ISOLATED DC-DC CONVERTER
EC9BW SERIES
APPLICATION NOTE

Approved By:

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Content

EC9BW Series

Application Note V12

1. Introduction

The EC9BW series offer 30 watts of output power in a 2.00x1.00x0.4 inches copper packages. The EC9BW series has a 4:1 wide input voltage range of 9-36 and 18-75VDC and provides a precisely regulated output. This series has features such as high efficiency, 1500VDC of isolation and allows an ambient operating temperature range of –40°C to 85°C (de-rating above 65°C). The modules are fully protected against input UVLO (under voltage lock out), output over-current, over-voltage and over-temperature and short circuit conditions. Furthermore, the standard control functions include remote on/off and adjustable output voltage. All models are very suitable for distributed power architectures, telecommunications, battery operated equipment and industrial applications.

2. DC-DC Converter Features

- 30W Isolated Output
- Efficiency to 92%
- 2”x1” Six-Sided Shield Metal Case
- 4:1 Input Range
- Regulated Outputs
- Fixed Switching Frequency
- Input Under Voltage Protection
- Over Current Protection
- Remote On/Off
- Continuous Short Circuit Protection
- No Tantalum Capacitor Inside
- Safety Meets IEC/EN/UL 62368-1

3. Electrical Block Diagram

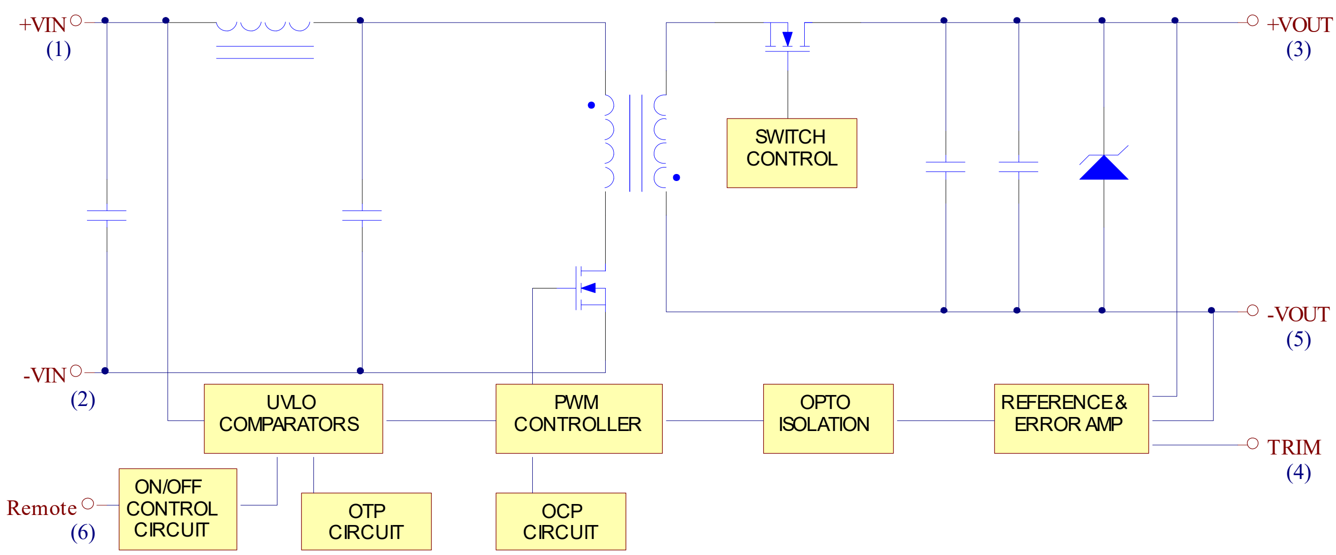


Figure 1 Electrical Block Diagram for Single Output Modules

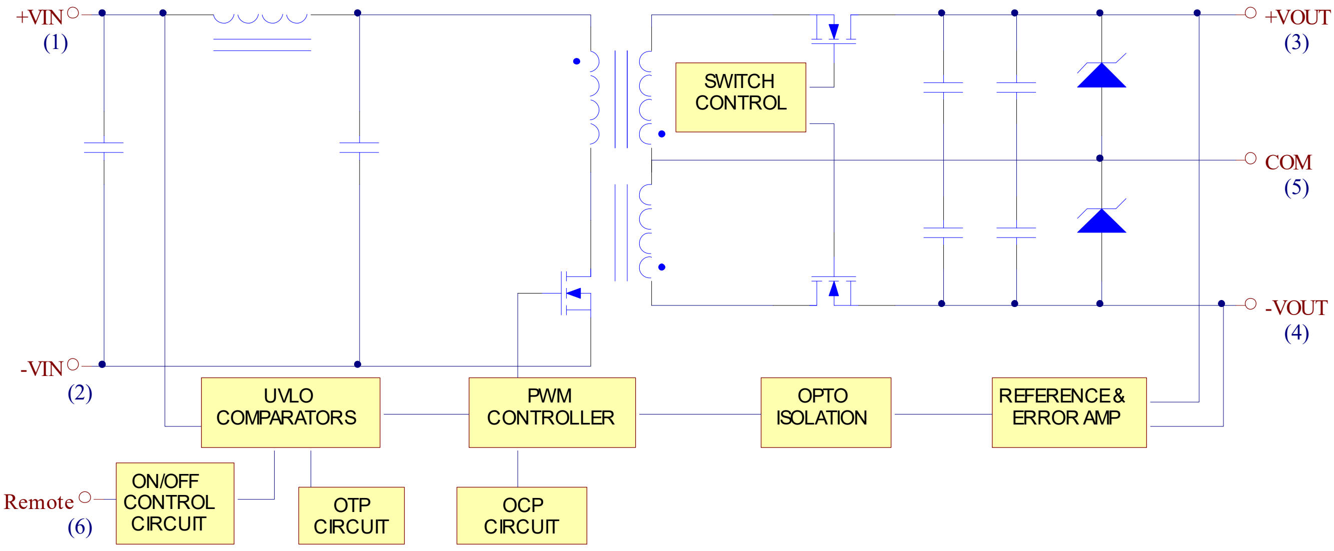


Figure 2 Electrical Block Diagram for Dual Output Modules

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		24Vin 48Vin	9 18	24 48	36 75	V_{dc}
Transient	100ms	24Vin 48Vin			50 100	Vdc
Operating Ambient Temperature	Derating, above 65℃	All	-40		+85	℃
Case Temperature		All			105	℃
Storage Temperature		All	-55		+125	℃
Input/Output Isolation Voltage	1 Minute	All			1500	V_{dc}

