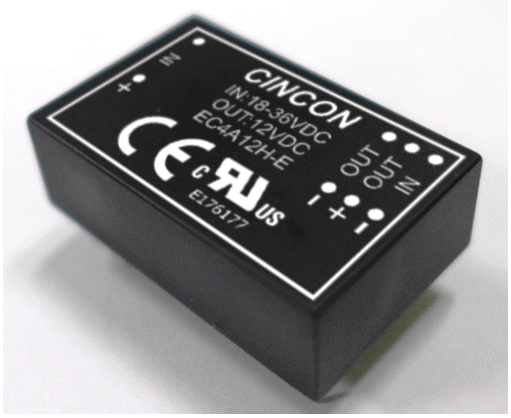
ISOLATED DC-DC Converter
EC4A-E SERIES
APPLICATION NOTE



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EC4A-E 4-6W Isolated DC-DC Converters

Application Note V10 June 2014

Content

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1. Introduction

The EC4A-E series offer 4-6 watts of output power in a 24 pin DIP and SMD package. The EC4A-E series has a 2:1 wide input voltage range of 9-18VDC, 18-36VDC and 36-72VDC, and provides a precisely regulated output. This series has features such as high efficiency, 500VDC, 1.5KVDC, 3KVDC of isolation and allows an ambient operating temperature range of ambient operating temperature range of –40℃ to 85℃ (de-rating above 80 ℃) . The modules are fully protected against outpu t short circuit. All models are very suitable for distributed power architectures, telecommunications, battery operated equipment and industrial applications.

2. DC-DC Converter Features

* 4-6W Isolated Output
* DIP-24 / SMD Package
* Efficiency Up to 87%
* 2:1 Input Range
* Regulated Outputs
* PI Input Filter
* Continuous Short Circuit Protection
* No Tantalum Capacitor Inside
* Input UVLO (Under Voltage Lockout)
* Meet EMI EN55022 class A
* Wide Operating Temperature Range
* UL60950-1 Approval

3. Electrical Block Diagram

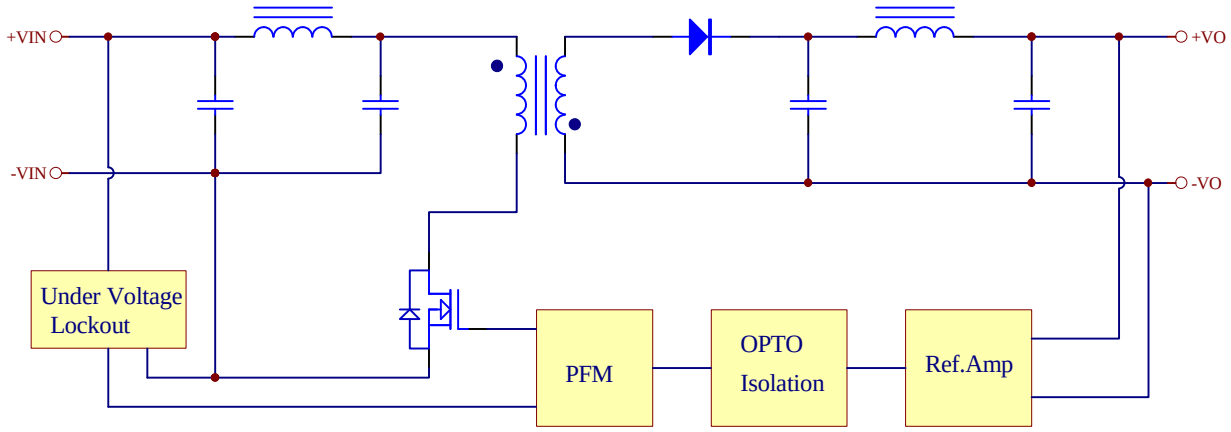


Figure 1 Electrical Block Diagram of single output module

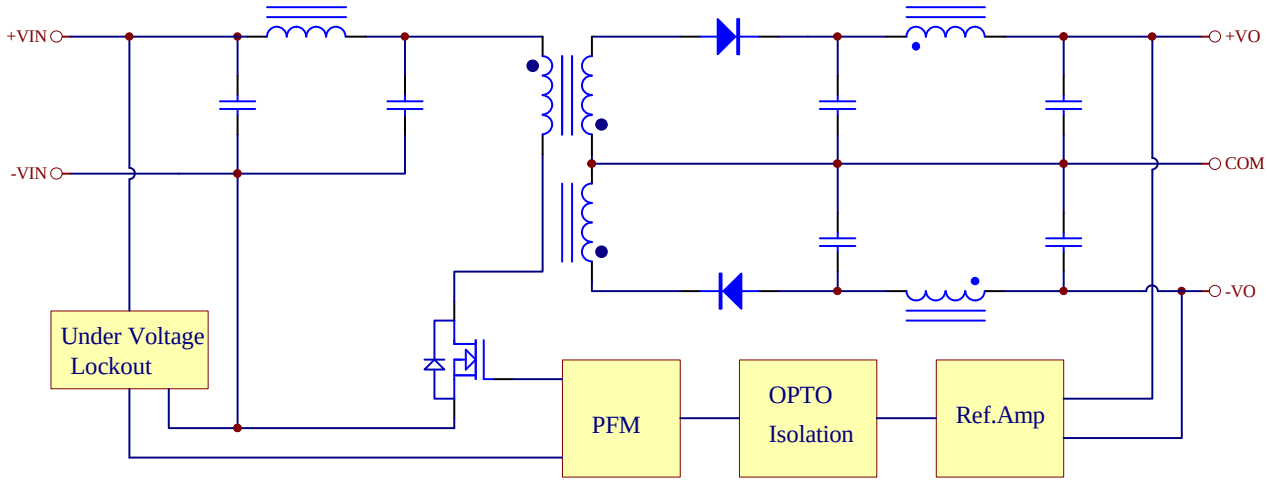


Figure 2 Electrical Block Diagram of dual output module

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		12Vin 24Vin 48Vin	-0.3 -0.3 -0.3		18 36 72	Vdc
Transient	100ms	12Vin 24Vin 48Vin			25 50 100	Vdc
Operating Ambient Temperature	With de-rating, above 80℃	All	-40		+85	℃
Case Temperature		All			100	℃
Storage Temperature		All	-40		+100	℃
Input/Output Isolation Voltage	1 minute	EC4AXX (M/MS)-E	500			Vdc
		EC4AXX (H/HS)-E	3000			
		EC4AXX (HM/HMS)-E	1500			
INPUT CHARACTERISTICS						
PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Operating Input Voltage		12Vin 24Vin 48Vin	9 18 36	12 24 48	18 36 72	Vdc
Turn-On Voltage Threshold		12Vin 24Vin 48Vin	8 16 31.5	8.5 16.5 32.5	8.8 17.5 34	Vdc
Turn-Off Voltage Threshold		12Vin 24Vin 48Vin	7.7 15 30.5	8 16 31.5	8.3 17 33	Vdc
Lockout Hysteresis Voltage		12Vin 24Vin 48Vin		0.5 0.8 1.5		Vdc
Maximum Input Current	Full load, Vin= 9V	12Vin		800		mA
	Full load, Vin=18V	24Vin		392		
	Full load, Vin=36V	48Vin		196		
No-Load Input Current	Vin=12V	Vo=3.3Vdc Vo=5Vdc Vo=12Vdc Vo=15Vdc Vo=±5Vdc Vo=±12Vdc Vo=±15Vdc		7.5 7.5 10 15 12 12 18		mA
	Vin=24V	Vo=3.3Vdc Vo=5Vdc Vo=12Vdc Vo=15Vdc Vo=±5Vdc Vo=±12Vdc Vo=±15Vdc		5 5 8 8 8 8 10		

