ISOLATED DC-DC Converter
EC5BU SERIES
APPLICATION NOTE

Approved By:

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Content

EC5BU 15W Isolated DC-DC Converters

Application Note V11 January 2015

1. Introduction

The EC5BU series offer 15 watts of output power in a 2.00x1.00x0.4 inches Copper packages. The EC5BU series has a 2:1 wide input voltage range of 9-18, 18-36 and 36-75VDC 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 78 °C). The features include short circuit protection and remote on/off control. 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 90%

* 2:1 Input Range

* Regulated Outputs

* Fixed Switching Frequency

* Input under-voltage Protection

* Over Current Protection

* Remote On/Off

* Continuous Short Circuit Protection

*Conductive EMI Meets EN55022 Class A

*Without Tantalum Capacitors Inside

3. Electrical Block Diagram

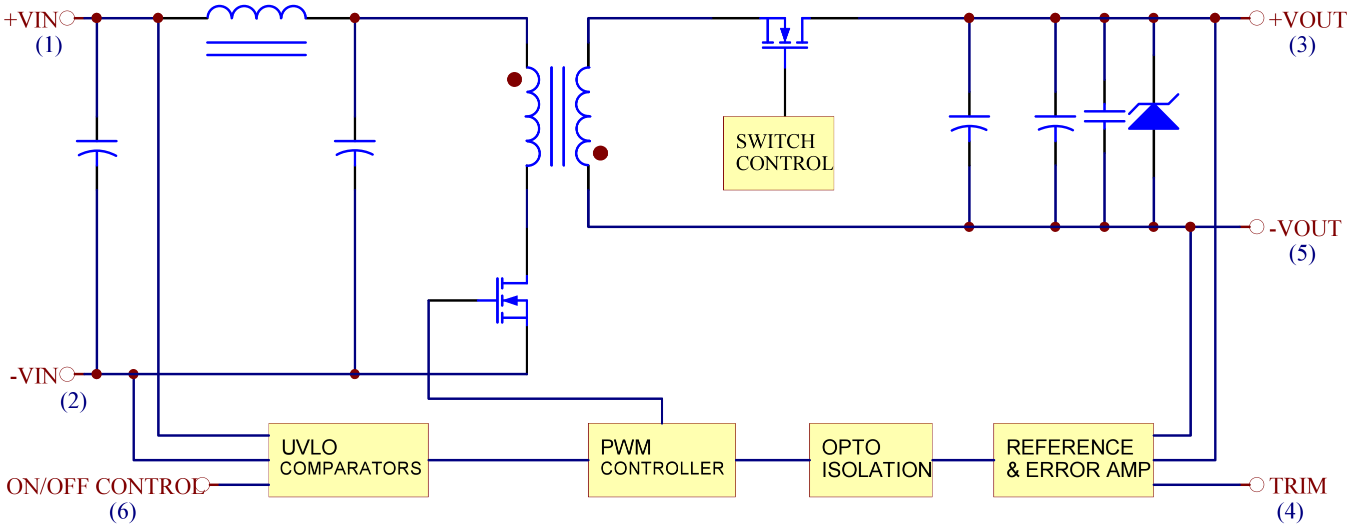


Figure 1 Electrical Block Diagram for Single Output Modules

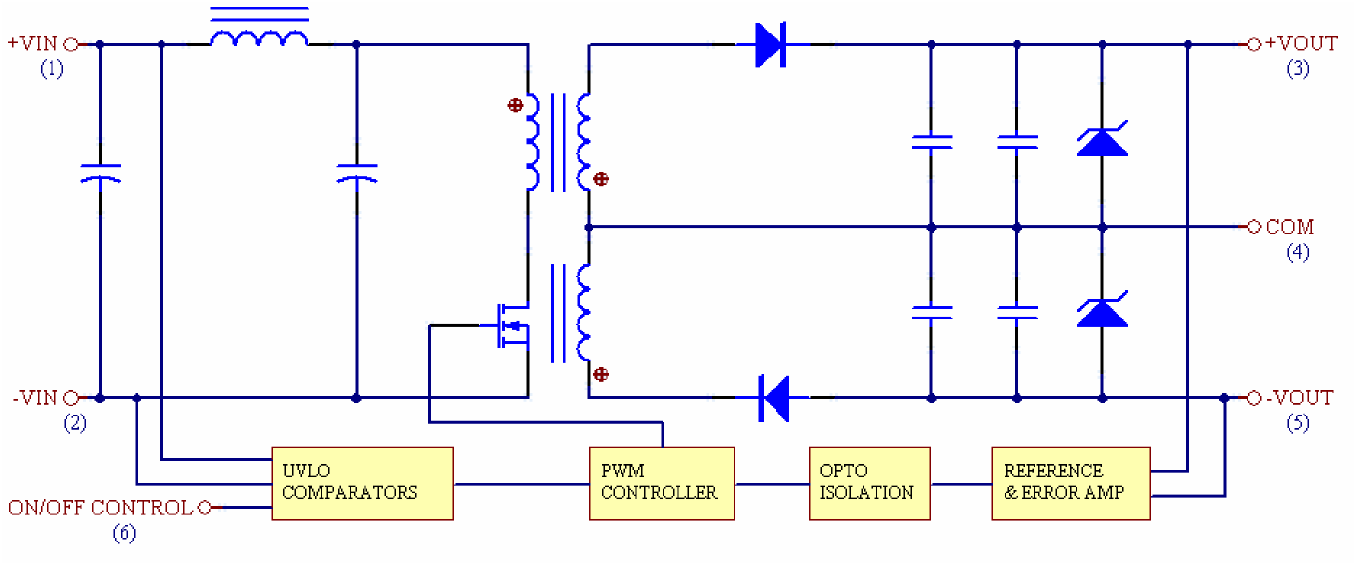


Figure 2 Electrical Block Diagram for Dual Output Modules

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		12Vin	-0.7		18	Vdc
		24Vin	-0.7		36	
		48Vin	-0.7		75	
Transient	100ms	12Vin			25	Vdc
		24Vin			50	
		48Vin			100	
Operating Ambient Temperature	De-rating, 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

PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Operating Input Voltage		12Vin	9	12	18	Vdc
		24Vin	18	24	36	
		48Vin	36	48	75	
Maximum Input Current	100% Load, Vin=9V for 12XXX	12Vin			1960	mA
	100% Load, Vin=18V for 24XXX	24Vin			969	
	100% Load, Vin=36V for 48XXX	48Vin			484	
No-Load Input Current	Vin=Nominal input	12S33		90		mA
		12S05		85		
		12S12		70		
		12S15		70		
		12D05		45		
		12D12		45		
		12D15		45		
		24S33		50		
		24S05		50		
		24S12		20		
		24S15		20		
		24D05		25		
		24D12		25		
		24D15		25		
		48S33		25		
		48S05		30		
		48S12		20		
		48S15		20		
		48D05		20		
		48D12		20		
		48D15		20		

Turn-On Voltage Threshold		12Vin		8.4		Vdc
		24Vin		17		
		48Vin		34		
Turn-Off Voltage Threshold		12Vin		8		Vdc
		24Vin		16		
		48Vin		32		
Lockout Hysteresis Voltage		12Vin		0.6		
		24Vin		0.5		
		48Vin		1		
Inrush Current (I^2t)		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	Vin=Nominal Vin , Io=Io.max, Tc=25℃	Vo=3.3V	3.2505	3.3	3.3495	Vdc
		Vo=5.0V	4.925	5.0	5.075	
		Vo=12V	11.82	12	12.18	
		Vo=15V	14.77	15	15.225	
		Vo=±5V	4.925	5.0	5.075	
		Vo=±12V	11.82	12	12.18	
		Vo=±15V	14.77	15	15.225	
Output Voltage Regulation						
Load Regulation	Io=Io.min to Io.max	Single			±0.2	%
		Dual			±1.0	
Line Regulation	Vin=low line to high line	Single			±0.2	%
		Dual			±0.5	
Temperature Coefficient	TC=-40℃ to 85℃				±0.03	%/℃
Output Voltage Ripple and Noise	20MHz bandwidth					
Peak-to-Peak	Full Load	All			100	mV
Operating Output Current Range		Vo=3.3V			4	A
		Vo=5.0V			3	
		Vo=12V			1.25	
		Vo=15V			1	
		Vo=±5V			±1.5	
		Vo=±12V			±0.625	
		Vo=±15V			±0.5	
Output DC Current-Limit Inception	Output Voltage =90% $Vo_{nominal}$		110	130	140	%
Maximum Output Capacitance	Full load, Resistance	Vo=3.3V			4000	uF
		Vo=5.0V			3000	
		Vo=12V			1330	
		Vo=15V			1000	
		Vo=±5V			1470	
		Vo=±12V			660	
		Vo=±15V			550	
DYNAMIC CHARACTERISTICS						
PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Output Voltage Current Transient	0.1A/us					
Step Change in Output Current	50% to 75% and 75% to 100% of Io.max				±4	%
Setting Time (within 1% $Vo_{nominal}$)	di/dt=0.1A/us				500	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		5		ms

