ISOLATED DC-DC CONVERTER EC7BW SERIES APPLICATION NOTE

Approved By:

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Contents

EC7BW Series
Application Note V14

1. Introduction

The EC7BW series of DC-DC converters offers 20 watts of output power @ output voltages of 3.3, 5, 12, 15, ±5, ±12, ±15VDC with industry 2"x1"x0.4" package. It has a wide (4:1) input voltage range of 9 to 36VDC (24VDC nominal) and 18 to 75VDC (48VDC nominal) and 1500VDC isolation.

Compliant with EN 55032, EN 55035, EN 50155, EN 45545, EN 50121-3-2. High efficiency up to 90%, allowing case operating temperature range of -40℃ to 105℃. An optional heat sink is available to extend the full power range of the unit. 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).
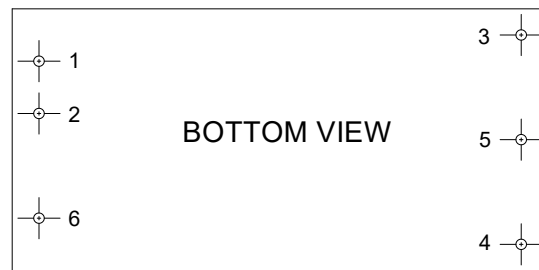
EC7BW series is designed suitable for distributed power architectures, telecommunications, battery operated equipment and industrial applications.

2. Pin Function Description

Standard Pin

BOTTOM VIEW
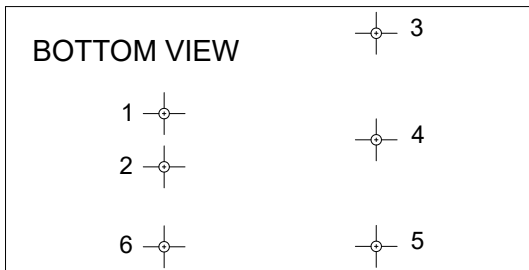
Alternative Pin Single Output Models Only

BOTTOM VIEW

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	+Vout	+V Output	Positive Power Output	**Section 7.2/7.3**
4	Trim	Trim	External Output Voltage Adjustment	**Section 6.5**
5	-Vout	-V Output	Negative Power Output	**Section 7.2/7.3**
6	Remote	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	+Vout	+V Output	Positive Power Output	**Section 7.2/7.3**
4	-Vout	-V Output	Negative Power Output	**Section 7.2/7.3**
5	Com	Common	Common Power Output	**Section 7.2/7.3**
6	Remote	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, 0.1uF ceramic capacitor for all models.
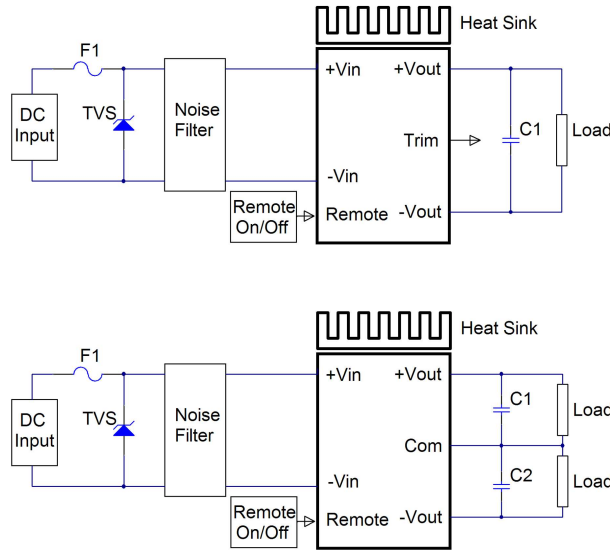
Symbol	Component	Reference
F1, TVS	Input fuse, TVS	**Section 9.1**
C1, C2	External capacitor on the output side	**Section 7.2/7.3**
Noise Filter	External input noise filter	**Section 9.2**
Remote On/Off	External remote on/off control	**Section 6.4**
Trim	External output voltage adjustment	**Section 6.5**
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
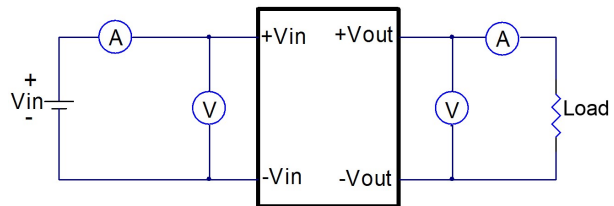
V_{NL} is the output voltage at 10% load

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

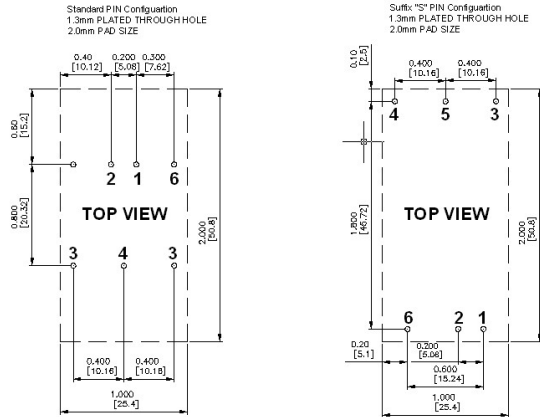V_{LL} is the output voltage of minimum input voltage at full load

EC7BW 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.

Standard PIN Configuration
1.3mm PLATED THROUGH HOLE
2.0mm PAD SIZE

0.40 [10.12] 0.200 [5.08] 0.300 [7.62]

0.80 [15.2]

0.800 [20.32]

2.000 [50.8]

2 1 6

TOP VIEW

3 4 3

0.400 [10.16] 0.400 [10.18]

1.000 [25.4]

Suffix "S" PIN Configuration
1.3mm PLATED THROUGH HOLE
2.0mm PAD SIZE

0.10 [2.5]

0.400 [10.16] 0.400 [10.16]

4 5 3

1.800 [45.72]

2.000 [50.8]

TOP VIEW

6 2 1

0.20 [5.1] 0.200 [5.08]

0.600 [15.24]

1.000 [25.4]

Note: Dimensions are in inches (millimeters)

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.