INPUT CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Operating Input Voltage		24Vin 48Vin	9 18	24 48	36 75	V_{dc}
Input Under Voltage Lockout						
Turn-On Voltage Threshold		24Vin 48Vin	8 16.5	8.5 17	8.8 17.5	V_{dc}
Turn-Off Voltage Threshold		24Vin 48Vin	7.7 15.5	8 16	8.3 16.5	V_{dc}
Lockout Hysteresis Voltage		24Vin 48Vin		0.5 0.9		V_{dc}
Maximum Input Current	100% Load, V_{in}=9V 100% Load, V_{in}=18V	24Vin 48Vin		3800 1900		mA
No-Load Input Current	V_{in}=24V	24S33 24S05 24S12 24S15 24D12 24D15		100 110 50 50 60 60		mA
	V_{in}=48V	48S33 48S05 48S12 48S15 48D12 48D15		50 50 30 30 40 40		
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

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Output Voltage Set Point	V_{in}=Nominal input, I_o= $Io_{max.}$	Vo=3.3V	3.267	3.3	3.333	V_{dc}
		Vo=5.0V	4.95	5	5.05	
		Vo=12V	11.88	12	12.12	
		Vo=15V	14.85	15	15.15	
		Vo=±12V	11.88	12	12.12	
		Vo=±15V	14.85	15	15.15	
Output Voltage Balance	V_{in}=Nominal input, I_o=$Io_{max.}$	Dual			±1.0	%
Output Voltage Regulation						
Load Regulation	I_o=Full load to min. load	Single			±0.5	%
		Dual			±1.0	
Line Regulation	V_{in}=High line to low line, full Load	Single			±0.2	%
		Dual			±0.5	
Cross Regulation	Load cross variation 10%/100%	Dual			±5	%
Temperature Coefficient	T_c=-40℃ to 85℃	All			±0.02	%/℃
Output Voltage Ripple and Noise 5Hz to 20MHz Bandwidth						
Peak-to-Peak	Full load, 0.1uF ceramic capacitor	Vo=3.3V Vo=5V			75	mV
		Vo=12V Vo=15V Vo=±12V Vo=±15V			100	
Operating Output Current Range		Vo=3.3V	0		7500	mA
		Vo=5V	0		6000	
		Vo=12V	0		2500	
		Vo=15V	0		2000	
		Vo=±12V	0		±1250	
		Vo=±15V	0		±1000	
Output DC Current-Limit Inception	Vo=90% $V_{O, nominal}$		110	135	160	%
Maximum Output Capacitance	Full load (resistive)	Vo=3.3V			7500	uF
		Vo=5V			6000	
		Vo=12V			2500	
		Vo=15V			2000	
		Vo=±12V			±1250	
		Vo=±15V			±1000	

DYNAMIC CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Output Voltage Current Transient						
Step Change in Output Current	75% to 100% of $I_{o.max.}$ di/dt=0.1A/us	All			±5	%
Setting Time (within 1% $V_{o\ nominal}$)					250	uS
Turn-On Delay and Rise Time						
Turn-On Delay Time, From On/Off Control	$V_{on/off}$ to 10%$V_{o, set}$	All		2.5		ms
Turn-On Delay Time, From Input	$V_{in, min.}$ to 10%$V_{o, set}$	All		3		ms
Output Voltage Rise Time	10%$V_{o, set}$ to 90%$V_{o, set}$	All		3		ms

EFFICIENCY

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
100% Load	V_{in}=12V	24S33		88		%
		24S05		89.5		
		24S12		91		
		24S15		91		
		24D12		91		
		24D15		92		
	V_{in}=24V	48S33		87		
		48S05		89.5		
		48S12		91.5		
		48S15		92		
		48D12		91.5		
		48D15		92		
100% Load	V_{in}=24V	24S33		88.5		%
		24S05		89.5		
		24S12		90.5		
		24S15		90.5		
		24D12		90.5		
		24D15		91		
	V_{in}=48V	48S33		87.5		
		48S05		90		
		48S12		90		
		48S15		91		
		48D12		90.5		
		48D15		91		

ISOLATION CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Input to Output	1 Minutes	All			1500	V_{dc}
Isolation Resistance		All	1000			MΩ
Isolation Capacitance		All		1000		pF

FEATURE CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Switching Frequency				430		KHz
On/Off Control, Positive Remote On/Off Logic						
Logic Low (Module Off)	$V_{on/off}$ at $I_{on/off}$=1.0mA	All	0		1.2	V_{dc}
Logic High (Module On)	$V_{on/off}$ at $I_{on/off}$=0.1uA	All	3.5 or Open Circuit		75	V_{dc}
On/Off Current (for Both Remote On/Off Logic)	$I_{on/off}$ at $V_{on/off}$=0.0V	All		0.3	1	mA
Leakage Current (for Both Remote On/Off Logic)	Logic high, $V_{on/off}$=15V	All			30	uA
Off Converter Input Current	Shutdown input idle current	All		4	10	mA
Output Voltage Trim Range	P_{out}=maximum rated power	All	-10		+10	%

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Output Over Voltage Protection	Zener or TVS clamp	Vo=3.3V Vo=5.0V Vo=12V Vo=15V Vo=±12V Vo=±15V		3.9 6.2 15 18 ±15 ±18		V_{dc}
Over-Temperature Shutdown		All		110		°C

GENERAL SPECIFICATIONS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
MTBF	Io=100%of Io.max.; Ta=25℃ per MIL-HDBK-217F	Single Dual		900 650		K hours
Weight		All		35		grams

5. Main Features and Functions

5.1 Operating Temperature Range

The EC9BW series converters can be operated by a wide ambient temperature range from -40℃ to 85℃ (de-rating above 65℃). The standard model has a copper case and case temperature can not over 105℃ at normal operating.

5.2 Remote On/Off

The remote ON/OFF input feature of the converter allows external circuitry to turn the converter ON or OFF. Active-high remote ON/OFF is available as standard. The converter is turned on if the remote ON/OFF pin is high (>3.5Vdc 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 "-Vin". If not using the remote on/off pin, leave the pin open (module will be on).

5.3 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the EC9BW 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.

5.6 Over-Temperature Protection (OTP)

The EC9BW series converters are equipped with non-latching over-temperature protection. If the temperature exceeds a threshold of 110℃ (typical) the converter will shut down, disabling the output. When the temperature has decreased the converter will automatically restart. The over-temperature condition can be induced by a variety of reasons such as external overload condition or a system fan failure.