EFFICIENCY

PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
100% Load		12S33		85		%
		12S05		88		
		12S12		88		
		12S15		88		
		12D05		85		
		12D12		87		
		12D15		88		
		24S33		86		
		24S05		89		
		24S12		90		
		24S15		90		
		24D05		86		
		24D12		88		
		24D15		89		
		48S33		86		
		48S05		88		
		48S12		90		
		48S15		90		
		48D05		86		
		48D12		88		
		48D15		89		

ISOLATION CHARACTERISTICS

PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Input to Output	1 minutes				1500	Vdc
Isolation Resistance		All			1000	MΩ
Isolation Capacitance		All		1000		pF

FEATURE CHARACTERISTICS

PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Switching Frequency				350		KHz
ON/OFF Control , Positive Remote On/Off logic						
Logic Low (Module Off)	Von/off at Ion/off=1.0mA				1.2	V
Logic High (Module On)	Von/off at Ion/off=0.1uA		5.5 or open circuit		75	V
On/Off Control, Negative Remote On/Off logic				N/A		
Logic High (Module On)	Von/off at Ion/off=1.0mA			N/A		V
Logic Low (Module Off)	Von/off at Ion/off=0.0uA			N/A		V

On/Off Current (for both remote on/off logic)	Ion/off at Von/off=0.0V				1	mA
Leakage Current (for both remote on/off logic)	Logic High, Von/off=15V				100	uA
Off Converter Input Current	Shutdown input idle current	12Vin		10	16	mA
		24Vin 48Vin		5	10	mA
Output Voltage Trim Range	Pout=max rated power		-10		+10	%
Output Over Voltage Protection		Vo=3.3V Vo=5.0V Vo=12V Vo=15V Vo=±5V Vo=±12V Vo=±15V		3.9 6.2 15 18 ±6.2 ±15 ±18		V
Over-Temperature Shutdown				N/A		℃

GENERAL SPECIFICATIONS

PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
MTBF	Io=100%of Io.max;Ta=25℃ per MIL-HDBK-217F			1.2		M hours
Weight				35		grams

5. Main Features and Functions

5.1 Operating Temperature Range

The EC5BU 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 Over Current Protection

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

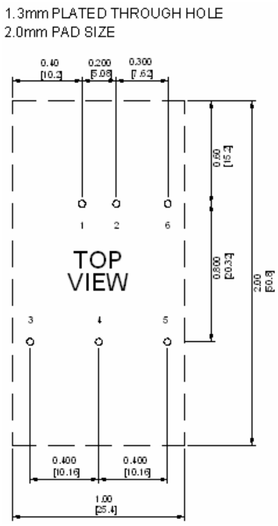
5.3 Remote On/Off

The EC5BU 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” versions. The converter turns on if the remote on/off pin is high (>5.5Vdc to 75Vdc 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).

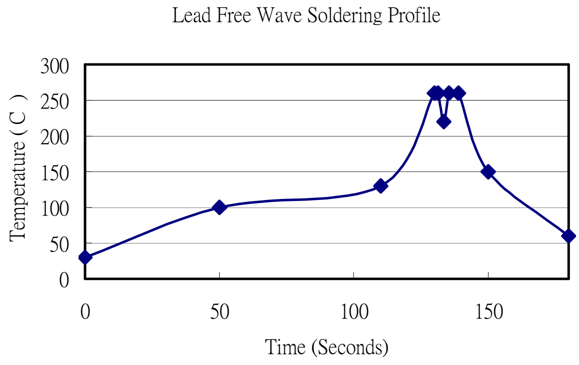
6. Applications

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 Figure 3.



Note: Dimensions are in inches (millimeters)



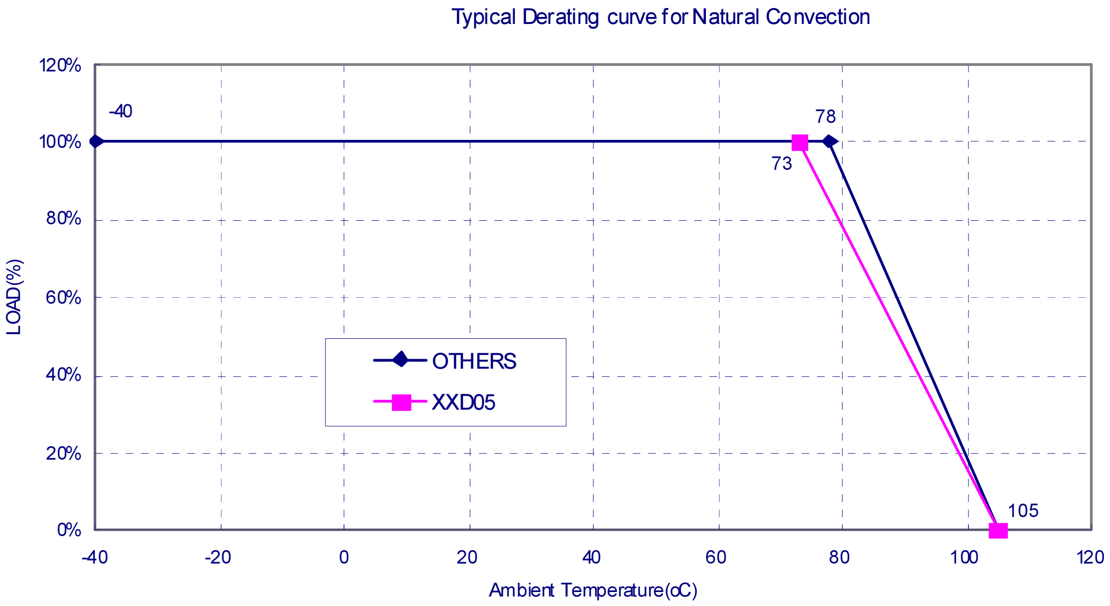
Note：

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℃)

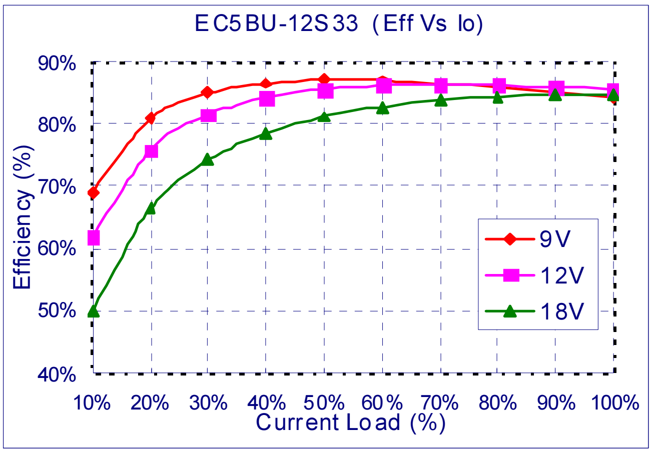
Figure3 Recommended PCB Layout Footprints and Wave Soldering Profiles for SB packages

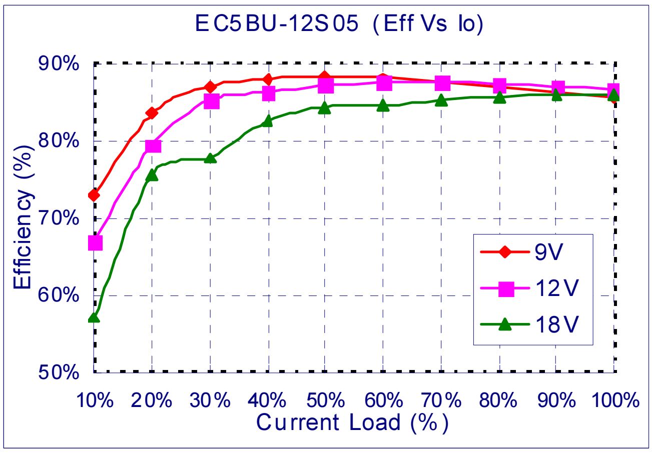
6.2 Power De-Rating Curves for EC5BU Series

