ISOLATED DC-DC Converter
EC4SAW SERIES
APPLICATION NOTE

Approved By:

Department	Approved By	Checked By	Reported By
Research and Development Department	Enoch	Danny/Wade Jacky	Joyce
Quality Assurance Department	Ryan	Benny	

Content

1. Introduction

The EC4SAW series offer 5-6 watts of output power in a 0.86x0.36x0.44 inches SIP-8 plastic packages. The EC4SAW 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 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

* 5-6W Isolated Output
* Compact SIP-8 Package
* Efficiency up to 89%
* 4:1 Input Range
* Regulated Outputs
* Remote On/Off Control
* 1500VDC Isolation
* Continuous Short Circuit Protection

3. Electrical Block Diagram

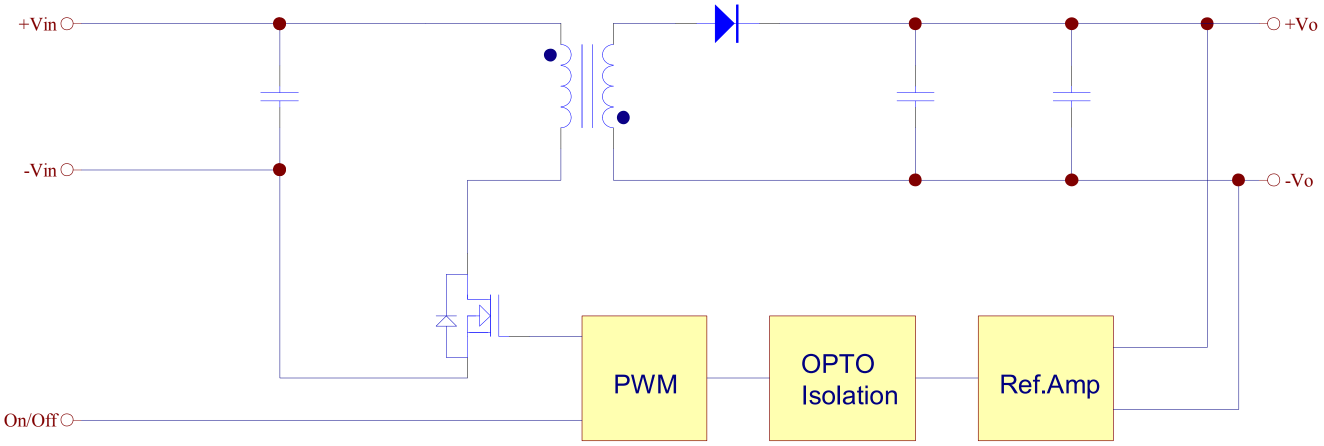


Figure 1 Electrical Block Diagram of single output module

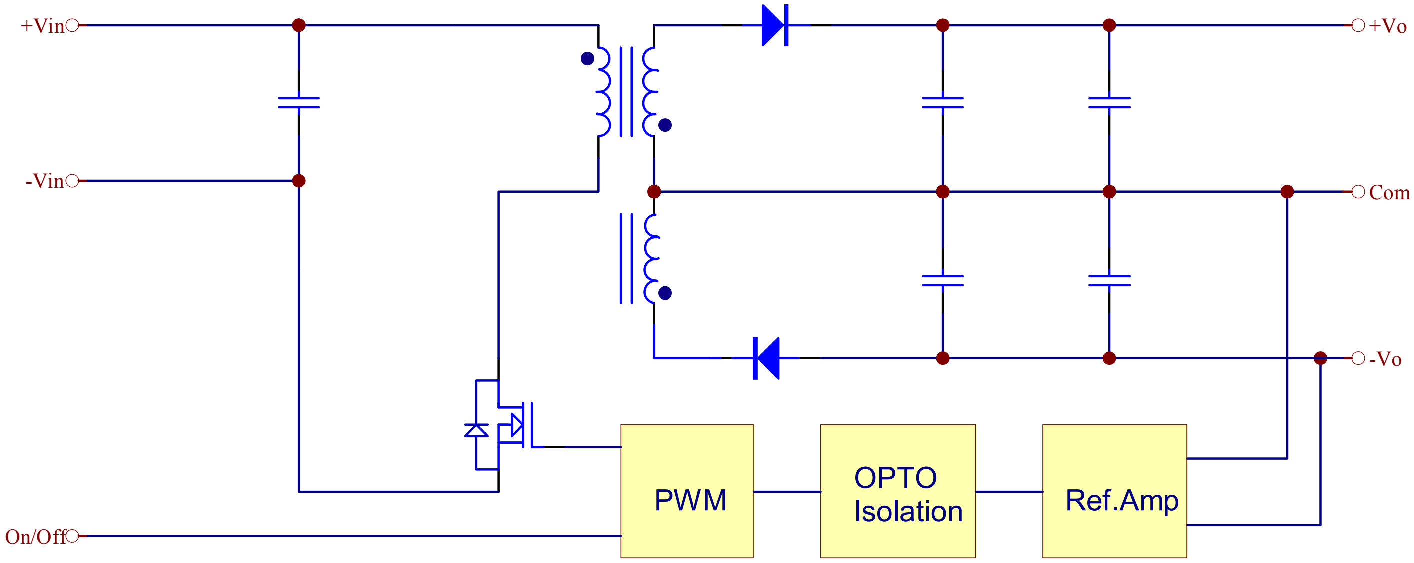


Figure 2 Electrical Block Diagram of Dual output module

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		$24V_{in}$ $48V_{in}$	-0.3 -0.3		36 75	V_{dc}
Transient	100ms	$24V_{in}$ $48V_{in}$			50 100	V_{dc}
Operating Ambient Temperature	With de-rating, above 61℃	V_o=3.3V V_o=5V V_o=±5V	-40		+85	℃
	With de-rating, above 65℃	V_o=12V V_o=15V V_o=±12V V_o=±15V	-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		$24V_{in}$ $48V_{in}$	9 18	24 48	36 75	V_{dc}
Maximum Input Current	100% Load, V_{in}=9V	$24V_{in}$		800		mA
	100% Load, V_{in}=18V	$48V_{in}$		400		
No-Load Input Current	V_{in}=Nominal input	24S33N 24S05N 24S12N 24S15N 24D05N 24D12N 24D15N 48S33N 48S05N 48S12N 48S15N 48D05N 48D12N 48D15N		4 4 5 5 4 6 6 3 3 3 3 4 3 3		mA
Off Converter Input Current	Shutdown input idle current	All		1		mA
Inrush Current (I^2t)		All			0.01	A^2s
Input Reflected-Ripple Current	P-P thru 12uH inductor, 5Hz to 20MHz	All		10		mA

OUTPUT CHARACTERISTIC

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Output Voltage Set Point	V_{in} nominal, Io=Io_{max}, Ta=25℃	V_o=3.3V	3.2505	3.3	3.3495	V_{dc}
		V_o=5.0V	4.925	5.0	5.075	
		V_o=12V	11.82	12	12.18	
		V_o=15V	14.775	15	15.225	
		V_o=±5.0V	4.925	5.0	5.075	
		V_o=±12V	11.82	12	12.18	
		V_o=±15V	14.775	15	15.225	
Output Voltage Regulation						
Load Regulation	Io=Full Load to No Load	Single Dual			±0.5 ±1.0	%
Line Regulation	V_{in}=High line to Low line Full Load	All			±0.2	%
Temperature Coefficient	Ta=-40℃ to 85℃	All			±0.03	%/℃
Output Voltage Ripple and Noise						
Peak-to-Peak	Full Load, 20MHz bandwidth (see 6.6)	All			100	mV
Operating Output Current Range		V_o=3.3V	0		1500	mA
		V_o=5.0V	0		1200	
		V_o=12V	0		500	
		V_o=15V	0		400	
		V_o=±5.0V	0		±600	
		V_o=±12V	0		±250	
		V_o=±15V	0		±200	
Output DC Current-Limit Inception	Output Voltage =90% $Vo_{nominal}$	All		180		%
Maximum Output Capacitance	Full load, Resistance	V_o=3.3V	0		4700	uF
		V_o=5.0V	0		2200	
		V_o=12V	0		1100	
		V_o=15V	0		470	
		V_o=±5.0V	0		1400	
		V_o=±12V	0		660	
		V_o=±15V	0		220	