No-Load Input Current	Vin=48V	Vo=3.3Vdc Vo=5Vdc Vo=12Vdc Vo=15Vdc Vo=±5Vdc Vo=±12Vdc Vo=±15Vdc		2 3 6 6 5 6 6		mA
Inrush Current (I^2t)	As per ETS300 132-2	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	Vin=nominal input, Io= $Io_{max.}$	Vo=3.3Vdc Vo=5Vdc Vo=12Vdc Vo=15Vdc Vo=±5Vdc Vo=±12Vdc Vo=±15Vdc	3.2505 4.925 11.82 14.775 ±4.925 ±11.82 ±14.775	3.3 5 12 15 ±5 ±12 ±15	3.3495 5.075 12.18 15.225 ±5.075 ±12.18 ±15.225	Vdc
Output Voltage Balance	Vin=nominal input, Io=$Io_{max.}$	Dual			±1.0	%
Output Voltage Regulation						
Load Regulation	Io=full load to 10% load	Single			±0.5	%
	Io=full load to 25% load	Dual			±1.0	
Line Regulation	Vin=low line to high line, full load	Single Dual			±0.5	%
Temperature Coefficient	Ta=-40℃ to 85℃	All			±0.05	%/℃
Output Voltage Ripple and Noise (5Hz to 20MHz bandwidth)						
Peak-to-Peak	Vin=nominal input, Io= full load (with 0.1uF MLCC for SMD package)	Vo=3.3Vdc Vo=5Vdc Vo=±5Vdc			100	mV
		Vo=12Vdc Vo=±12Vdc			120	
		Vo=15Vdc Vo=±15Vdc			150	
Operating Output Current Range		Vo=3.3Vdc Vo=5Vdc Vo=12Vdc Vo=15Vdc Vo=±5Vdc Vo=±12Vdc Vo=±15Vdc			1200 1000 500 400 ±500 ±250 ±200	mA
Output DC Current-Limit Inception	Vo=90% $V_{O, nominal}$	All	120			%
Maximum Output Capacitance	Full load (resistive)	Vo=3.3Vdc Vo=5Vdc Vo=12Vdc Vo=15Vdc Vo=±5Vdc Vo=±12Vdc Vo=±15Vdc	0 0 0 0 0 0 0		4700 4700 4700 4700 2200 2200 2200	uF
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	All		±6		%
Setting Time (within 1% Vout nominal)	di/dt=0.1A/us	All			500	us

Turn-On Delay and Rise Time						
Turn-On Delay Time, From Input	Vin, min. to 10%Vo, set	All			2	ms
Output Voltage Rise Time	10%Vo, set to 90%Vo, set	All			2	ms

EFFICIENCY

PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
100% Load	Vin=12V	EC4A01-E		81		%
		EC4A02-E		84		
		EC4A03-E		85		
		EC4A04-E		85		
		EC4A05-E		85		
		EC4A06-E		81		
		EC4A07-E		77		
	Vin=24V	EC4A11-E		83		
		EC4A12-E		86		
		EC4A13-E		87		
		EC4A14-E		86		
		EC4A15-E		87		
		EC4A16-E		82		
		EC4A17-E		79		
	Vin=48V	EC4A21-E		83		
		EC4A22-E		87		
		EC4A23-E		87		
		EC4A24-E		87		
		EC4A25-E		87		
		EC4A26-E		83		
		EC4A27-E		79		

ISOLATION CHARACTERISTICS

PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Isolation Voltage	Input to Output, 1 minutes	EC4AXX (S/M/MS)-E			500	Vdc
		EC4AXX (H/HS)-E			3000	
		EC4AXX (HM/HMS)-E			1500	
Isolation Resistance	Input to Output	All	1000			MΩ
Isolation Capacitance	Input to Output	All		250		pF

FEATURE CHARACTERISTICS

PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Switching Frequency		All	100			KHz

GENERAL SPECIFICATIONS

PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
MTBF	Io=100% of Io.max; Ta=25℃ per MIL-HDBK-217F	All		1.8		M hours
Weight		All		12.5		grams

5. Main Features and Functions

5.1 Operating Temperature Range

The EC4A-E series converters can be operated by a wide ambient temperature range from -40℃ to 85℃ (de-rating above 80℃). The standard models case temperature should not be exceeded 100℃ at normal operating (Detail see content 6.2).

5.2 UVLO (Under Voltage Lockout)

Input under voltage lockout is standard on the EC4A-E models. 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.

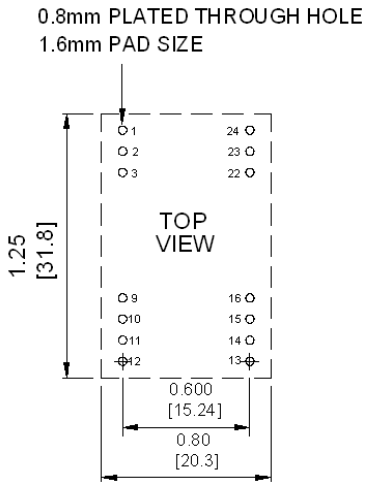
5.3 Over Current Protection

All 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 over current protection.

6. Applications

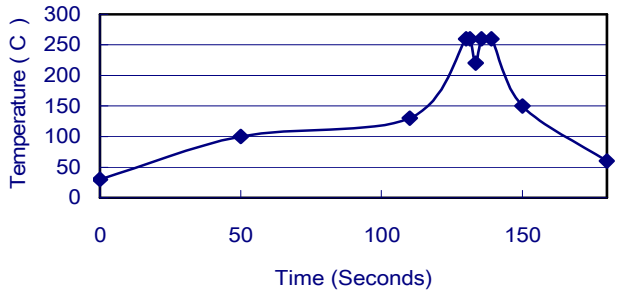
6.1 Recommended Layout PCB Footprints and Soldering Information

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.

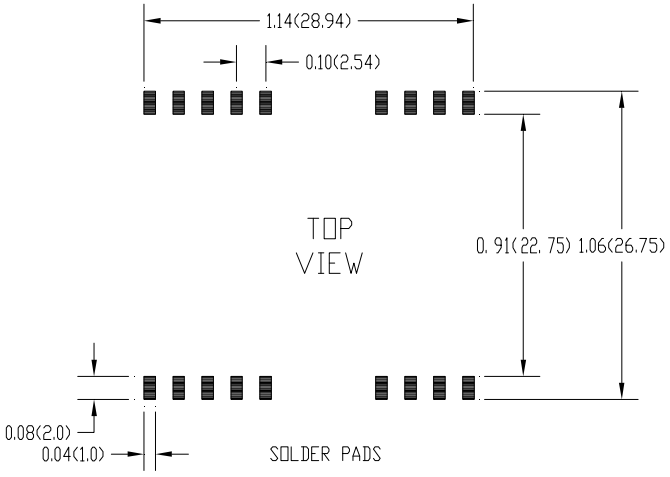


Note: Dimensions are in inches (millimeters)

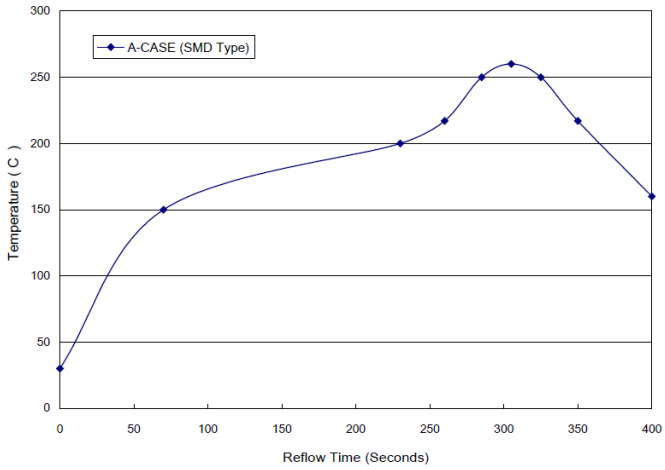
Lead Free Wave Soldering Profile



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℃)