The suggested soldering iron is 420±10°C for up to 4-10 seconds (less than 90W) used in double PCB and multilayer PCB, The other one is used in the single PCB is 385±10°C for up to 2-6 seconds (less than 90W). Furthermore the recommended soldering profile is shown below.
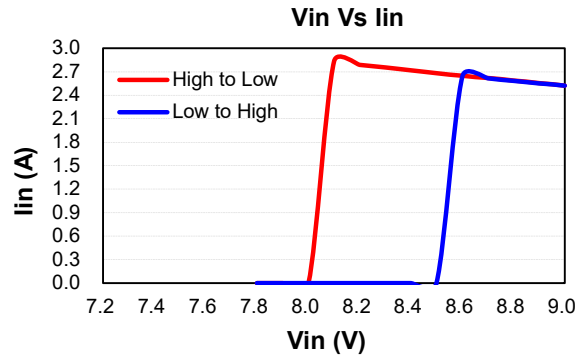
Lead Free Wave Soldering Profile
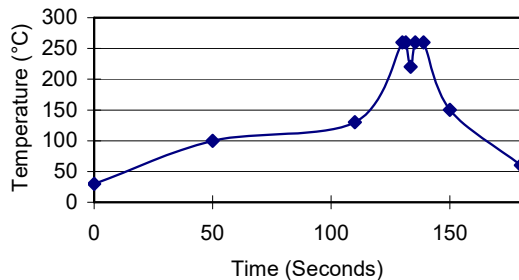
6. Features and Functions

6.1 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the EC7BW series unit. The unit will shut down when the input voltage drops below a lower threshold, and the unit will operate when the input voltage goes above the upper threshold.

Vin Vs Iin

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.
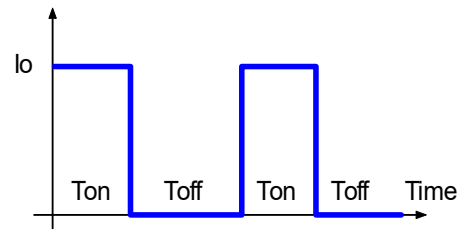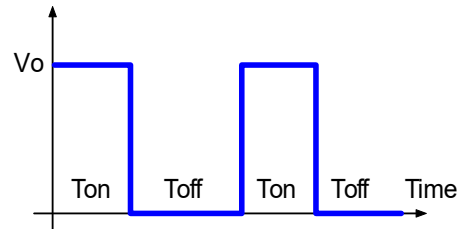
6.3 Output Over Voltage Protection

The over-voltage protection consists of a zener diode to limiting the out voltage.
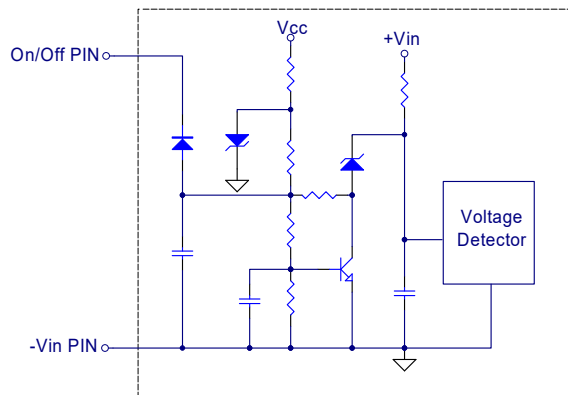
6.4 Remote On/Off

The EC7BW 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 (>5.5Vdc to 75Vdc 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). 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 (>5.5Vdc to 75Vdc 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.

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 -Vin pin. Inside connection sees below.
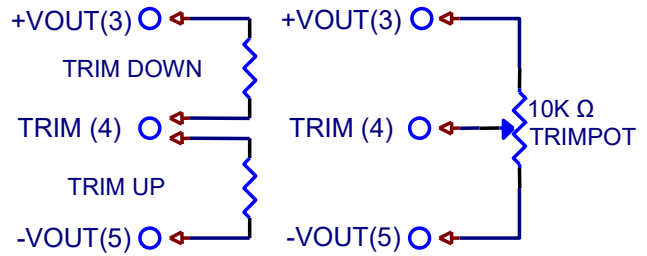

Connection examples see below.
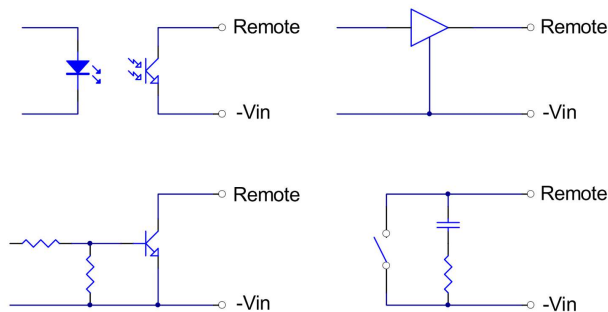
Remote On/Off Connection Examples

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 -Vout for trim-up or between trim pin and +Vout for trim-down. The output voltage trim range is +10% to -10%. This is shown:
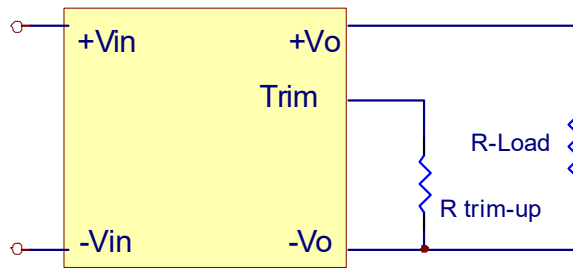
Trim-up Voltage Setup

Trim-down Voltage Setup

6
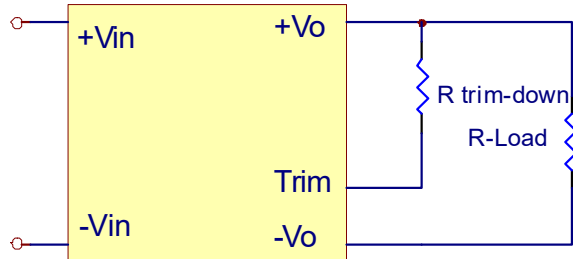
The value of R$_{trim-up}$ defined as:

$$Rtrim - up = (\frac{Vr \times R1 \times (R2 + R3)}{(Vo - Vo, nom) \times R2}) - Rt \ (K\Omega)$$

