ISOLATED DC-DC Converter
EC5SAW SERIES
APPLICATION NOTE

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Content

EC5SAW 6.6-10W Isolated DC-DC Converters

Application Note V10 October 2019

1. Introduction

The EC5SAW series offer 6.6-10 watts of output power in a 0.87x0.37x0.47 inches SIP-8 plastic packages. The EC5SAW 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, 3000VDC/2000VAC of isolation and allows an ambient operating temperature range of –40°C to 85°C with de-rating. 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

* 4:1 Input Range
* Regulated Outputs
* 3000VDC/2000VAC Isolation
* Efficiency Up to 89.5%
* Compact SIP8 Package
* Remote On/Off Control
* 6.6-10W Isolated Output
* Fixed Switching Frequency
* No Tantalum Capacitor Inside
* Input Under-Voltage Protection
* Low No Load Power Consumption
* Continuous Short Circuit Protection

3. Electrical Block Diagram

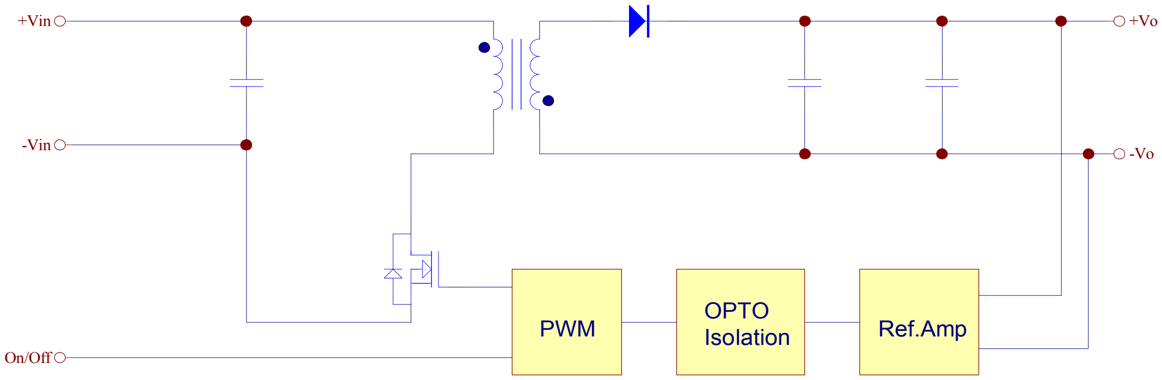


Figure1 Electrical Block Diagram of single output module

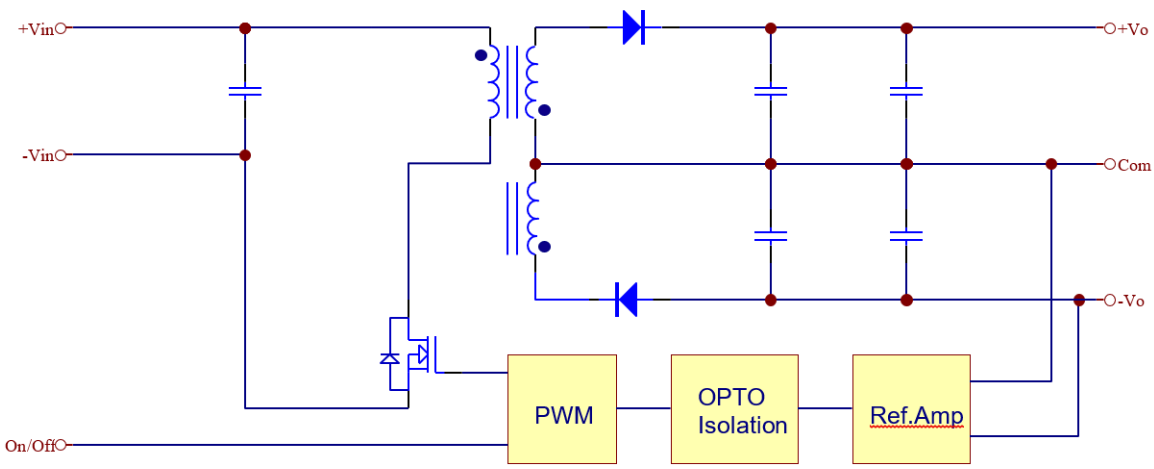


Figure2 Electrical Block Diagram of dual output module

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	-0.3		36	Vdc
		48Vin	-0.3		75	
Transient	100ms	24Vin			50	Vdc
		48Vin			100	
Operating Ambient Temperature	With de-rating, above See 6.2	All	-40		+85	℃
Case Temperature		All			105	℃
Storage Temperature		All	-55		+125	℃
Input/Output Isolation Voltage	1 minute	All	3000			Vdc
			2000			Vac

INPUT CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Operating Input Voltage		24Vin	9	24	36	Vdc
		48Vin	18	48	75	
Turn-On Voltage Threshold		24Vin	8	8.5	8.8	Vdc
		48Vin	16.5	17	17.5	
Turn-Off Voltage Threshold		24Vin	7.7	8	8.3	Vdc
		48Vin	15.5	16	16.5	
Lockout Hysteresis Voltage		24Vin		0.5		Vdc
		48Vin		1		
Maximum Input Current	100% load, Vin= 9V	24Vin		1400		mA
	100% load, Vin=18V	48Vin		700		
No-Load Input Current	Vin=Nominal input	24S33N		6		mA
		24S05N		6		
		24S12N		6		
		24S15N		6		
		24D05N		6		
		24D12N		7		
		24D15N		7		
		48S33N		6		
		48S05N		6		
		48S12N		6		
		48S15N		6		
		48D05N		6		
		48D12N		6		
		48D15N		6		
Inrush Current (I^2t)		All			0.01	A^2s
Input Reflected-Ripple Current	P-P thru 1uH 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=3.3Vdc	3.267	3.3	3.333	Vdc
		Vo=5Vdc	4.95	5	5.05	
		Vo=12Vdc	11.88	12	12.12	
		Vo=15Vdc	14.85	15	15.15	
		Vo=±5Vdc	±4.95	±5	±5.05	
		Vo=±12Vdc	±11.88	±12	±12.12	
		Vo=±15Vdc	±14.85	±15	±15.15	
Output Voltage Balance	Vin=nominal, Io=Iomax, Tc=25℃	Dual			±1.0	%
Output Voltage Regulation						
Load Regulation	Io=Full Load to 0% Load	All			±1.0	%
Line Regulation	Vin=low line to high line full load	All			±0.2	%
Temperature Coefficient	Ta=-40℃ to 85℃	All			±0.02	%/℃
Output Voltage Ripple and Noise						
Peak-to-Peak	Full Load,20MHz bandwidth with 1uF ceramic capacitor	Vo=3.3Vdc			100	mV
		Vo=5Vdc			100	
		Vo=12Vdc			120	
		Vo=15Vdc			150	
		Vo=±5Vdc			100	
		Vo=±12Vdc			120	
		Vo=±15Vdc			150	
Operating Output Current Range		Vo=3.3Vdc	0		2000	mA
		Vo=5Vdc	0		2000	
		Vo=12Vdc	0		833	
		Vo=15Vdc	0		666	
		Vo=±5Vdc	0		±1000	
		Vo=±12Vdc	0		±417	
		Vo=±15Vdc	0		±333	
Output DC Current-Limit Inception	Output voltage =90% nominal Output voltage	All		180		%
Maximum Output Capacitance	Full load, resistance	Vo=3.3Vdc	0		2000	uF
		Vo=5Vdc	0		2000	
		Vo=12Vdc	0		836	
		Vo=15Vdc	0		666	
		Vo=±5Vdc	0		1000	
		Vo=±12Vdc	0		417	
		Vo=±15Vdc	0		333	

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	All			±5	%
Setting Time (within 1% Vout nominal)		All			250	us

