EC5BW 15W Isolated DC-DC Converters

Application Note V10 May 2011

ISOLATED DC-DC Converter
EC5BW SERIES
APPLICATION NOTE

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Content

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1. Introduction

The EC5BW series offer 15 watts of output power in a 2.00x1.00x0.4 inches copper packages. The EC5BW series has a 4:1 wide input voltage range of 9-36 and 18-75VDC, and provides a precisely regulated output. This series has many features including high efficiency, 1500VDC of isolation, meets EN55022 class A and allows an ambient operating temperature range of –40℃ to 85℃ (de-rating above 78 ℃). The modules are fu lly protected against input UVLO (under voltage lock out), output over-current, over-voltage protection and continuous short circuit conditions. Furthermore, the option control functions include remote on/off (suffix "T" to the model number) and adjustable output voltage(suffix "A" to the model number). All models are very suitable for distributed power architectures, telecommunications, battery operated equipment and industrial applications.

2. DC-DC Converter Features

* 15W Isolated Output
* Efficiency to 88%
* 4:1 INPUT RANGE
* Regulated Outputs
* Fixed Switching Frequency
* Input under-voltage Protection
* Over Current Protection
* Remote ON/OFF (Option)
* Continuous Short Circuit Protection
* Without Tantalum Capacitor inside
* Conductive EMI Meet EN55022 Class A