Lead Free Hot Air Reflow Profile



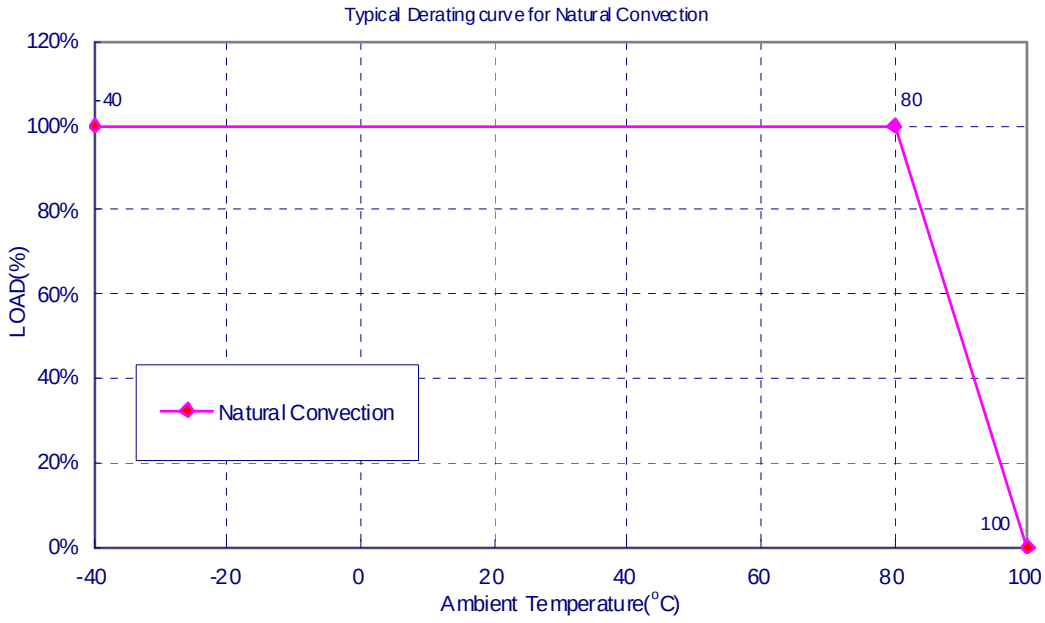
Note：

1. Soldering Paste: SHENMAO PF610-P (Sn/Ag/Cu)
2. Ramp up rate during preheat: 1.71 ℃/Sec (From 30℃ to 150℃)
3. Soaking temperature: 0.31 ℃/Sec (From 150℃ to 200℃), 160±10 seconds
4. Ramp up rate during reflow: 0.96 ℃/Sec (From 217℃ to 260℃)
5. Peak temperature: 260℃, above 217℃ 90 Seconds
6. Ramp up rate during cooling: -1.2 ℃/Sec (From 260℃ to 160℃)

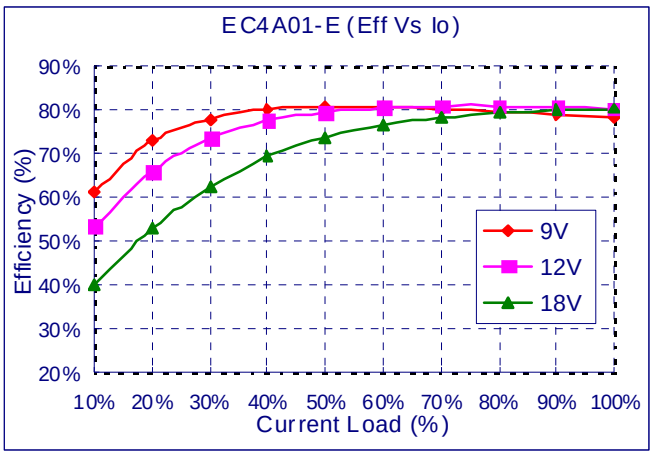
Figure 3 Recommended PCB Layout Footprints and Wave Soldering Profiles for DIP-24 and SMD packages

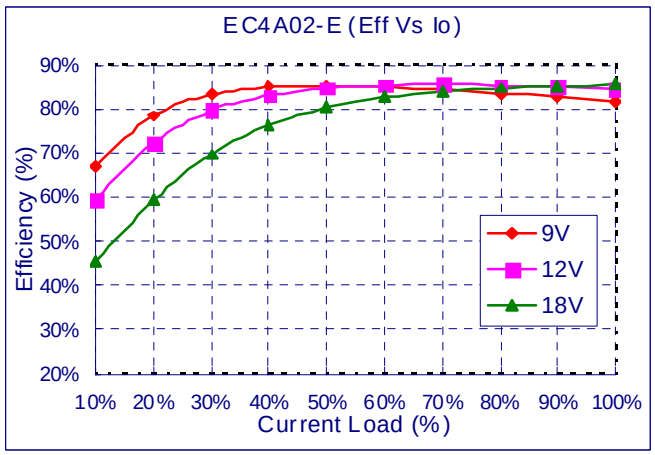
6.2 Power De-Rating Curves for EC4A-E Series

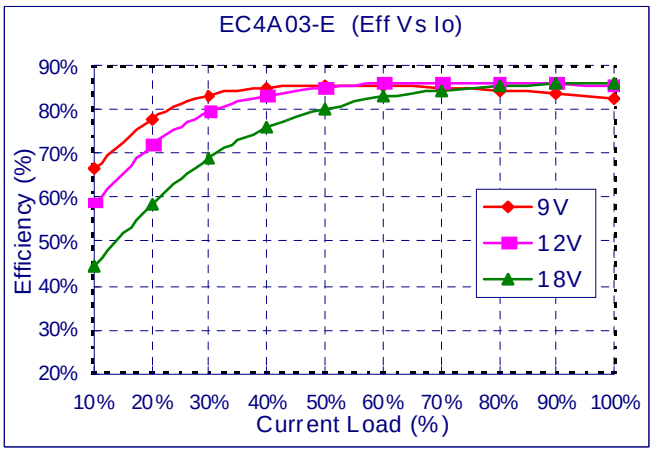
Operating Ambient temperature Range: -40℃ ~ 85℃ with de-rating above 80℃