5.7 Output Voltage Adjustment

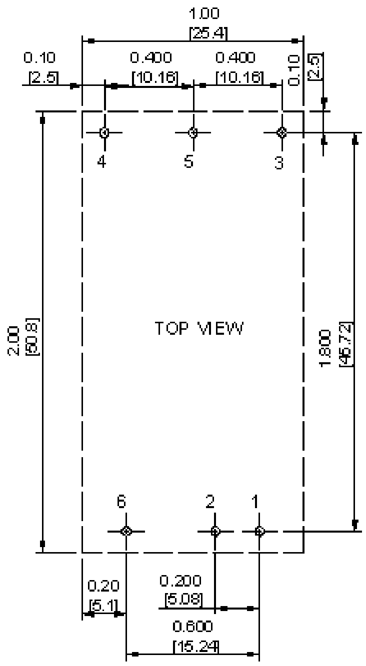
Section 6.6 describes in detail how to trim the output voltage with respect to its set point. The output voltage on all models is adjustable within the range of +10% to –10%. (Single output models only)

6. Applications

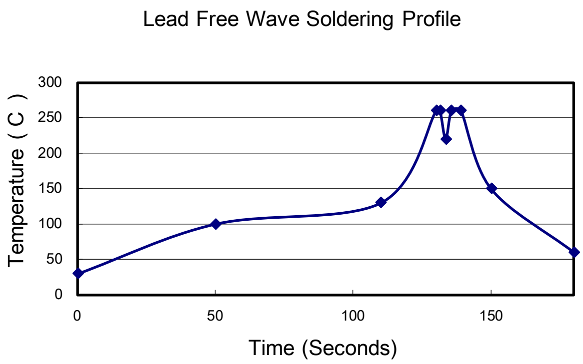
6.1 Recommended Layout PCB Footprints and Soldering Information

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 below.

1.3mm PLATED THROUGH HOLE
2.5mm PAD SIZE



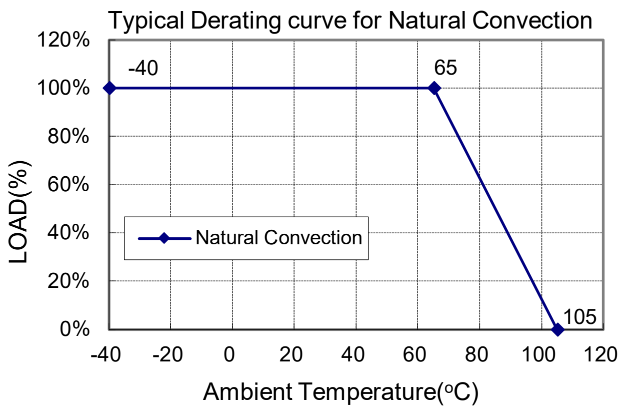
Note: Dimensions are in inches (millimeters)



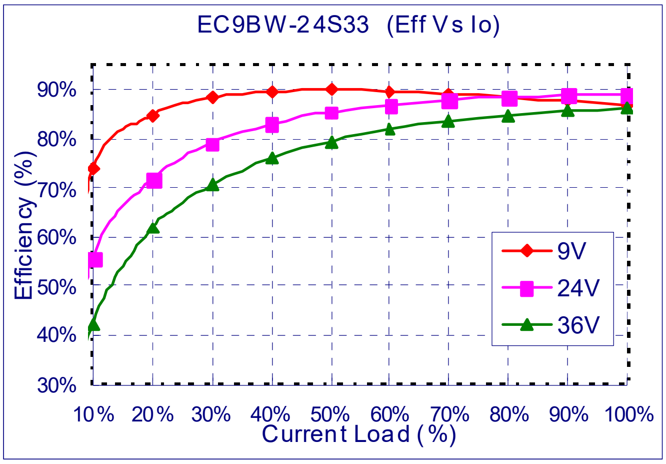
Note：
1. Soldering Materials: Sn/Cu/Ni
2. Ramp up rate during preheat: 1.4℃/Sec (from 50℃ to 100℃)
3. Soaking temperature: 0.5℃/Sec (from 100℃ to 130℃), 60±20 seconds
4. Peak temperature: 260℃, above 250℃ 3~6 Seconds
5. Ramp up rate during cooling: -10.0℃/Sec (from 260℃ to 150℃)

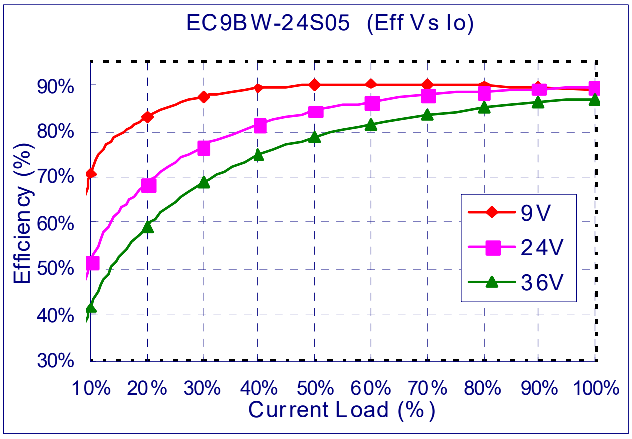
6.2 Power De-Rating Curves for EC9BW Series

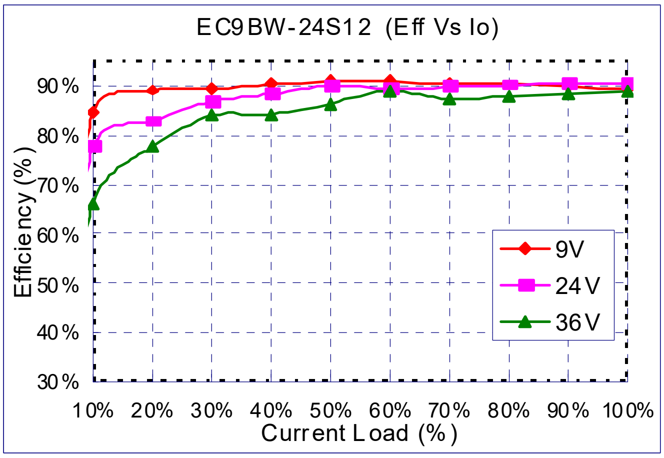
Operating Ambient temperature Range: -40℃ ~ 85℃ (derating above 65℃).
Maximum case temperature under any operating condition should not exceed 105℃.