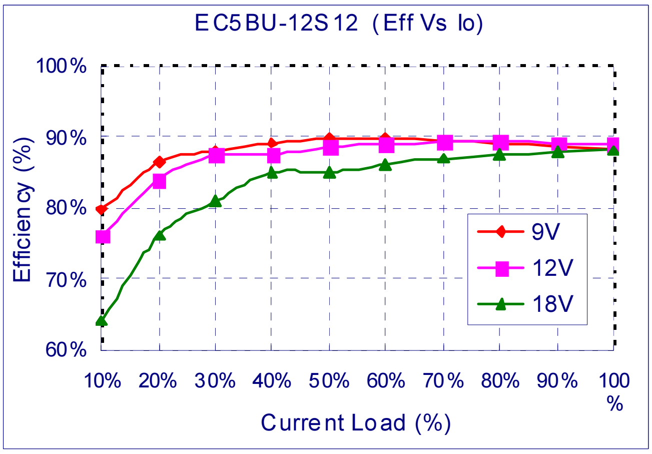
Operating Ambient temperature Range: -40℃ ~ 85℃ without de-rating.
Maximum case temperature under any operating condition should not exceed 105℃.

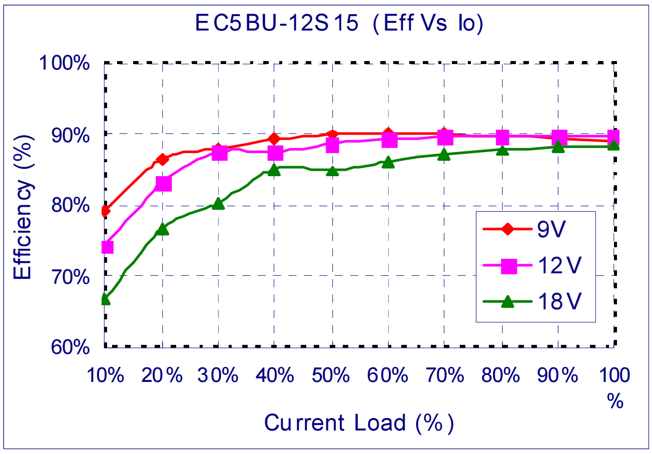


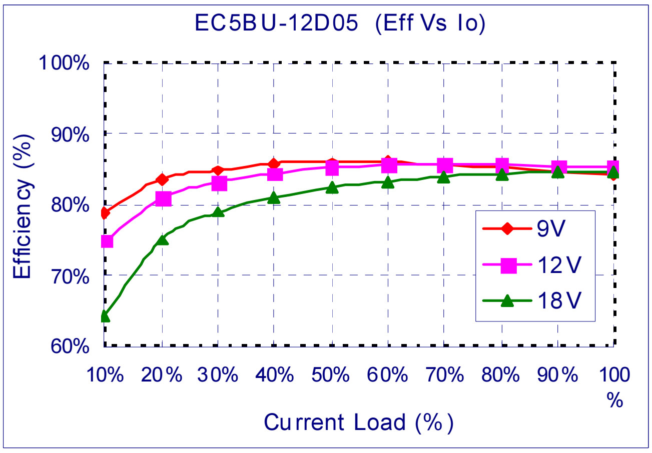
6.3 Efficiency vs. Load Curves

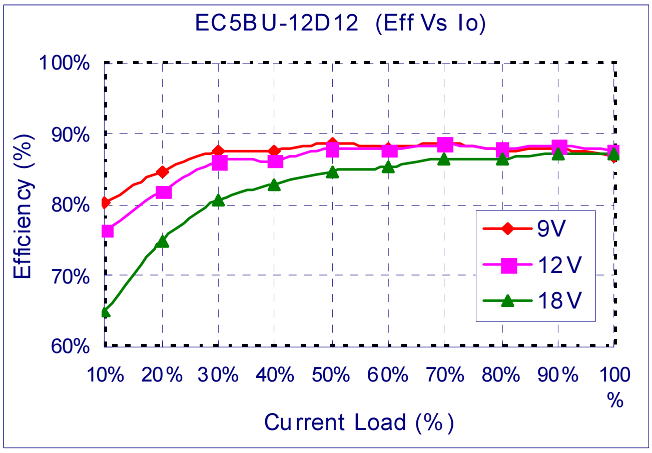


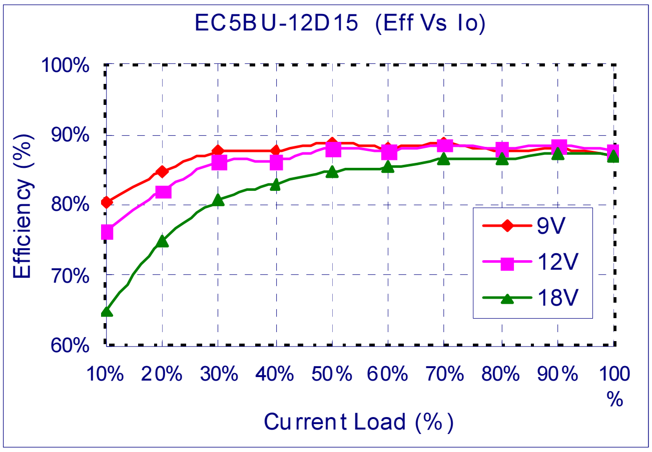


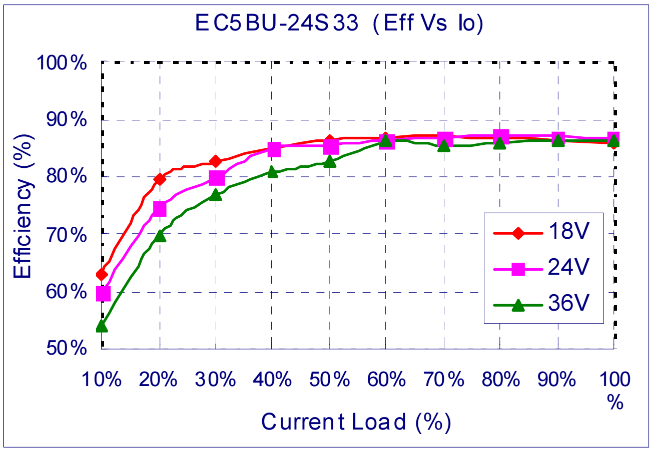


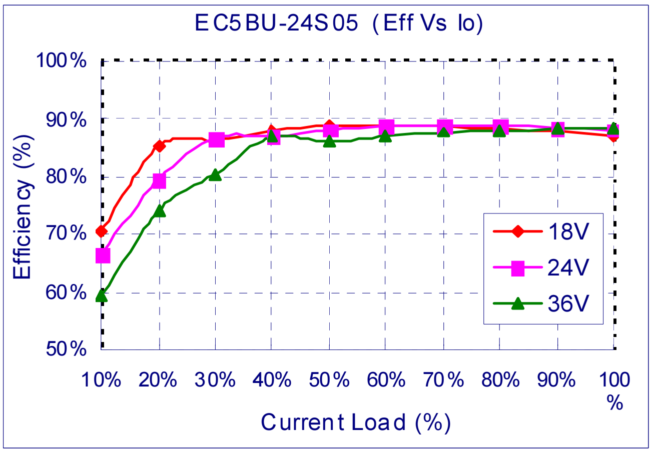


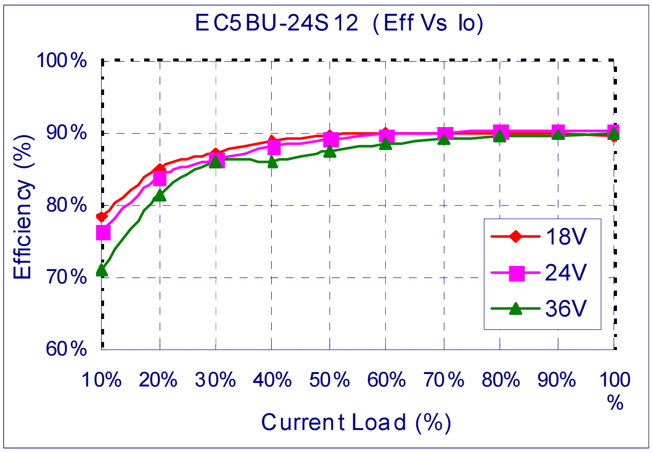


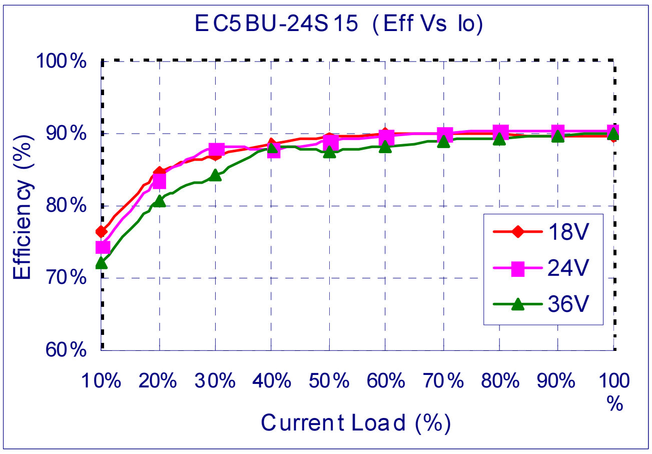


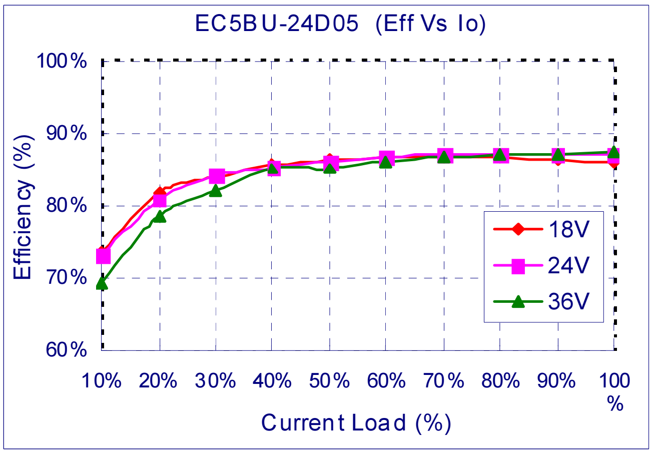

EC5BU-12D15 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100 %
Current Load (%)
9V
12V
18V