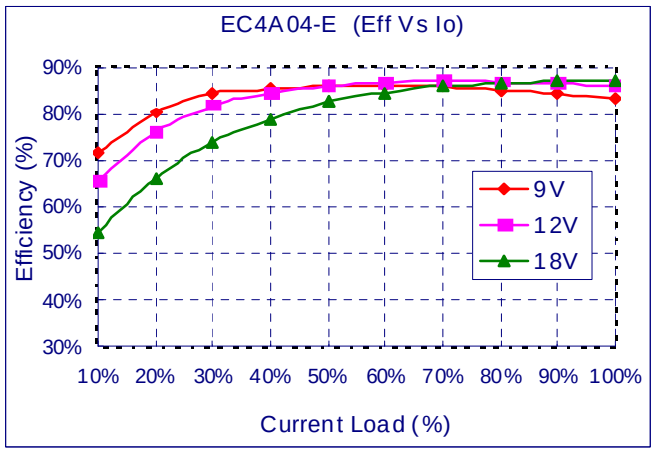


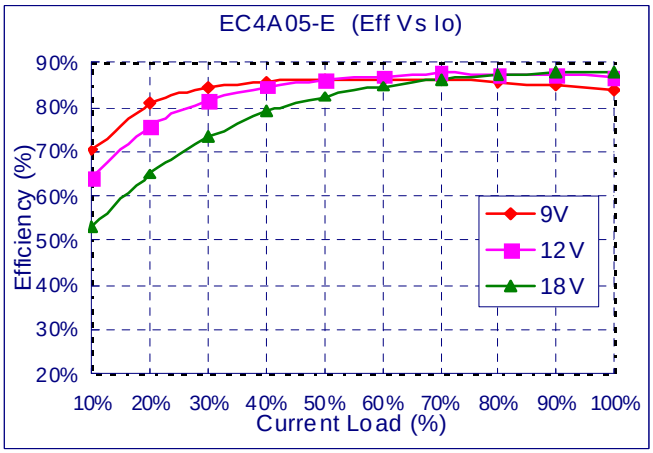
6.3 Efficiency vs. Load Curves

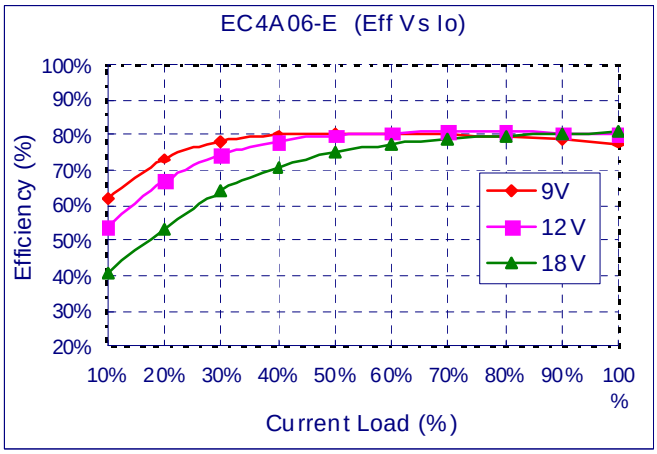


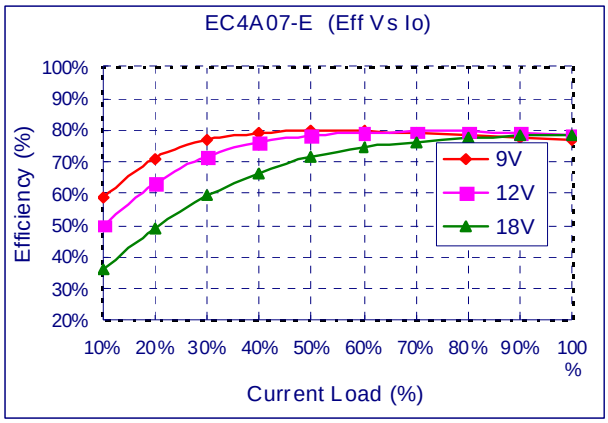


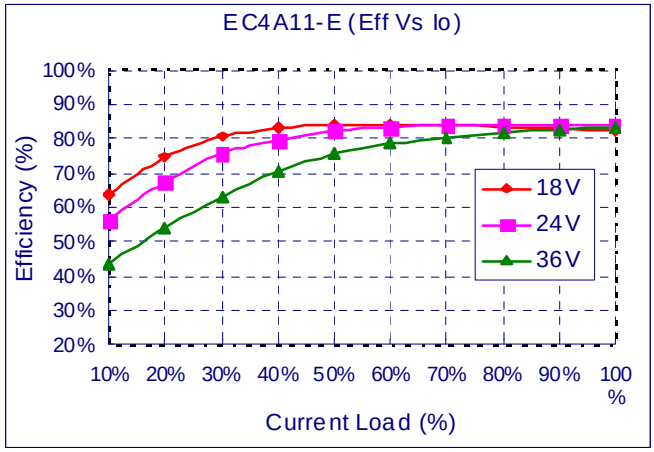


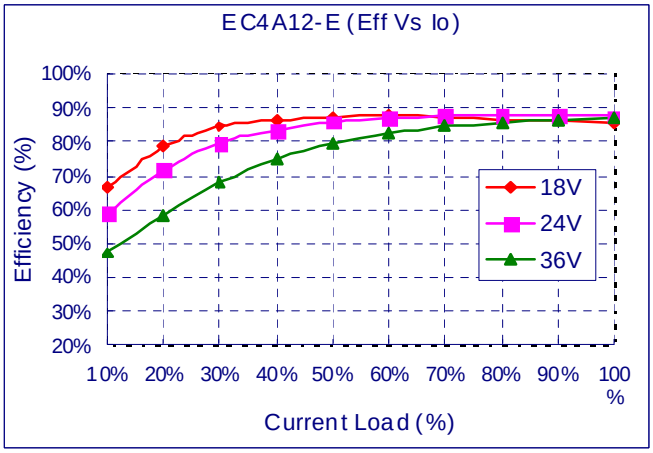


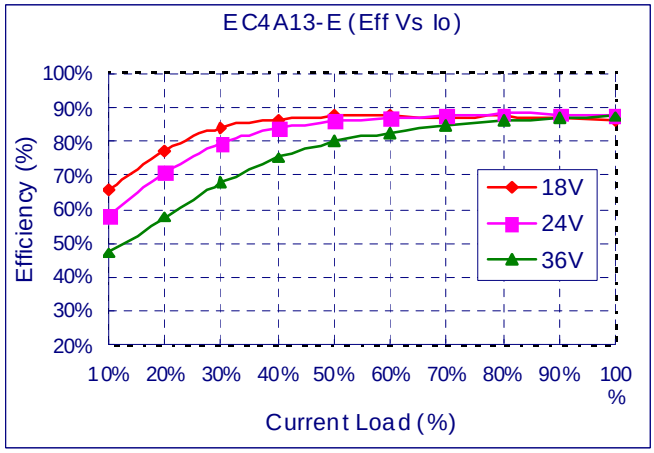


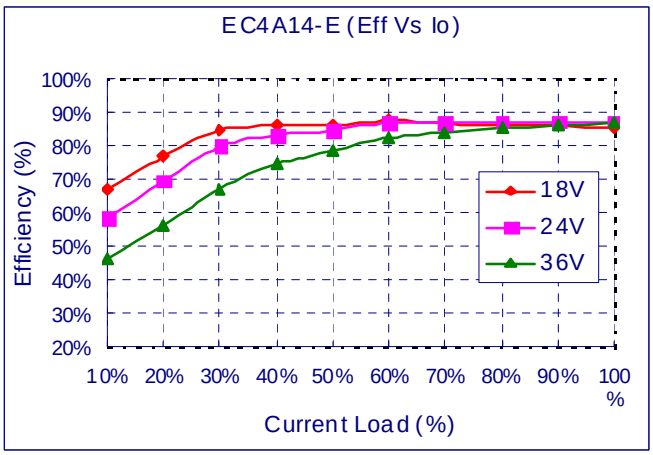


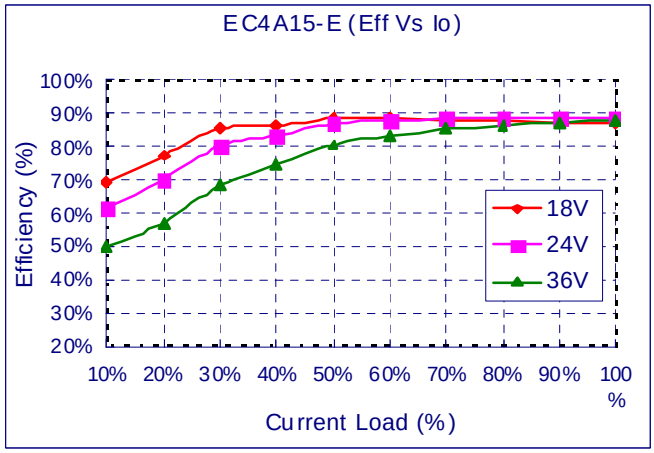

EC4A07-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
9V
12V
18V

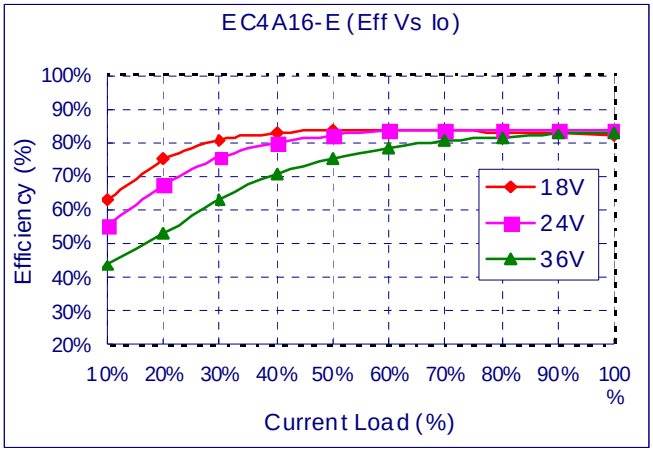

EC4A11-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
18V
24V
36V

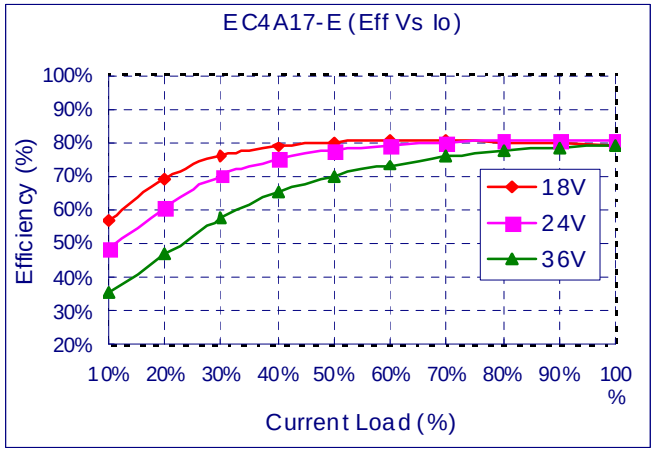

EC4A12-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
18V
24V
36V

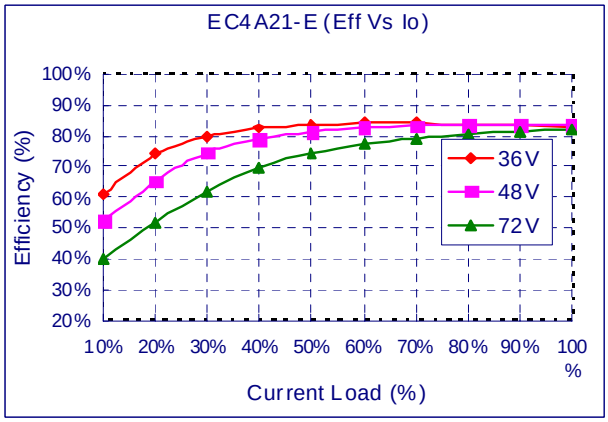

EC4A13-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
18V
24V
36V

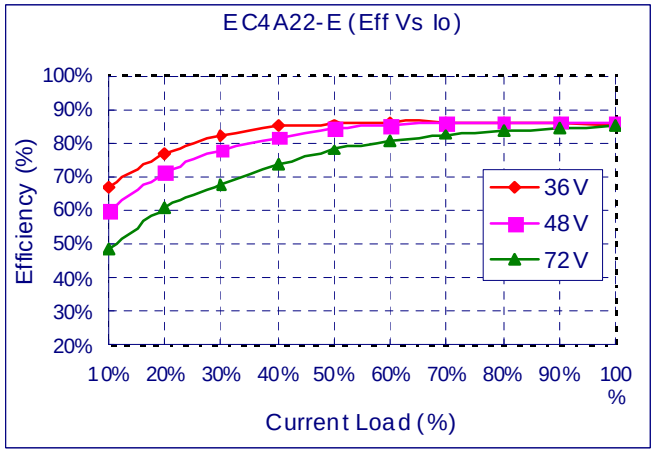

EC4A14-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
18V
24V
36V

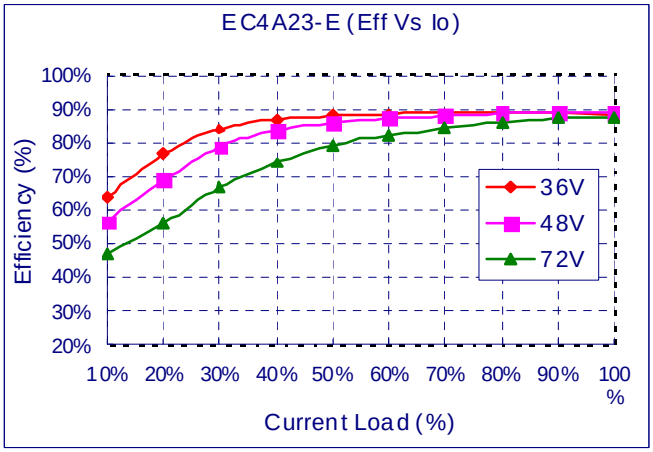

EC4A15-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
18V
24V
36V

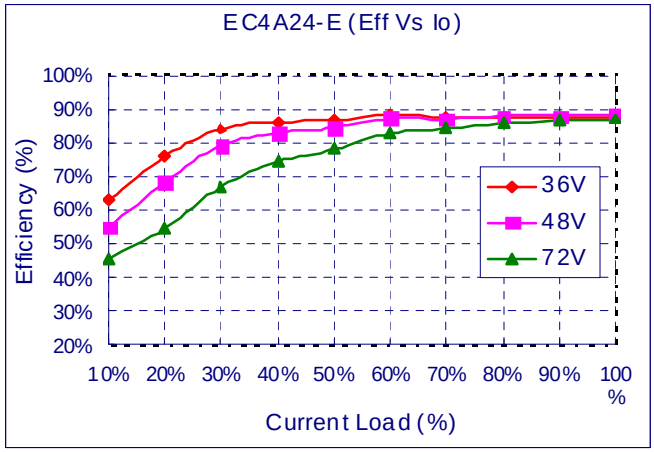

EC4A16-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
18V
24V
36V

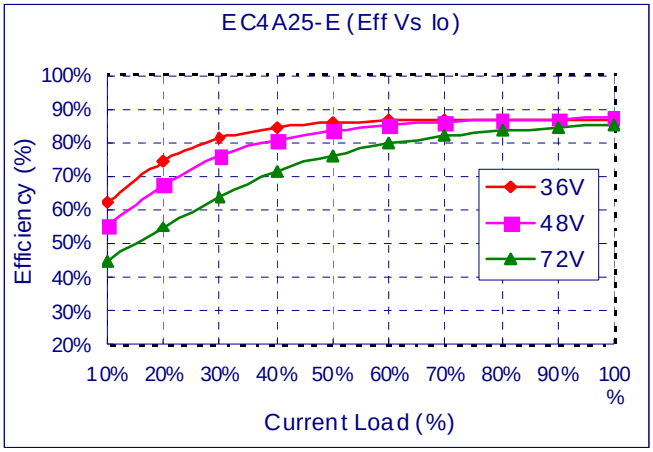

EC4A17-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
18V