DYNAMIC CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Output Voltage Current Transient						
Step Change in Output Current	75% to 100% Io_max , di/dt=0.1A/us	All			±5	%
Setting Time (within 1% $Vo_{nominal}$)	di/dt=0.1A/us	All			250	us
Turn-On Delay and Rise Time						
Turn-On Delay Time, From Input	Vin_{min} to 10% $Vo_{nominal}$	All		15		ms
Turn-On Delay Time, From On/off	$V_{on/off}$ to 10% $Vo_{nominal}$	All		15		ms
Output Voltage Rise Time	10% to 90%$Vo_{nominal}$	All		8		ms

EFFICIENCY

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
100% Load	V_{in}=12Vdc, Io=Io_{max}, Ta=25℃	24S33N		82		%
		24S05N		86		
		24S12N		88		
		24S15N		89		
		24D05N		86		
		24D12N		88		
		24D15N		88		
	V_{in}=24Vdc, Io=Io_{max}, Ta=25℃	48S33N		82		
		48S05N		85		
		48S12N		88		
		48S15N		89		
		48D05N		85		
		48D12N		88		
		48D15N		88		
100% Load	V_{in}=Nominal V_{in}, Io=Io_{max}, Ta=25℃	24S33N		82		%
		24S05N		86		
		24S12N		88		
		24S15N		88		
		24D05N		86		
		24D12N		88		
		24D15N		88		
		48S33N		82		
		48S05N		85		
		48S12N		89		
		48S15N		88		
		48D05N		85		
		48D12N		89		
		48D15N		89		

ISOLATION CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Isolation Voltage	Input to Output 1 minute	All			1500	V_{dc}
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		All		580		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		1850		K hours
Weight		All		4.8		g

5. Main Features and Functions

5.1 Operating Temperature Range

The EC4SAW 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 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.

5.3 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.

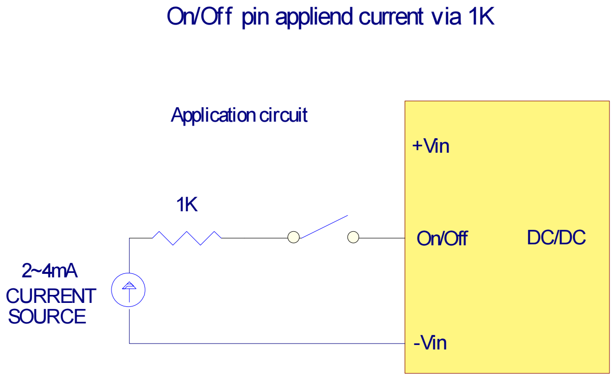
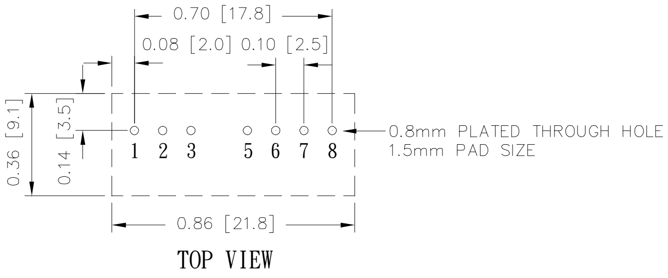


Figure 3 Recommended Application Circuit

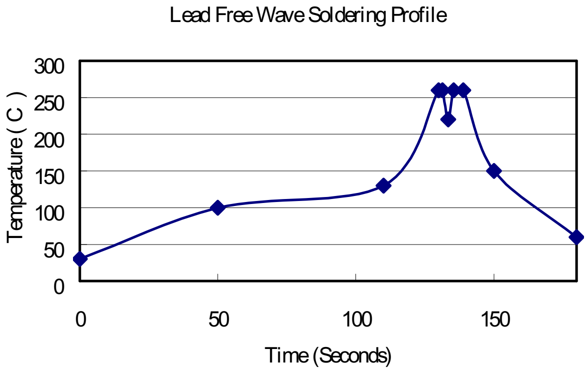
6. Applications

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℃)

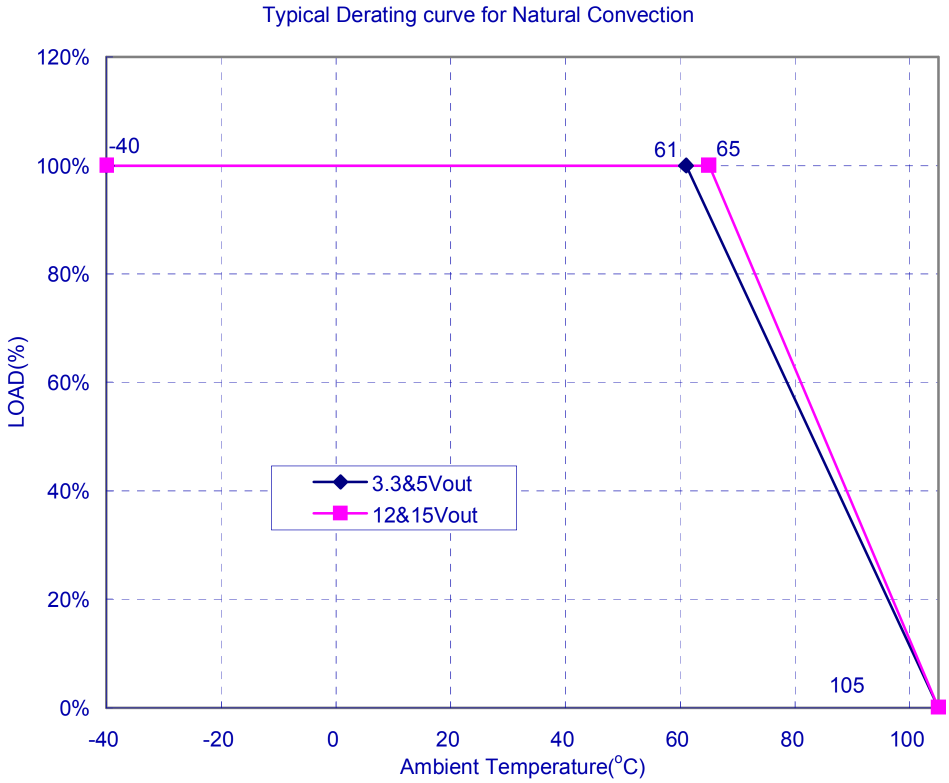
Figure 4 Recommended PCB Layout Footprints and Wave Soldering Profiles for SIL packages

6.2 Power Derating Curves for EC4SAW Series

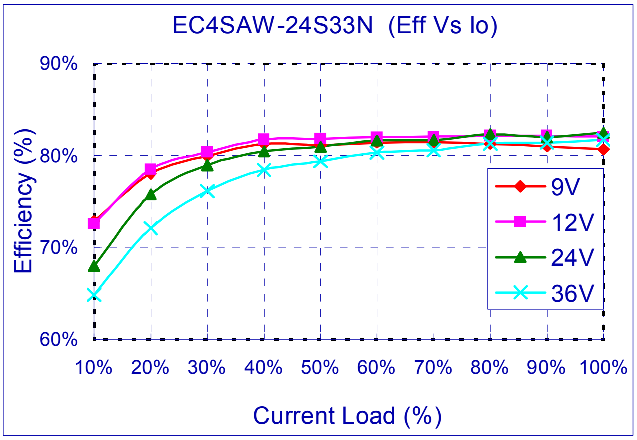
Operating Ambient temperature Range: -40℃ ~ 61℃ without derating for 3.3&5Vout.