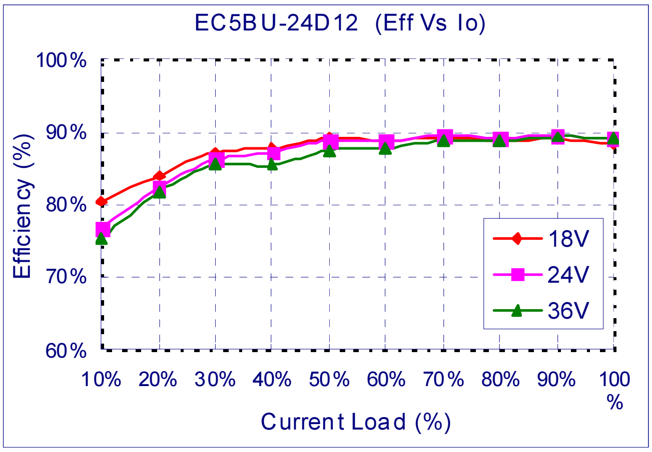

EC5BU-24S33 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100 %
Current Load (%)
18V
24V
36V

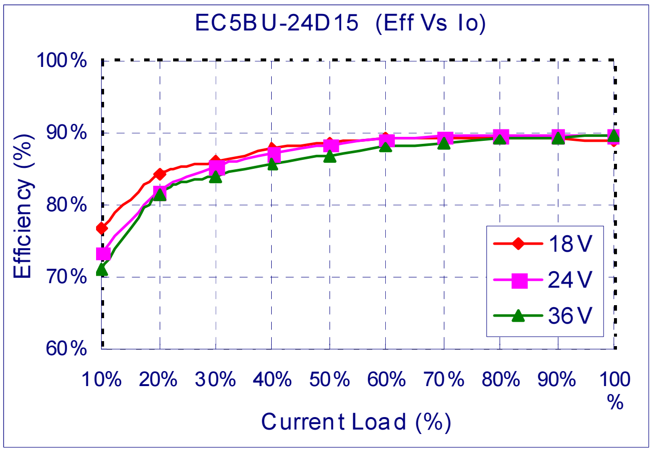

EC5BU-24S05 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100 %
Current Load (%)
18V
24V
36V

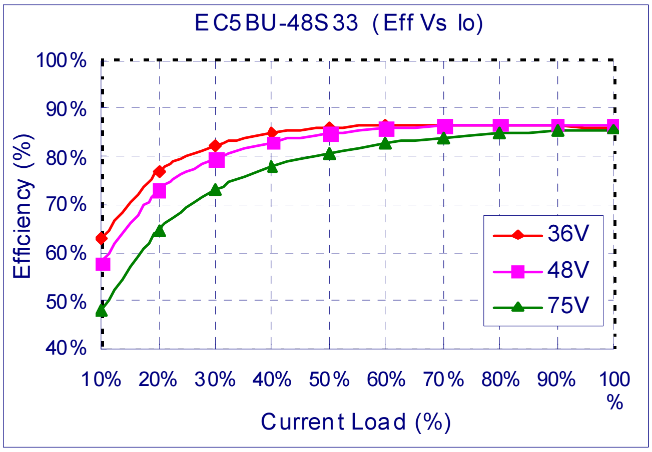

EC5BU-24S12 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100 %
Current Load (%)
18V
24V
36V

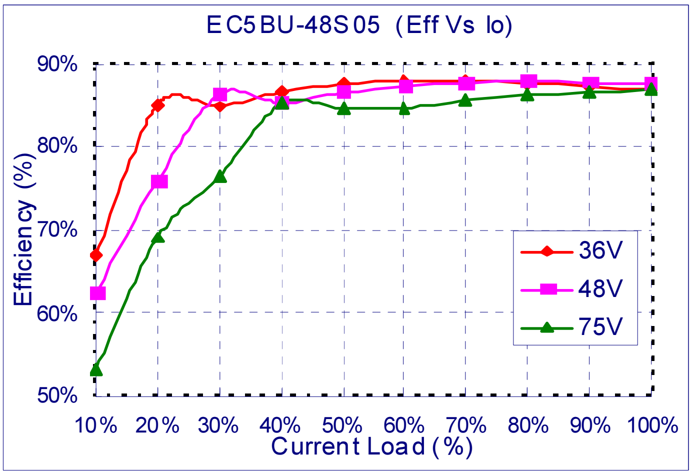

EC5BU-24S15 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100 %
Current Load (%)
18V
24V
36V

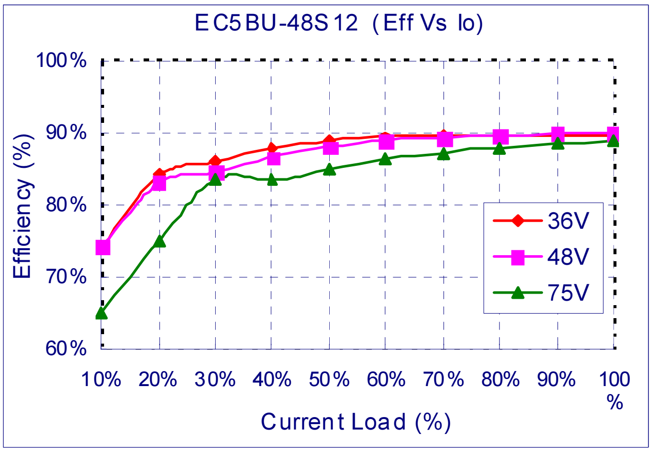

EC5BU-24D05 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100 %
Current Load (%)
18V
24V
36V