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Turn-On Delay and Rise Time						
Turn-On Delay Time, From Input	Vin,min. to 10%Vo,set	All		3		ms
Turn-On Delay Time, From On/off	Von/off to 10% Vo,set	All		2		ms
Output Voltage Rise Time	10%Vo,set to 90%Vo,set	All		3		ms

EFFICIENCY

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
100% Load	Vin=Nominal Vin, Io=Io_{max}, Tc=25℃	24S33		81.5		%
		24S05		85		
		24S12		89		
		24S15		89.5		
		24D05		85		
		24D12		89		
		24D15		89		
		48S33		81		
		48S05		85		
		48S12		88		
		48S15		88		
		48D05		85		
		48D12		88		
		48D15		88		
100% Load	V_{in}=12Vdc, Io=Io_{max}, Ta=25℃	24S33		81		%
		24S05		83.5		
		24S12		87		
		24S15		88.5		
		24D05		84		
		24D12		88.5		
		24D15		88.5		
	V_{in}=24Vdc, Io=Io_{max}, Ta=25℃	48S33		81		
		48S05		84		
		48S12		87.5		
		48S15		88.5		
		48D05		84		
		48D12		88		
		48D15		87.5		

ISOLATION CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Isolation Voltage	Input to output 1 minutes	All			3000	Vdc
					2000	Vac
Isolation Resistance	Input to output	All			1000	MΩ
Isolation Capacitance	Input to output	All			50	pF

FEATURE CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Switching Frequency	Vin=Nominal, Io=Io.max	All		530		KHz
On/Off Control						
Module On	Open circuit, high impedance	All				
Module Off	Current of $V_{on/off}$ pin	All	2		4	mA
Off Converter Input Current	Shutdown input idle current	All			2.5	mA

GENERAL SPECIFICATIONS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
MTBF	Io=100%of $Io_{max,}$ Ta=25℃ per MIL-HDBK-217F	All		1930		K hours
Weight		All		4.9		g

5. Main Features and Functions

5.1 Operating Temperature Range

The EC5SAW series converters can be operated by a wide ambient temperature range from -40℃ to 85℃ with de-rating. The standard model has a plastic case and case temperature can not over 105℃ at normal operating.

5.2 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the EC5SAW 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.

5.3 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 mode.

5.5 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 open circuit. Supplying the on/off pin at 2mA to 4mA will turn the converter off. The signal level of the on/off pin is defined with respect to ground. If not using the on/off pin, leave the pin open (module will be on), recommended application circuit refer figure 3.

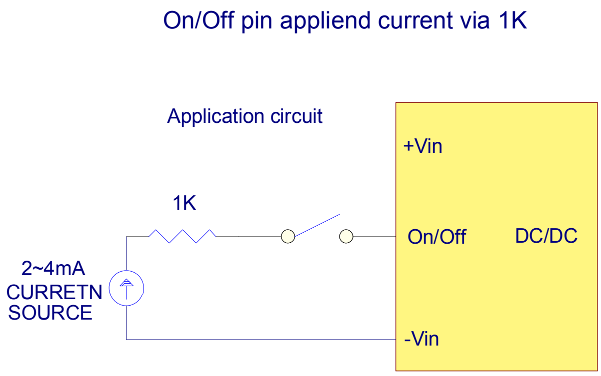
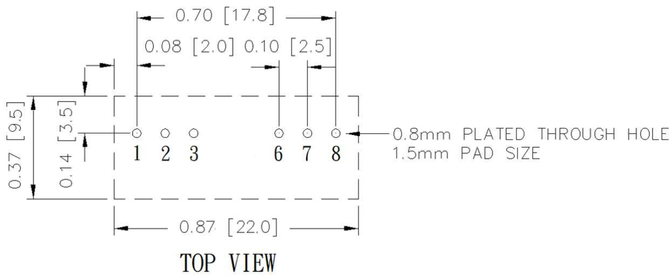


Figure 3 Recommended Application Circuit

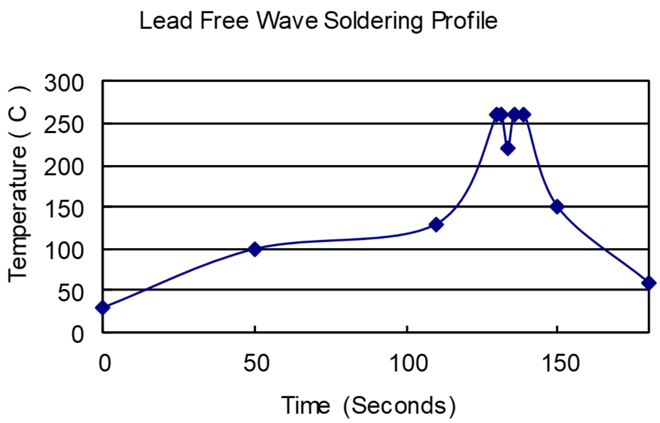
6. Applications

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 4.



Note: Dimensions are in inches (millimeters)



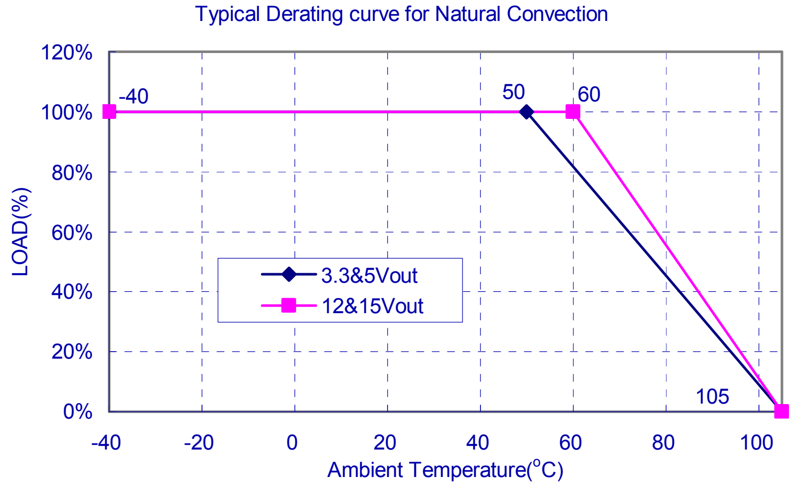
Note：

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℃)

Figure 4 Recommended PCB Layout Footprints and Wave Soldering Profiles for SIL packages

6.2 Power De-Rating Curves for EC5SAW Series

Operating Ambient temperature Range: -40℃ ~ 50℃ without derating for 3.3&5Vout.
-40℃ ~ 60℃ without derating for 12&15Vout.
Maximum case temperature under any operating condition should not exceed 105℃.
De-rating measured with nominal line. Mounted test board (43.18x27.94x1.6mm, 2Oz)



6.3 Input De-Rating Curves for EC5SAW Series

For 3.3Vo, 5Vo & ±5Vo has derating by input voltage is required. shown Figure 5.