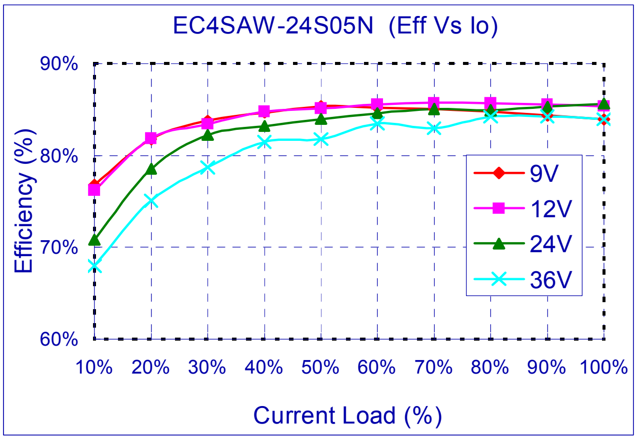
-40℃ ~ 65℃ without derating for 12&15Vout.

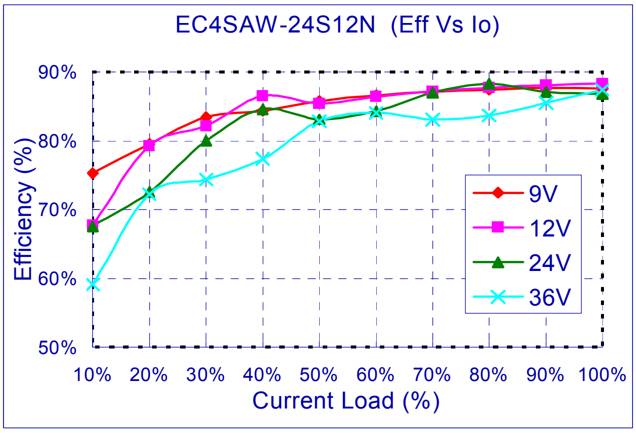
Maximum case temperature under any operating condition should not exceed 105℃.