3. Electrical Block Diagram

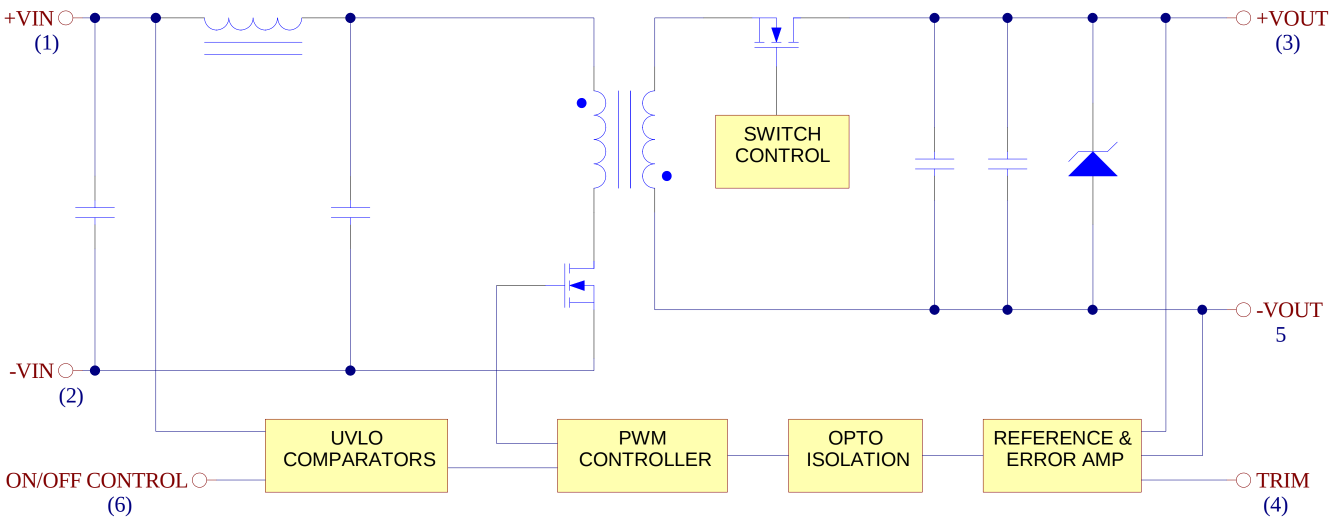

Figure1 Electrical Block Diagram of XXS33 and XXS05

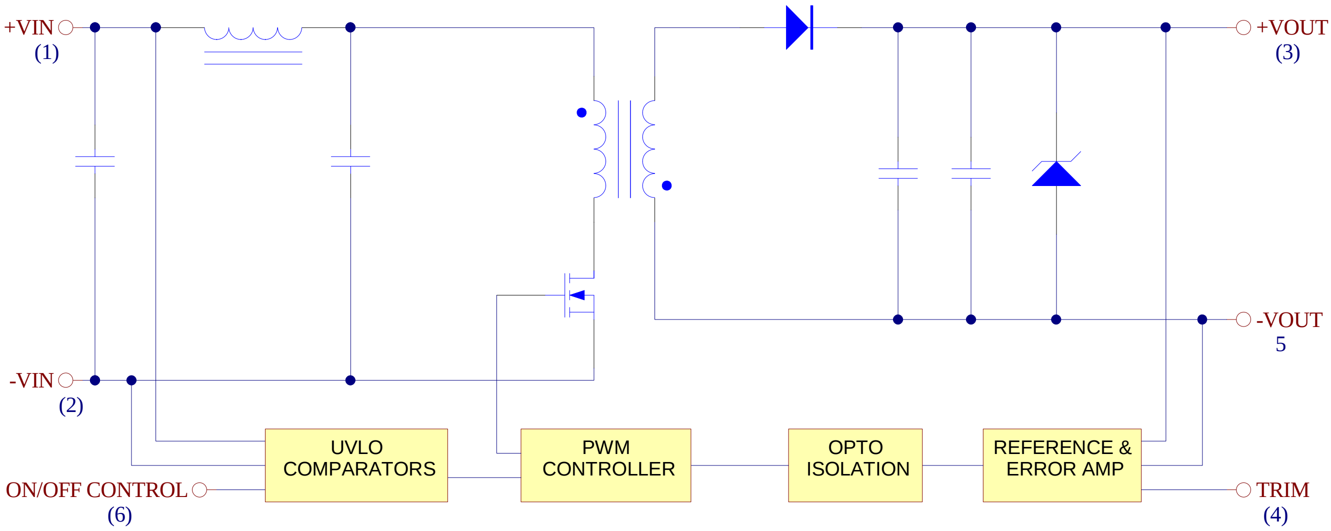

Figure2 Electrical Block Diagram of XXS12 and XXS15

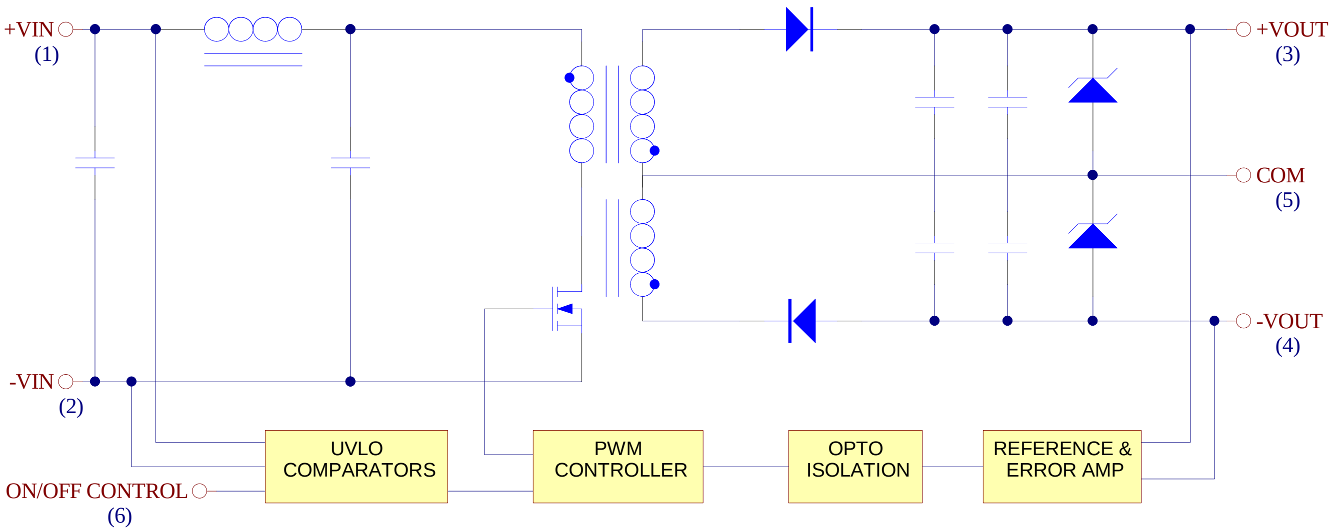

Figure3 Electrical Block Diagram of dual output module

4. Technical Specifications

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

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
ABSOLUTE MAXIMUM RATINGS						
Input Voltage						
Continuous		24Vin 48Vin	9 18	24 48	36 75	Vdc
Transient	100ms	24Vin 48Vin			50 100	Vdc
Operating Ambient Temperature	Derating, Above 78℃	All	-40		+85	℃
Case Temperature		All			105	℃
Storage Temperature		All	-55		+125	℃
Input/Output Isolation Voltage	1 minute	All			1500	Vdc
INPUT CHARACTERISTICS						
Operating Input Voltage		24Vin 48Vin	9 18	24 48	36 75	Vdc
Maximum Input Current	100% Load, Vin=9V 100% Load, Vin=18V	24Vin 48Vin			2100 1000	mA
No-Load Input Current	Vin=Nominal input	24S33 24S05 24S12 24S15 24D05 24D12 24D15 48S33 48S05 48S12 48S15 48D05 48D12 48D15		60 70 30 30 30 30 30 40 40 20 20 20 20 20		mA
Off Converter Input Current	Shutdown input idle current	All		4	10	mA
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	All			30	mA
OUTPUT CHARACTERISTIC						
Output Voltage Set Point	Vin=Nominal Vin , Io=Io.max, Tc=25℃	Vo=3.3 Vo=5.0 Vo=12 Vo=15 Vo=±5.0 Vo=±12 Vo=±15	3.2505 4.925 11.82 14.775 4.925 11.82 14.775	3.3 5 12 15 5 12 15	3.3495 5.075 12.18 15.225 5.075 12.18 15.225	Vdc
Output Voltage Balance	Vin=nominal, Io=Io_{max}, Tc=25℃	Dual			±2.0	%
Output Voltage Regulation						
Load Regulation	Io= Full Load to min. Load	Single Dual			±0.2 ±1.0	% %
Line Regulation	Vin=High line to Low line Full Load	Single Dual			±0.2 ±0.5	% %
Cross Regulation	Load cross variation 10%/100%	Dual			±5	%
Temperature Coefficient	TC=-40℃ to 85℃				±0.03	%/℃
Output Voltage Ripple and Noise	5Hz to 20MHz bandwidth					

Peak-to-Peak	Full Load,20MHz bandwidth 0.1uF Ceramic capacitor	Vo=3.3V Vo=5V Vo=±5V			75	mV
		Vo=15V Vo=12V Vo=±15V Vo=±12V			100	
Operating Output Current Range		Vo=3.3V	0		4000	mA
		Vo=5V			3000	
		Vo=12V			1250	
		Vo=15V			1000	
		Vo=±5V			±1500	
		Vo=±12V			±625	
		Vo=±15V			±500	