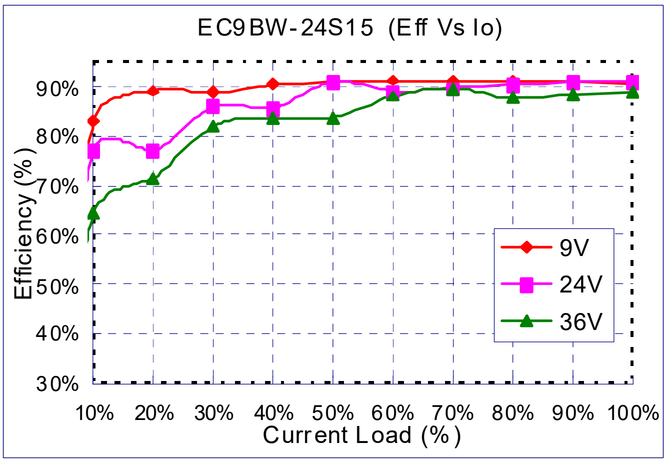


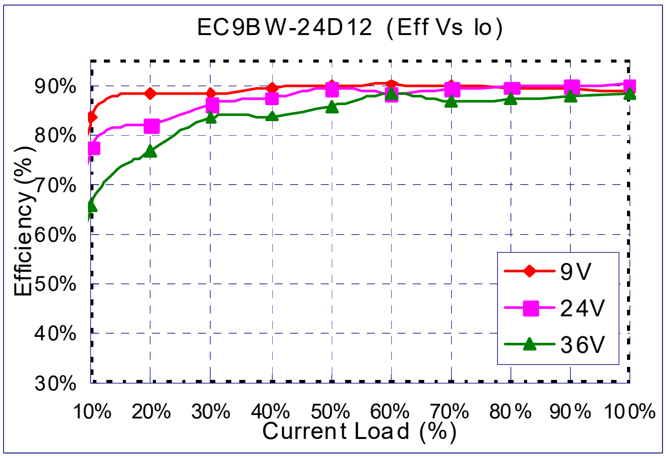
6.3 Efficiency vs. Load Curves

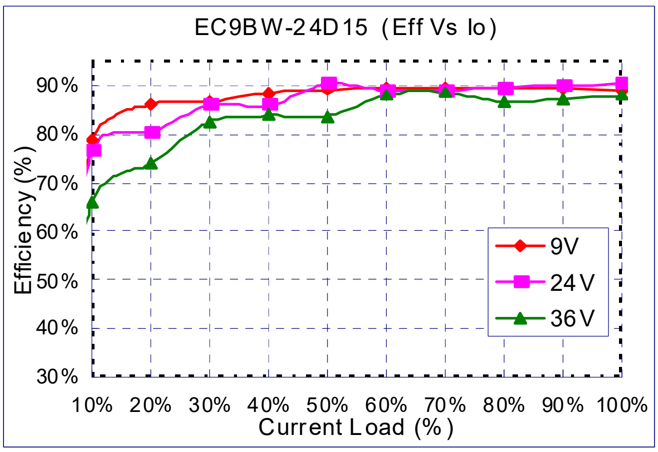












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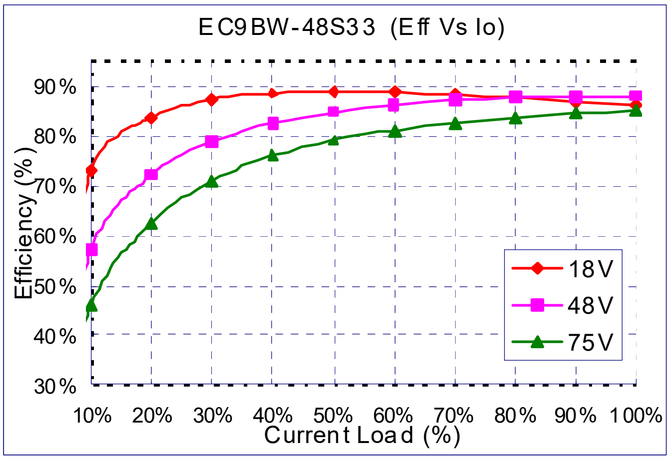
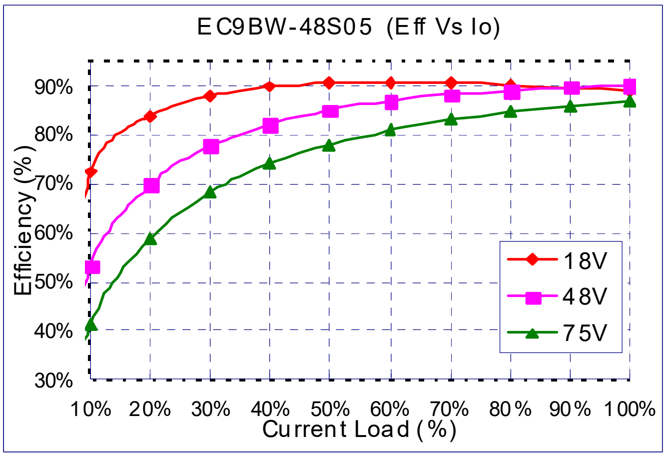
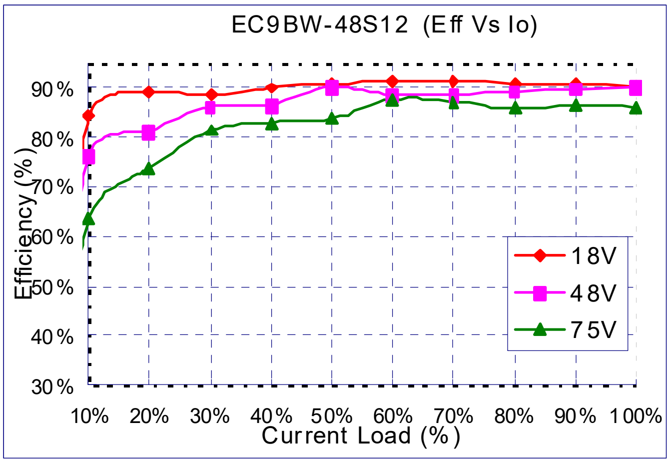
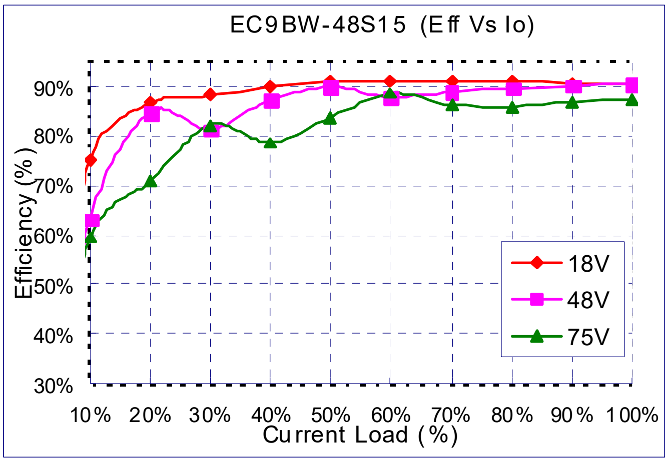
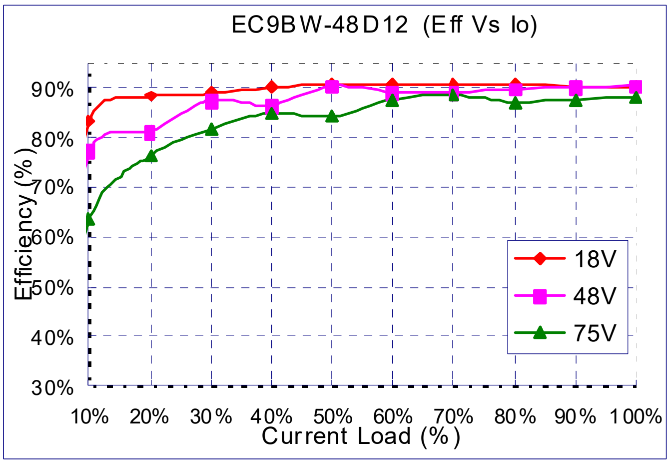
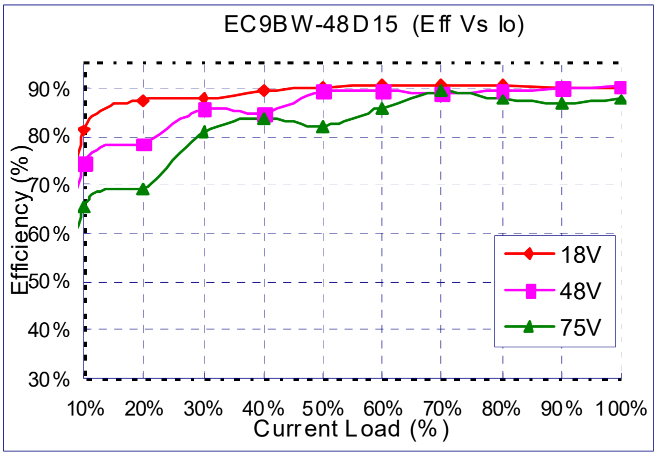