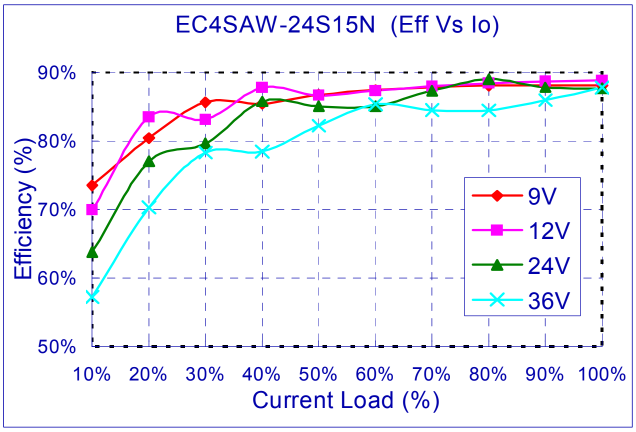


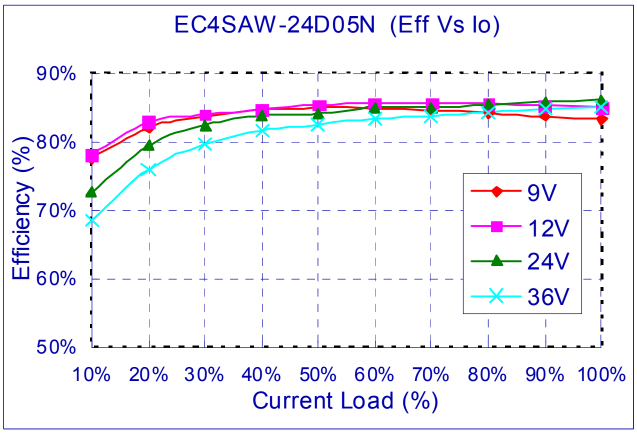
6.3 Efficiency vs. Load Curves

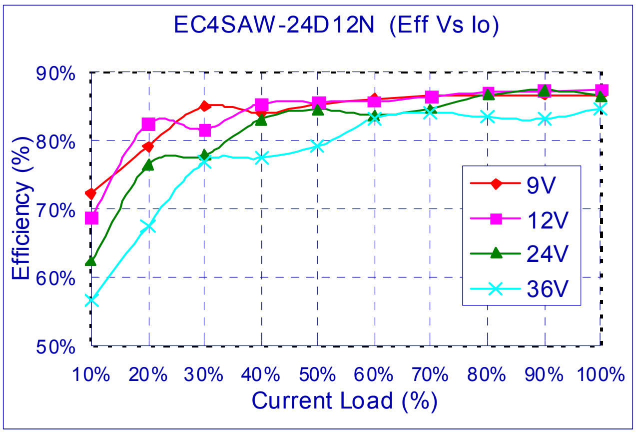


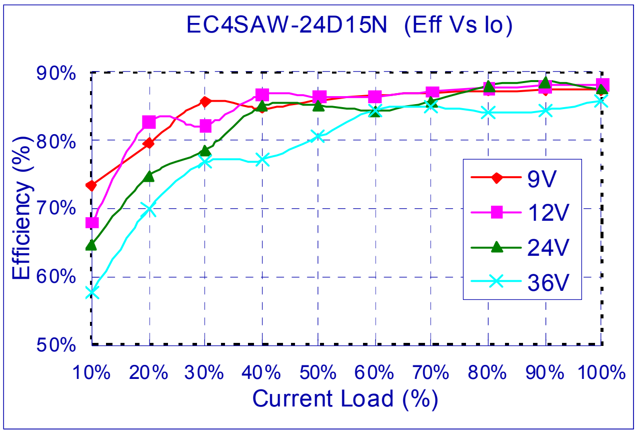


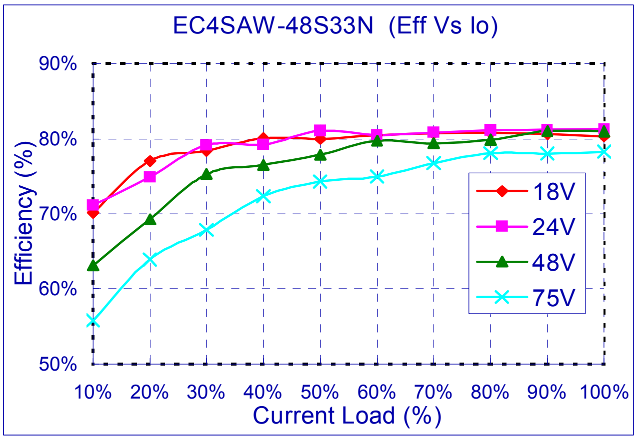


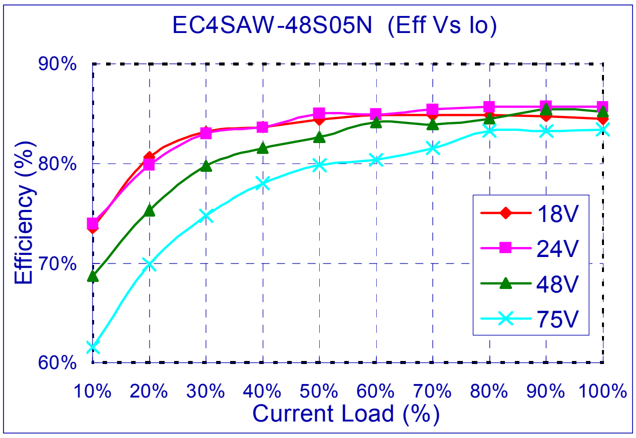


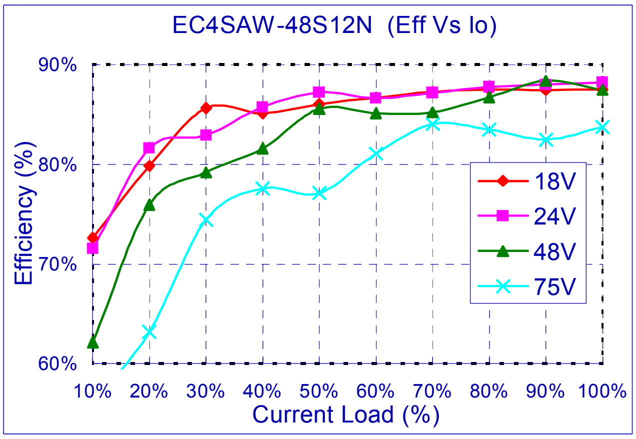


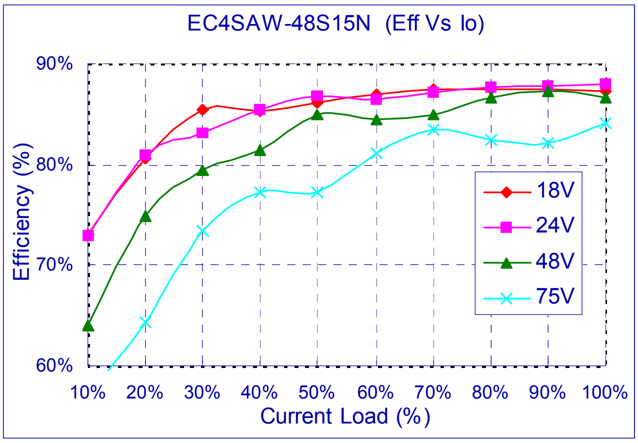


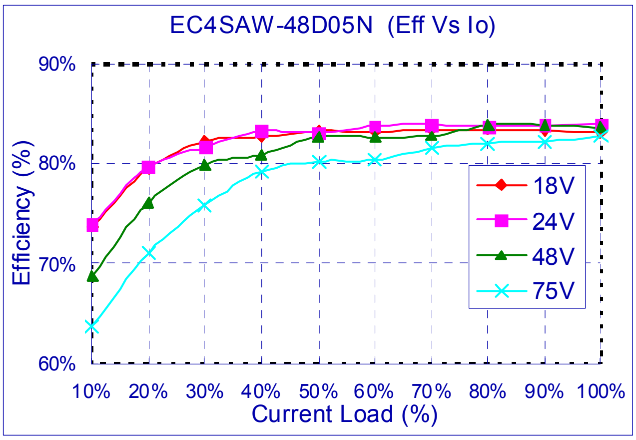

EC4SAW-24D15N (Eff Vs Io)
Efficiency (%)
90%
80%
70%
60%
50%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
9V
12V
24V
36V

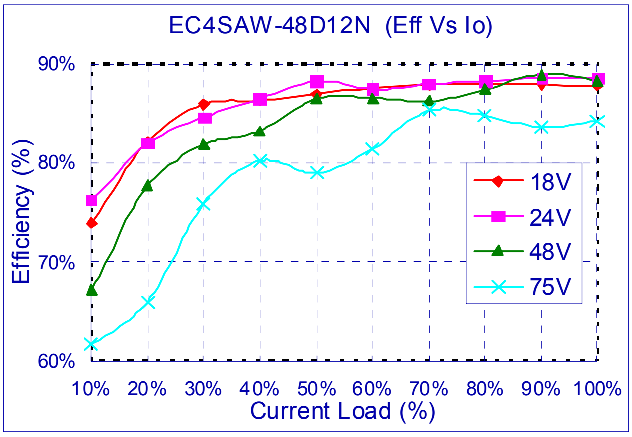

EC4SAW-48S33N (Eff Vs Io)
Efficiency (%)
90%
80%
70%
60%
50%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
24V
48V
75V

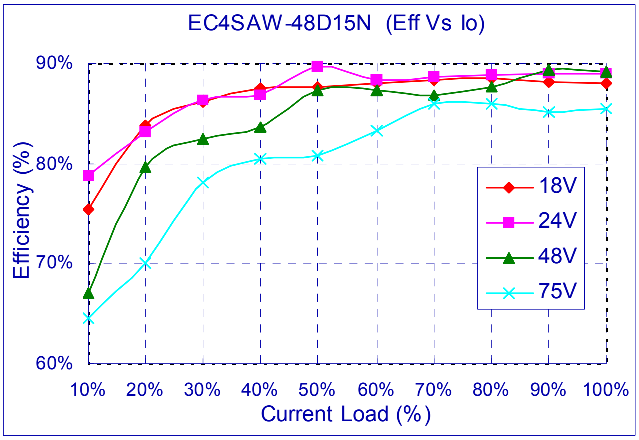

EC4SAW-48S05N (Eff Vs Io)
Efficiency (%)
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
24V
48V
75V


EC4SAW-48S12N (Eff Vs Io)
Efficiency (%)
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
24V
48V
75V


EC4SAW-48S15N (Eff Vs Io)
Efficiency (%)
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
24V
48V
75V

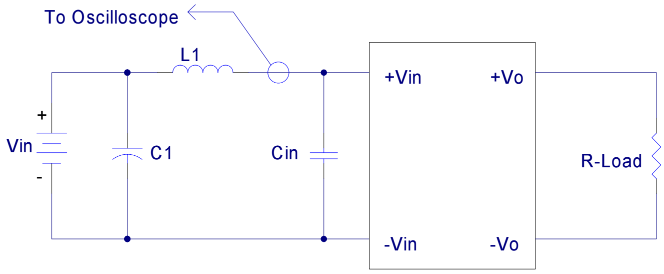

EC4SAW-48D05N (Eff Vs Io)
Efficiency (%)
90%
80%
70%
60%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Current Load (%)
18V
24V
48V
75V


EC4SAW-48D12N (Eff Vs Io)
Efficiency (%)
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
18V
24V
48V
75V


EC4SAW-48D15N (Eff Vs Io)
Efficiency (%)
90%
80%
70%
60%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Current Load (%)
18V
24V
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 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: 12uH
C1: None
Cin: 47uF 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 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.

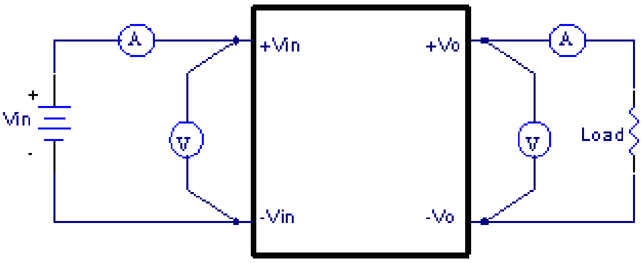
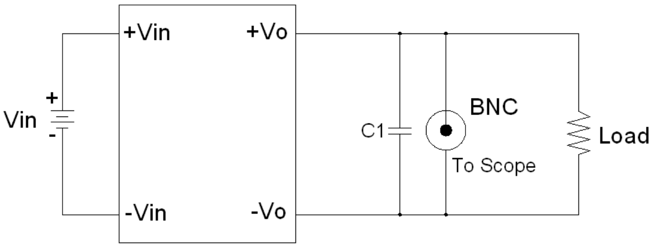


Figure 6 EC4SAW Series Test Setup

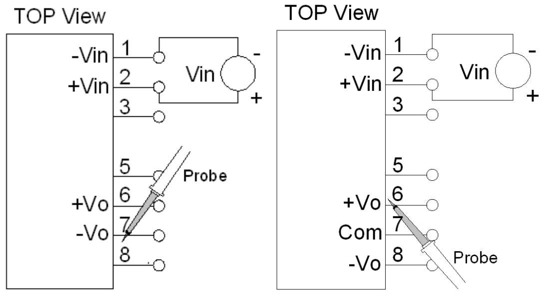
6.6 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in figure 7 and 8. 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: 0.1uF Ceramic capacitor.

Figure 7 Using BNC to Measure Output Ripple and Noise



Single Models Dual Models

Figure 8 Using Probe to Measure Output Ripple and Noise

6.7 Output Capacitance

The EC4SAW 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 EC4SAW 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 1.25A for 24Vin models and 630mA 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.