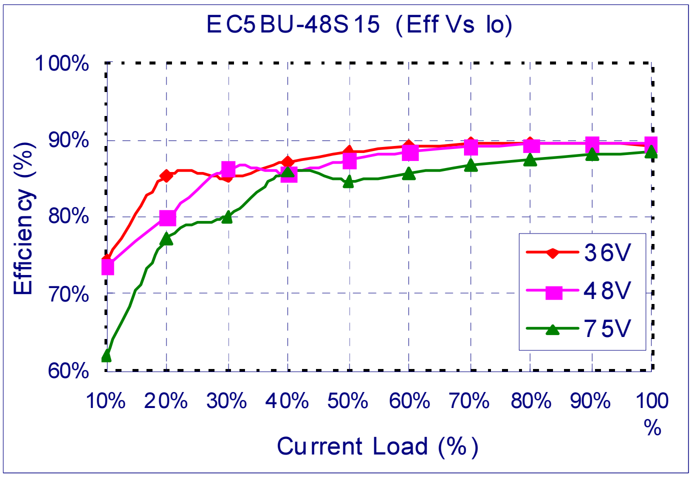

EC5BU-24D12 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
18V
24V
36V

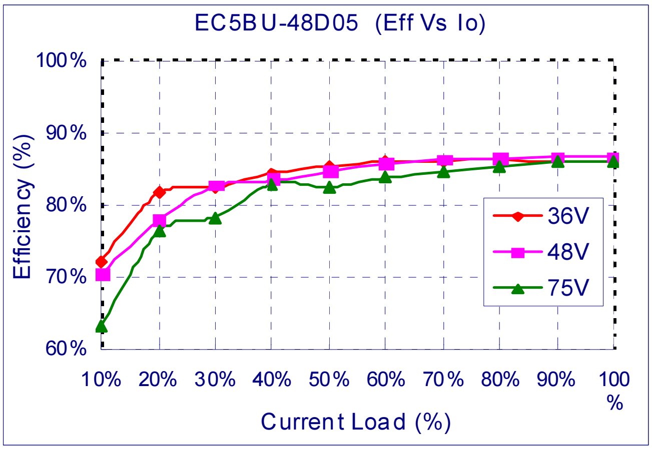

EC5BU-24D15 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
18V
24V
36V

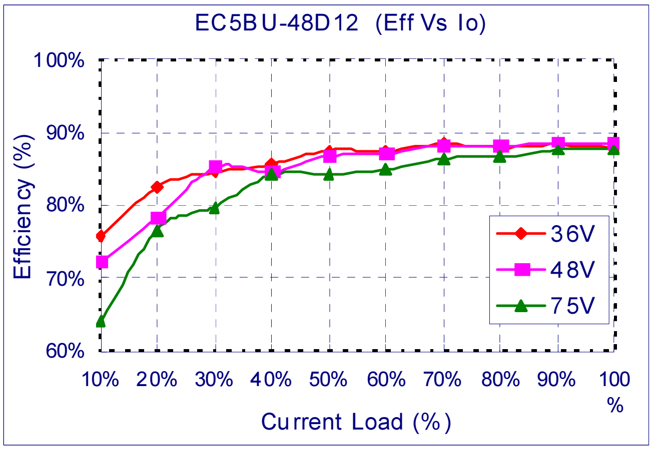

EC5BU-48S33 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
36V
48V
75V

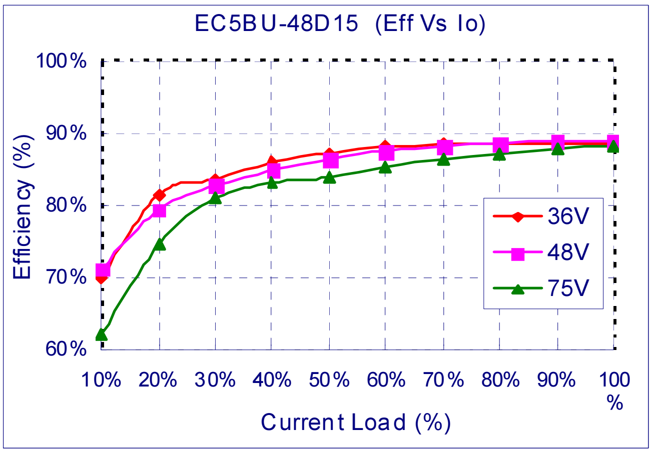

EC5BU-48S05 (Eff Vs Io)
Efficiency (%)
90%
80%
70%
60%
50%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
36V
48V
75V


EC5BU-48S12 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
36V
48V
75V


EC5BU-48S15 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
36V
48V
75V

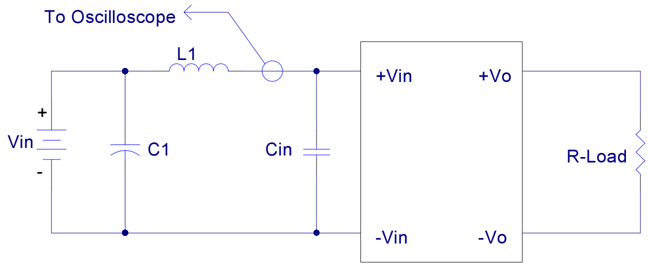

EC5BU-48D05 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
36V
48V
75V


EC5BU-48D12 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
36V
48V
75V


EC5BU-48D15 (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
36V
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 Figure4 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: 10uH
C1: None
Cin: 22uF ESR<0.66ohm @100KHz

Figure4 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 Figure5. 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:

$$\eta = \frac{Vo\times Io}{Vin\times Iin}\times 100\%$$

Where

Vo is output voltage,
Io is output current,
Vin is input voltage,
Iin 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.

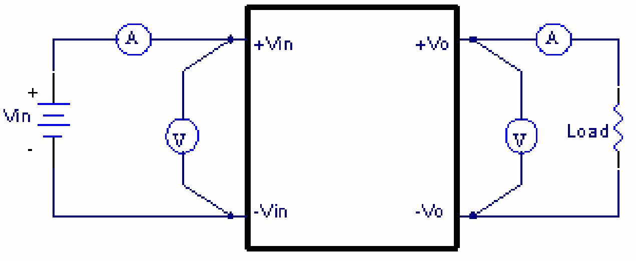


Figure5 EC5BU Series Test Setup

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%. This is shown in Figures 1 and 2:

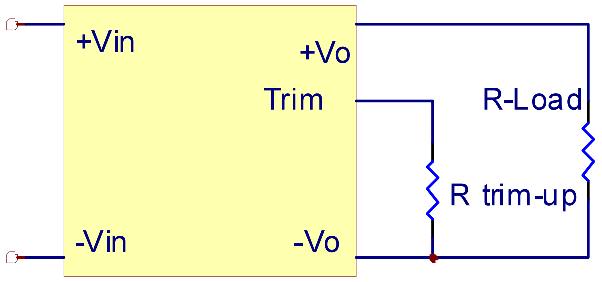


Figure 1 Trim-up Voltage Setup

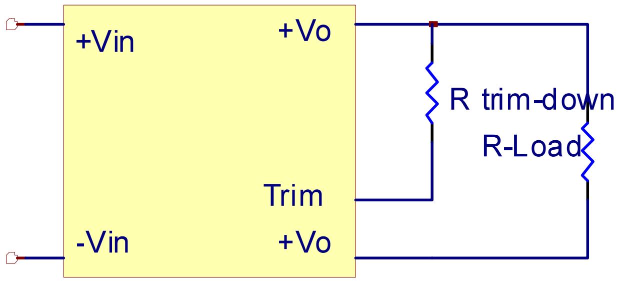


Figure 2 Trim-down Voltage Setup

1. The value of Rtrim-up defined as:

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

Where: R trim-up is the external resistor in Kohm.
Vo,nom is the nominal output voltage.
Vo is the desired output voltage.
R1, Rt, R2, R3 and Vr are internal to the unit and are defined in Table 1.

Model Number	Output Voltage(V)	R1 (Kohm)	R2 (Kohm)	R3 (Kohm)	Rt (Kohm)	Vr
EC5BU-12S33 EC5BU-24S33 EC5BU-48S33	3.3	2.70	1.8	0.27	9.1	1.25
EC5BU-12S05 EC5BU-24S05 EC5BU-48S05	5.0	2.32	2.32	0	8.2	2.5
EC5BU-12S12 EC5BU-24S12 EC5BU-48S12	12.0	6.8	2.4	2.32	22	2.5
EC5BU-12S15 EC5BU-24S15 EC5BU-48S15	15.0	8.06	2.4	3.9	27	2.5

Table 1 – Trim up and Trim down Resistor Values

For example, to trim-up the output voltage of 5.0V module (EC5BU12S05) by 10% to 5.5V, R trim-up is calculated as follows:

Vo – Vo, nom = 5.5 – 5.0 = 0.5V
R1 = 2.32 Kohm
R2 = 2.32 Kohm
R3 = 0 Kohm
Rt = 8.2 Kohm, Vr= 2.5

$$R_{trim-up} = (\frac{2.5 \times 2.32 \times (2.32 + 0)}{0.5 \times 2.32}) - 8.2 = 3.06(\mathrm{K}\Omega)$$