Output DC Current-Limit Inception	Output Voltage=90% $V_{O,\ nominal}$		110	140	160	%
Maximum Output Capacitance	Full load, Resistance	Vo=3.3V			4000	uF
		Vo=5V			3000	
		Vo=12V			1250	
		Vo=15V			1000	
		Vo=±5V			1500	
		Vo=±12V			625	
		Vo=±15V			470	
DYNAMIC CHARACTERISTICS						
PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Output Voltage Current Transient						
Step Change in Output Current	75% to 100% of Io.max di/dt=0.1A/us				±5	%
Setting Time (within 1% $Vo_{nominal}$)					250	us
Turn-On Delay and Rise Time						
Turn-On Delay Time, From On/Off Control	Von/off to 10%Vo,set	All		10		ms
Turn-On Delay Time, From Input	Vin,min. to 10%Vo,set	All		10		ms
Output Voltage Rise Time	10%Vo,set to 90%Vo,set	All		10		ms
EFFICIENCY						
100% Load	Vin=Nominal Vin, Io=Io_{max}, Tc=25℃	24S33		87		%
		24S05		87		
		24S12		87		
		24S15		88		
		24D05		85		
		24D12		87		
		24D15		88		
		48S33		88		
		48S05		88		
		48S12		87		
		48S15		87		
		48D05		85		
		48D12		87		
		48D15		87		
ISOLATION CHARACTERISTICS						
Input to Output	1 minutes				1500	Vdc
Isolation Resistance		All	1000			MΩ
Isolation Capacitance		All		1000		pF
FEATURE CHARACTERISTICS						
Switching Frequency				400		KHz
ON/OFF Control ,Positive Remote On/Off logic (-"T" version)						
Logic Low (Module Off)	Von/off at Ion/off=1.0mA	ALL			1.2	V
Logic High (Module On)	Von/off at Ion/off=0.1uA	ALL	3.5 or		75	V

			Open Circuit			
ON/OFF Current	Ion/off at Von/off=0.0V			0.3	1	mA
Leakage Current	Logic High, Von/off=15V				30	uA
Off Converter Input Current	Shutdown input idle current			4	10	mA
Output Voltage Trim Range (-“A” version)	Pout=max rated power	XXSXX	-10		+10	%
Output Over Voltage Protection	Zener or TVS Clamp	Vo=3.3V		3.9		Vdc
		Vo=5.0V		6.2		
		Vo=12V		15		
		Vo=15V		18		
		Vo=±5.0V		±6.2		
		Vo=±12V		±15		
		Vo=±15V		±18		
GENERAL SPECIFICATIONS						
MTBF	Io=100%of Io.max;Ta=25℃ per MIL-HDBK-217F			TBD		M hours
Weight				35		grams

EC5BW 15W Isolated DC-DC Converters

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5. Main Features and Functions

5.1 Operating Temperature Range

The EC5BW series converters can be operated by a wide ambient temperature range from -40℃ to 85℃(de-rating above 78℃). The standard model has a Copper case and case temperature can not over 105℃ at normal operating.