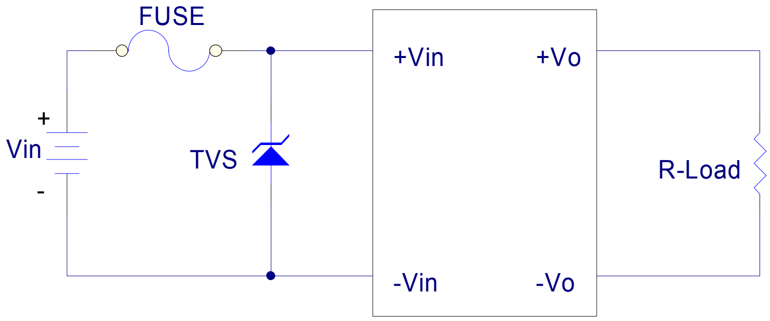


Figure 9 Input Protection

7.2 EMC Considerations

(1) EMI Test standard: EN55022 Class A/B Conducted Emission
Test Condition: Input Voltage: Nominal, Output Load: Full Load

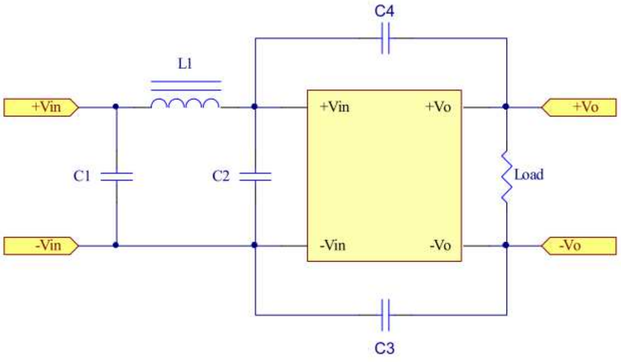
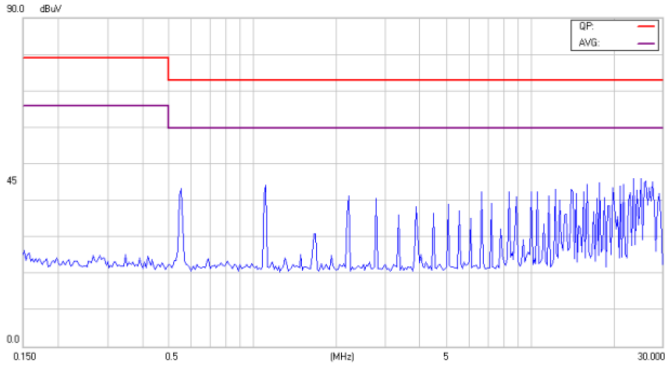


Figure 10 Connection circuit for conducted EMI testing

Model No.	EN55022 class A					EN55022 class B				
	C1	C2	C3	C4	L1	C1	C2	C3	C4	L1
EC4SAW-24S33N	10uF/50V	NC	150pF/2KV	150pF/2KV	10uH	10uF/50V	NC	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-24S05N	10uF/50V	NC	150pF/2KV	150pF/2KV	10uH	10uF/50V	NC	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-24S12N	10uF/50V	NC	150pF/2KV	150pF/2KV	10uH	10uF/50V	NC	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-24S15N	10uF/50V	NC	150pF/2KV	150pF/2KV	10uH	10uF/50V	NC	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-24D05N	10uF/50V	NC	150pF/2KV	150pF/2KV	10uH	10uF/50V	NC	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-24D12N	10uF/50V	NC	150pF/2KV	150pF/2KV	10uH	10uF/50V	NC	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-24D15N	10uF/50V	NC	150pF/2KV	150pF/2KV	10uH	10uF/50V	NC	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-48S33N	1uF/100V	NC	150pF/2KV	150pF/2KV	10uH	2.2uF/100V	2.2uF/100V	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-48S05N	1uF/100V	NC	150pF/2KV	150pF/2KV	10uH	2.2uF/100V	2.2uF/100V	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-48S12N	1uF/100V	NC	150pF/2KV	150pF/2KV	10uH	2.2uF/100V	2.2uF/100V	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-48S15N	1uF/100V	NC	150pF/2KV	150pF/2KV	10uH	2.2uF/100V	2.2uF/100V	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-48D05N	1uF/100V	NC	150pF/2KV	150pF/2KV	10uH	2.2uF/100V	NC	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-48D12N	1uF/100V	NC	150pF/2KV	150pF/2KV	10uH	2.2uF/100V	NC	1500pF/2KV	1500pF/2KV	10uH
EC4SAW-48D15N	1uF/100V	NC	150pF/2KV	150pF/2KV	10uH	2.2uF/100V	NC	1500pF/2KV	1500pF/2KV	10uH

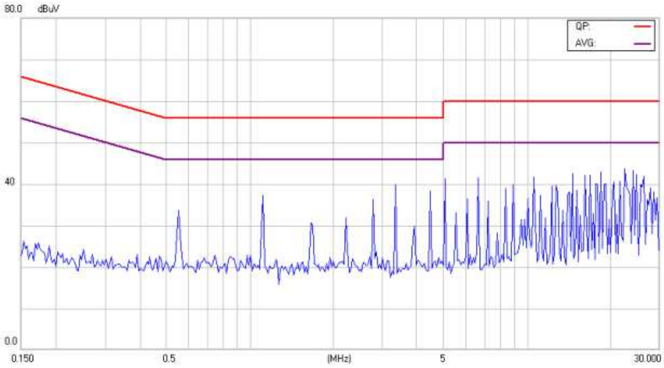
Note: All of capacitors are ceramic capacitors

