes the shortest possible connection across the output terminals.



7.3 Output Capacitance

The EC4SBW 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.

8. Thermal Design

8.1 Operating Temperature Range

The EC4SBW series converters can be operated within a wide case temperature range of -40℃ to 105℃. Consideration must be given to the derating curves when ascertaining maximum power that can be drawn from the converter. The maximum power drawn from models is influenced by usual factors, such as:

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

8.2 Convection Requirements for Cooling

To predict the approximate cooling needed for the 1”×1” module, refer to the power derating curves in **section 8.4**. 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 105℃ as measured at the center of the top of the case (thus verifying proper cooling).

8.3 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 8.4**. The power output of the module should not be allowed to exceed rated power (V_{o_set} x $I_{o\_max.}$).

8.4 Power Derating

The operating case temperature range of EC4SBW series is -40℃ to +105℃. When operating the EC4SBW series, proper derating or cooling is needed. The maximum case temperature under any operating condition should not exceed 105℃ (refer to **datasheet**).

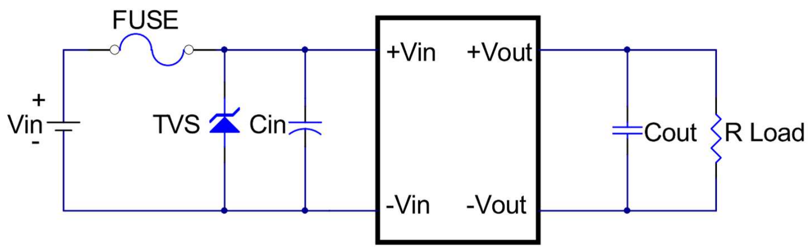
8.5 1”x1” Case Heat Sinks Kit

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

9. Safety & EMC

9.1 Input Fusing and Safety Considerations

The EC4SBW series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a fast acting fuse 3.15A for 24V_{in} models and 1.6A for 48V_{in} modules. 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) are required if EC4SBWseries has to meet EN 61000-4-4, EN 61000-4-5.

The Cin recommended a 10uF/100V (Nippon Chemi-Con KY series) aluminum capacitor. And the TVS recommended SMDJ40CA for 24V_{in} models, and SMDJ78A for 48V_{in} models.

9.2 EMC Considerations

(1) EMI Test standard: EN 55032 Class A Conducted Emission

Test Condition: Input Voltage: Nominal Input, Output Load: Full Load

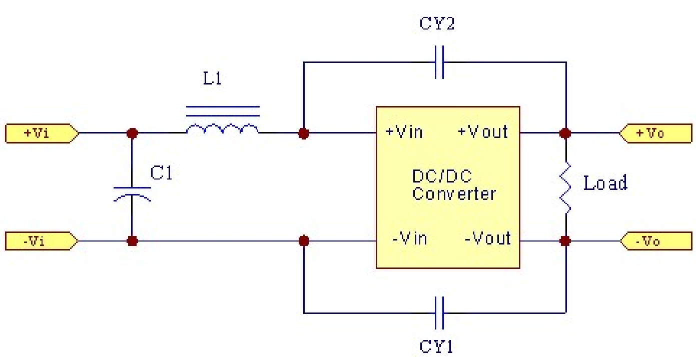


Figure 11. Connection Circuit for Conducted EMI Testing

EN55032 Class A									
Model No.	C1	L1	CY1	CY2	Model No.	C1	L1	CY1	CY2
EC4SBW-24S33	47uF/100V	1.0uH	NC	NC	EC4SBW-48S33	47uF/100V	2.2uH	NC	NC
EC4SBW-24S05	47uF/100V	1.0uH	NC	NC	EC4SBW-48S05	47uF/100V	2.2uH	NC	NC
EC4SBW-24S12	47uF/100V	1.0uH	1000pF/2KV 1206	1000pF/2KV 1206	EC4SBW-48S12	47uF/100V	2.2uH	1000pF/2KV 1206	1000pF/2KV 1206
EC4SBW-24S15	47uF/100V	1.0uH	1000pF/2KV 1206	1000pF/2KV 1206	EC4SBW-48S15	47uF/100V	2.2uH	1000pF/2KV 1206	1000pF/2KV 1206
EC4SBW-24D12	47uF/100V	1.0uH	NC	NC	EC4SBW-48D12	47uF/100V	2.2uH	NC	NC
EC4SBW-24D15	47uF/100V	1.0uH	NC	NC	EC4SBW-48D15	47uF/100V	2.2uH	NC	NC