5.2 Remote ON/OFF (Option)

The EC5BW series model number of suffix”T” has this option, It allows the user to switch the module on and off electronically with the remote on/off feature. All models are available in “positive logic” versions. The converter turns on if the remote ON/OFF pin is high (>3.5Vdc or open circuit). Setting the pin low (<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).

5.3 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the EC5BW 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.

5.4 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.

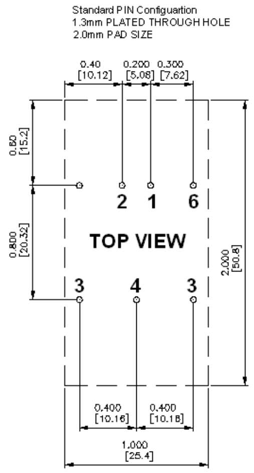
5.5 Over Voltage Protection

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

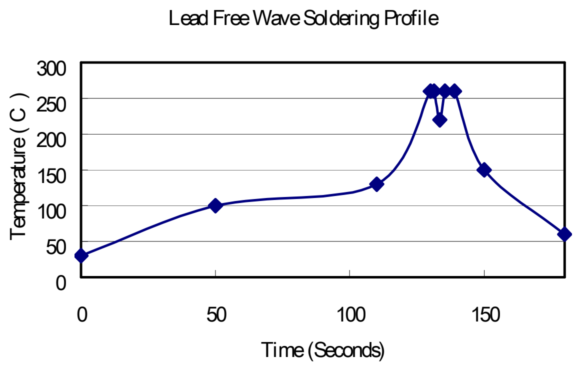
6. Applications

6.1 Recommended Layout PCB Footprints and Soldering Information

The system designer or the end user must ensure that other components and metal in the vicinity of the converter meet the spacing requirements to which the system is approved. Low resistance and low 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 as Figure4.



Note: Dimensions are in inches (millimeters)



Note：

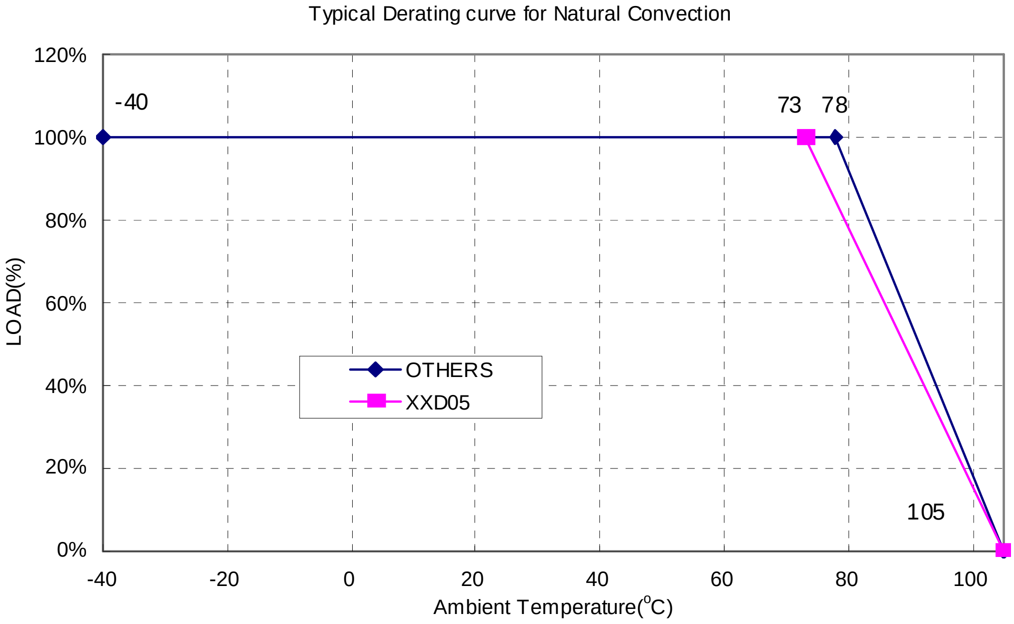
1. Soldering Materials: Sn/Cu/Ni
2. Ramp up rate during preheat: 1.4 ℃/Sec (From 50℃ to 100℃)
3. Soaking temperature: 0.5 ℃/Sec (From 100℃ to 130℃), 60±20 seconds
4. Peak temperature: 260℃, above 250℃ 3~6 Seconds
5. Ramp up rate during cooling: -10.0 ℃/Sec (From 260℃ to 150℃)

Figure4 Recommended PCB Layout Footprints and Wave Soldering Profiles for SB packages

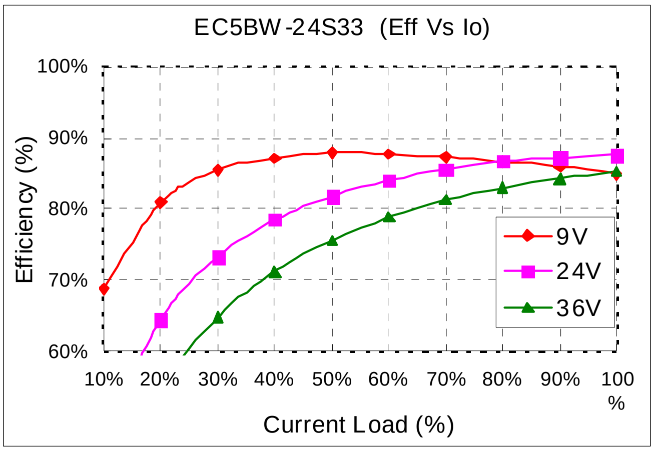
6.2 Power De-Rating Curves for EC5BW Series

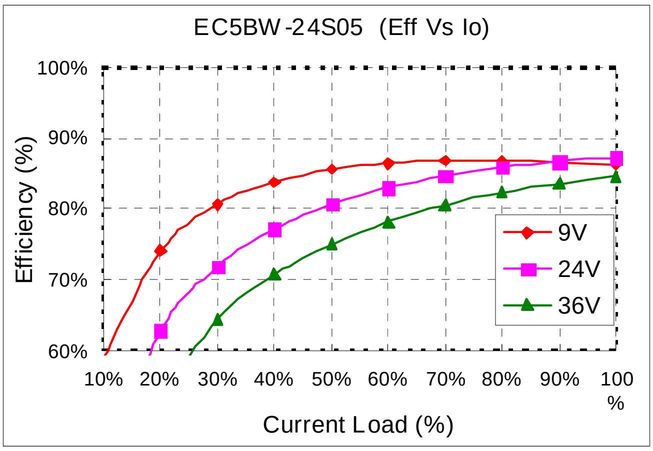
Operating Ambient temperature Range : -40℃ ~ 85℃ (derating above 78℃).