Vin = 24Vdc



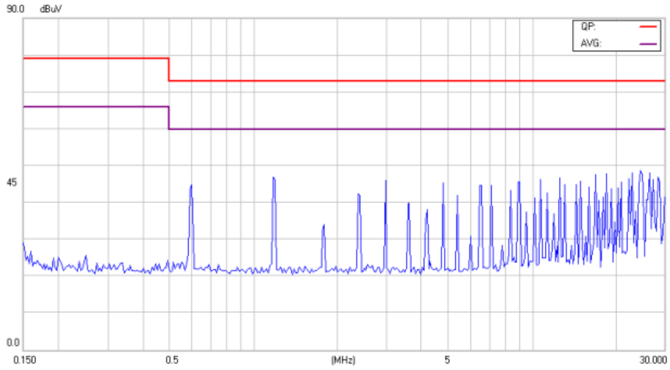
Conducted Class A of EC4SAW-24S33N

Vin = 24Vdc



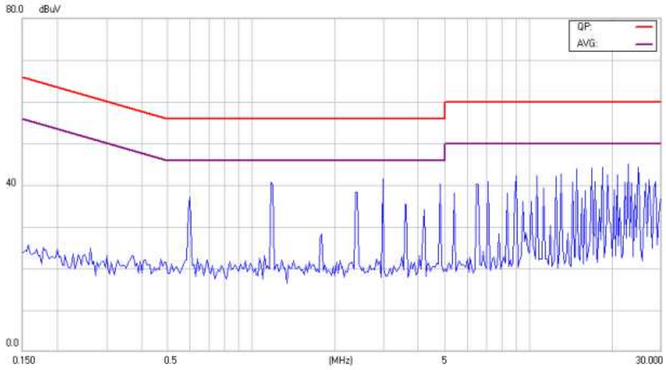
Conducted Class B of EC4SAW-24S33N

Vin = 24Vdc



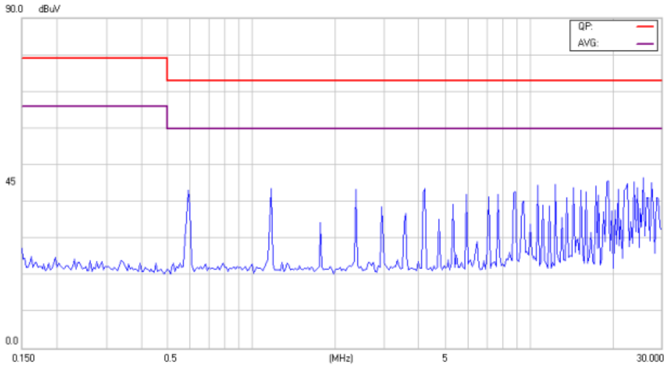
Conducted Class A of EC4SAW-24S05N

Vin = 24Vdc



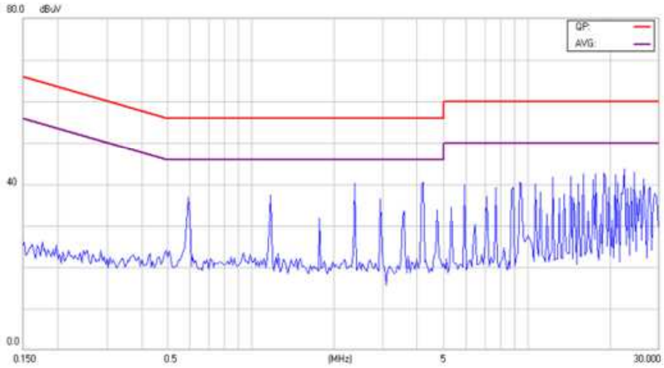
Conducted Class B of EC4SAW-24S05N

Vin = 24Vdc



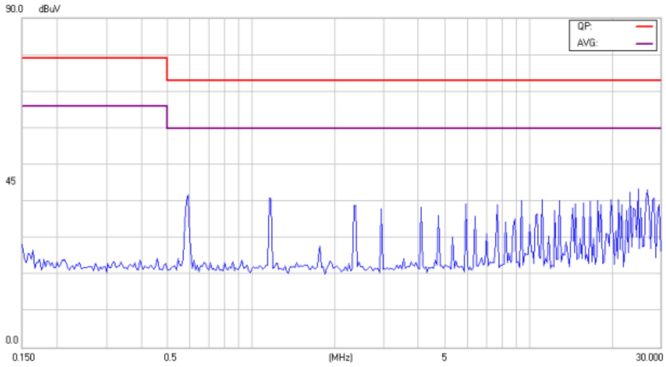
Conducted Class A of EC4SAW-24S12N

Vin = 24Vdc



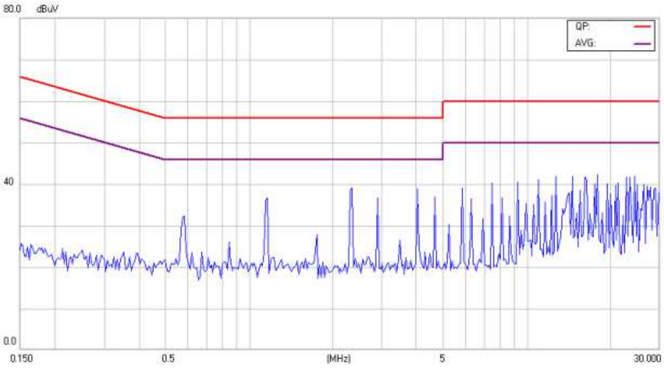
Conducted Class B of EC4SAW-24S12N

Vin = 24Vdc



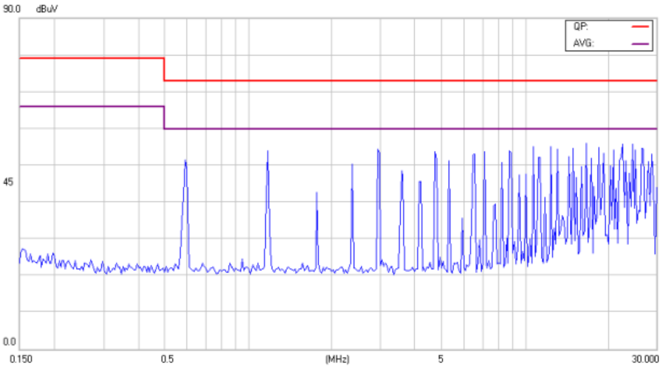
Conducted Class A of EC4SAW-24S15N

Vin = 24Vdc



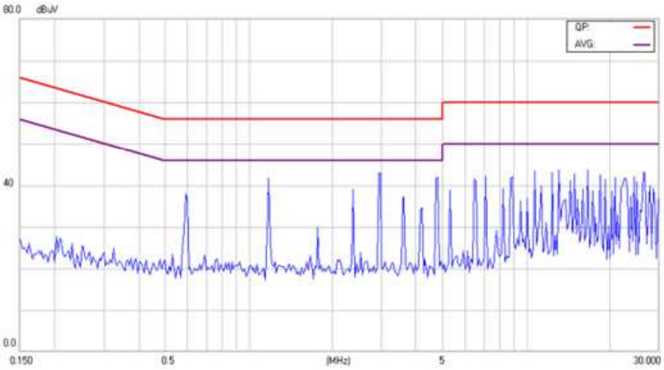
Conducted Class B of EC4SAW-24S15N

Vin = 24Vdc



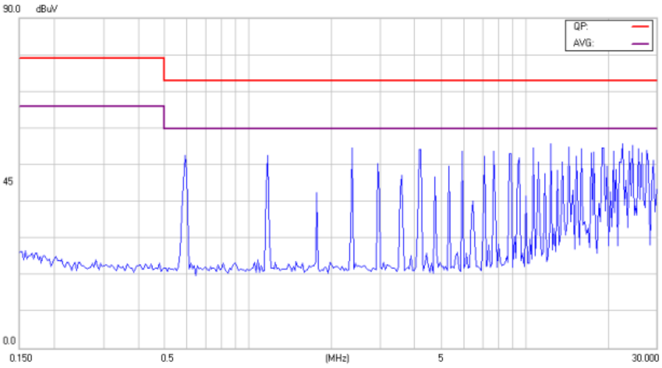
Conducted Class A of EC4SAW-24D05N

Vin = 24Vdc



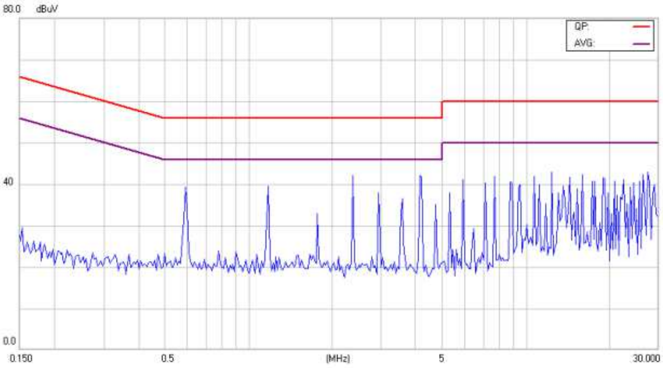
Conducted Class B of EC4SAW-24D05N

Vin = 24Vdc



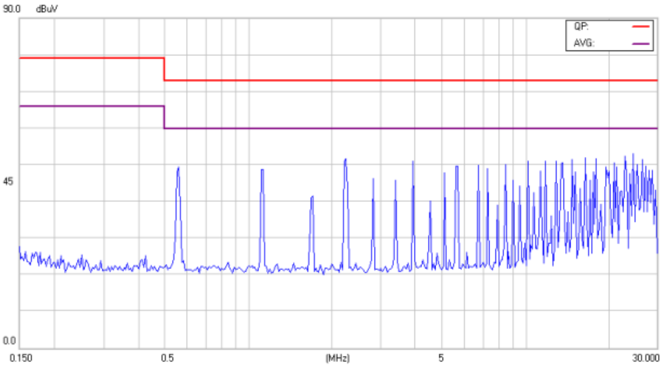
Conducted Class A of EC4SAW-24D12N

Vin = 24Vdc



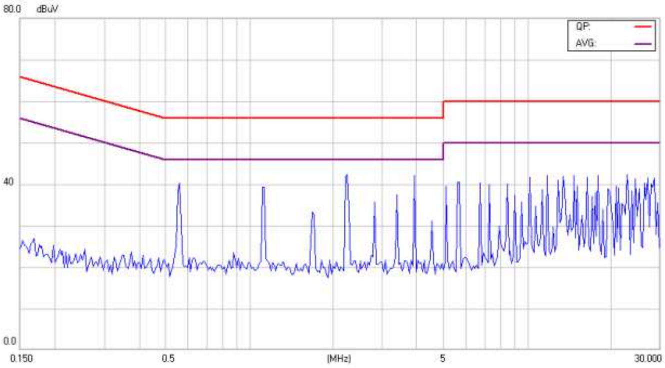
Conducted Class B of EC4SAW-24D12N

Vin = 24Vdc