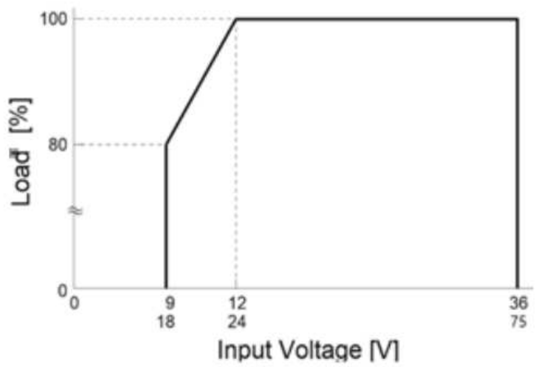
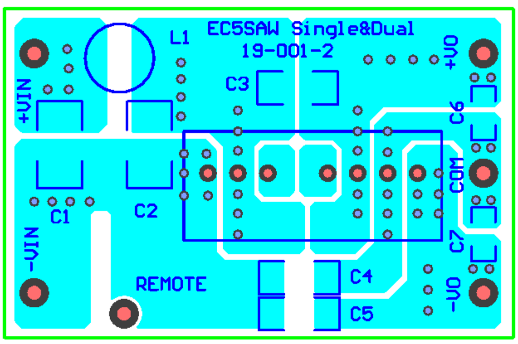
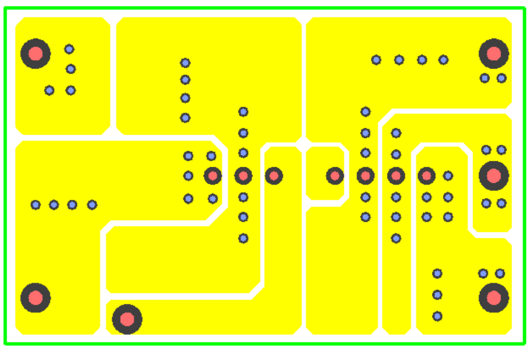


Figure 5: Input De-Rating Curves

Recommended PCB Layout with de-rating. (43.18x27.94x1.6mm, 2Oz))