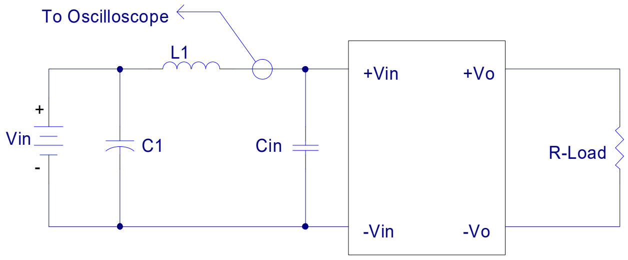






6.4 Input Capacitance at the Power Module

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 Figure 5 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

Figure 5 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 Figure 6. 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.

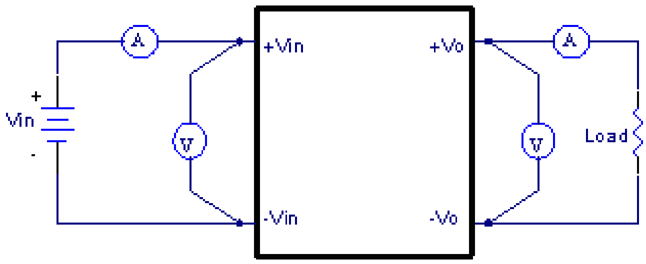


Figure 6 EC9BW Series Test Setup

6.6 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 and between trim pin and +Vo for trim-down. The output voltage trim range is ±10%. (Single output models only) This is shown in Figure 7 and 8:

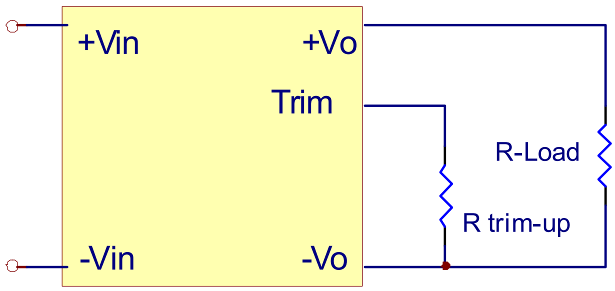


Figure 7 Trim-up Voltage Setup

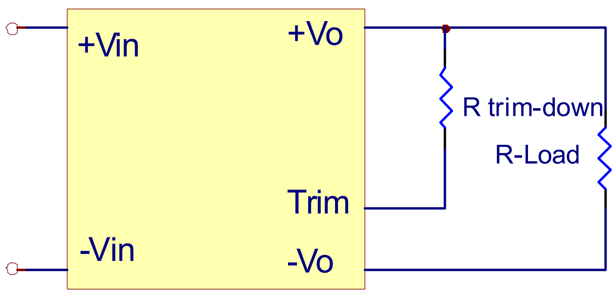


Figure 8 Trim-down Voltage Setup

1. The value of $R_{trim-up}$ defined as:

$$R_{trim-up} = \left(\frac{V_r \times R1 \times (R2 + R3)}{(Vo - V_{o,nom}) \times R2}\right) - Rt \quad (K\Omega)$$

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)
EC9BW24S03 EC9BW48S03	3.3	2.74	1.8	0.27	9.1	1.24
EC9BW24S05 EC9BW48S05	5.0	2.32	2.32	0	8.2	2.5
EC9BW24S12 EC9BW48S12	12.0	6.8	2.4	2.32	22	2.5
EC9BW24S15 EC9BW48S15	15.0	8.06	2.4	3.9	27	2.5

For example, to trim-up the output voltage of 5.0V module (EC9BW-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

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

2.The value of $R_{trim-down}$ defined as:

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

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 (EC9BW-24S05) 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

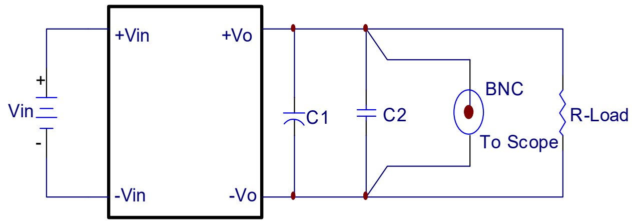
Rt = 8.2 KΩ

Vr= 2.5 V

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

6.7 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure 9. 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 5Hz to 20MHz bandwidth.



Note:

C1: none

C2: 0.1uF ceramic capacitor

Figure 9 Output Voltage Ripple and Noise Measurement Set-Up

6.8 Output Capacitance

The EC9BW 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 EC9BW 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 6A for 24Vin models and 3A for 48Vin modules. Figure 10 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.

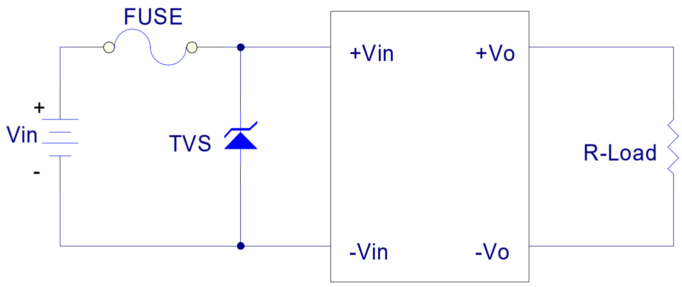


Figure 10 Input Protection

7.2 EMC Considerations

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

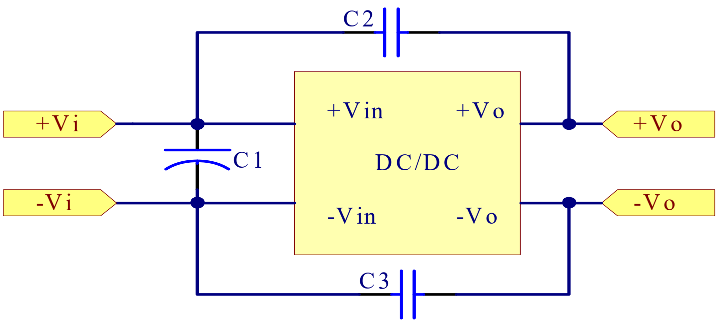


Figure 11 Connection circuit for conducted EMI testing

EN55022 class A							
Model No.	C1	C2	C3	Model No.	C1	C2	C3
EC9BW-24S33	4.7uF/50V 1812	1000pF/3KV 1808	NC	EC9BW-48S33	2.2uF/100V 1812	1000pF/3KV 1808	NC
EC9BW-24S05				EC9BW-48S05			
EC9BW-24S12				EC9BW-48S12			
EC9BW-24S15				EC9BW-48S15			
EC9BW-24D12				EC9BW-48D12			
EC9BW-24D15				EC9BW-48D15			

Note: All of capacitors are ceramic ones.