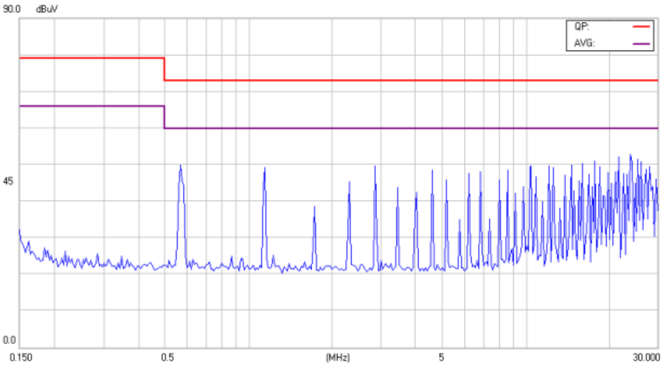
Conducted Class A of EC4SAW-24D15N

Vin = 24Vdc



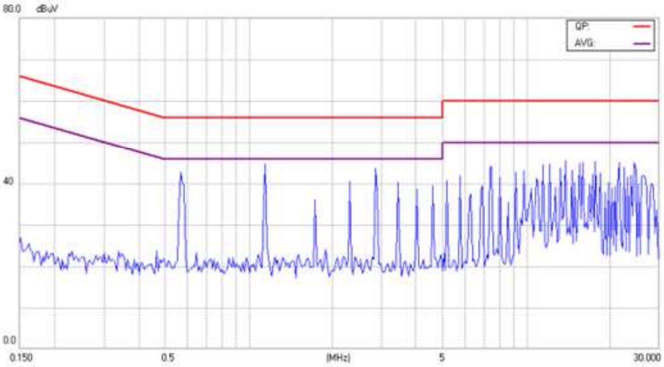
Conducted Class B of EC4SAW-24D15N

Vin =48Vdc



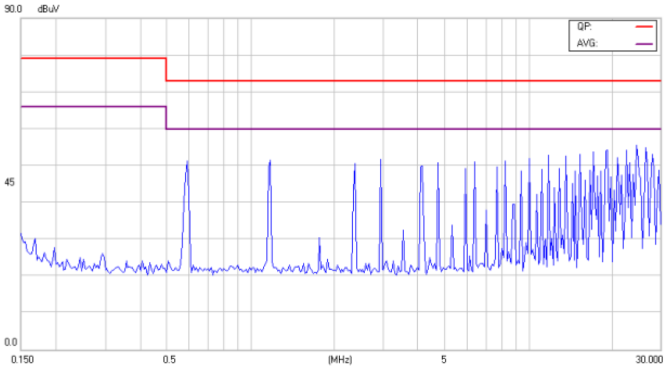
Conducted Class A of EC4SAW-48S33N

Vin =48Vdc



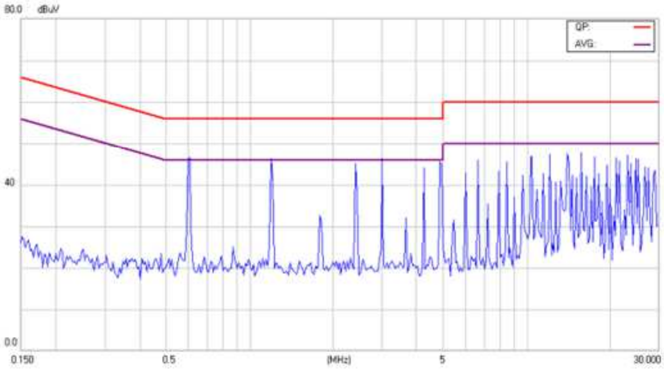
Conducted Class B of EC4SAW-48S33N

Vin = 48Vdc



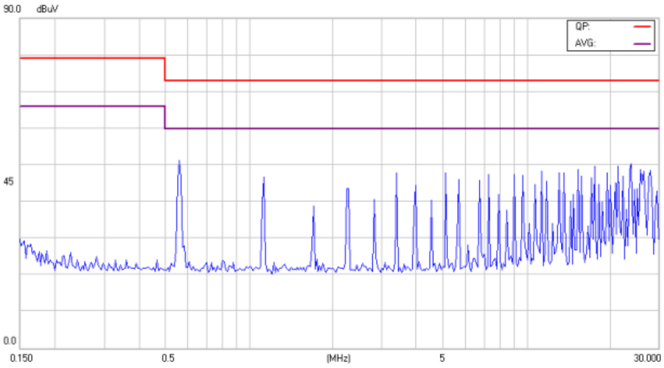
Conducted Class A of EC4SAW-48S05N

Vin = 48Vdc



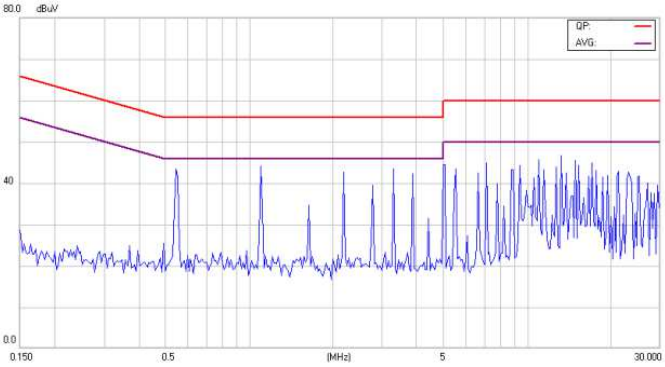
Conducted Class B of EC4SAW-48S05N

Vin = 48Vdc



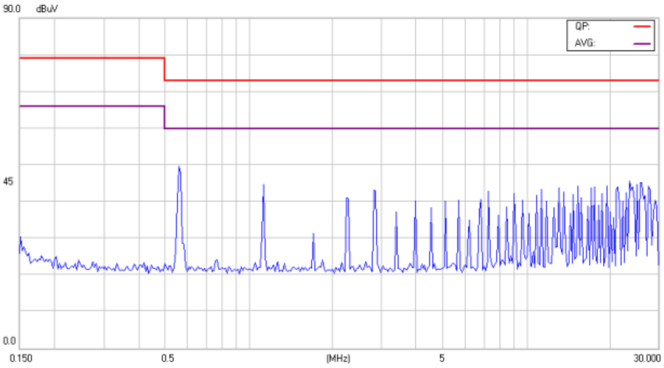
Conducted Class A of EC4SAW-48S12N

Vin = 48Vdc



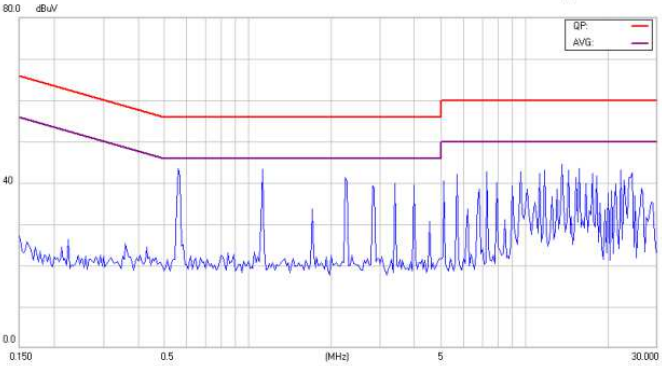
Conducted Class B of EC4SAW-48S12N

Vin =48Vdc



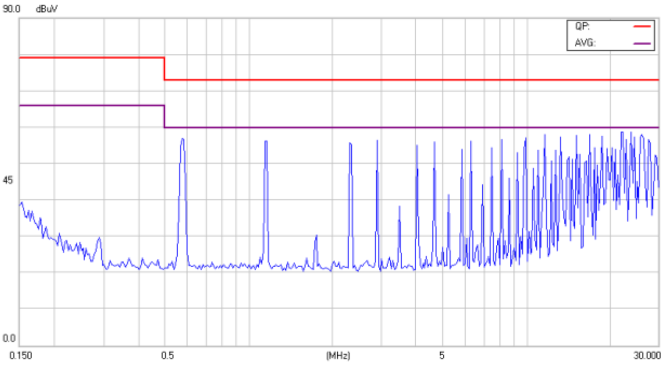
Conducted Class A of EC4SAW-48S15N

Vin =48Vdc



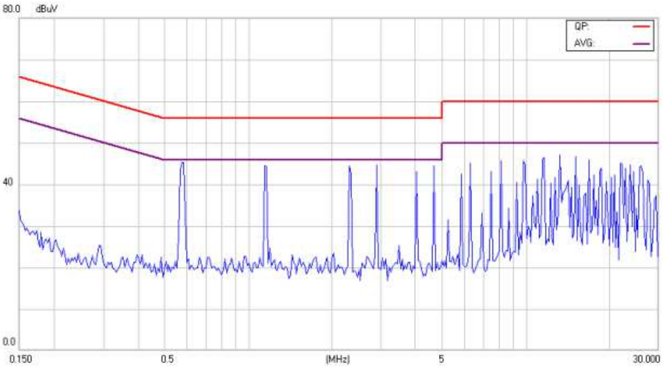
Conducted Class B of EC4SAW-48S15N

Vin =48Vdc



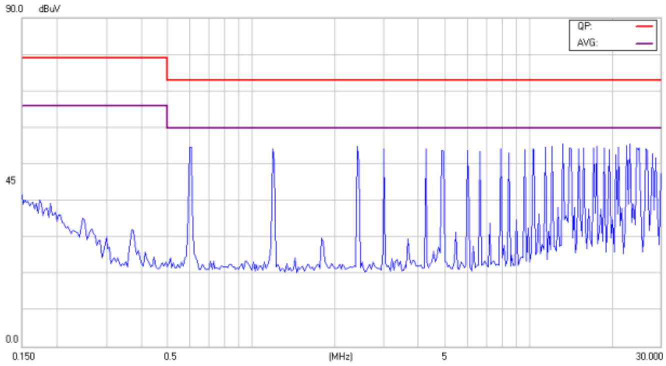
Conducted Class A of EC4SAW-48D05N

Vin =48Vdc



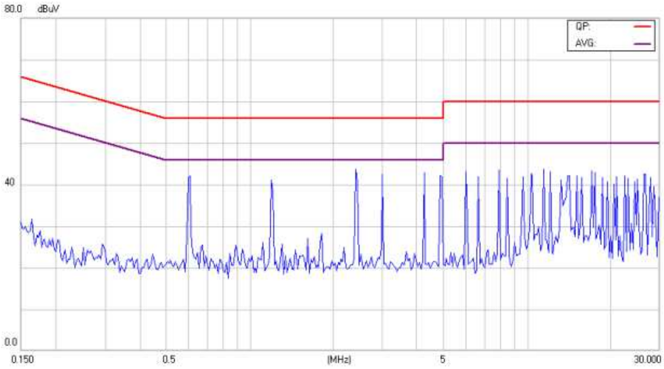
Conducted Class B of EC4SAW-48D05N

Vin =48Vdc



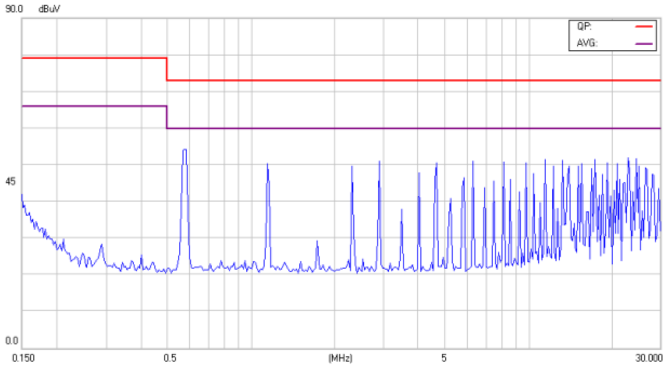