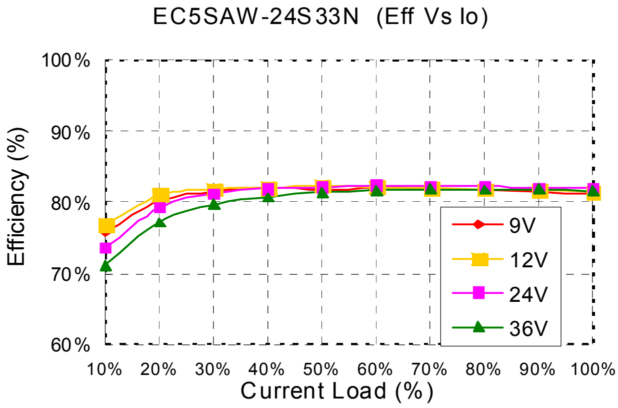


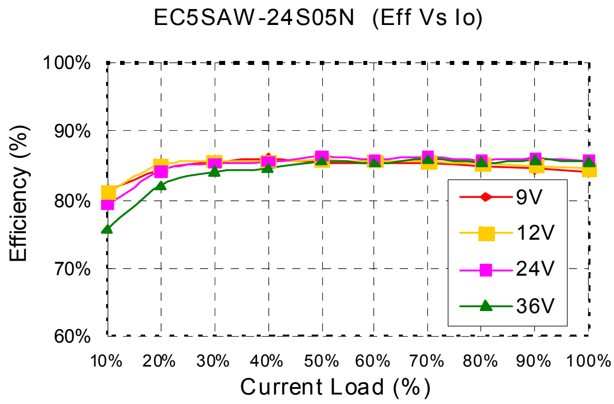
TOP Layer

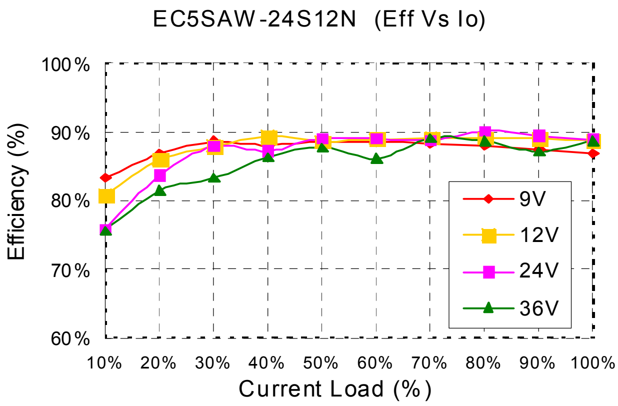


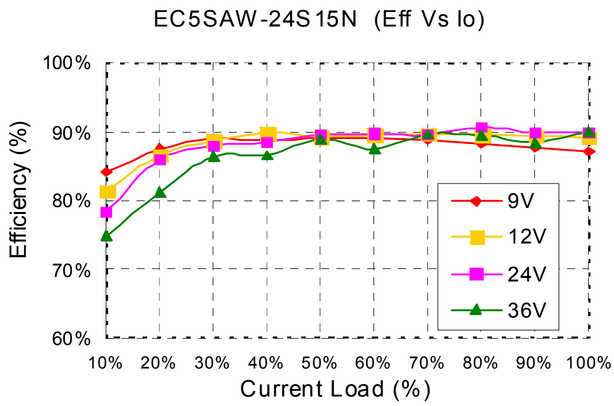
Bottom Layer

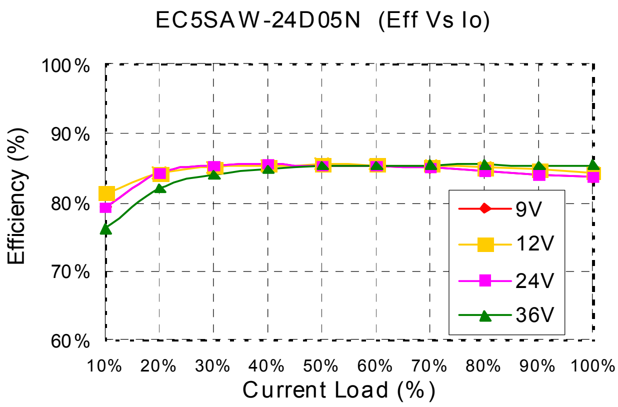
6.4 Efficiency vs. Load Curves

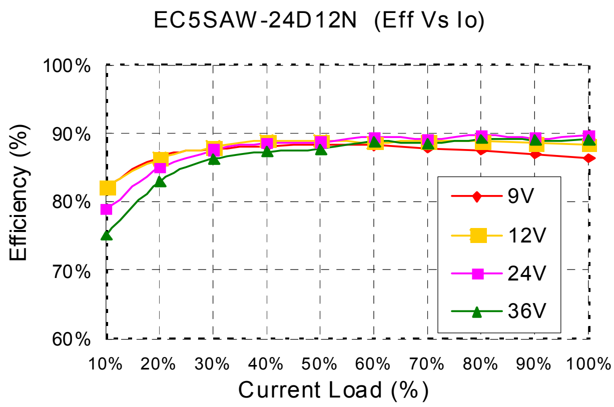


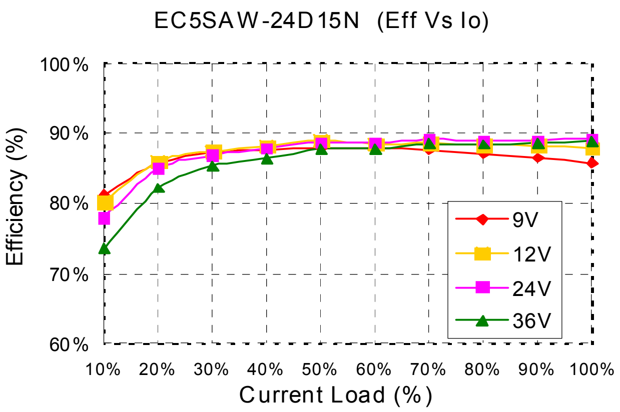


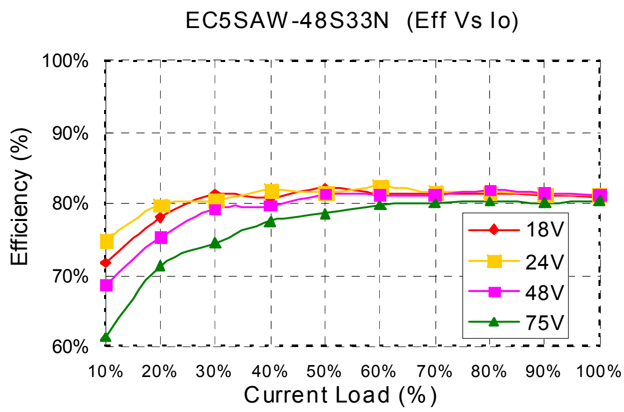


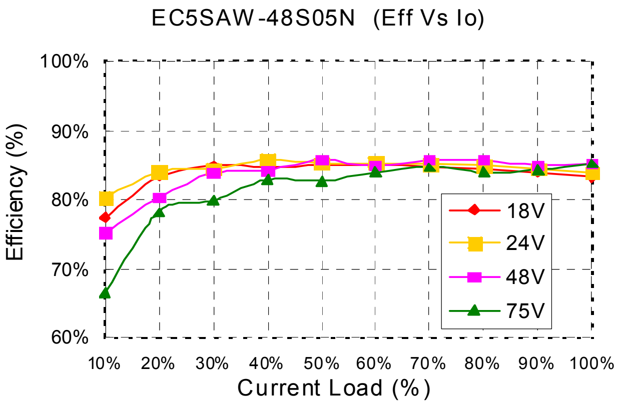


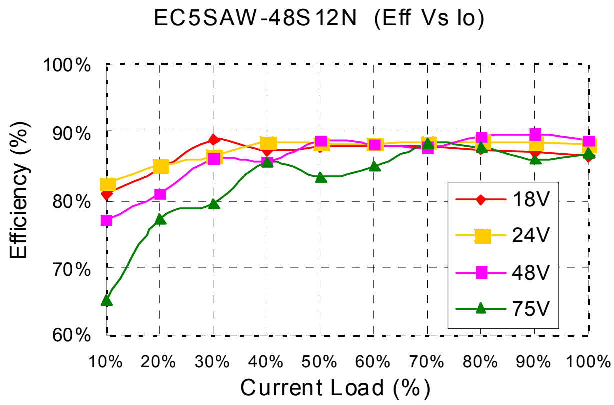


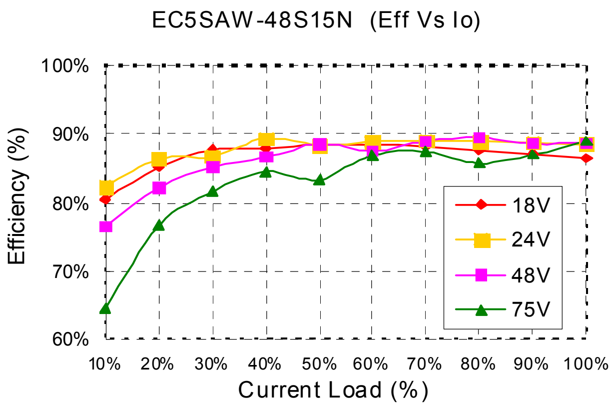


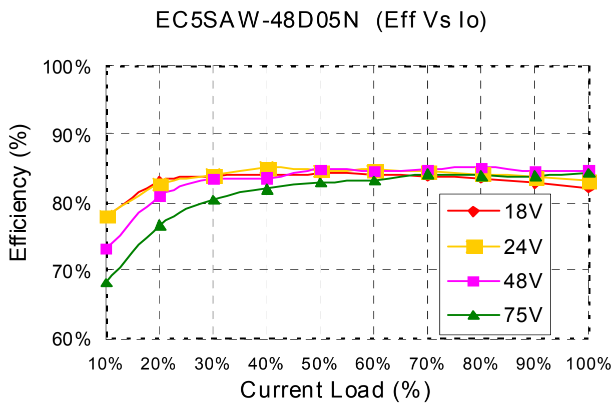

EC5SAW-24D15N (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
9V
12V
24V
36V

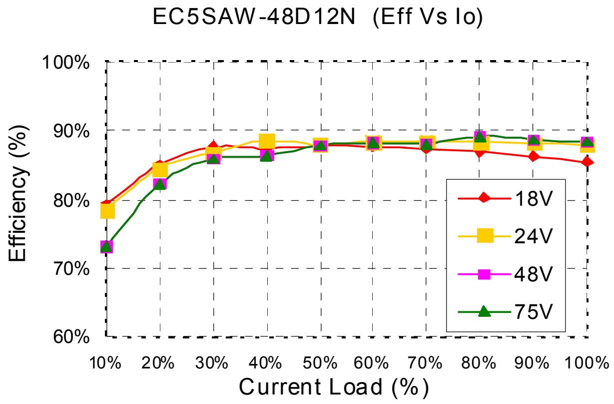

EC5SAW-48S33N (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
24V
48V
75V

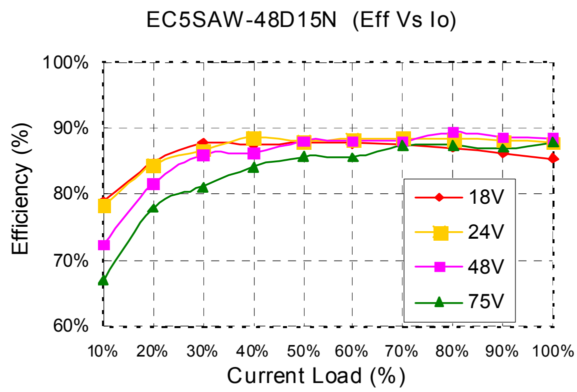

EC5SAW-48S05N (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
24V
48V
75V


EC5SAW-48S12N (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
24V
48V
75V


EC5SAW-48S15N (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
24V
48V
75V

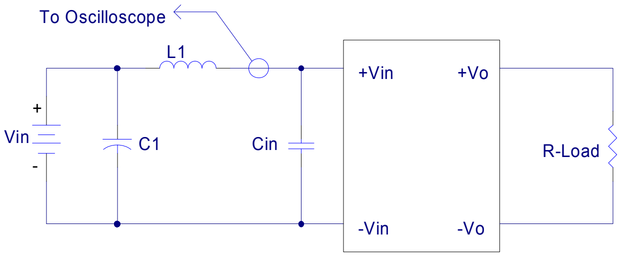

EC5SAW-48D05N (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
24V
48V
75V


EC5SAW-48D12N (Eff Vs Io)
100%
90%
80%
70%
60%
Efficiency (%)
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
18V
24V
48V
75V


EC5SAW-48D15N (Eff Vs Io)
100%
90%
80%
70%
60%
Efficiency (%)
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
18V
24V
48V
75V

6.5 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 3 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: 12uF
C1: None
Cin: 47uF ESR<0.7ohm @100KHz

Figure 6 Input Reflected-Ripple Test Setup

6.6 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 no load

The value of line regulation is defined as:

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

Where

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

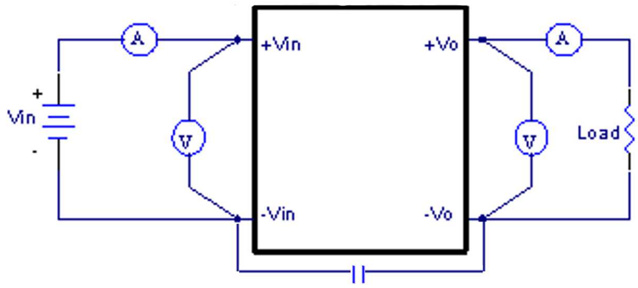
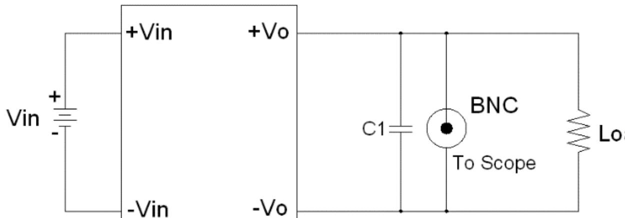


Figure 7 EC5SAW Series Test Setup
NOTE:-Vin to -Vo With 470pF/250V Y1

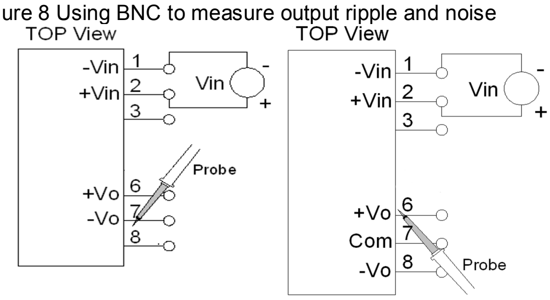
6.7 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in figure 8 and 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 Band Width.