Table 1 – Trim up and Trim down Resistor Values

Model Number	Output Voltage(V)	R1 (KΩ)	R2 (KΩ)	R3 (KΩ)	Rt (KΩ)	Vr (V)
EC7BW-24S33 EC7BW-48S33	3.3	2.74	1.8	0.27	9.1	1.24
EC7BW-24S05 EC7BW-48S05	5.0	2.32	2.32	0	8.2	2.5
EC7BW-24S12 EC7BW-48S12	12.0	6.8	2.4	2.32	22	2.5
EC7BW-24S15 EC7BW-48S15	15.0	8.06	2.4	3.9	27	2.5

Where

R$_{trim-up}$ 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

For example, to trim-up the output voltage of 5.0V module (EC7BW-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
R$_t$ = 8.2 KΩ
V$_r$= 2.5 V

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

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

The value of R$_{trim-down}$ defined as:

$$Rtrim - down = R1 \times (\frac{Vr \times R1}{(Vo, nom - Vo) \times R2} - 1) - Rt \ (K\Omega)$$

Where

R$_{trim-down}$ 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 Vr are internal to the unit and are defined in Table 1

For example, to trim-down the output voltage of 5.0V module (EC7BW-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
Vr= 2.5 V

$$Rtrim - down = 2.32 \times (\frac{(2.5 \times 2.32)}{0.5 \times 2.32} - 1) - 8.2$$
$$= 1.08 \ (K\Omega)$$

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

## 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).
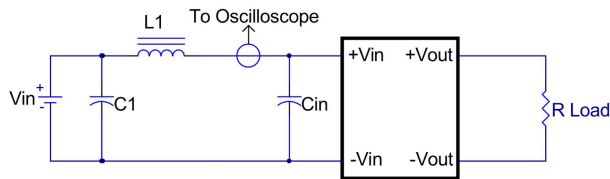
L1: 12uH
C1: 220uF ESR<0.3ohm @100KHz
Cin: 33uF ESR<0.7ohm @100KHz

7.2 Output Ripple and Noise
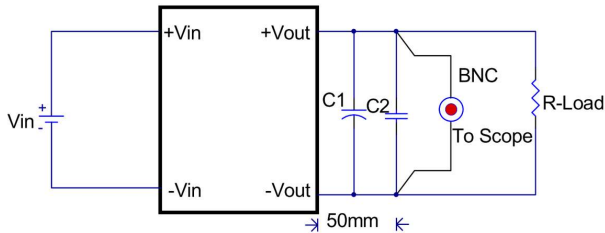
Note:
C1: None
C2: 0.1uF ceramic capacitor

EC7BW single output module
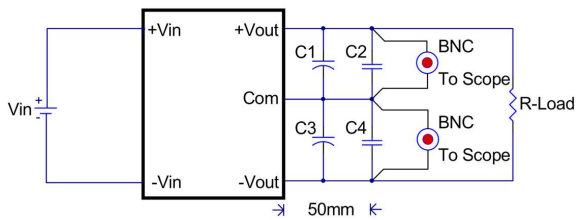
Note:
C1 & C3: None
C2 & C4: 0.1uF ceramic capacitor

EC7BW dual output module

Output ripple and noise measured with 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.

Ground Clip

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.

Ground Ring

+Vo   -Vo

External MLCC
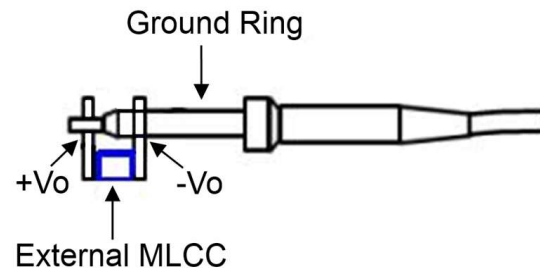
7.3 Output Capacitance

The EC7BW 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 EC7BW 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 2"×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 EC7BW series is -40℃ to +105℃. When operating the EC7BW series, proper derating or cooling is needed. The maximum case temperature under any operating condition should not exceed 105℃.

The following curve is the de-rating curve of EC7BW series with heat sink.

EC7BW Derating Curve with Heatsink BC100 (Vin=72V)
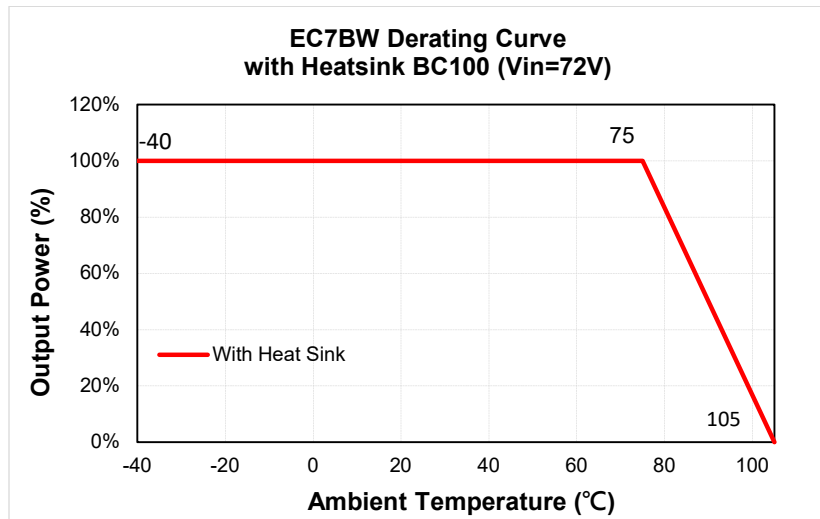
AIR FLOW RATE	TYPICAL R_{ca}
Natural Convection 20ft./min. (0.1m/s)	10.2 ℃/W

8.5 2"x1" Case Heat Sinks Kit:

Cross Cut Heat Sink: BC100 (K-C088)