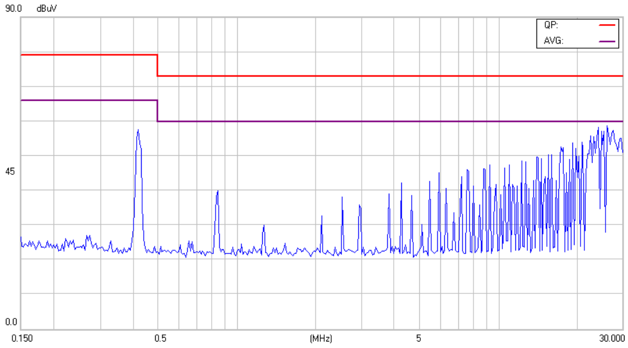


Figure 12 Conducted Class A of EC9BW-24S33

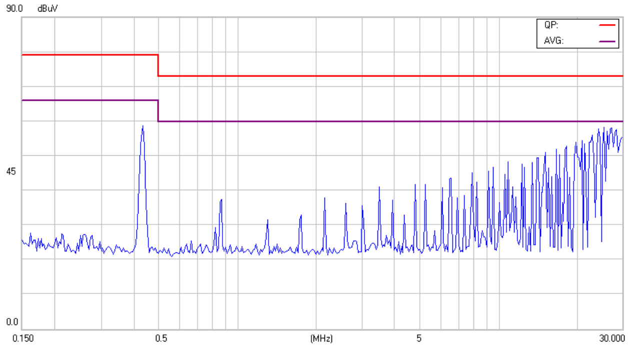


Figure 13 Conducted Class A of EC9BW-24S05

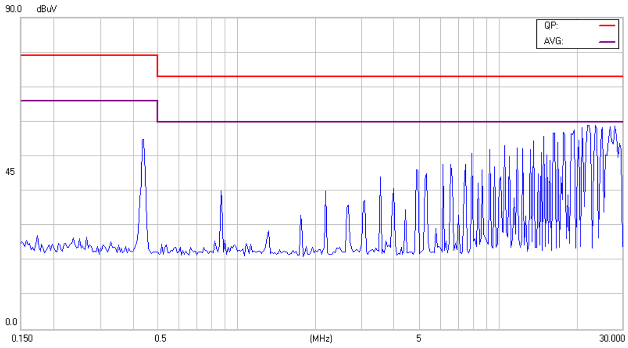


Figure 14 Conducted Class A of EC9BW-24S12

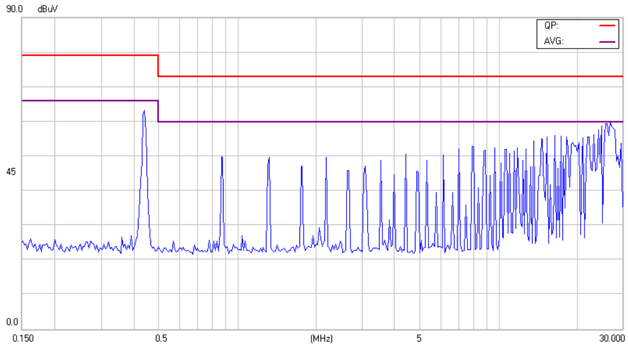


Figure 15 Conducted Class A EC9BW-24S15

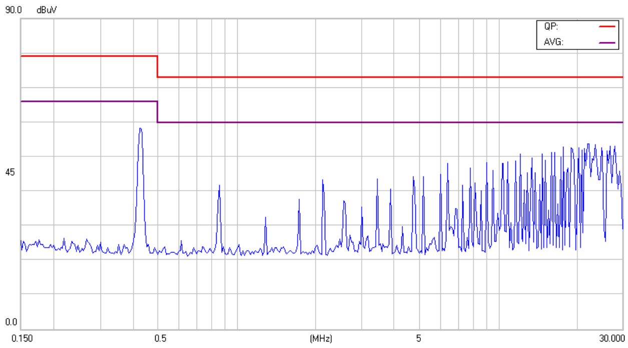


Figure 16 Conducted Class A of EC9BW-24D12

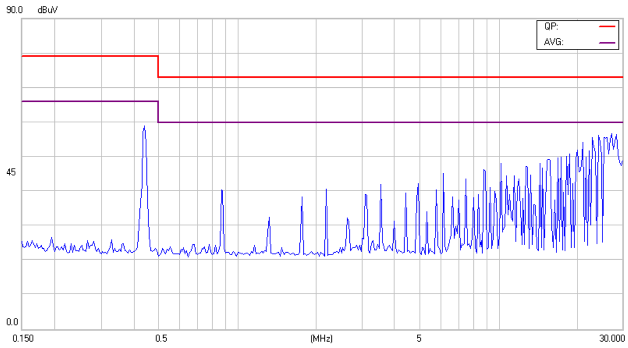


Figure 17 Conducted Class A of EC9BW-24D15

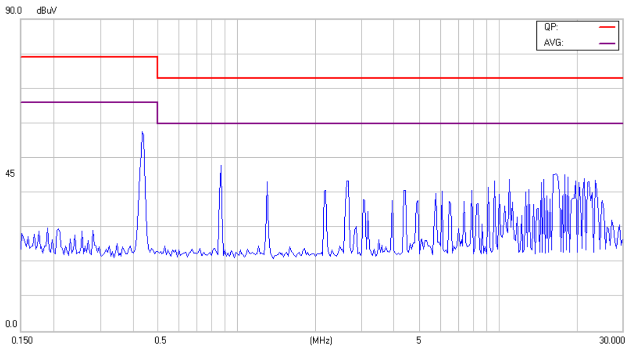


Figure 18 Conducted Class A of EC9BW-48S33

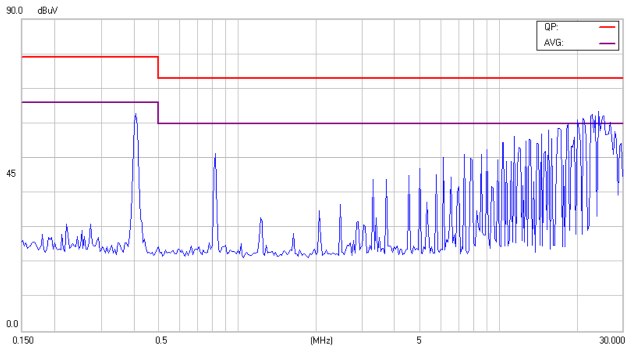


Figure 19 Conducted Class A of EC9BW-48S05

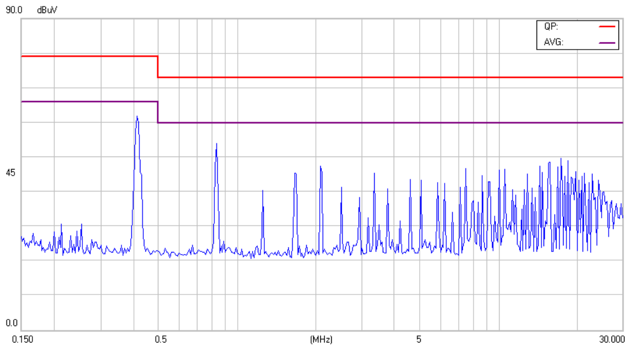


Figure 20 Conducted Class A of EC9BW-48S12

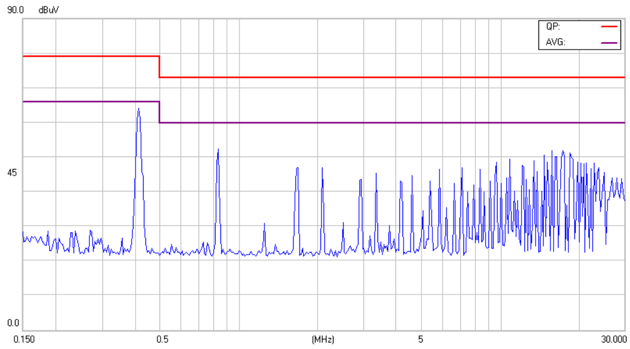