Note: C1: 1uF ceramic capacitor.

Figure 8 Using BNC to measure output ripple and noise



Single Models Dual Models

Figure 9 Using Probe to Measure Output Ripple and Noise

6.8 Output Capacitance

The EC5SAW 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 EC5SAW series converters have not an internal fuse. However, to achieve maximum safety and system protection, always use an input line fuse. We recommended a fast acting fuse 3A for 24Vin models and 1.5A for 48Vin modules. Figure 9 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.

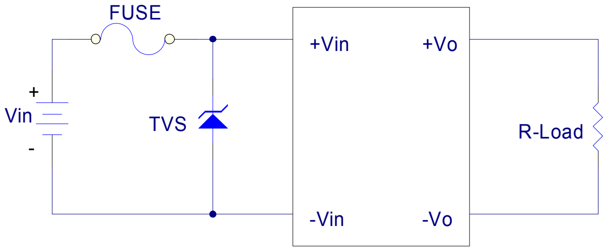


Figure 10 Input Protection

7.2 EMC Considerations

(1) EMI Test standard: EN55032 Class A/B Conducted Emission
Test Condition: Input Voltage: Nominal, Output Load: Full Load

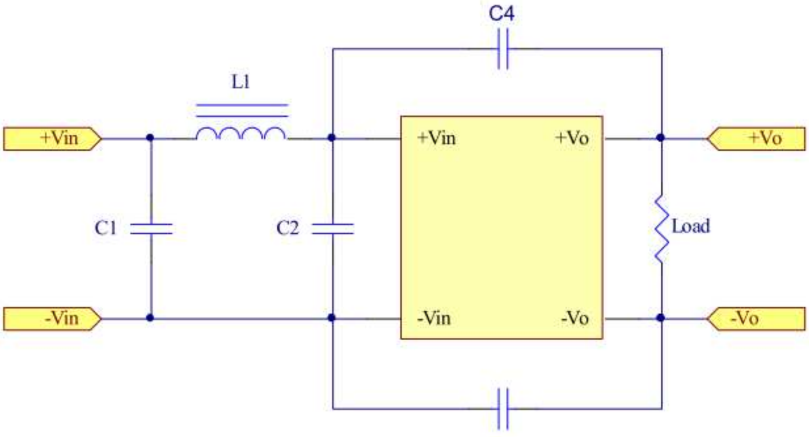


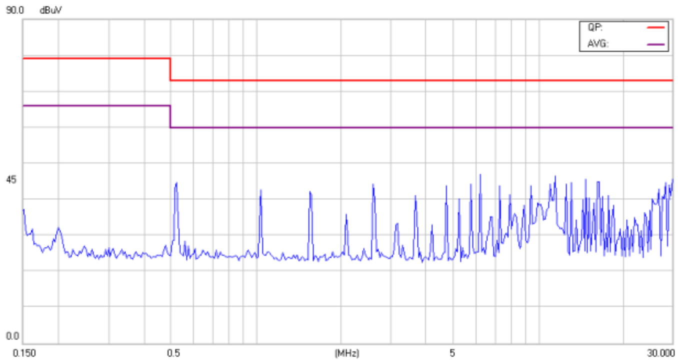
Figure11 Connection circuit for conducted EMI testing

Model No.	EN55032 class A			EN55032 class B		
	C1, C2	C3, C4	L1	C1, C2	C3, C4	L1
EC5SAW-24S33N	10uF/50V 1210	330pF/3KV 1808	3.9uH	10uF/50V 1210	1000pF/4KV 1808	3.9uH
EC5SAW-24S05N	10uF/50V 1210	330pF/3KV 1808	3.9uH	10uF/50V 1210	1000pF/4KV 1808	3.9uH
EC5SAW-24S12N	10uF/50V 1210	330pF/3KV 1808	3.9uH	10uF/50V 1210	1000pF/4KV 1808	3.9uH
EC5SAW-24S15N	10uF/50V 1210	330pF/3KV 1808	3.9uH	10uF/50V 1210	1000pF/4KV 1808	3.9uH
EC5SAW-24D05N	10uF/50V 1210	330pF/3KV 1808	3.9uH	10uF/50V 1210	1000pF/4KV 1808	3.9uH
EC5SAW-24D12N	10uF/50V 1210	330pF/3KV 1808	3.9uH	10uF/50V 1210	1000pF/4KV 1808	3.9uH
EC5SAW-24D15N	10uF/50V 1210	330pF/3KV 1808	3.9uH	10uF/50V 1210	1000pF/4KV 1808	3.9uH
EC5SAW-48S33N	4.7uF/100V 1812	330pF/3KV 1808	6.8uH	4.7uF/100V 1812	1000pF/4KV 1808	6.8uH
EC5SAW-48S05N	4.7uF/100V 1812	330pF/3KV 1808	6.8uH	4.7uF/100V 1812	1000pF/4KV 1808	6.8uH
EC5SAW-48S12N	4.7uF/100V 1812	330pF/3KV 1808	6.8uH	4.7uF/100V 1812	1000pF/4KV 1808	6.8uH
EC5SAW-48S15N	4.7uF/100V 1812	330pF/3KV 1808	6.8uH	4.7uF/100V 1812	1000pF/4KV 1808	6.8uH
EC5SAW-48D05N	4.7uF/100V 1812	330pF/3KV 1808	6.8uH	4.7uF/100V 1812	1000pF/4KV 1808	6.8uH
EC5SAW-48D12N	4.7uF/100V 1812	330pF/3KV 1808	6.8uH	4.7uF/100V 1812	1000pF/4KV 1808	6.8uH
EC5SAW-48D15N	4.7uF/100V 1812	330pF/3KV 1808	6.8uH	4.7uF/100V 1812	1000pF/4KV 1808	6.8uH

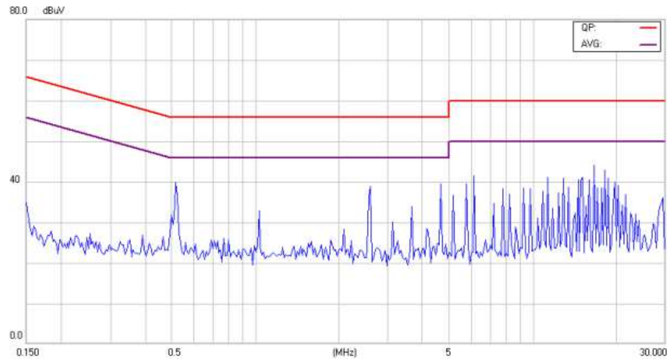
Note:

All of capacitors are ceramic capacitors

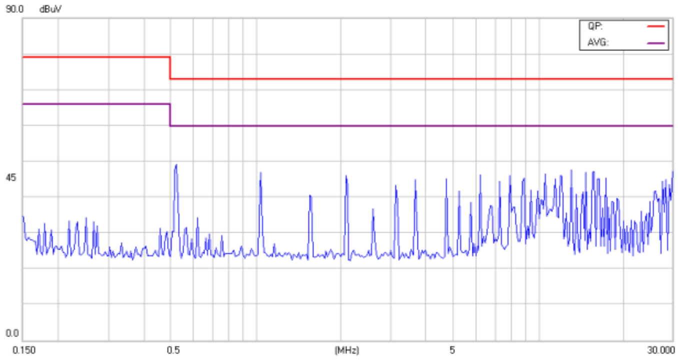
3.9uH (P/N: SR0805-3R9MLB ABC), 6.8uH (P/N: UPIA0604-6R8M 3L)