All Dimensions in mm

Rca: 10.2 ℃/W (typ.), at natural convection
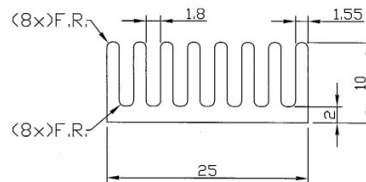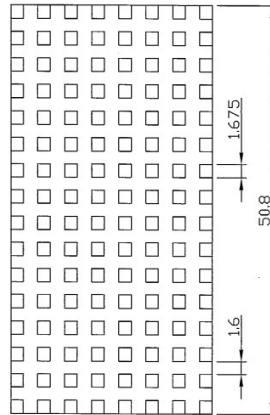
Assembly:
Heat Sink: BC100
Clip: HC01
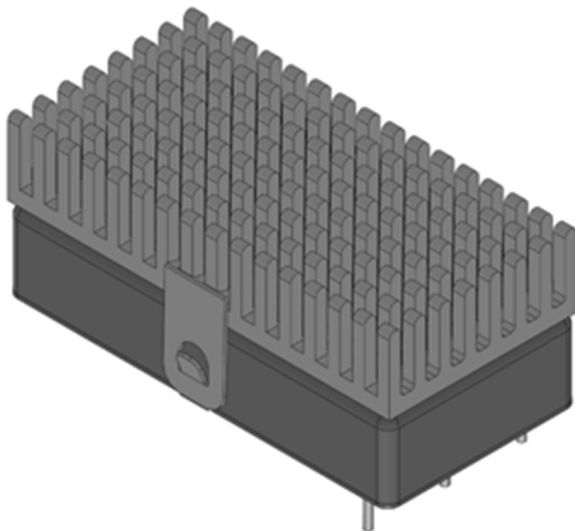
9. Safety & EMC

9.1 Input Fusing and Safety Considerations

The EC7BW series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a time delay fuse 4A for 24Vin models and 2A for 48Vin 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).
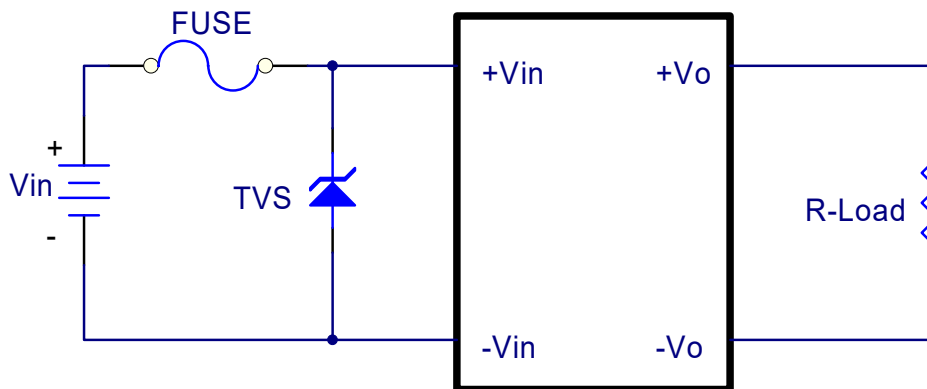
Input Protection

The external input capacitor (Cin) and transient voltage suppressor diode (TVS) are required if EC7BW series has to meet EN61000-4-4, EN61000-4-5.

The Cin recommended a 47uF/100V (Nippon Chemi-Con KY series) aluminum capacitor. And the TVS recommended 1.5KE47A for 24V_{in} models, and 1.5KE91A for 48V_{in} models.

9.2 EMC Considerations

EMI Test Standard: EN 55032 Class A and B, EN 50121-3-2

(1) EMI Test Standard: EN 55032 Class B Conducted Emission with External Input Filter

Test Condition: Input Voltage: Nominal, Output Load: Full Load
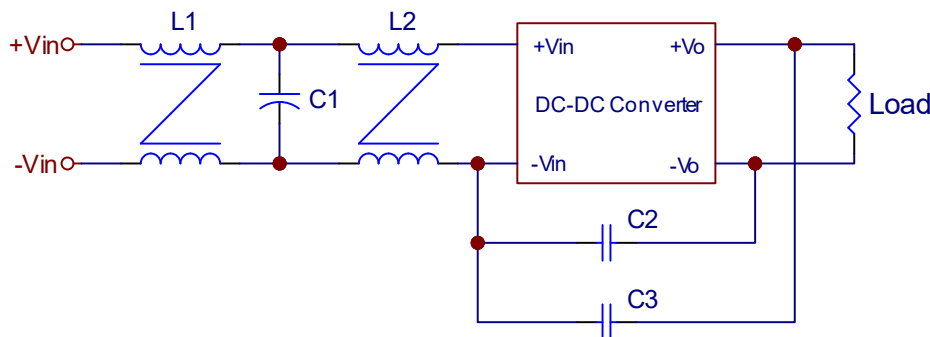
Connection circuit for conducted EMI testing

Model No.	EN 55032 Class B				
	C1	C2	C3	L1	L2
EC7BW-24S33	220uF/50V KY	1000pF/2KV	1000pF/2KV	Jump Wire	1.2mH
EC7BW-24S05	220uF/50V KY	1000pF/2KV	1000pF/2KV	Jump Wire	1.2mH
EC7BW-24S12	220uF/50V KY	1000pF/2KV	1000pF/2KV	Jump Wire	1.2mH
EC7BW-24S15	220uF/50V KY	1000pF/2KV	1000pF/2KV	Jump Wire	1.2mH
EC7BW-48S33	220uF/100V PW	1000pF/2KV	1000pF/2KV	0.15mH	1.2mH
EC7BW-48S05	220uF/100V PW	1000pF/2KV	1000pF/2KV	0.15mH	1.2mH
EC7BW-48S12	220uF/100V PW	1000pF/2KV	1000pF/2KV	0.15mH	1.2mH
EC7BW-48S15	220uF/100V PW	1000pF/2KV	1000pF/2KV	0.15mH	1.2mH

Note:

C1 is NIPPON-CHEMICON KY series or NICHICON PW series aluminum capacitor, C2, C3 are ceramic capacitors

Jump Wire: 0.7mm min.