The value of R trim-down defined as:

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

Where: R trim-down is the external resistor in Kohm.
Vo, nom is the nominal output voltage.
Vo is the desired output voltage.
R1, Rt, R2, R3 and Vr are internal to the unit and are defined in Table 1

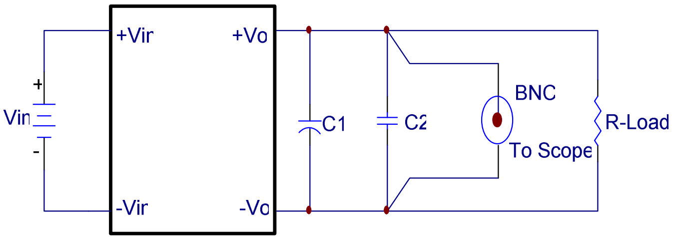
For example, to trim-down the output voltage of 5.0V module (EC5BU12S05) by 10% to 4.5V, R trim-down is calculated as follows:

Vo,nom – Vo = 5.0 – 4.5 = 0.5V
R1 = 2.32 Kohm
R2 = 2.32 Kohm
R3 = 0 Kohm
Rt = 8.2 Kohm, Vr= 2.5

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

6.7 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure6. 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: 10uF tantalum capacitor
C2: 1uF Ceramic capacitor

Figure6 Output Voltage Ripple and Noise Measurement Set-Up

6.8 Output Capacitance

The EC5BU 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 EC5BU 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 12Vin models, 2A for 24Vin models, 1A 48Vin modules. Figure7 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.

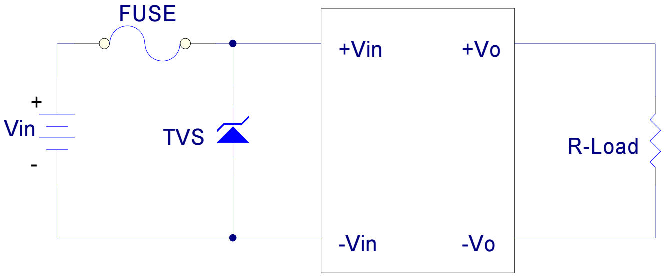


Figure7 Input Protection

7.2 EMC Considerations

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

(1) EMI and conducted noise meet EN55022 Class A

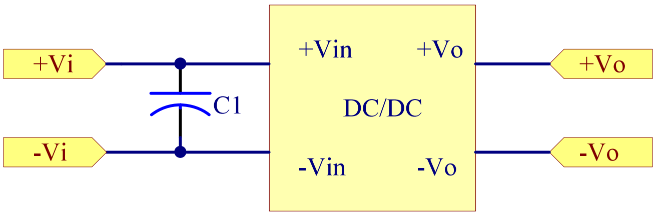


Figure8 Note: To meet EN55022 Class A without capacitor to the input pin.