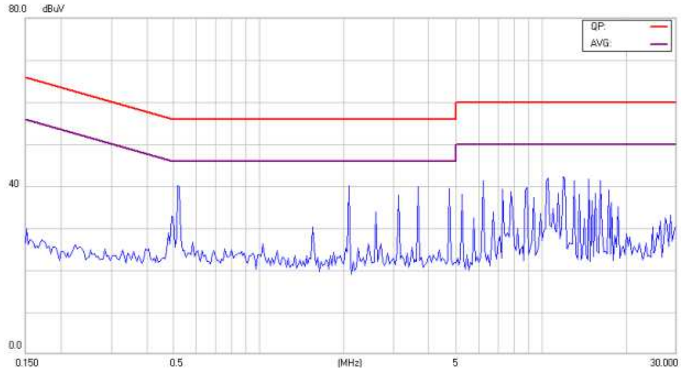
Conducted Class A of EC5SAW-24S33N



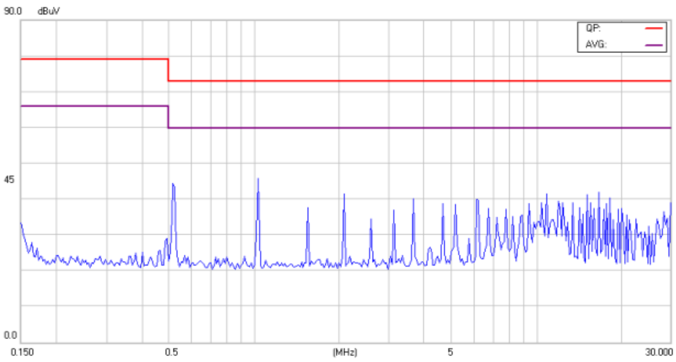
Conducted Class B of EC5SAW-24S33N



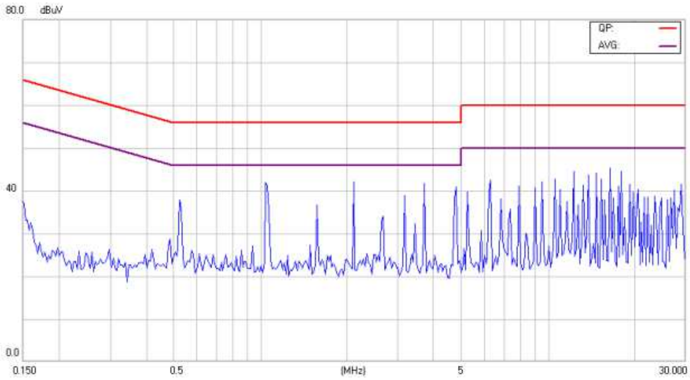
Conducted Class A of EC5SAW -24S05N



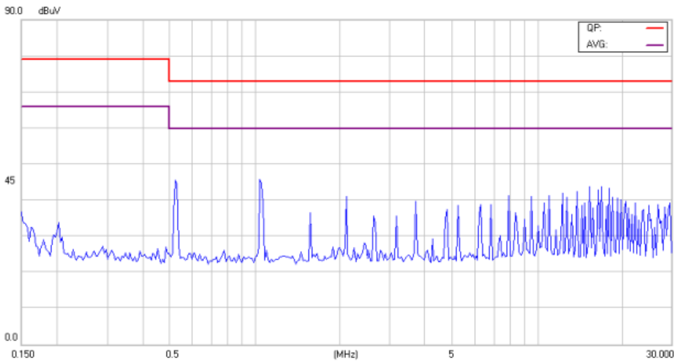
Conducted Class B EC5SAW -24S05N



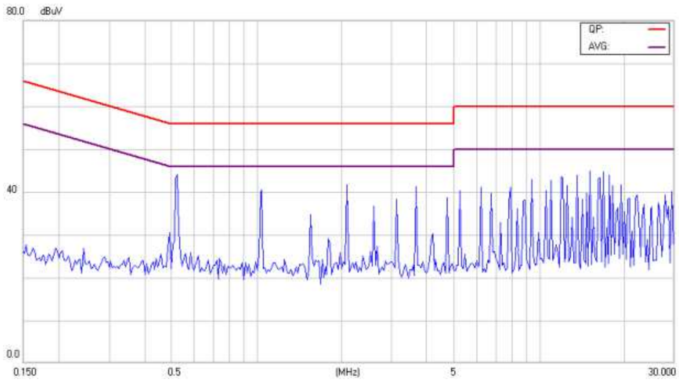
Conducted Class A of EC5SAW -24S12N



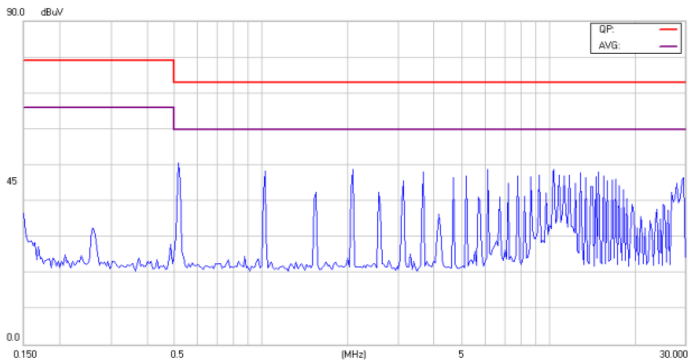
Conducted Class B of EC5SAW -24S12N



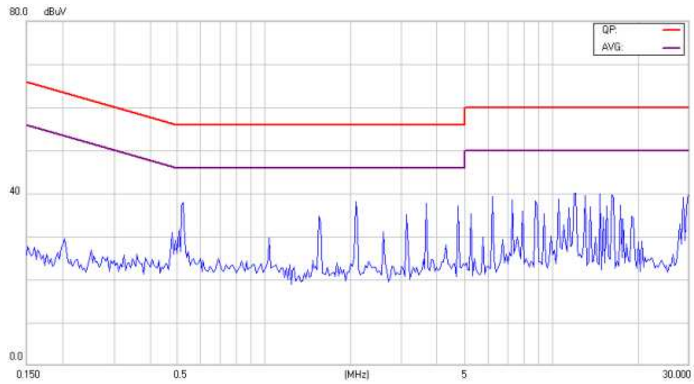
Conducted Class A of EC5SAW -24S15N



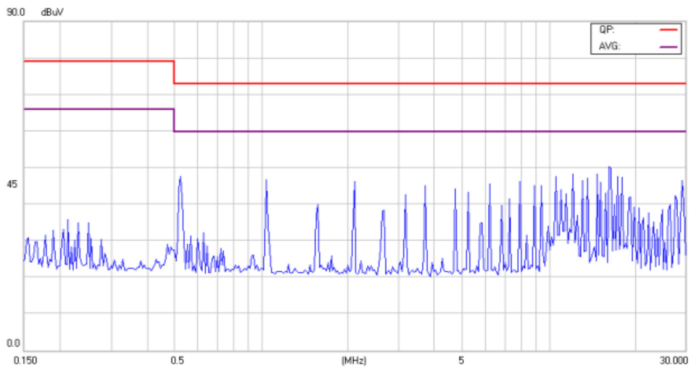
Conducted Class B of EC5SAW -24S15N



Conducted Class A of EC5SAW -24D05N



Conducted Class B of EC5SAW -24D05N



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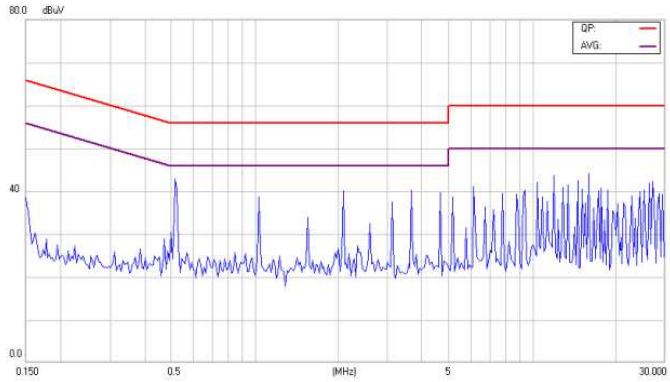