## EMI and Conducted Noise Meet EN 55032 Class B:

EC7BW-24S33
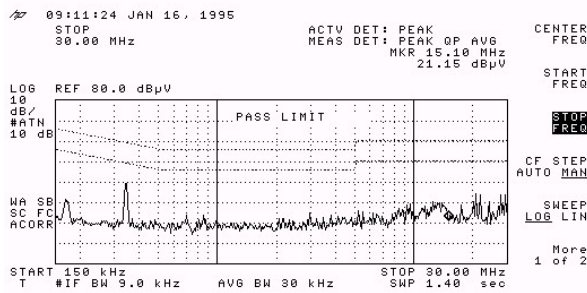
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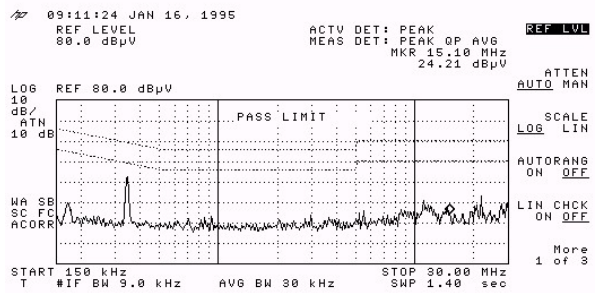
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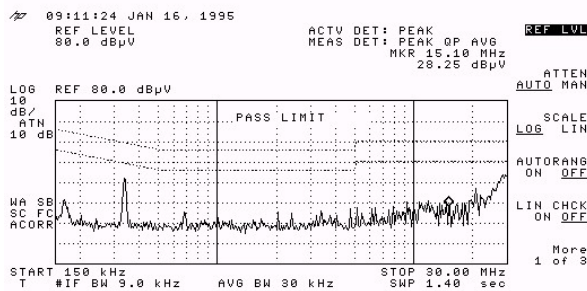
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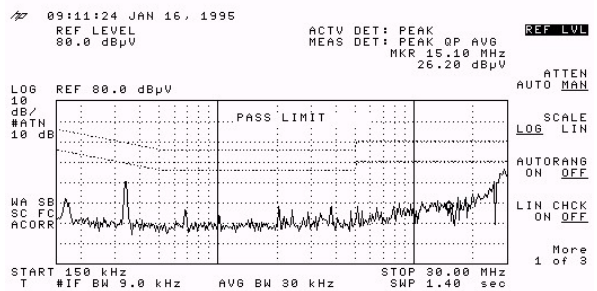
EC7BW-48S33
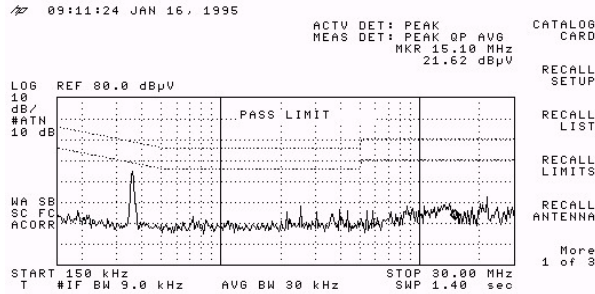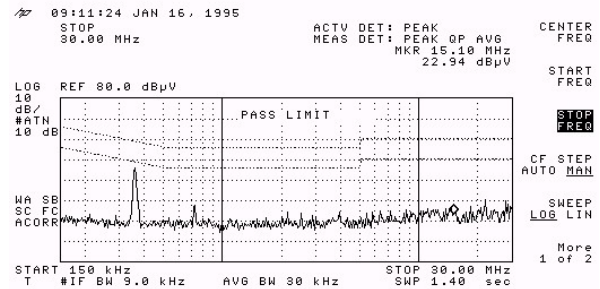
EC7BW-48S05

EC7BW-48S12
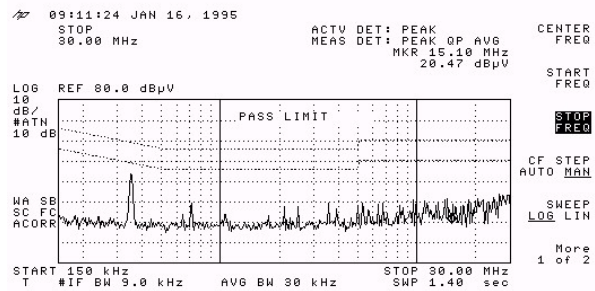
EC7BW-48S15
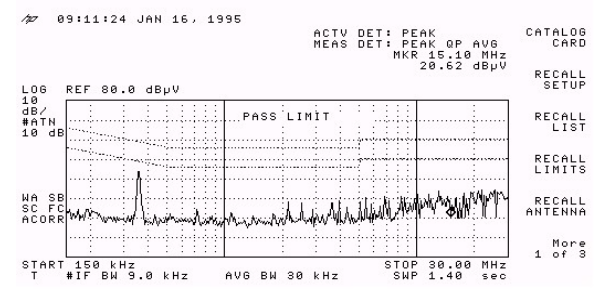
(2) EMI and conducted noise meet EN 55032 Class A:
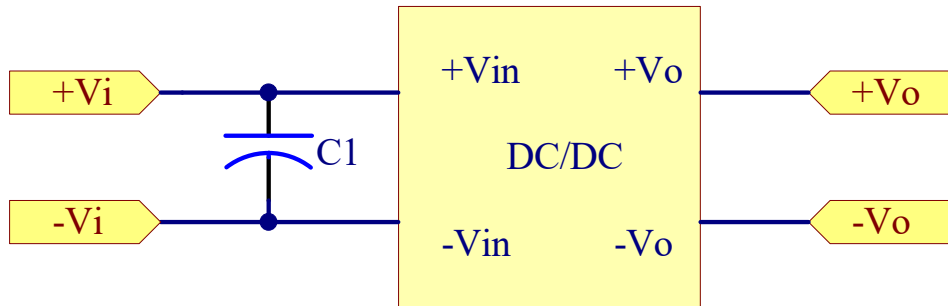
Connection circuit for conducted EMI testing

Model No.	EN 55032 Class A
	C1
EC7BW-24D05	10uF/50V/MLCC 1210
EC7BW-24D12	10uF/50V/MLCC 1210
EC7BW-24D15	10uF/50V/MLCC 1210
EC7BW-48D05	NC
EC7BW-48D12	NC
EC7BW-48D15	NC

EMI and Conducted Noise Meet EN 55032 Class A:

EC7BW-24D05
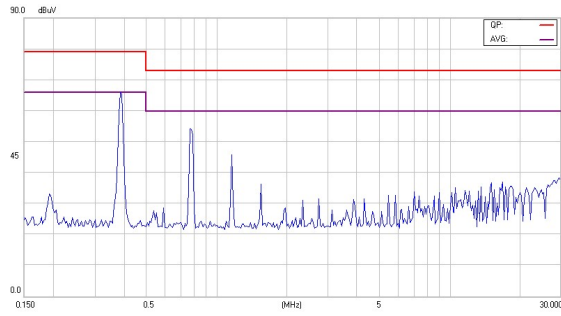
EC7BW-24D12
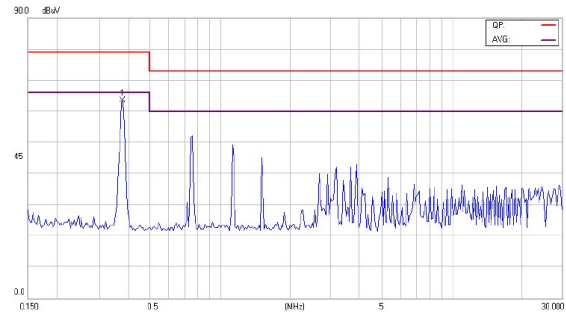
EC7BW-24D15
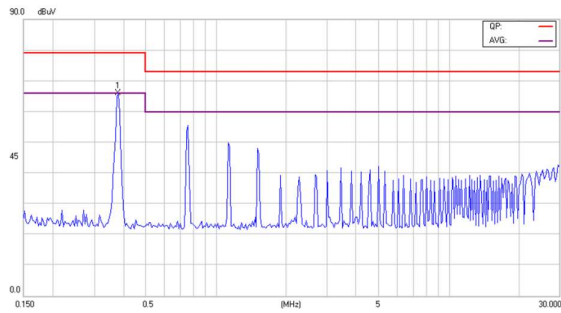
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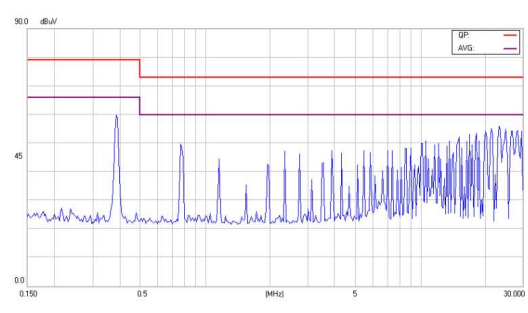
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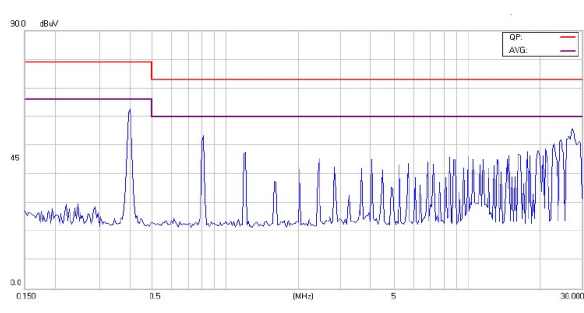
EC7BW-48D15
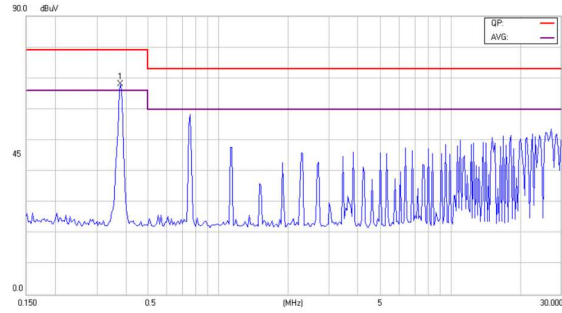
(3) EMC Test standard: EN 50121-3-2:2016

Test Condition: Input Voltage: Nominal, Output Load: Full Load
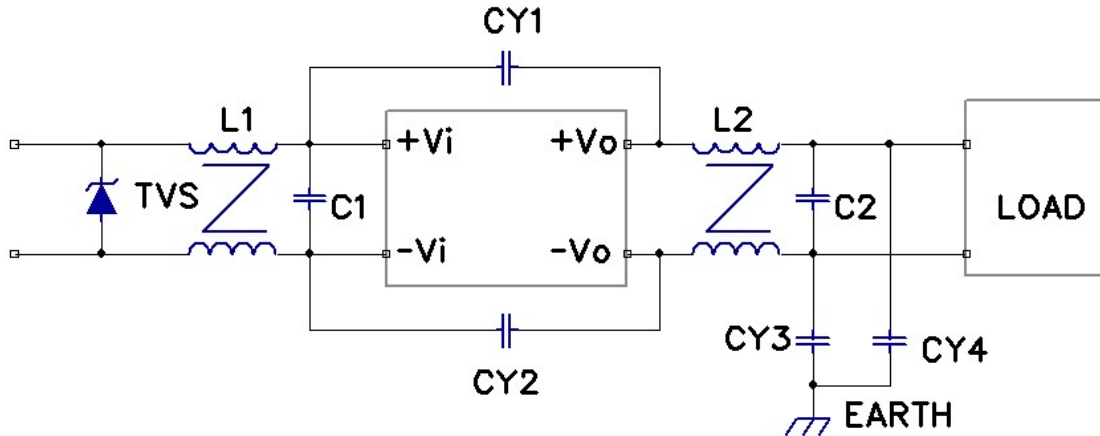
Connection circuit for Single Output