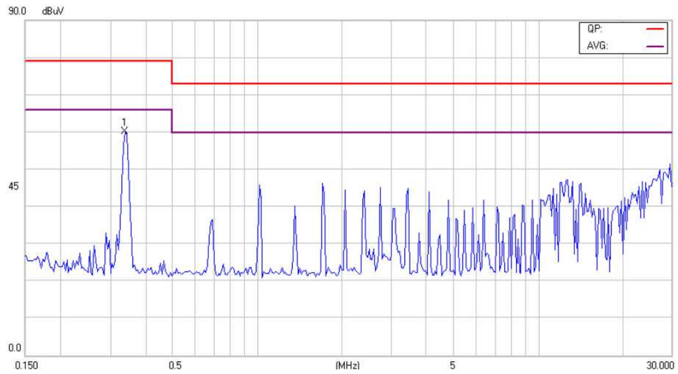


Figure 9 Conducted Class A of EC5BU-12S33

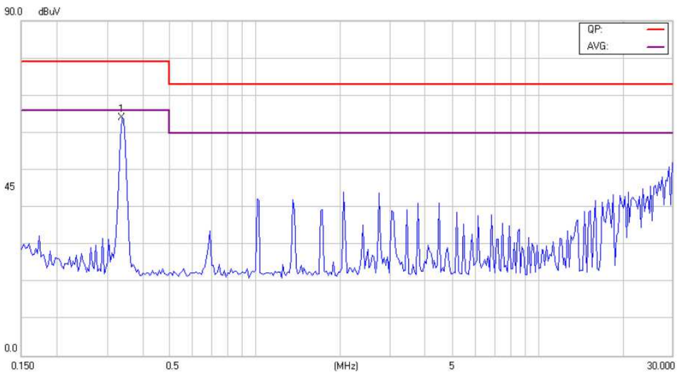


Figure 10 Conducted Class A EC5BU-12S05

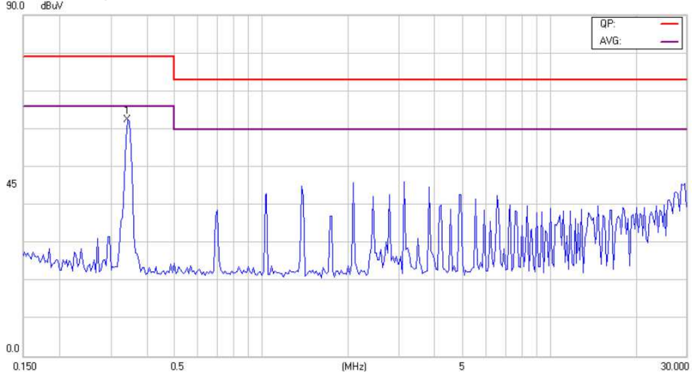


Figure 11 Conducted Class A of EC5BU-12S12

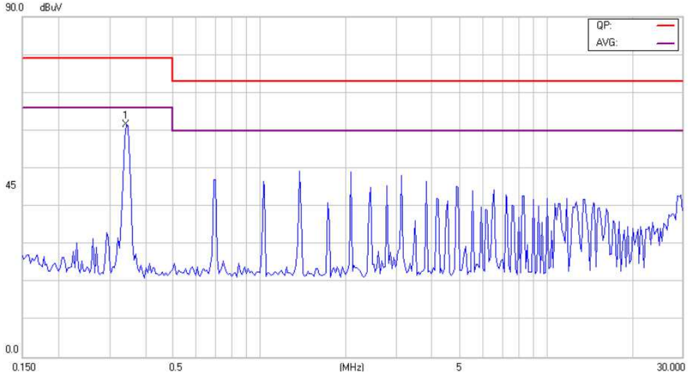


Figure 12 Conducted Class A of EC5BU-12S15

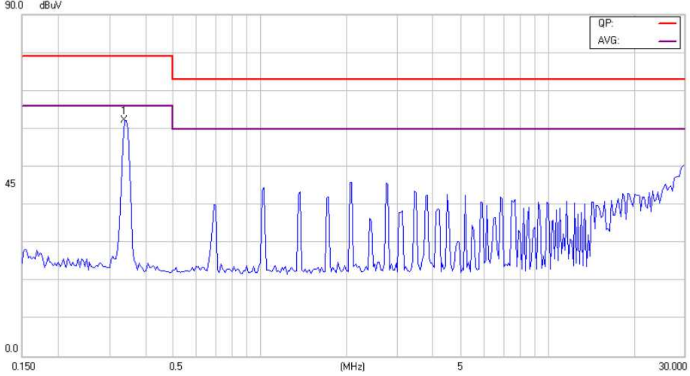


Figure 13 Conducted Class A of EC5BU-12D05

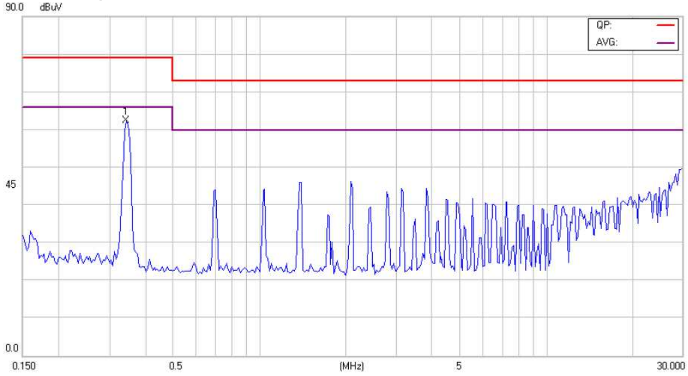


Figure 14 Conducted Class A of EC5BU-12D12

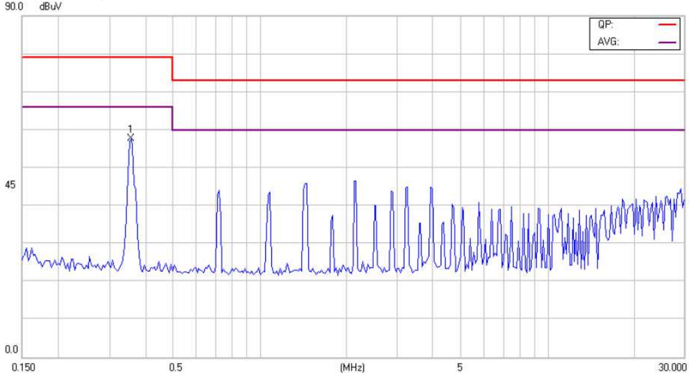


Figure15 Conducted Class A of EC5BU-12D15

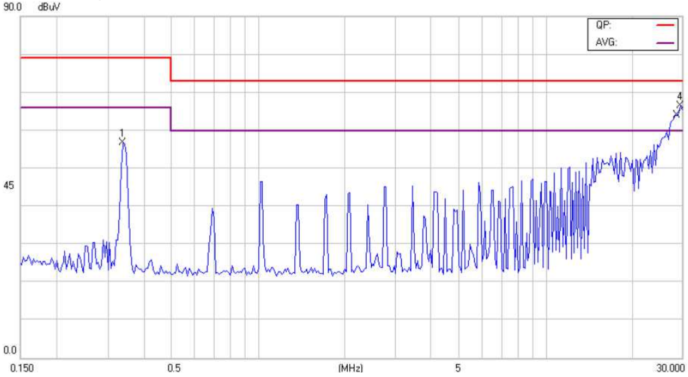


Figure16 Conducted Class A of EC5BU-24S33

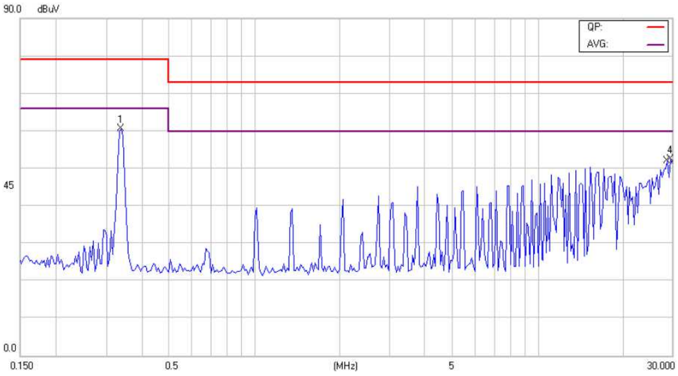


Figure17 Conducted Class A of EC5BU-24S05

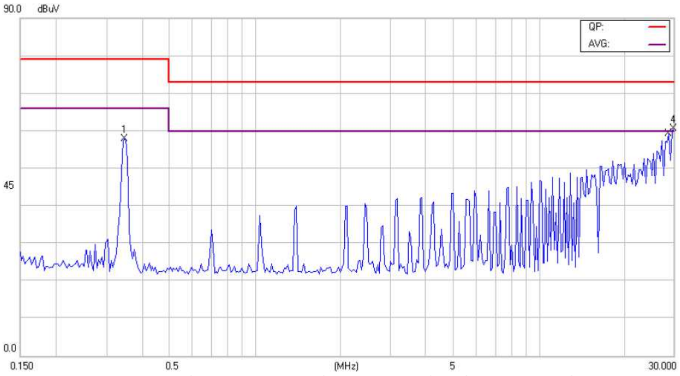


Figure18 Conducted Class A of EC5BU-24S12

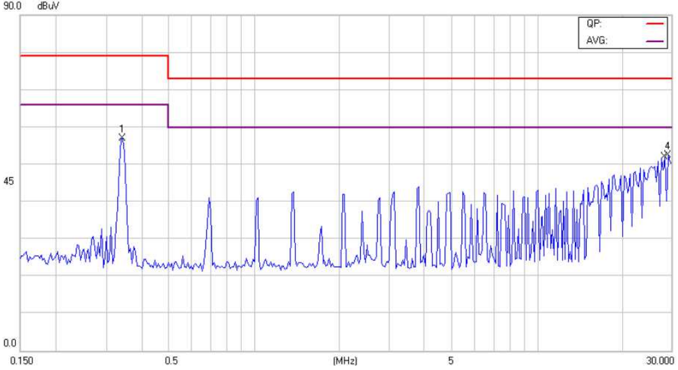


Figure19 Conducted Class A of EC5BU-24S15

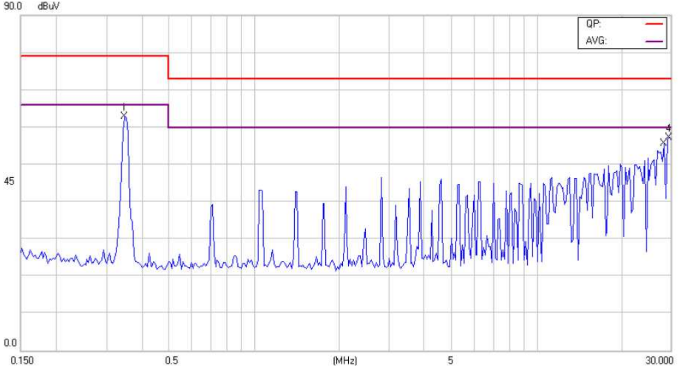