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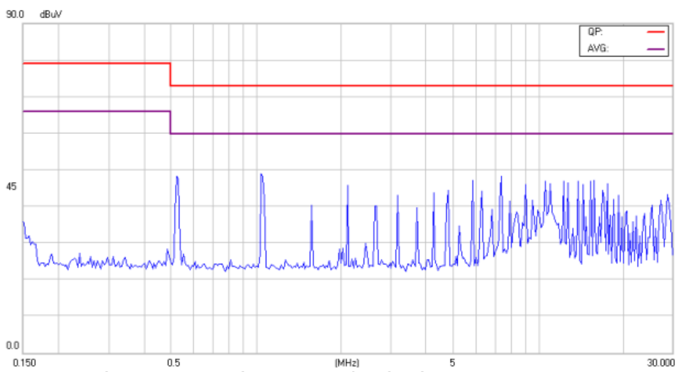
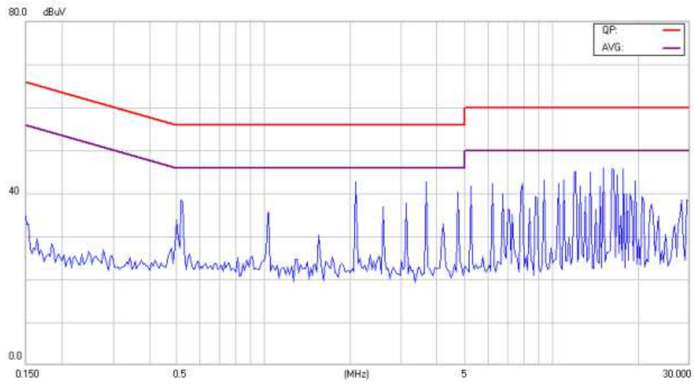
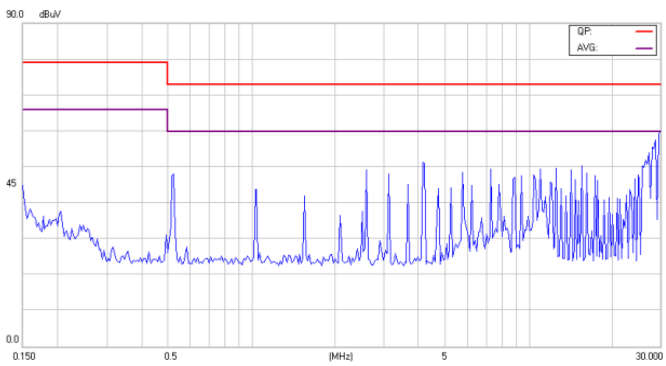


Conducted Class A of EC5SAW -24D15N

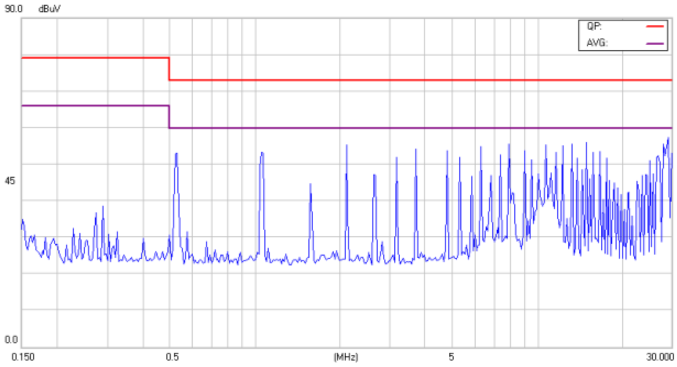


Conducted Class B of EC5SAW -24D15N

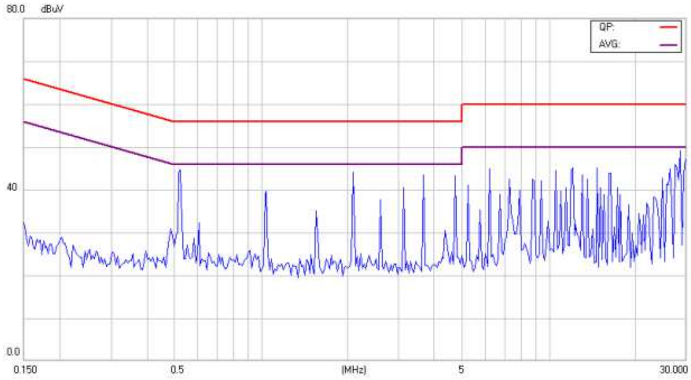


Conducted Class A of EC5SAW -48S33N

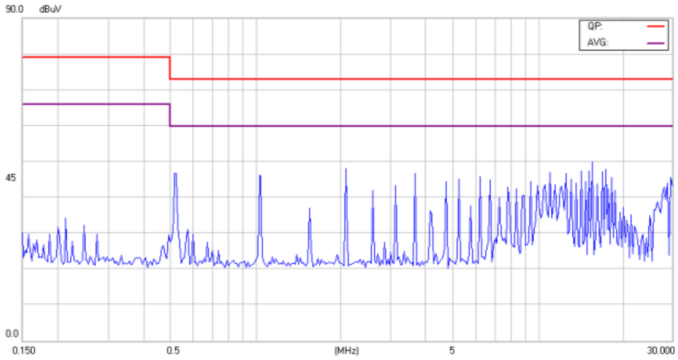
Conducted Class B of EC5SAW -48S33N



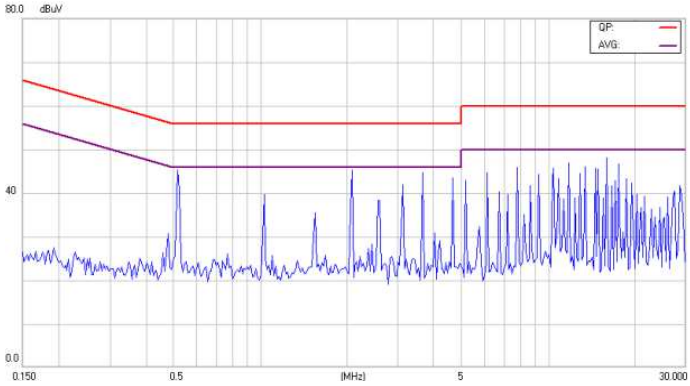
Conducted Class A of EC5SAW -48S05N



Conducted Class B of EC5SAW -48S05N



Conducted Class A of EC5SAW -48S12N



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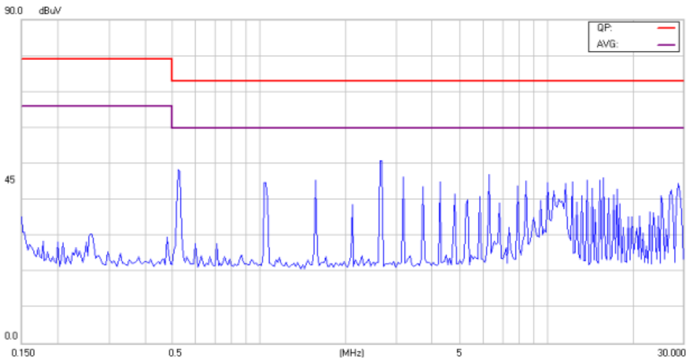
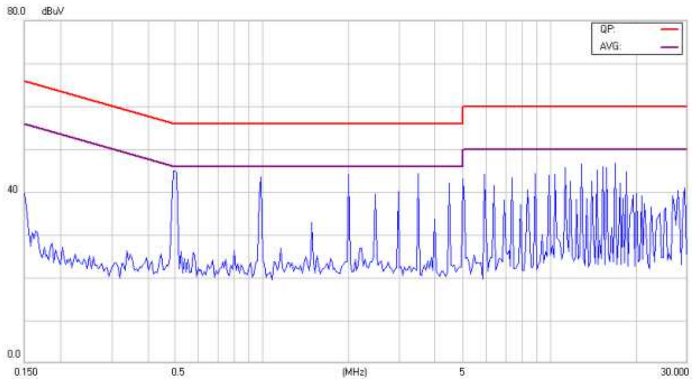