Figure 21 Conducted Class A of EC9BW-48S15

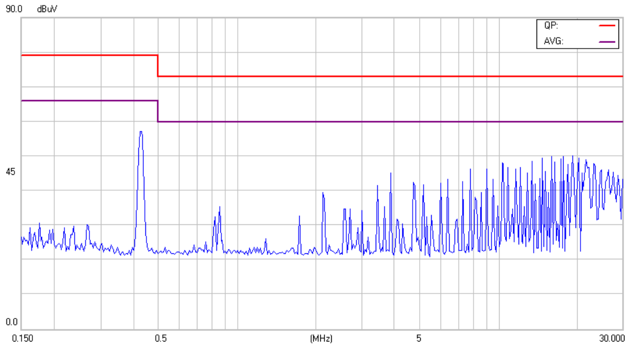


Figure 22 Conducted Class A of EC9BW-48D12

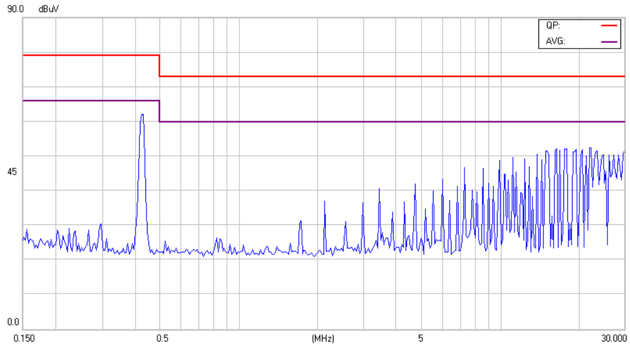
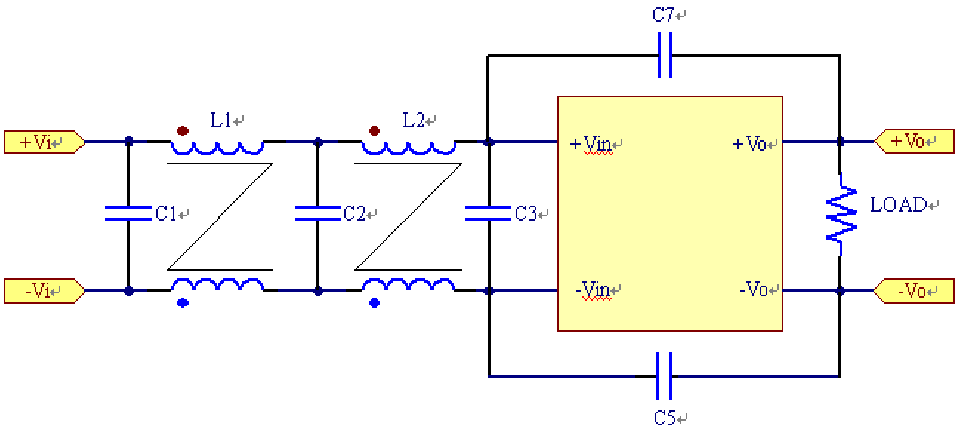
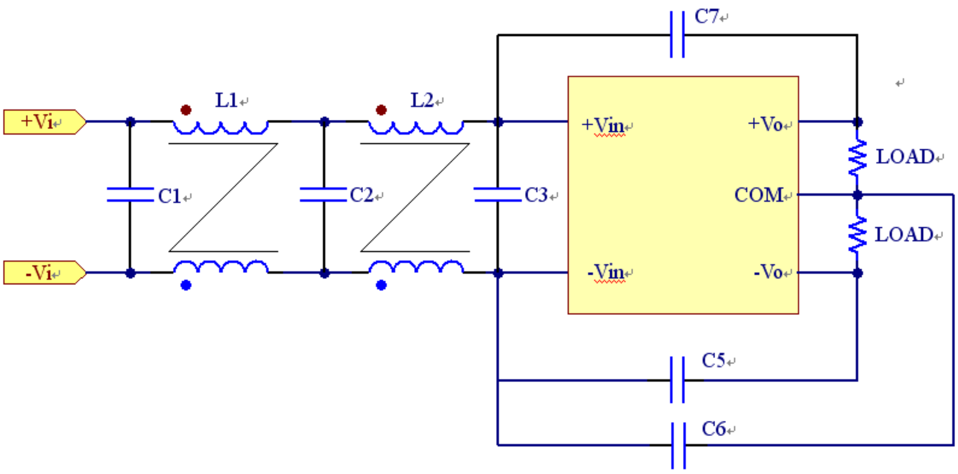


Figure 23 Conducted Class A of EC9BW-48D15

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



Single Output



Dual Output

Figure 12 Connection circuit for conducted EMI testing

EN55022 class B								
Model No.	C1	L1	C2	L2	C3	C5	C6	C7
EC9BW-24S33	4.7uF/50V 1812	450uH Common Choke	4.7uF/50V 1812	150uH Common Choke	4.7uF/50V 1812	1000pF /2000V 1206	NC	1000pF /2000V 1206
EC9BW-24S05								
EC9BW-24S12								
EC9BW-24S15								
EC9BW-24D12								
EC9BW-24D15								

Note: All of capacitors are ceramic ones.