Model No.	EN 50121-3-2							
	TVS	C1	C2	CY1 & CY2	CY3	CY4	L1	L2
EC7BW-24S33	1.5KE47A	47uF/100V KY	2.2uF/50V MLCC	1500pF/2KV MLCC	4700pF Y1	4700pF Y1	1.37mH	0.4mH
EC7BW-24S05	1.5KE47A	47uF/100V KY	2.2uF/50V MLCC	1500pF/2KV MLCC	2200pF Y1	NC	Jump Wire	0.4mH
EC7BW-24S12	1.5KE47A	47uF/100V KY	2.2uF/50V MLCC	1500pF/2KV MLCC	4700pF Y1	4700pF Y1	1.37mH	0.4mH
EC7BW-24S15	1.5KE47A	47uF/100V KY	2.2uF/50V MLCC	1500pF/2KV MLCC	6800pF Y1	6800pF Y1	1.37mH	0.4mH
EC7BW-48S33	1.5KE91A	47uF/100V KY	2.2uF/50V MLCC	1500pF/2KV MLCC	4700pF Y1	4700pF Y1	1.37mH	0.4mH
EC7BW-48S05	1.5KE91A	47uF/100V KY	2.2uF/50V MLCC	1500pF/2KV MLCC	4700pF Y1	4700pF Y1	1.37mH	0.4mH
EC7BW-48S12	1.5KE91A	47uF/100V KY	2.2uF/50V MLCC	1500pF/2KV MLCC	6800pF Y1	6800pF Y1	1.37mH	0.4mH
EC7BW-48S15	1.5KE91A	47uF/100V KY	2.2uF/50V MLCC	1500pF/2KV MLCC	6800pF Y1	6800pF Y1	1.37mH	0.4mH

Note:

C1: NIPPON-CHEMICON KY series or NICHICON PW series aluminum capacitor

C2, CY1, CY2: Ceramic capacitors

CY3, CY4: 2200pF (CD Series TDK) or equivalent, 4700pF (CD Series TDK) or equivalent, 6800pF (CD Series TDK) or equivalent

L1: 1.37mH (VAC L2012 W902 12*8*4.5) or equivalent

L2: 0.4mH (GREDMANN FCN0129 12*8*4.5) or equivalent

Jump Wire: 0.7mm min.
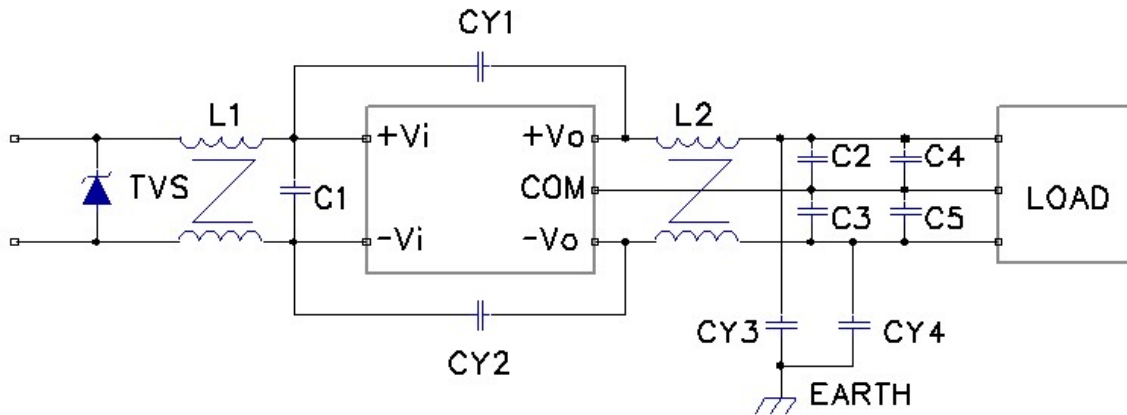
Connection circuit for Dual Output

Model No.	EN 50121-3-2						
	TVS	C1 & C4 & C5	C2 & C3	CY1 & CY2	CY3 & CY4	L1	L2
EC7BW-24DXX	1.5KE47A	47uF/100V KY	2.2uF/50V MLCC	1500pF/2KV MLCC	2200pF Y1	0.4mH	2.5mH
EC7BW-48DXX	1.5KE91A	47uF/100V KY	2.2uF/50V MLCC	1500pF/2KV MLCC	2200pF Y1	0.4mH	2.5mH

Note:
    C1, C4, C5: NIPPON-CHEMICON KY series or NICHICON PW series aluminum capacitor
    C2, C3, CY1, CY2: Ceramic capacitors
    CY3, CY4: 2200pF (CD Series TDK) or equivalent
    L1, L2: 0.4mH, 2.5mH (GREDMANN FCN0129 12*8*4.5) or equivalent

Conducted Emission (Input):

EC7BW-24S05

Line
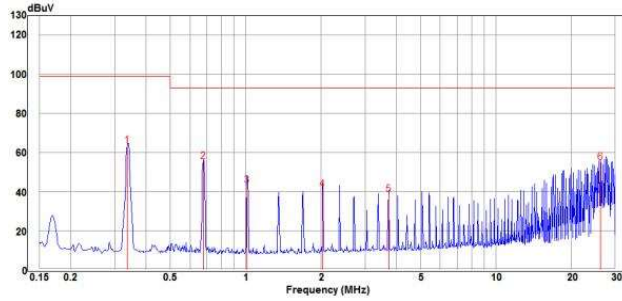
Neutral
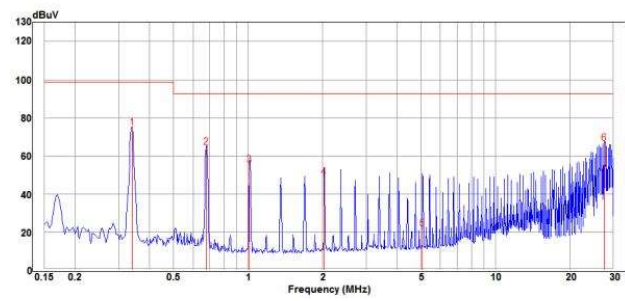
EC7BW-48D15

Line
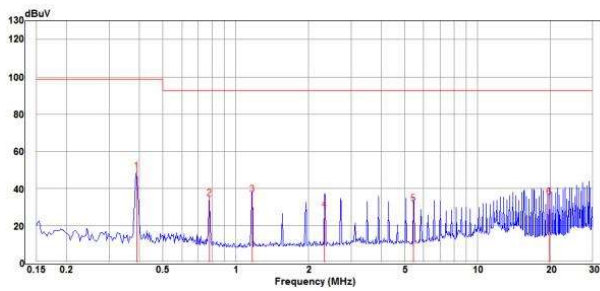
Neutral
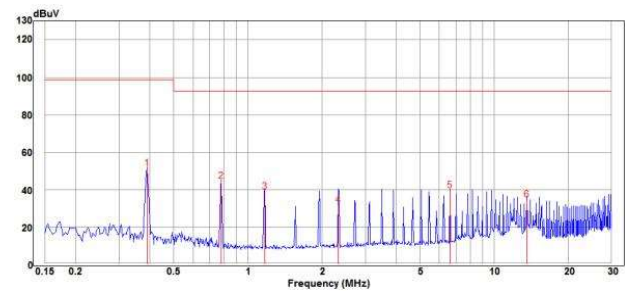
Conducted Emission (Output):