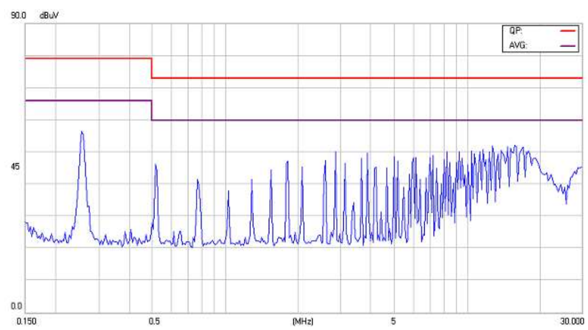
Note:

C1 is CHEMI-CON KY aluminum capacitors, CY1&CY2 are ceramic capacitors

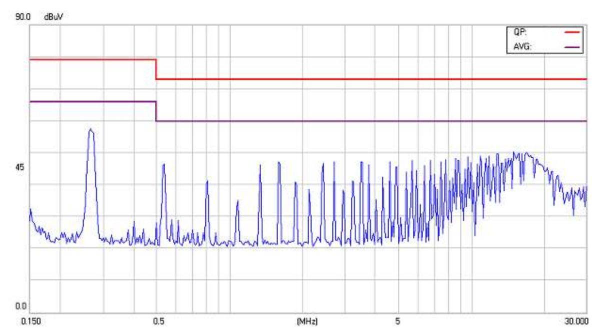
L1:1.0uH is ABC SR04031R0MLB, 2.2uH is CHILISIN SCD0403T-2R2M-N

Conducted Emission Class A:

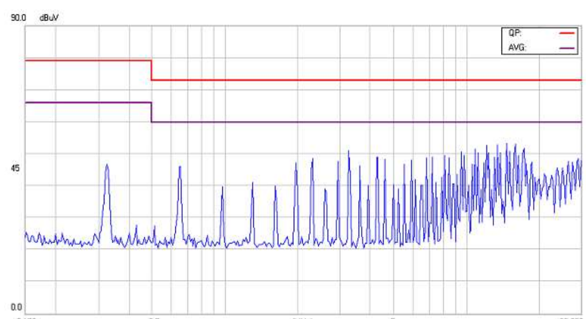
EC4SBW-24S33



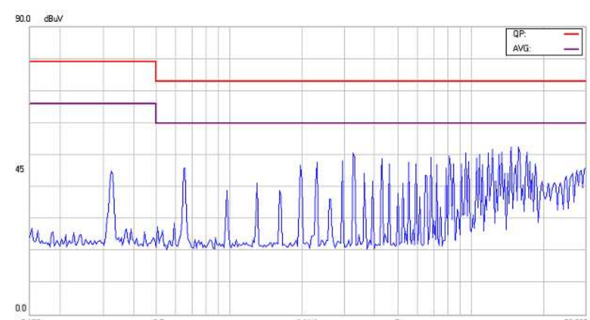
EC4SBW-24S05



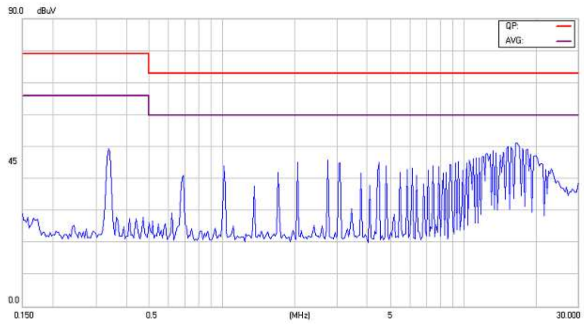
EC4SBW-24S12



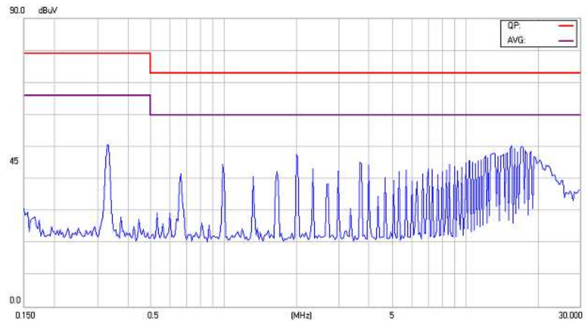
EC4SBW-24S15



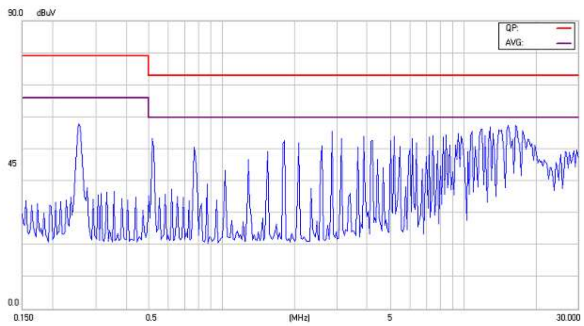
EC4SBW-24D12



EC4SBW-24D15



EC4SBW-48S33



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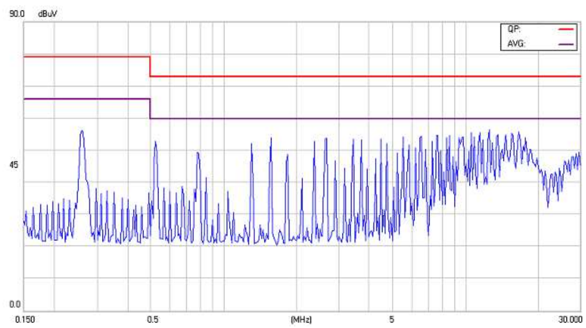

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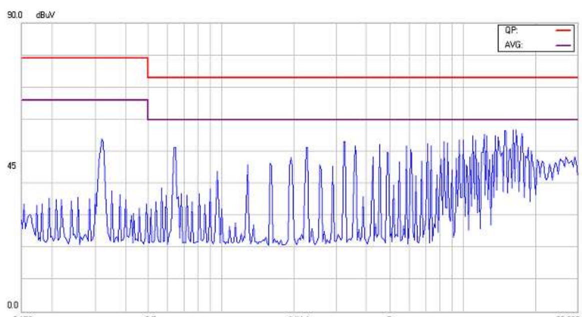

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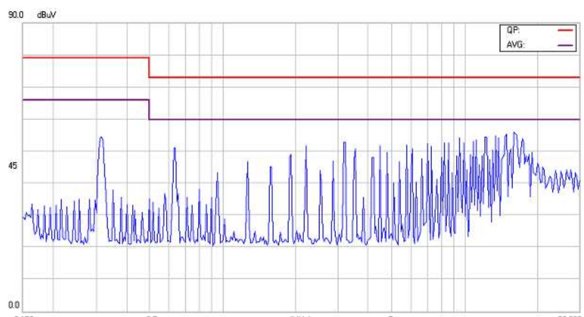

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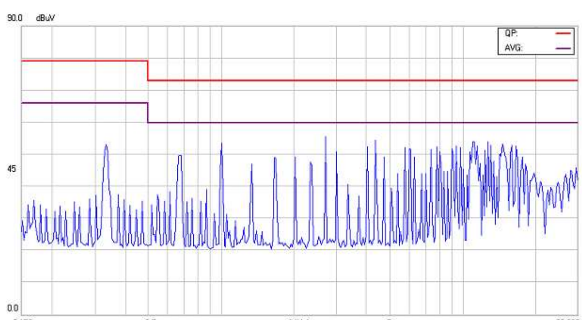
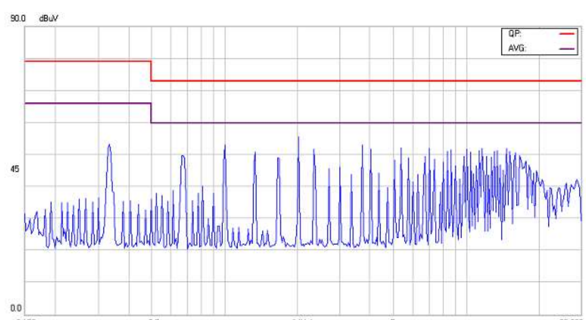