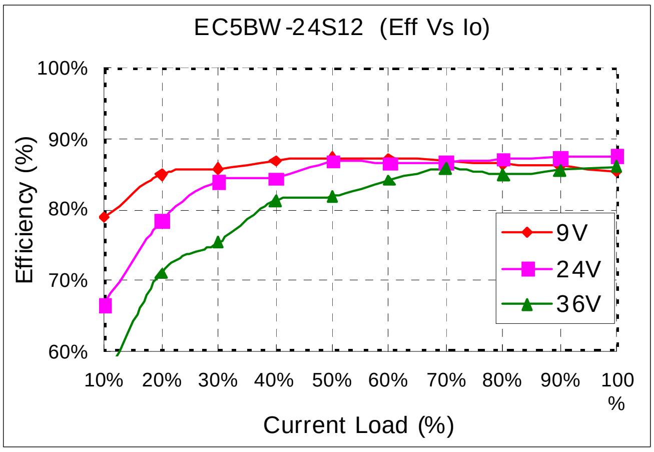
Maximum case temperature under any operating condition should not exceed 105℃.

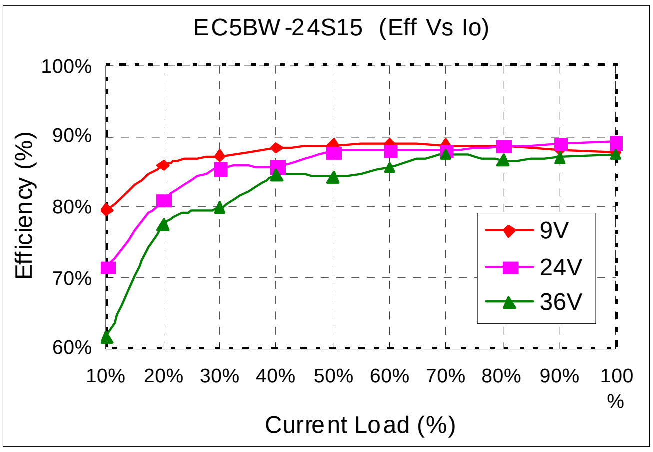


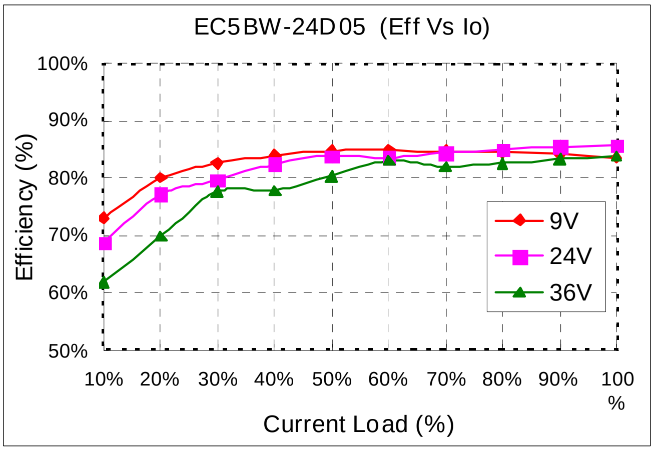
6.3 Efficiency vs. Load Curves

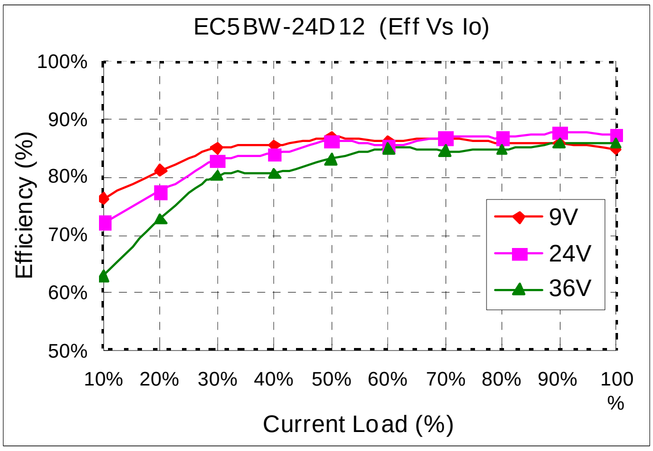


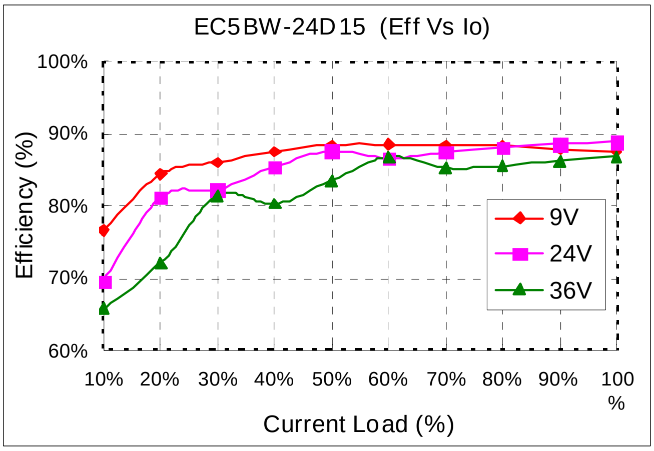




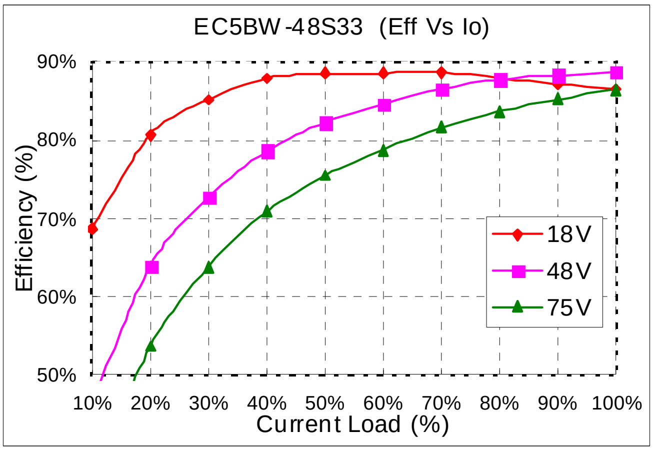




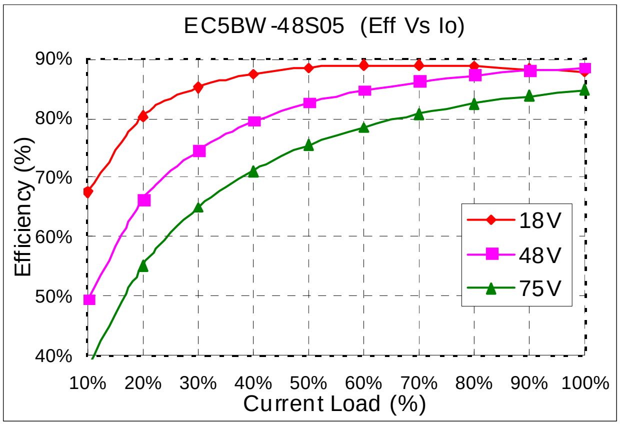




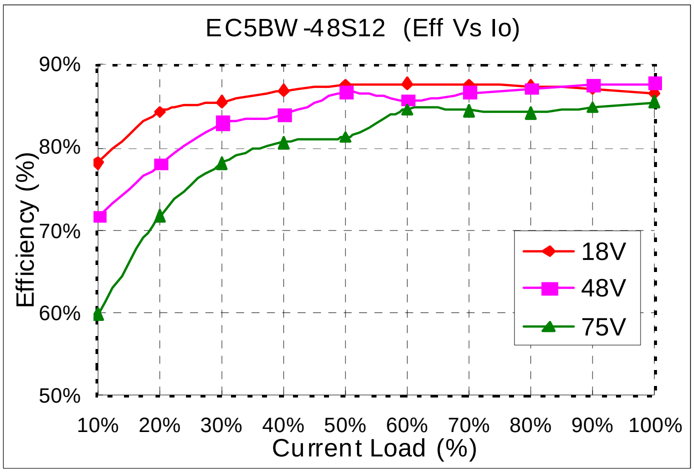
EC5BW-24D15 (Eff Vs Io)
100%
90%
80%
70%
60%
Efficiency (%)
9V
24V
36V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100 %
Current Load (%)



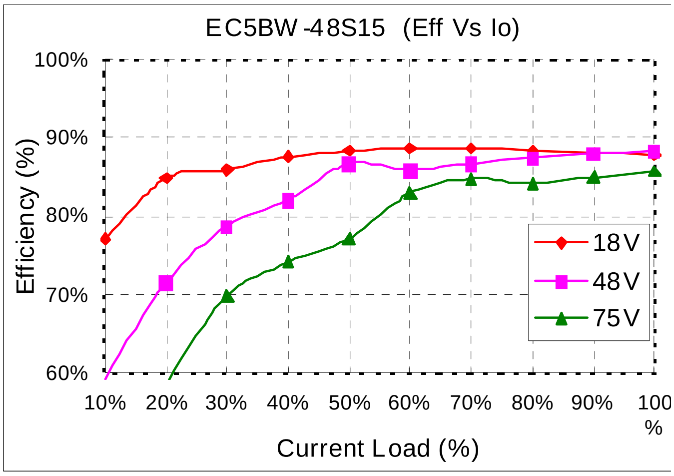
EC5BW-48S33 (Eff Vs Io)
90%
80%
70%
60%
50%
Efficiency (%)
18V
48V
75V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)



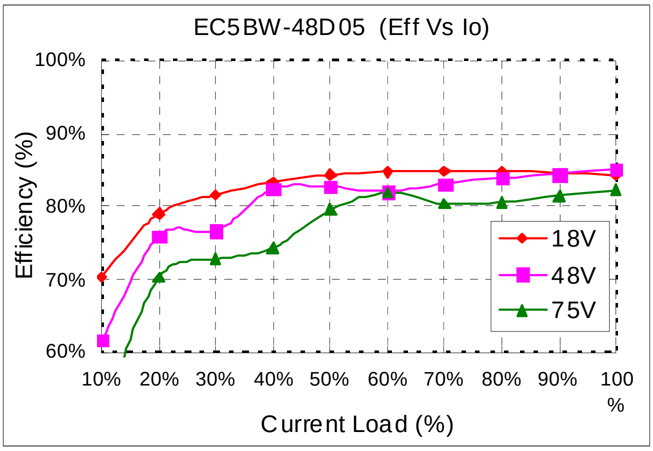
EC5BW-48S05 (Eff Vs Io)
90%
80%
70%
60%
50%
40%
Efficiency (%)
18V
48V
75V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)



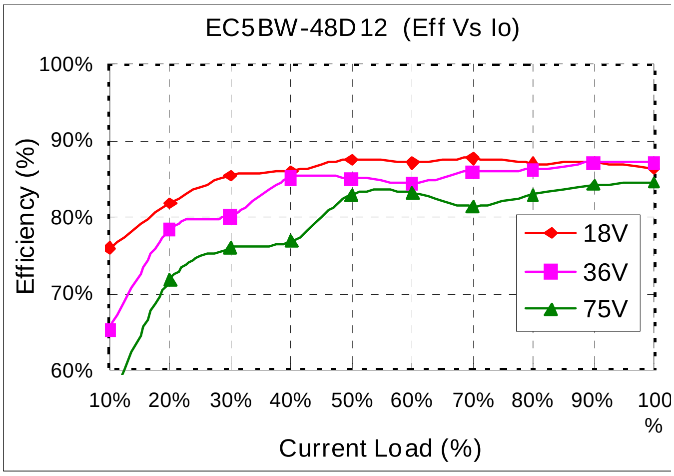
EC5BW-48S12 (Eff Vs Io)
90%
80%
70%
60%
50%
Efficiency (%)
18V
48V
75V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)