EC7BW-24S05

Positive
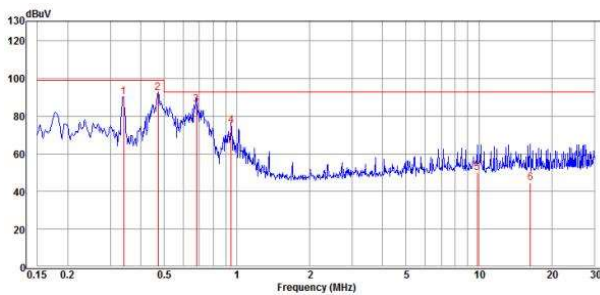
Negative
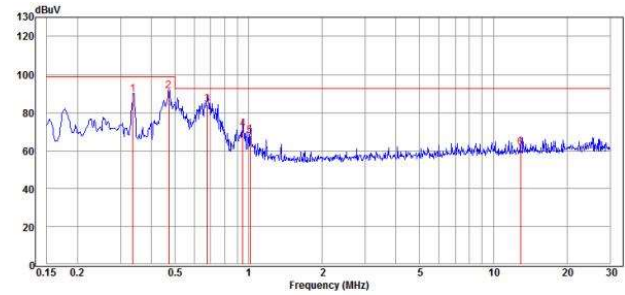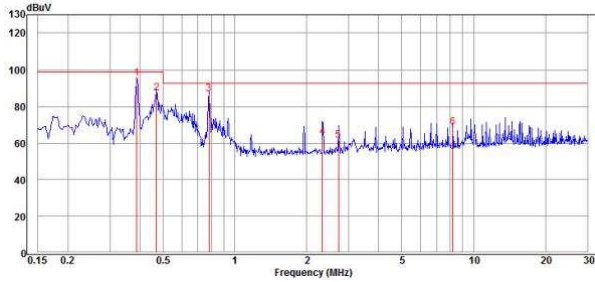
EC7BW-48D15
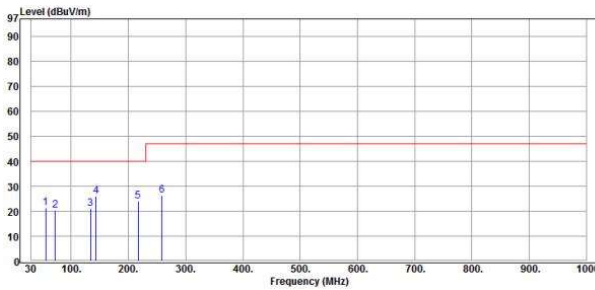Positive   Negative
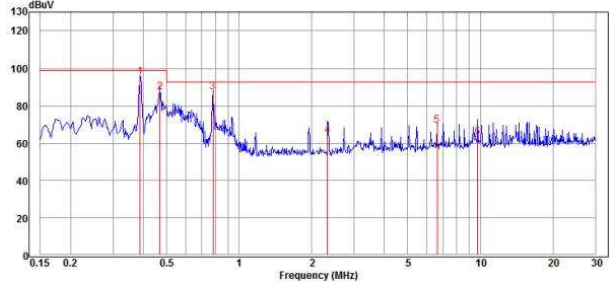
Radiated Emission:

EC7BW-24S05
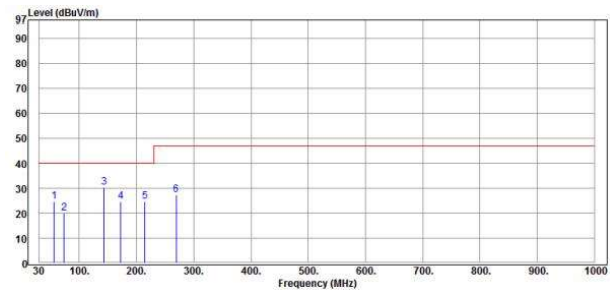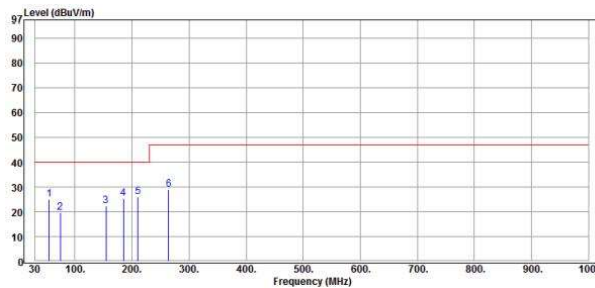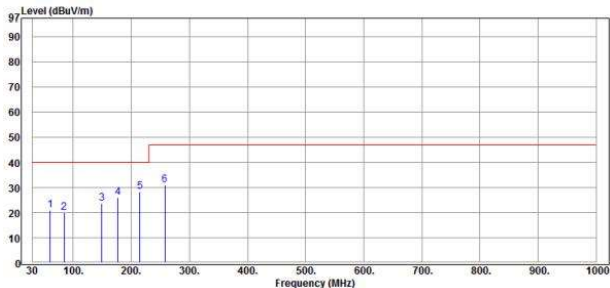Horizontal   Vertical
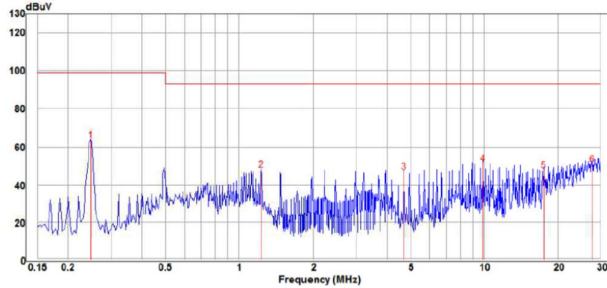
EC7BW-48D15
Horizontal   Vertical

EC7BWD15