EC4SBW-48D15



(2) EMI Test standard: EN 55032 Class B Conducted Emission

Test Condition: Input Voltage: Nominal, Output Load: Full Load

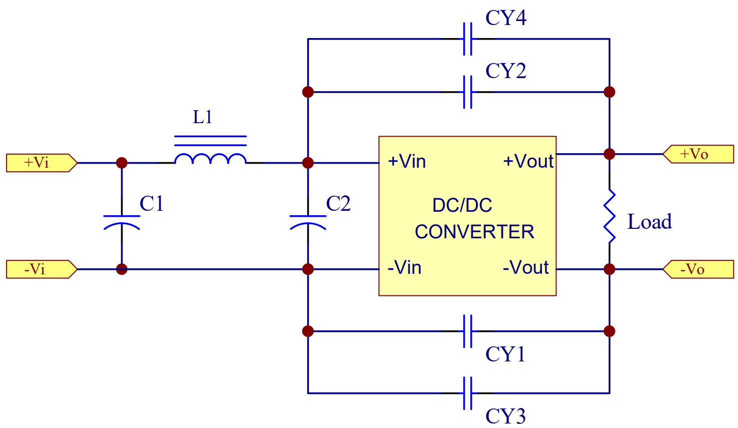


Figure 12. Connection Circuit for Conducted EMI Testing

EN 55032 Class B													
Model No.	C1, C2	L1	CY1	CY2	CY3	CY4	Model No.	C1, C2	L1	CY1	CY2	CY3	CY4
EC4SBW-24S33	47uF/100V	2.2uH	4700pF/2KV 1808	NC	NC	NC	EC4SBW-48S33	47uF/100V	2.2uH	4700pF/2KV 1808	4700pF/2KV 1808	2200pF/2KV 1808	2200pF/2KV 1808
EC4SBW-24S05	47uF/100V	2.2uH	4700pF/2KV 1808	NC	NC	NC	EC4SBW-48S05	47uF/100V	2.2uH	4700pF/2KV 1808	4700pF/2KV 1808	2200pF/2KV 1808	2200pF/2KV 1808
EC4SBW-24S12	47uF/100V	2.2uH	4700pF/2KV 1808	4700pF/2KV 1808	NC	NC	EC4SBW-48S12	47uF/100V	2.2uH	4700pF/2KV 1808	4700pF/2KV 1808	2200pF/2KV 1808	2200pF/2KV 1808
EC4SBW-24S15	47uF/100V	2.2uH	4700pF/2KV 1808	4700pF/2KV 1808	NC	NC	EC4SBW-48S15	47uF/100V	2.2uH	4700pF/2KV 1808	4700pF/2KV 1808	2200pF/2KV 1808	2200pF/2KV 1808
EC4SBW-24D12	47uF/100V	2.2uH	4700pF/2KV 1808	NC	NC	NC	EC4SBW-48D12	47uF/100V	2.2uH	4700pF/2KV 1808	4700pF/2KV 1808	2200pF/2KV 1808	2200pF/2KV 1808
EC4SBW-24D15	47uF/100V	2.2uH	4700pF/2KV 1808	NC	NC	NC	EC4SBW-48D15	47uF/100V	2.2uH	4700pF/2KV 1808	4700pF/2KV 1808	2200pF/2KV 1808	2200pF/2KV 1808