Conducted Class A of EC5SAW -48S15N



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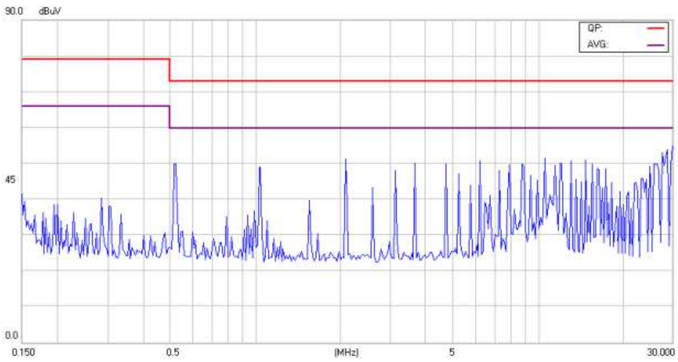
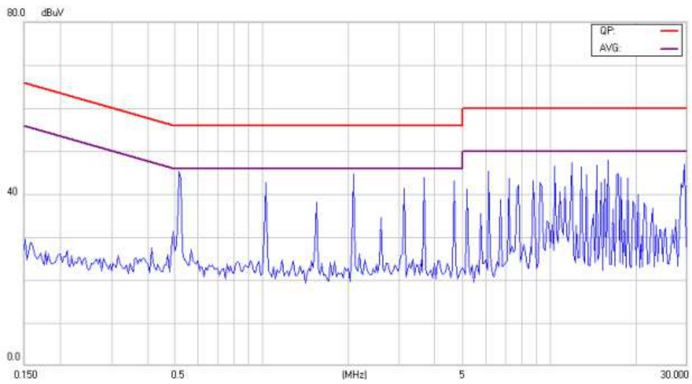


Conducted Class A of EC5SAW -48D05N



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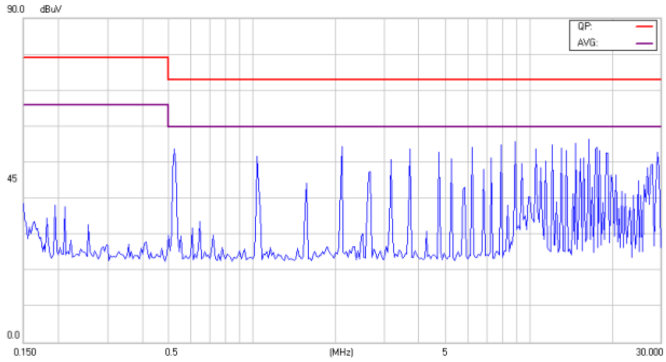
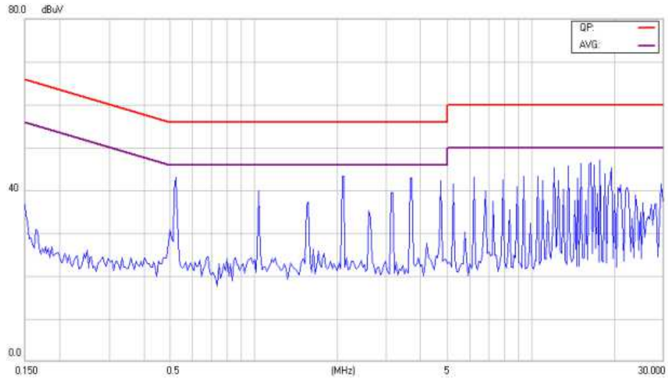
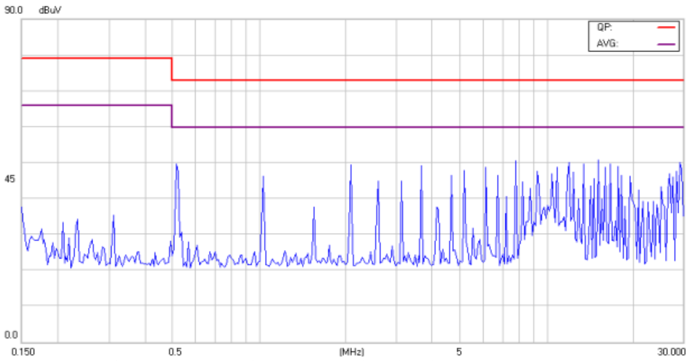


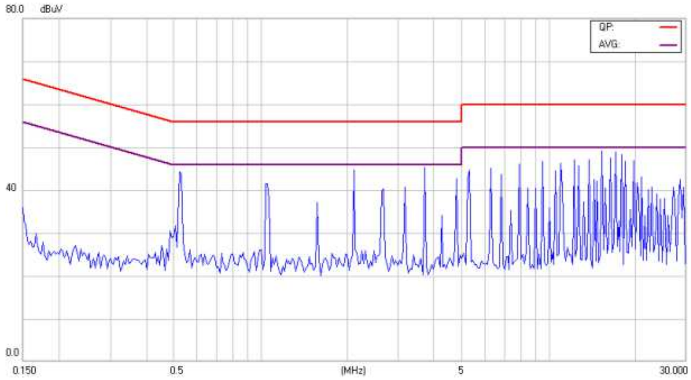
Conducted Class A of EC5SAW-48D12N



Conducted Class B of EC5SAW-48D12N



Conducted Class A of EC5SAW-48D15N



Conducted Class B of of EC5SAW-48D15N

8. Part Number

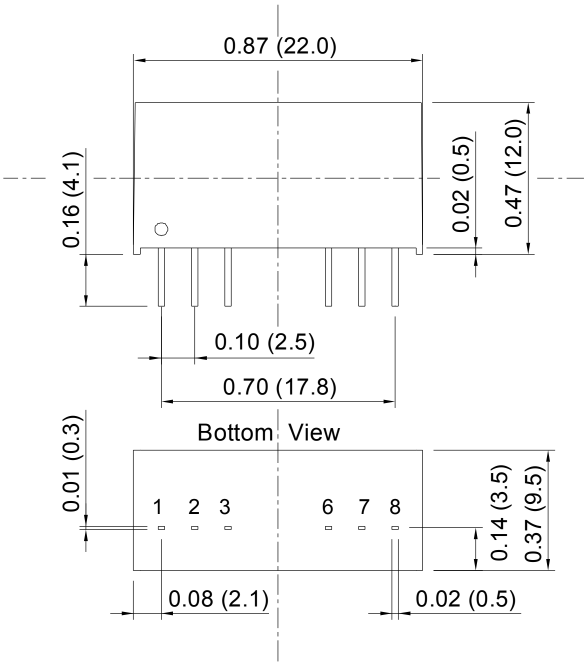
EC5SAW – XX S XX N

- EC5SAW 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
- N：Negative Logic

9. Mechanical Specifications

All Dimensions In Inches (mm)

	Inches	Millimeters
Tolerances：	X.XX=±0.02	X. X=±0.5
Pin	±0.002	±0.05



PIN CONNECTION		
Pin	Single	Dual
1	-V Input	-V Input
2	+V Input	+V Input
3	On/Off	On/Off
6	+V Output	+V Output
7	-V Output	Common
8	NC	-V Output

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