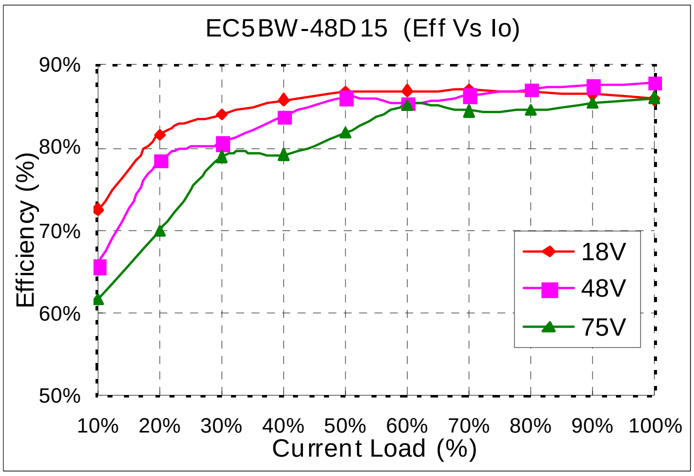


EC5BW-48S15 (Eff Vs Io)
100%
90%
80%
70%
60%
Efficiency (%)
18V
48V
75V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100 %
Current Load (%)



EC5BW-48D05 (Eff Vs Io)
100%
90%
80%
70%
60%
Efficiency (%)
18V
48V
75V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100 %
Current Load (%)

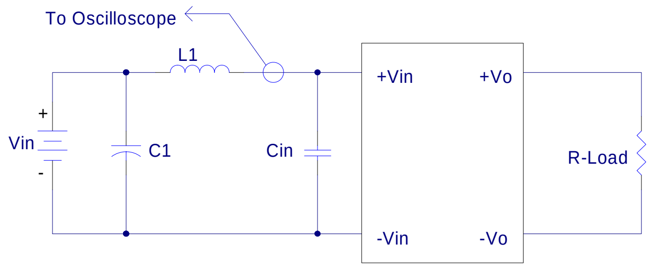

EC5BW-48D12 (Eff Vs Io)
100%
90%
80%
70%
60%
Efficiency (%)
10%
20%
30%
40%
50%
60%
70%
80%
90%
100 %
Current Load (%)
18V
36V
75V


EC5BW-48D15 (Eff Vs Io)
90%
80%
70%
60%
50%
Efficiency (%)
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
18V
48V
75V

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 in Figure5 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: None
Cin: 33uF ESR<0.7ohm @100KHz

Figure5 Input Reflected-Ripple Test Setup

6.5 Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown in Figure6. 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 the

- 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.

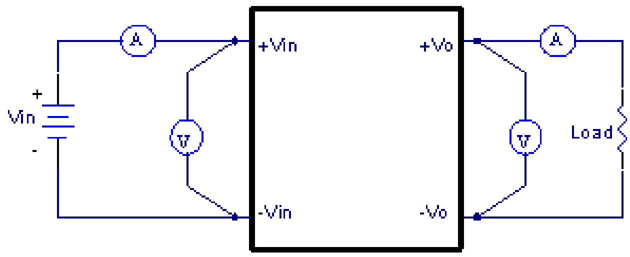


Figure6 EC5BW Series Test Setup

6.6 Output Voltage Adjustment (Option)

Suffix "A" to the model number with output voltage adjustable. 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 and between trim pin and +Vo for trim-down. The output voltage trim range is ±10%. This is shown in Figures 7 and 8:

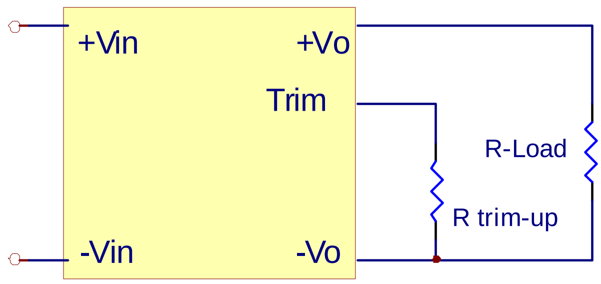


Figure7 Trim-up Voltage Setup

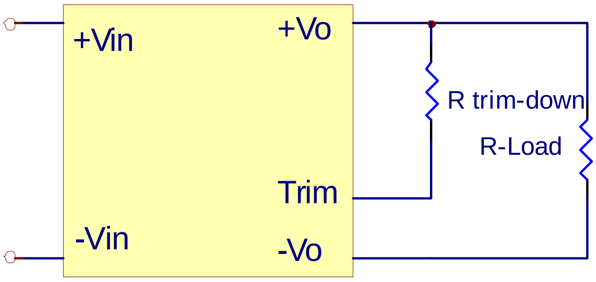


Figure8 Trim-down Voltage Setup

1. The value of Rtrim-up defined as:

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

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 Vr 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)
EC5BW24S33 EC5BW48S33	3.3	2.74	1.8	0.27	9.1	1.24
EC5BW24S05 EC5BW48S05	5.0	2.32	2.32	0	8.2	2.5
EC5BW24S12 EC5BW48S12	12.0	6.8	2.4	2.32	22	2.5
EC5BW24S15 EC5BW48S15	15.0	8.06	2.4	3.9	27	2.5

For example, to trim-up the output voltage of 5.0V module (EC5BW-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,
Vr= 2.5 V

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

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

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

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

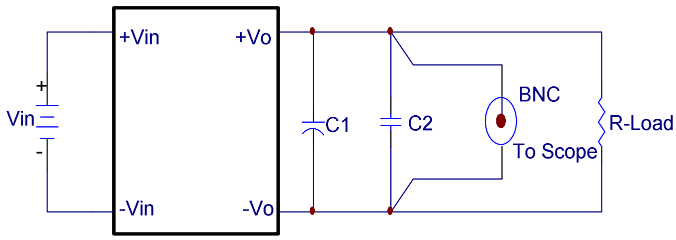
For example, to trim-down the output voltage of 5.0V module (EC5BW-12S05) by 10% to 4.5V, R trim-down is calculated as follows:

$V_{O,nom} - Vo = 5.0 - 4.5 = 0.5V$
R1 = 2.32 KΩ
R2 = 2.32 KΩ
R3 = 0 KΩ
Rt = 8.2 KΩ
Vr= 2.5 V

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

6.7 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure9. A coaxial cable was used to prevent impedance mismatch reflections disturbing the noise readings at higher frequencies. Measurements are taken with output appropriately loaded and all ripple/noise specifications are from D.C. to 20MHz Band Width.



Note: C1: None
C2: 0.1uF Ceramic capacitor

Figure9 Output Voltage Ripple and Noise Measurement Set-Up

6.8 Output Capacitance

The EC5BW 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. These series converters are designed to work with load capacitance to see technical specifications.

7. Safety & EMC

7.1 Input Fusing and Safety Considerations.

The EC5BW series converters have not an internal fuse. However, 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. Figure10 circuit is recommended by a Transient Voltage Suppressor diode across the input terminal to protect the unit against surge or spike voltage and input reverse voltage.