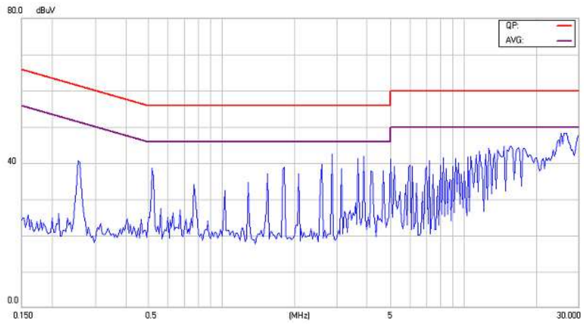
Note:

C1&C2 are CHEMI-CON KY aluminum capacitors, CY1&CY2&CY3&CY4 are ceramic capacitors

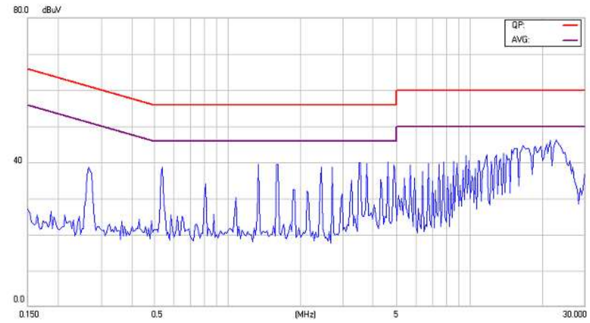
L1:2.2uH is VISHAY IHLP2525CZER2R2M01

Conducted Emission Class B:

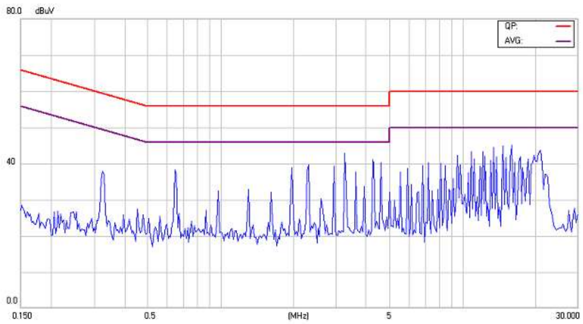
EC4SBW-24S33



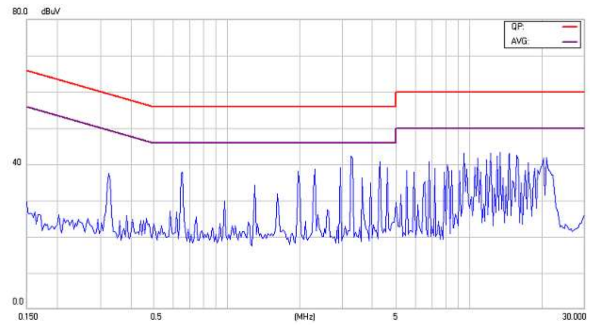
EC4SBW-24S05



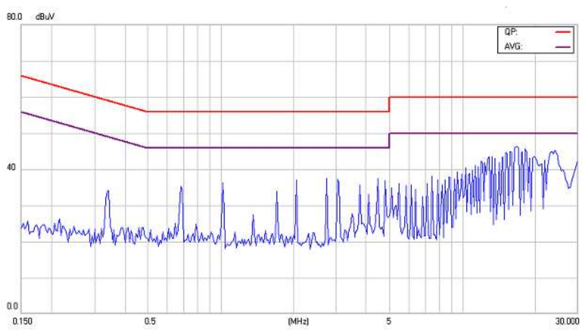
EC4SBW-24S12



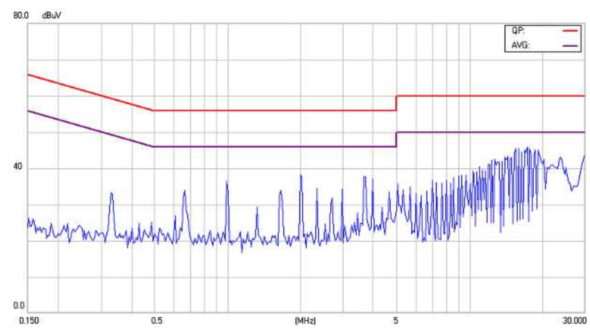
EC4SBW-24S15



EC4SBW-24D12



EC4SBW-24D15



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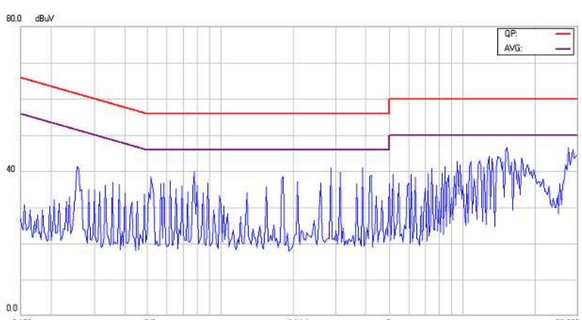

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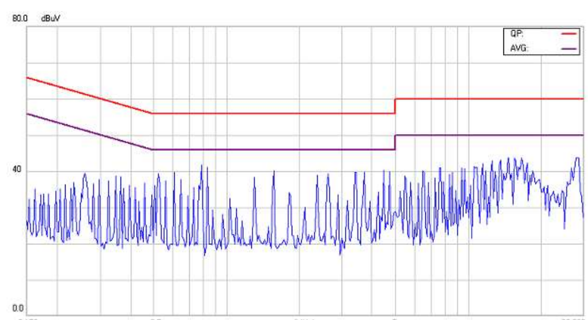

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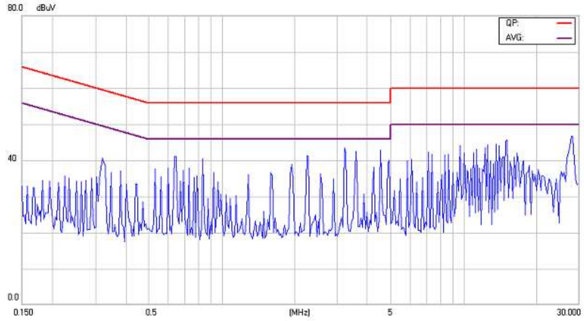
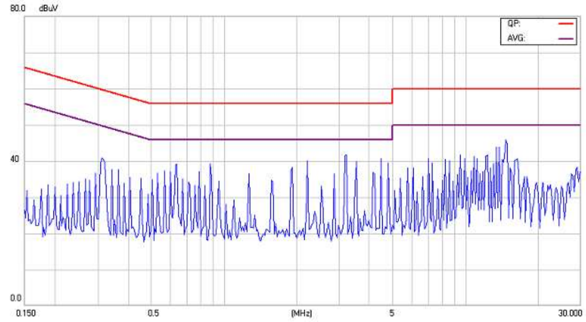
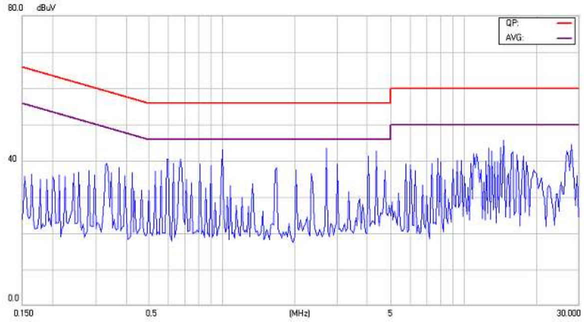


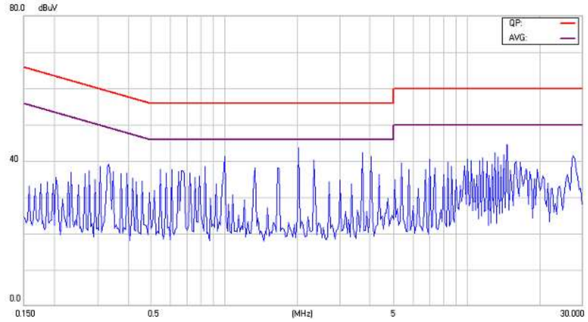
EC4SBW-48S15



EC4SBW-48D12



EC4SBW-48D15



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