24V
36V

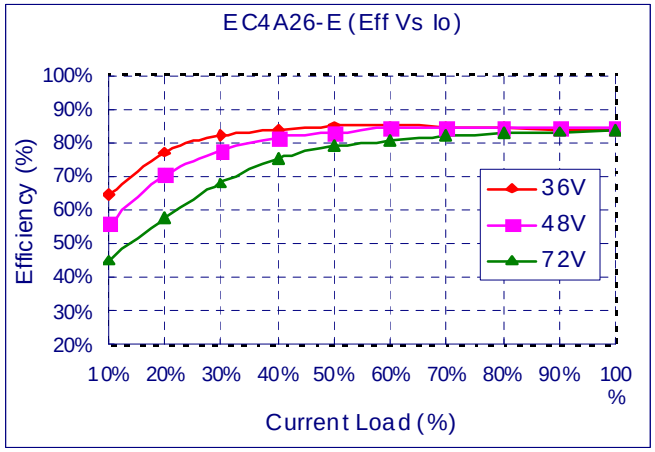

EC4A21-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
36V
48V
72V

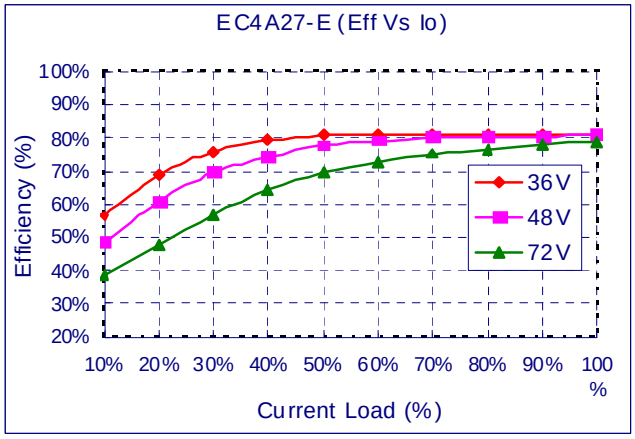

EC4A22-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
36V
48V
72V


EC4A23-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
36V
48V
72V


EC4A24-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
36V
48V
72V

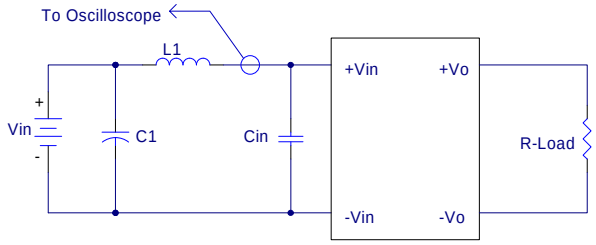

EC4A25-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
36V
48V
72V


EC4A26-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
36V
48V
72V


EC4A27-E (Eff Vs Io)
Efficiency (%)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10% 20% 30% 40% 50% 60% 70% 80% 90% 100 %
Current Load (%)
36V
48V
72V

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 4 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 tooscilloscope with a simulated source Inductance (L1).



L1: 12uH.
C1: 220uF ESR <0.1Ω @ 20℃, 100KHz.
Cin: None

Figure 4 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 5. 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 (Single output)
V_{NL} is the output voltage at 25% load (Dual output)

The value of line regulation is defined as:

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

Where