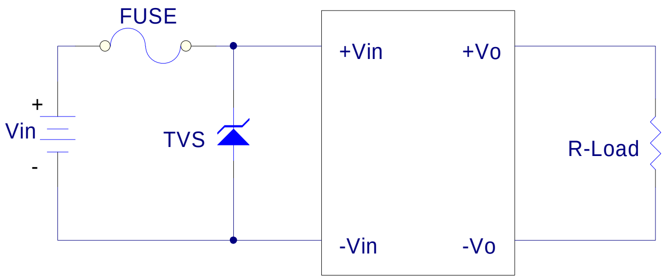
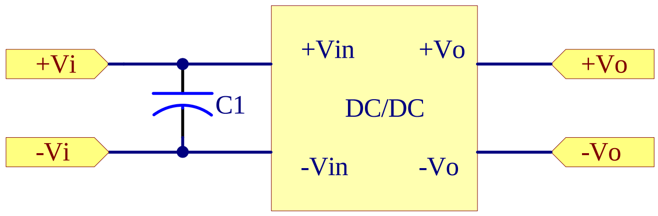


Figure10 Input Protection

7.2 EMC Considerations

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

(1) EMI and conducted noise meet EN55022 Class A:



Figur11 Connection circuit for conducted EMI testing

Note: To meet EN55022 Class A without capacitor to the input pin.