Figure20 Conducted Class A of EC5BU-24D05

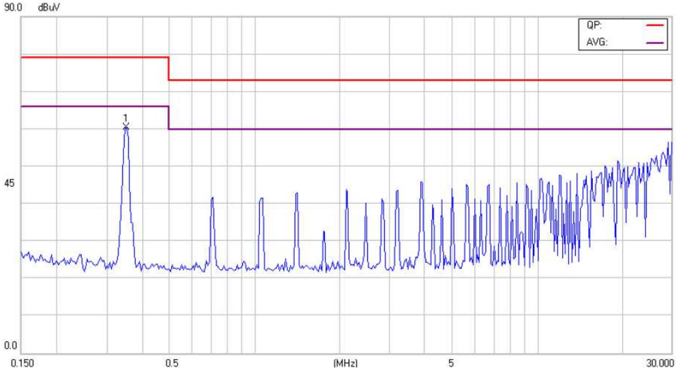


Figure21 Conducted Class A of EC5BU-24D12

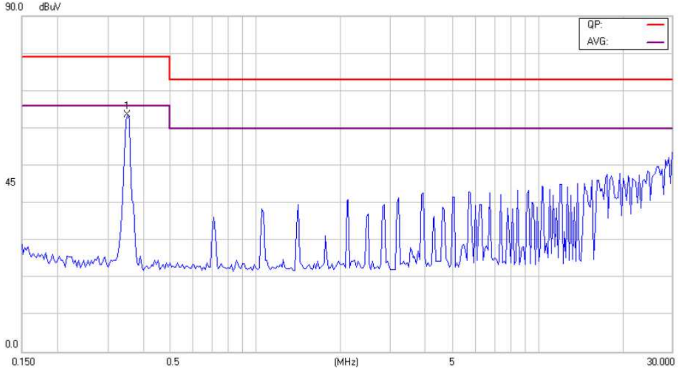


Figure22 Conducted Class A of EC5BU-24D15

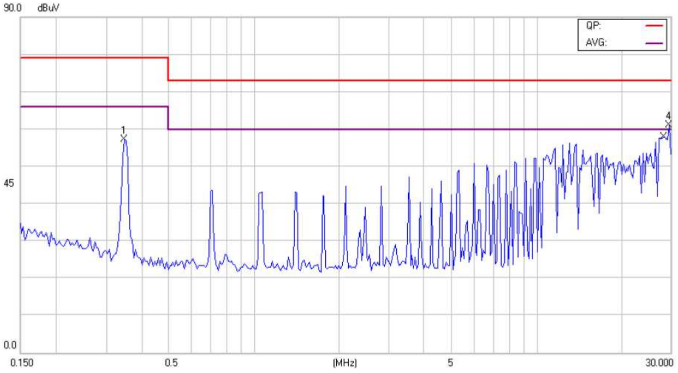


Figure23 Conducted Class A of EC5BU-48S33

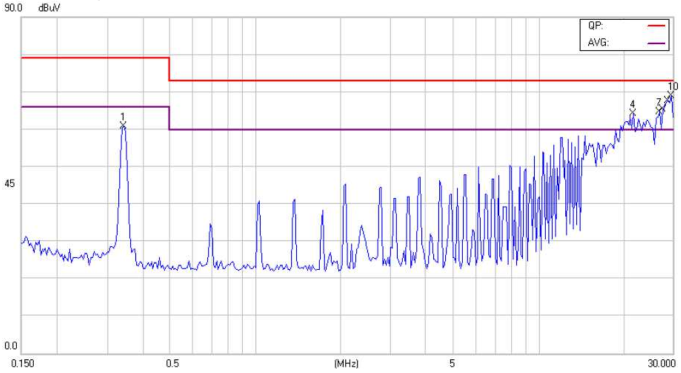


Figure24 Conducted Class A of EC5BU-48S05

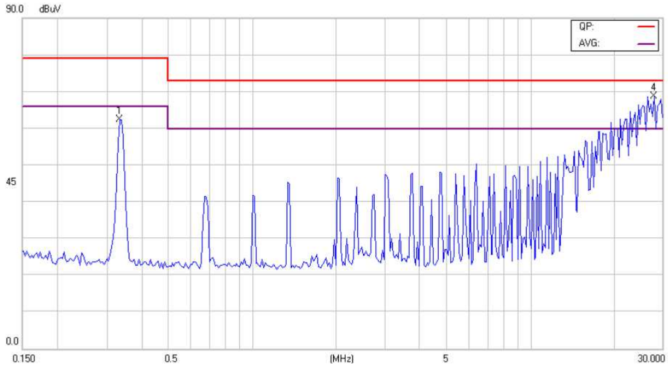


Figure25 Conducted Class A of EC5BU-48S12

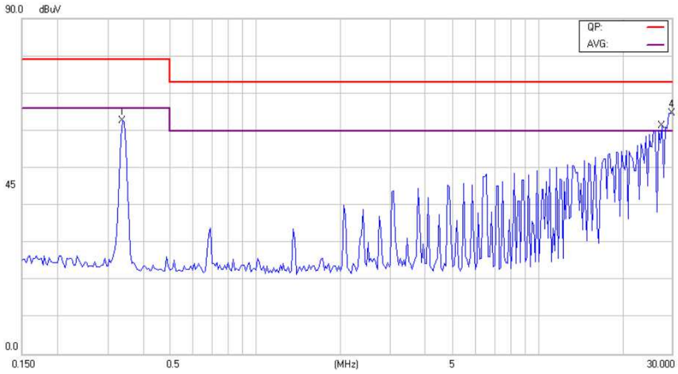


Figure26 Conducted Class A of EC5BU-48S15

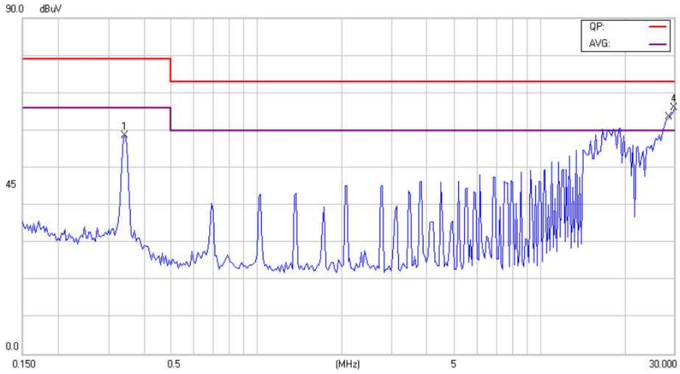


Figure27 Conducted Class A of EC5BU-48D05

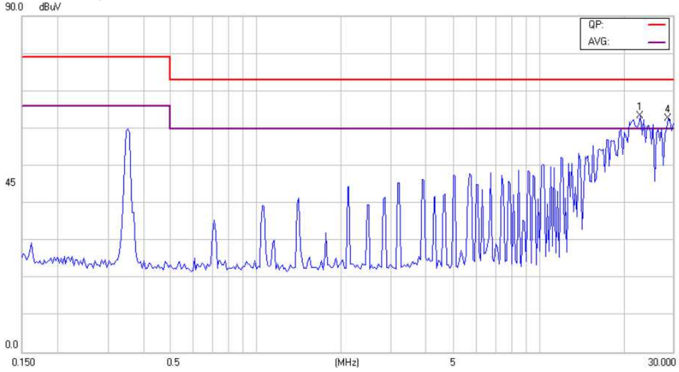


Figure28 Conducted Class A of EC5BU-48D12

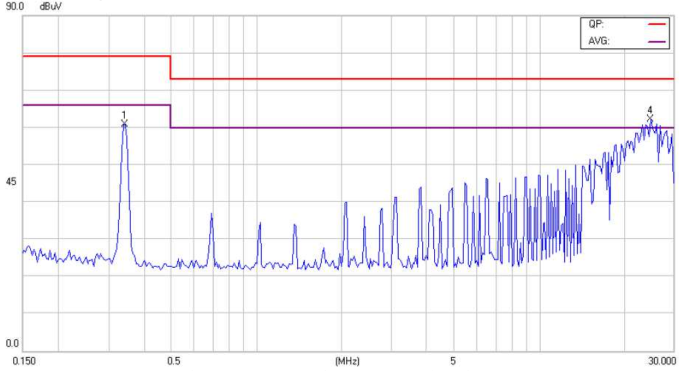
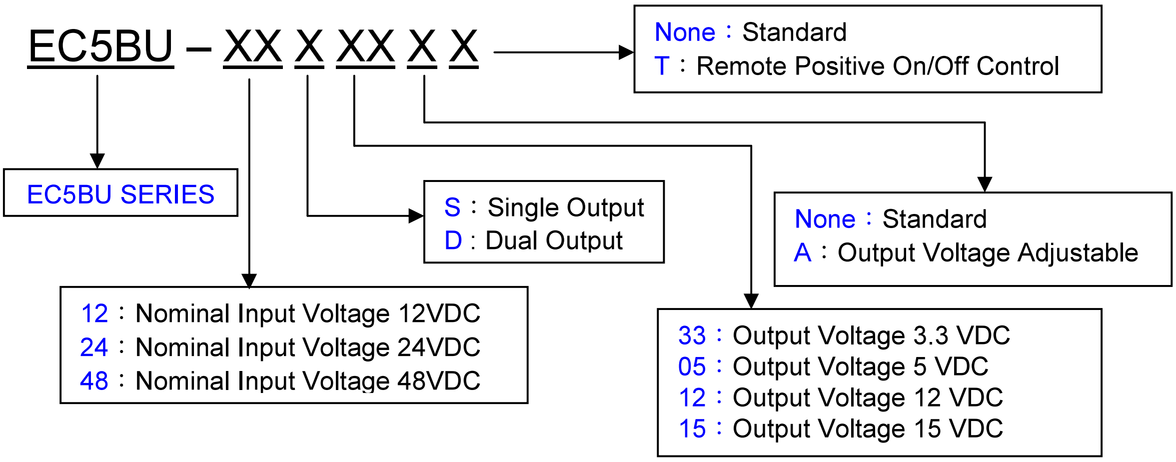


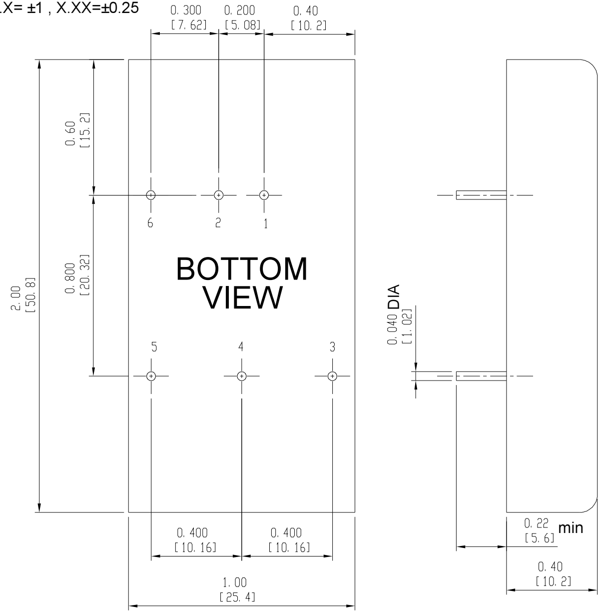
Figure29 Conducted Class A of EC5BU-48D15

8. Part Number



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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