VHL is the output voltage of maximum input voltage at full load.
VLL is the output voltage of minimum input voltage at full load.

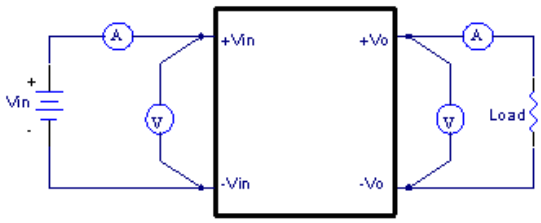
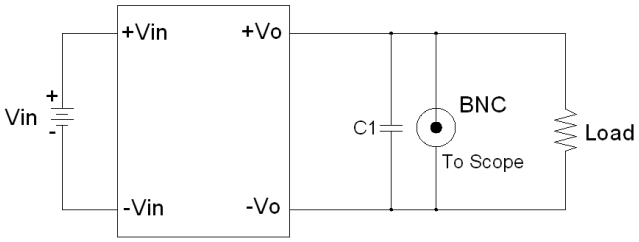


Figure 5 EC4A Series Test Setup

6.6 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure 6 and 7. 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 for SMD Models Only

Figure 6 Using BNC to Measure Output Ripple and Noise

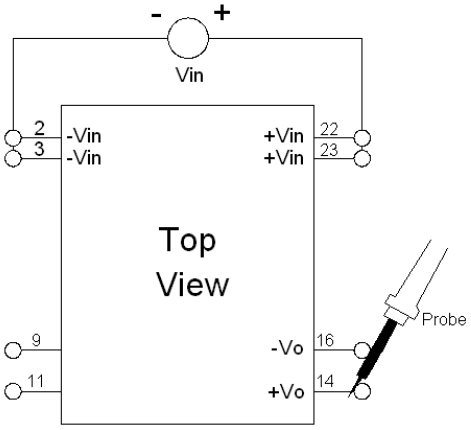


Figure 7 Using Probe to Measure Output Ripple and Noise

6.7 Output Capacitance

The EC4A-E 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 EC4A-E 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 1.6A for 12Vin models, 1A for 24Vin models and 0.5A for 48Vin modules. Figure 10 circuits are recommended by a Transient Voltage Suppressor diode across the input terminal to protect the unit against surge or spike voltage and input reverse voltage.

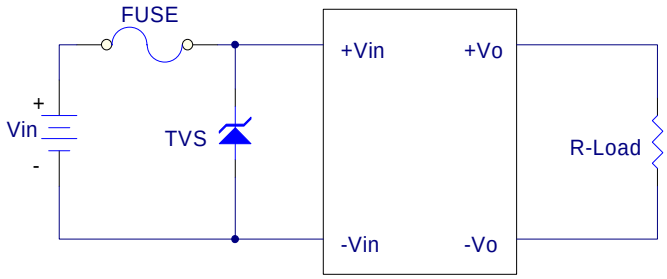


Figure 8 Input Protection

7.2 EMC Considerations

EMI Test standard: EN55022
Test Condition: Input Voltage: Nominal, Output Load: Full Load

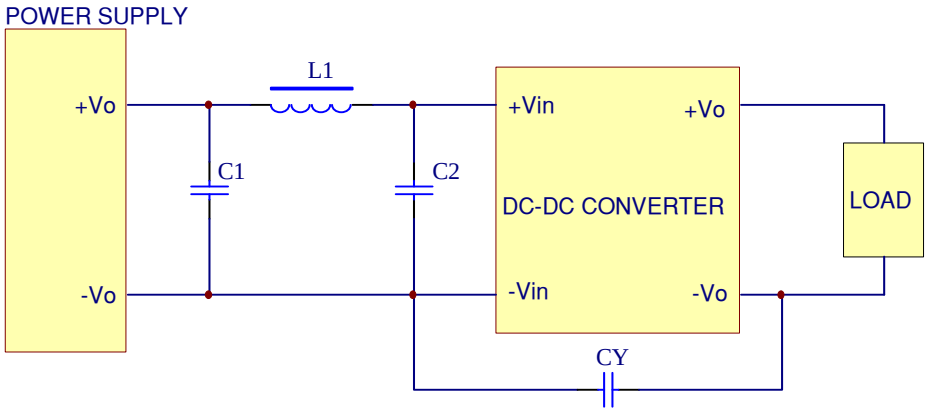
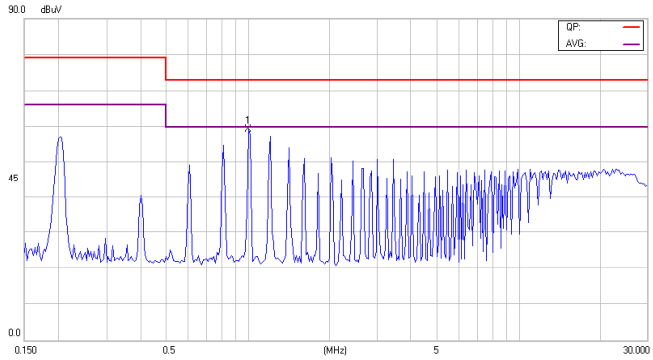


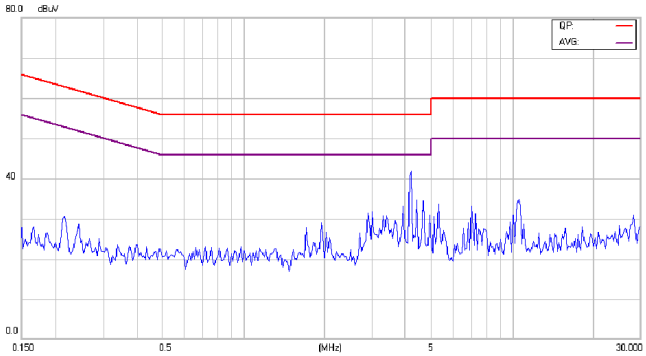
Figure 9 Connection circuit for conducted EMI testing