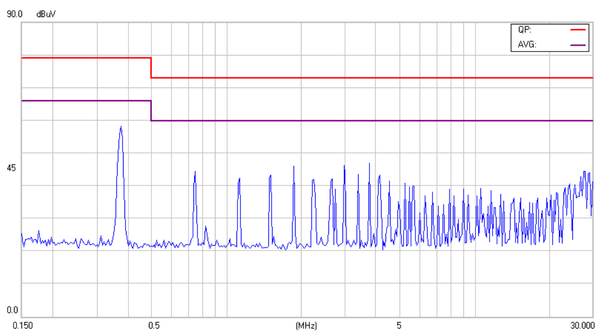


Figure12 Conducted Class A of EC5BW-24S33

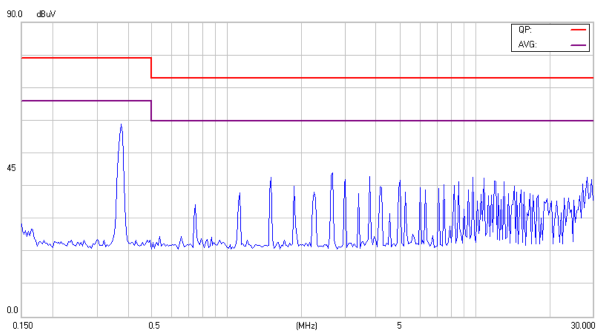


Figure13 Conducted Class A of EC5BW-24S05

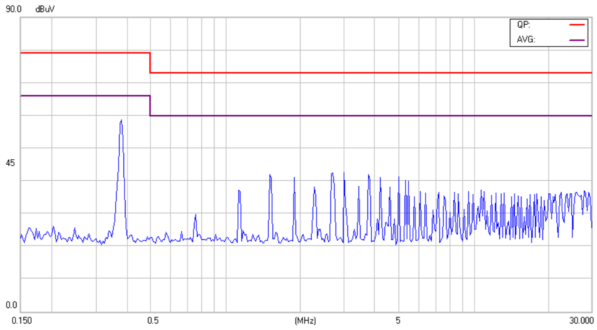


Figure14 Conducted Class A of EC5BW-24S12

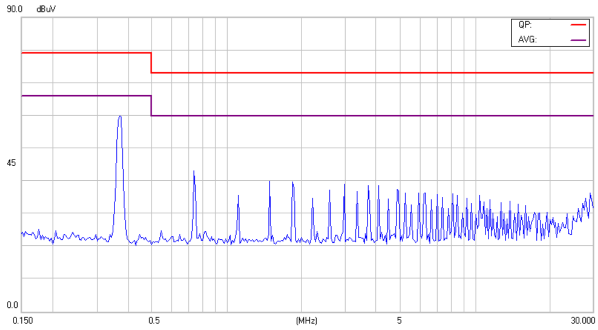


Figure15 Conducted Class A EC5BW-24S15

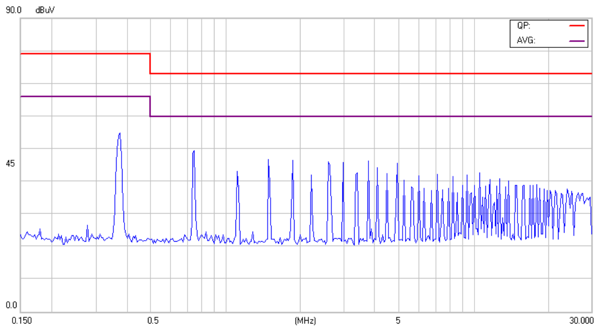


Figure16 Conducted Class A of EC5BW-24D05

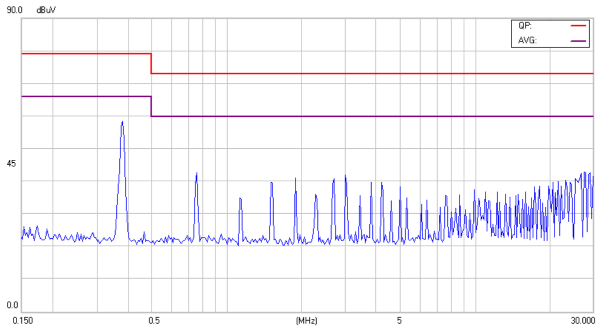


Figure17 Conducted Class A of EC5BW-24D12

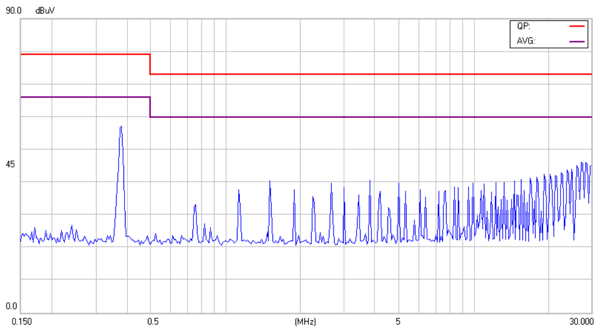


Figure18 Conducted Class A of EC5BW-24D15

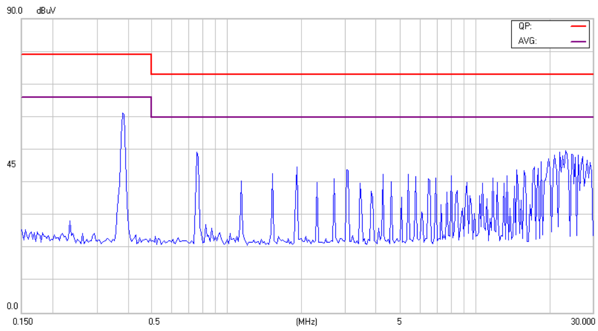


Figure19 Conducted Class A of EC5BW-48S33

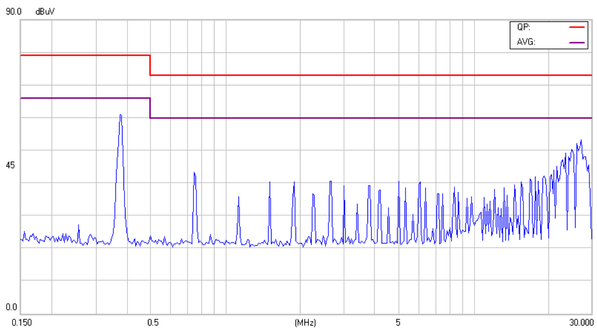


Figure20 Conducted Class A of EC5BW-48S05

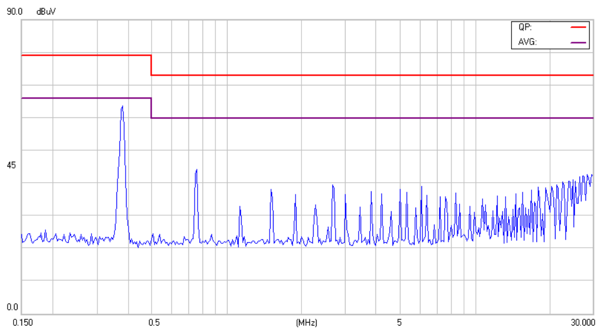


Figure21 Conducted Class A of EC5BW-48S12

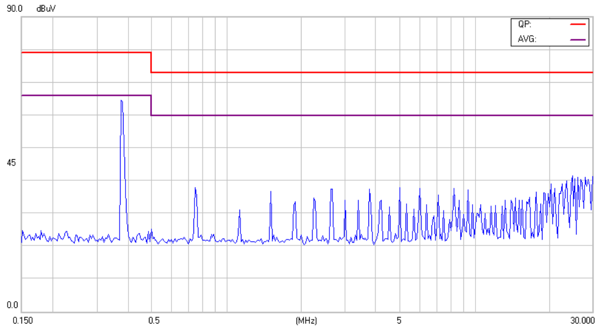


Figure22 Conducted Class A of EC5BW-48S15

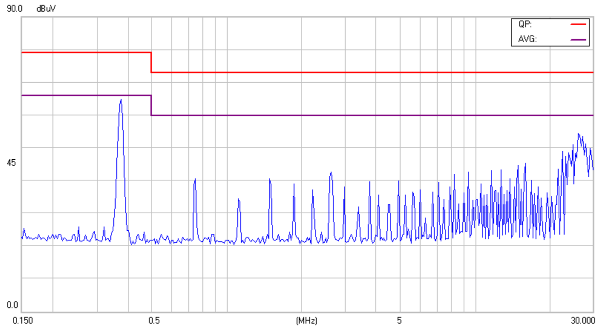


Figure23 Conducted Class A of EC5BW-48D05

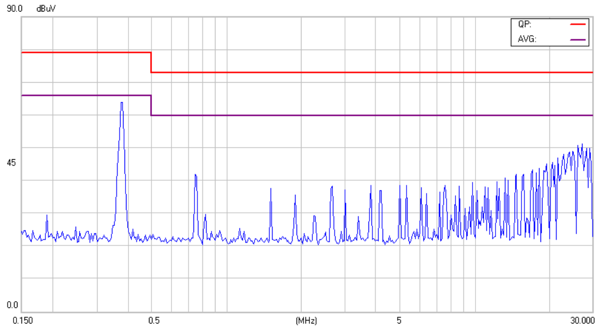


Figure24 Conducted Class A of EC5BW-48D12

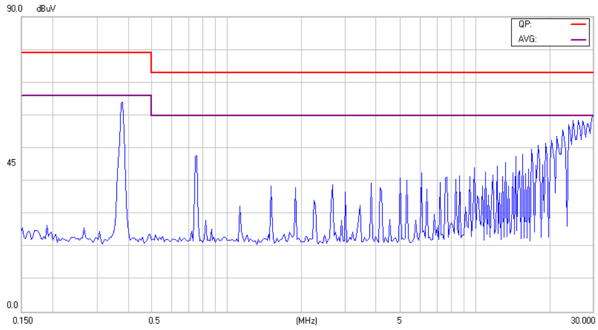


Figure25 Conducted Class A of EC5BW-48D15

(2) EMI and conducted noise meet EN55022 Class B:

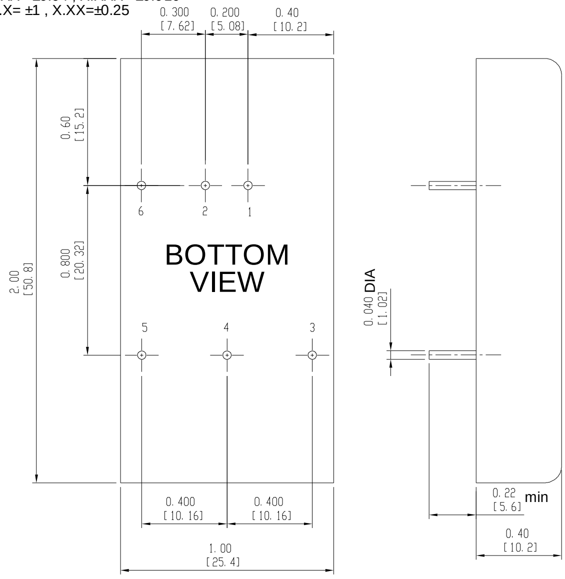
8. Part Number

EC5BW – XX X XX X X

- EC5BW Series
- 24：Nominal Input Voltage 24VDC
  48：Nominal Input Voltage 48VDC
- S：Single Output
  D：Dual Output
- 33：Output Voltage 3.3 VDC
  05：Output Voltage 5 VDC
  12：Output Voltage 12 VDC
  15：Output Voltage 15 VDC
- None：Standard
  A：Output Voltage Adjustable
- None：Standard
  T：Remote Positive On/Off Control

9. Mechanical Specifications

All Dimensions In Inches (mm)
Tolerances Inches: X.XX= ±0.04 , X.XXX= ±0.010
Millimeters: X.X= ±1 , X.XX=±0.25



PIN CONNECTION	
Pin	Function
1.	+Input
2.	-Input
3.	+Output
4.	Common/NP/Trim (Option)
5.	-V Output
6.	NP/Remote(Option)

*NP-NO PIN ON SINGLE OUTPUT

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