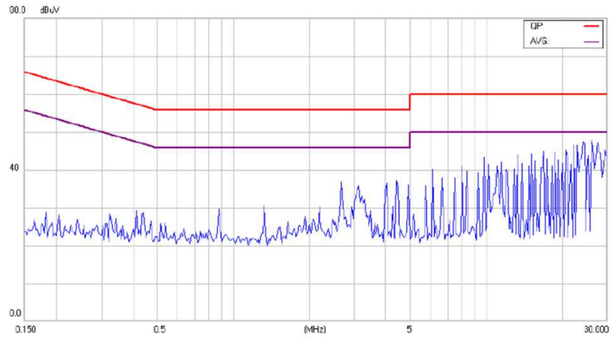


Figure 12 Conducted Class B of EC9BW-24S33

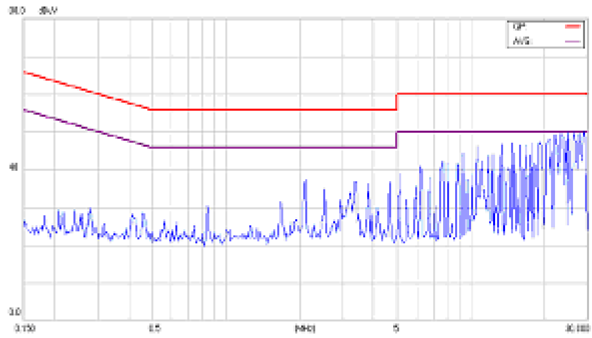


Figure 13 Conducted Class B of EC9BW-24S05

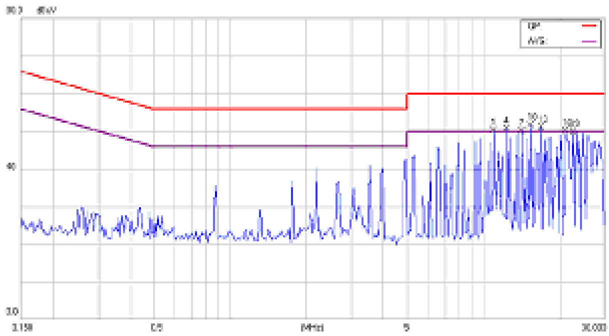


Figure 14 Conducted Class B of EC9BW-24S12

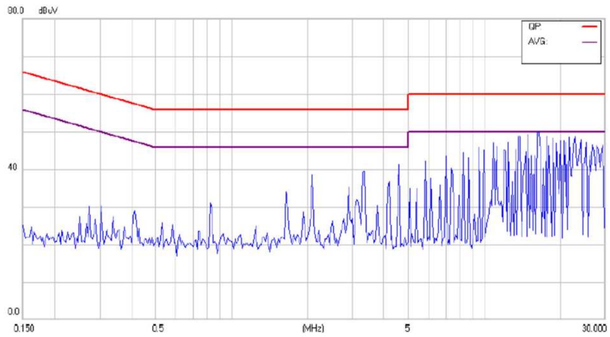


Figure 15 Conducted Class B EC9BW-24S15

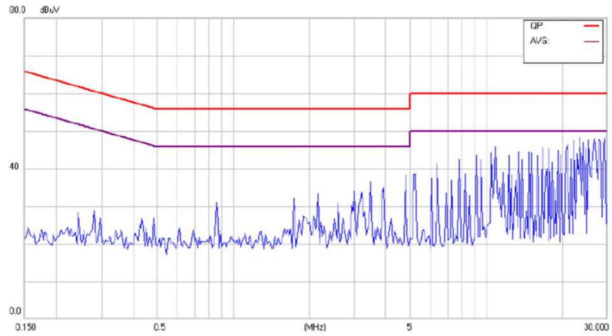


Figure 16 Conducted Class B of EC9BW-24D12

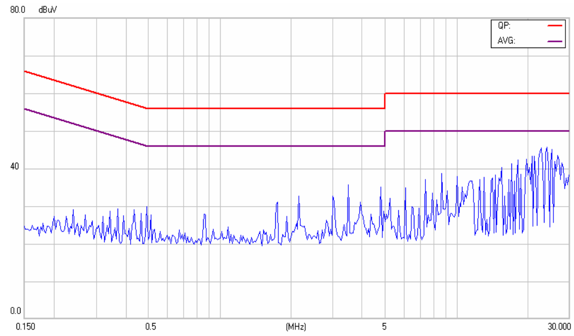


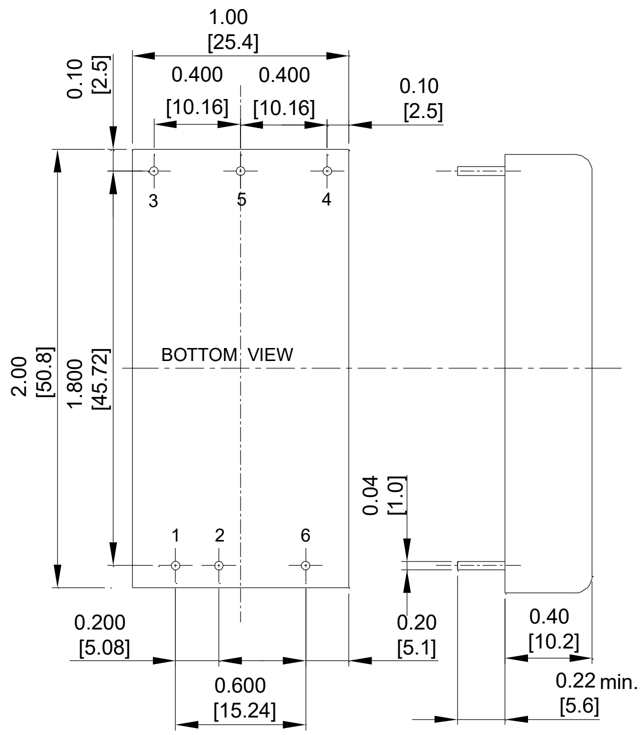
Figure 17 Conducted Class B of EC9BW-24D15

8. Part Number

EC9BW – XX X XX

- EC9BW Series
- S : Single Output
  D : Dual Output
- 24 : Nominal Input Voltage 24VDC
  48 : Nominal Input Voltage 48VDC
- 33 : Output Voltage 3.3 VDC
  05 : Output Voltage 5 VDC
  12 : Output Voltage 12 VDC
  15 : Output Voltage 15 VDC

9. Mechanical Specifications



PIN CONNECTION		
Pin	Single	Dual
1	+V Input	+V Input
2	-V Input	-V Input
3	+V Output	+V Output
4	Trim	-V Output
5	-V Output	Common
6	Remote On/Off	

NOTE: Pin Size is 0.04±0.004 Inch (1.0±0.1 mm)DIA
All Dimensions In Inches (mm)
Tolerances Inches: X.XX= ±0.02 , X.XXX= ±0.010
Millimeters: X.X= ±1.0, X.XX= ±0.25

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