Model No.	EN55022 Class A				EN55022 Class B			
	C1	C2	L1	CY	C1	C2	L1	CY
EC4A01-E	NC	NC	Short	NC	10uF/25V	NC	5.6uH	1000pF/3KV
EC4A02-E	NC	NC	Short	NC	10uF/25V	NC	5.6uH	1000pF/3KV
EC4A03-E	NC	NC	Short	NC	10uF/25V	NC	5.6uH	1000pF/3KV
EC4A04-E	NC	NC	Short	NC	10uF/25V	NC	5.6uH	1000pF/3KV
EC4A05-E	NC	NC	Short	NC	10uF/25V	NC	5.6uH	1000pF/3KV
EC4A06-E	NC	NC	Short	NC	10uF/25V	NC	5.6uH	1000pF/3KV
EC4A07-E	NC	NC	Short	NC	10uF/25V	NC	5.6uH	1000pF/3KV
EC4A11-E	NC	NC	Short	NC	3.3uF/50V	NC	5.6uH	470pF/3KV
EC4A12-E	NC	NC	Short	NC	3.3uF/50V	NC	5.6uH	470pF/3KV
EC4A13-E	NC	NC	Short	NC	3.3uF/50V	NC	5.6uH	470pF/3KV
EC4A14-E	NC	NC	Short	NC	3.3uF/50V	NC	5.6uH	470pF/3KV
EC4A15-E	NC	NC	Short	NC	3.3uF/50V	NC	5.6uH	470pF/3KV
EC4A16-E	NC	NC	Short	NC	3.3uF/50V	NC	5.6uH	470pF/3KV
EC4A17-E	NC	NC	Short	NC	3.3uF/50V	NC	5.6uH	470pF/3KV
EC4A21-E	NC	NC	Short	NC	2.2uF/100V	NC	12uH	1000pF/3KV
EC4A22-E	NC	NC	Short	NC	2.2uF/100V	NC	12uH	1000pF/3KV
EC4A23-E	NC	NC	Short	NC	2.2uF/100V	NC	12uH	1000pF/3KV
EC4A24-E	NC	NC	Short	NC	2.2uF/100V	NC	12uH	1000pF/3KV
EC4A25-E	NC	NC	Short	NC	2.2uF/100V	NC	12uH	1000pF/3KV
EC4A26-E	NC	NC	Short	NC	2.2uF/100V	NC	12uH	1000pF/3KV
EC4A27-E	NC	NC	Short	NC	2.2uF/100V	NC	12uH	1000pF/3KV

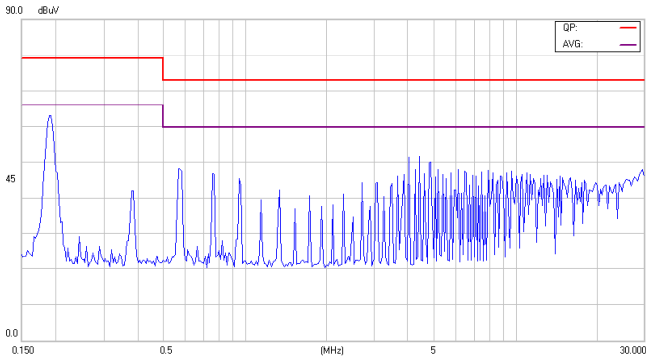
Note: All of capacitors are ceramic capacitors.