Conducted Class A of EC4SAW-48D12N

Vin =48Vdc



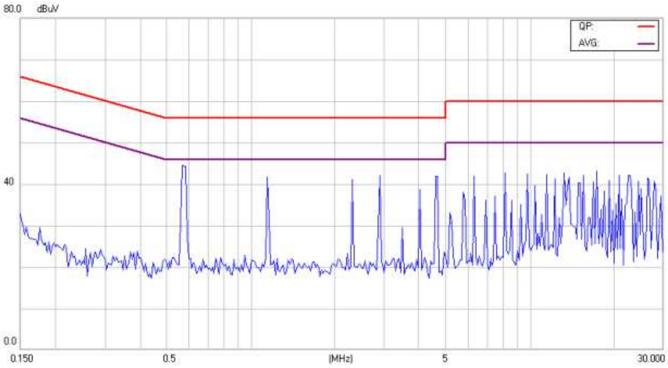
Conducted Class B of EC4SAW-48D12N

Vin =48Vdc



Conducted Class A of EC4SAW-48D15N

Vin =48Vdc



Conducted Class B of EC4SAW-48D15N

8. Part Number

EC4SAW – XX S XX N

N：Negative Logic Remote On/Off

EC4SAW SERIES

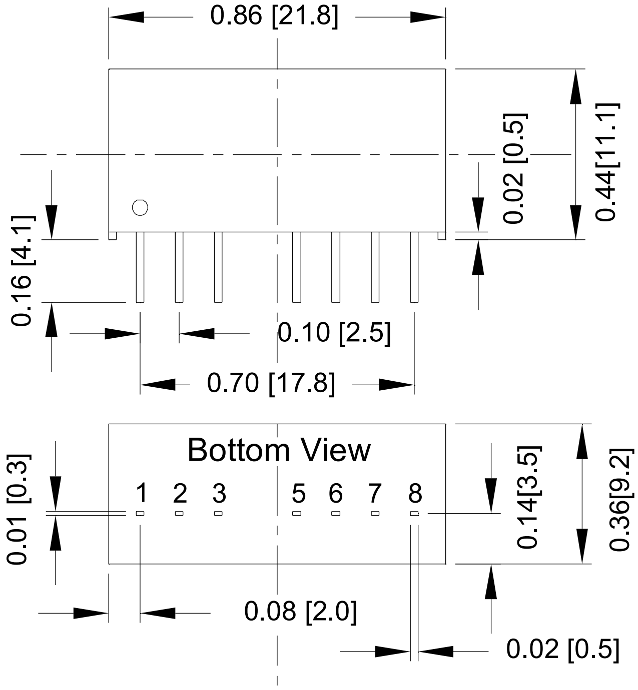
S：Single Output
D：Dual Output

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

All Dimensions In Inches(mm)
Tolerances : Inches millimeters
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
5	NC	NC
6	+V Output	+V Output
7	-V Output	Common
8	NC	-V Output

CINCON ELECTRONICS CO., LTD.

Headquarter Office:

14F, No.306, Sec.4, Hsin Yi Rd.,
Taipei, Taiwan
Tel: 886-2-27086210
Fax: 886-2-27029852
E-mail: sales@cincon.com.tw
Web Site: http://www.cincon.com

Factory:

No. 8-1, Fu Kong Rd.,
Fu Hsing Industrial Park
Fu Hsing Hsiang, ChangHua Hsien,
Taiwan
Tel: 886-4-7690261
Fax: 886-4-7698031

Cincon American Office:

1655 Mesa Verde Ave, Ste 180,
Ventura, CA 93003
Tel: 805-639-3350
Fax: 805-639-4101
E-mail: info@cincon.com

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