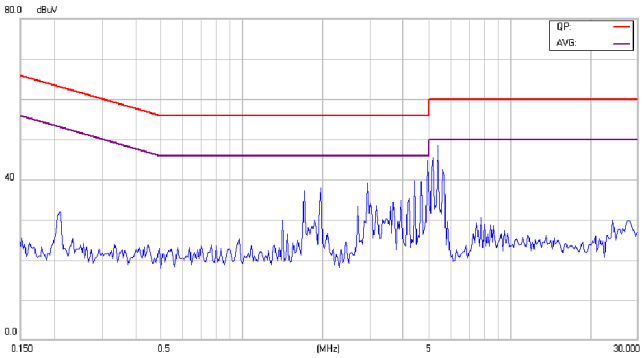
Conducted Class A of EC4A01-E



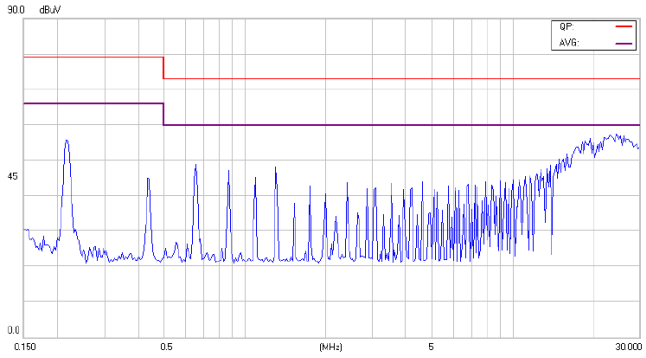
Conducted Class B EC4A01-E



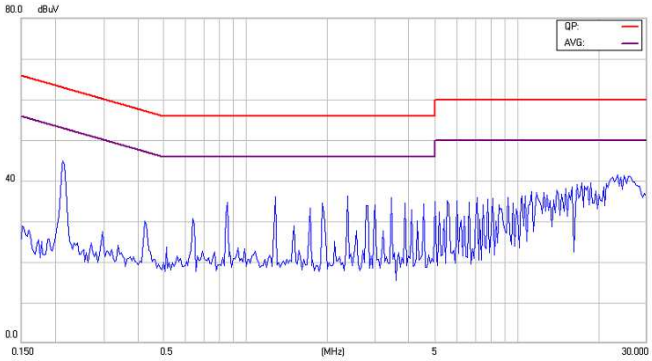
Conducted Class A EC4A05-E



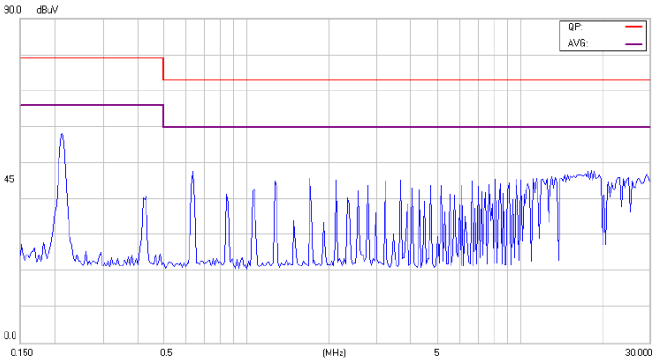
Conducted Class B EC4A05-E



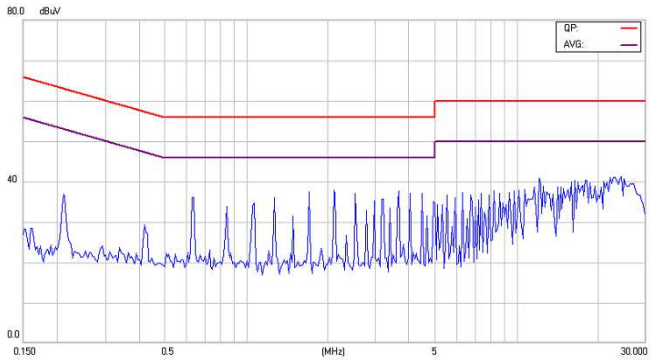
Conducted Class A of EC4A11-E



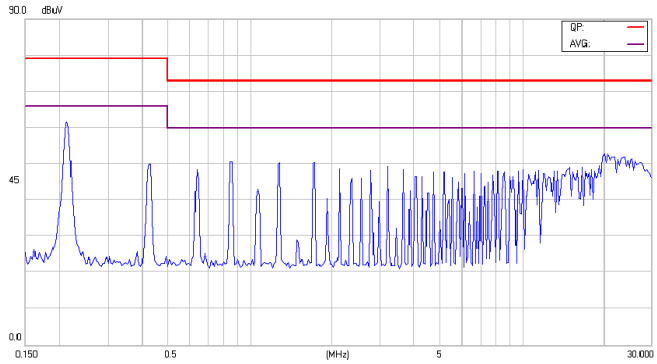
Conducted Class B of EC4A11-E



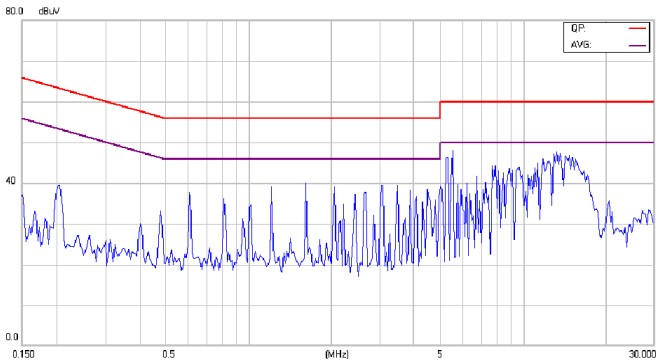
Conducted Class A EC4A14-E



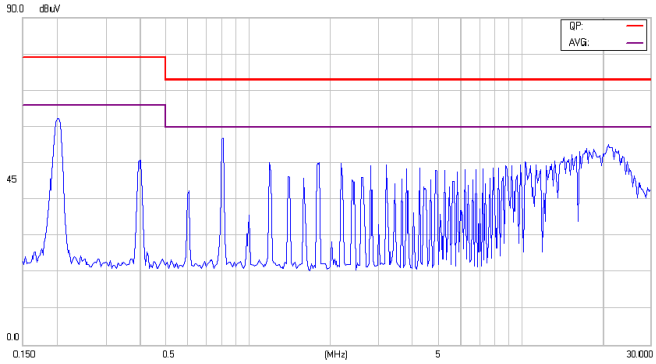
Conducted Class B EC4A14-E



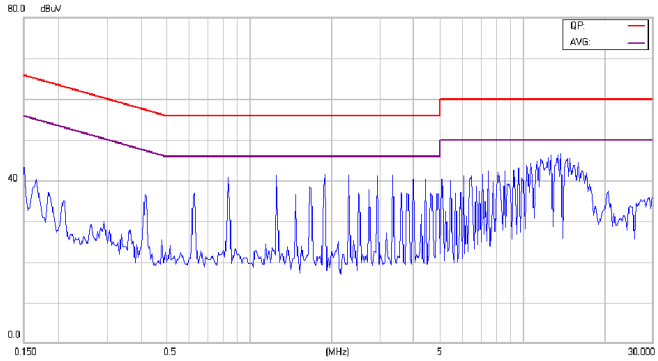
Conducted Class A EC4A22-E



Conducted Class B EC4A22-E

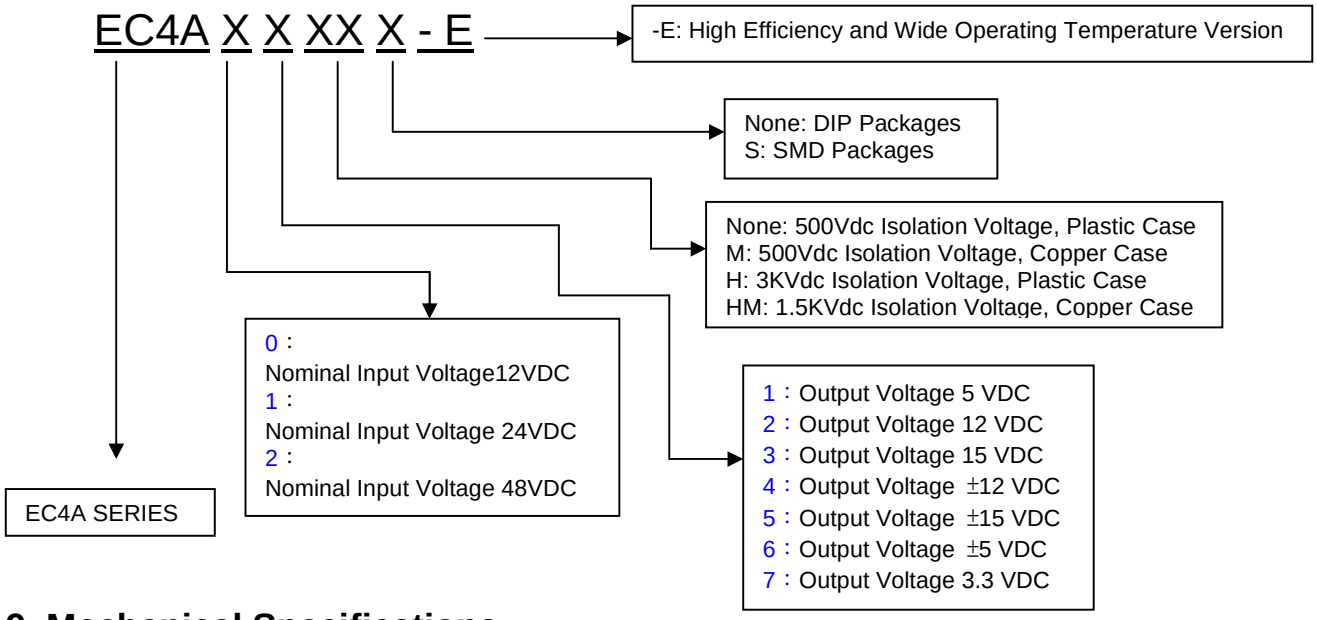


Conducted Class A of EC4A26-E



Conducted Class B of EC4A26-E

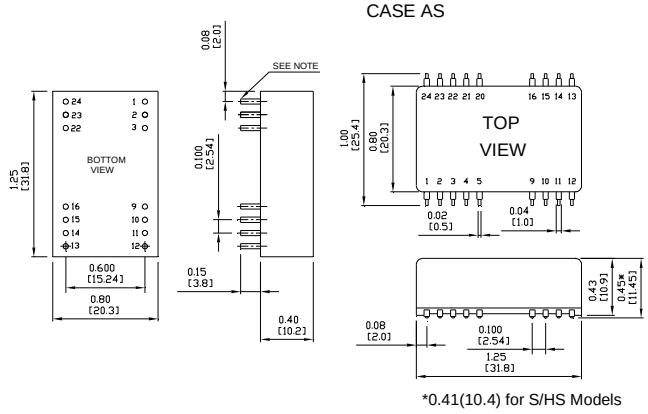
8. Part Number



9. Mechanical Specifications

NOTE:Pin Size is 0.02 ±0.002 Inch (0.5±0.05 mm)DIA
All Dimensions In Inches (mm)
Tolerances Inches: X.XX= ±0.02 , X.XXX= ±0.010
Millimeters: X.X= ±0.5 , X.XX=±0.25

CASE AS



*0.41(10.4) for S/HS Models

PIN CONNECTION									
500 VDC					1.5K & 3K VDC				
Pin	Single Output		Dual Output		Pin	Single Output		Dual Output	
	DIP	SMD	DIP	SMD		DIP	SMD	DIP	SMD
1,24	+V Input		+V Input		1,24	NP	NC	NP	NC
2,23	NC		-V Output		2,3	-V Input		-V Input	
3,22	NC		Common		4,5	NP	NC	NP	NC
4	NP	NC	NP	NC	9	NC		Common	
5	NP	NC	NP	NC	10,15	NC		NC	
9	NP	NC	NP	NC	11	NC		-V Output	
10,15	-V Output		Common		12,13	NP	NC	NP	NC
11,14	+V Output		+V Output		14	+V Output		+V Output	
12,13	-V Input		-V Input		16	-V Output		Common	
16	NP	NC	NP	NC	20,21	NP	NC	NP	NC
20,21	NP	NC	NP	NC	22,23	+V Input		+V Input	

* NP-NO PIN
* NC-NO CONNECTION WITH PIN

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