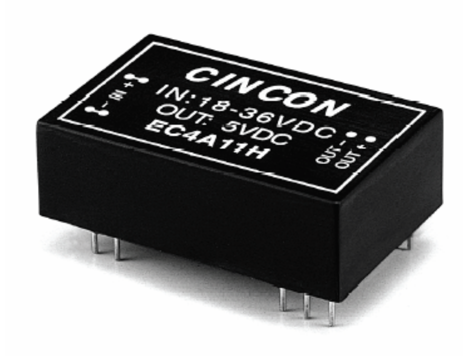
ISOLATED DC-DC Converter
EC4A SERIES
APPLICATION NOTE



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EC4A 3.3-6W Isolated DC-DC Converters

Application Note V22 September 2014

1. Introduction

The EC4A series offer 3.3-6 watts of output power in a 24 pin DIP and SMD copper package. The EC4A 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,1500VDC, 3KVDC of isolation and allows an ambient operating temperature range of –25°C to 71°C (de-rating above 71 °C). The modules are fully protected against output short circuit. All models are very suitable for distributed power architectures, telecommunications, battery operated equipment and industrial applications.

2. DC-DC Converter Features

* 3.3-6W Isolated Output
* DIP-24 / SMD Package
* Efficiency Up to 84%
* 2:1 Input Range
* Regulated Outputs
* PI Input Filter
* Continuous Short Circuit Protection
* UL60950-1 Approval for H/HM Versions only

3. Electrical Block Diagram

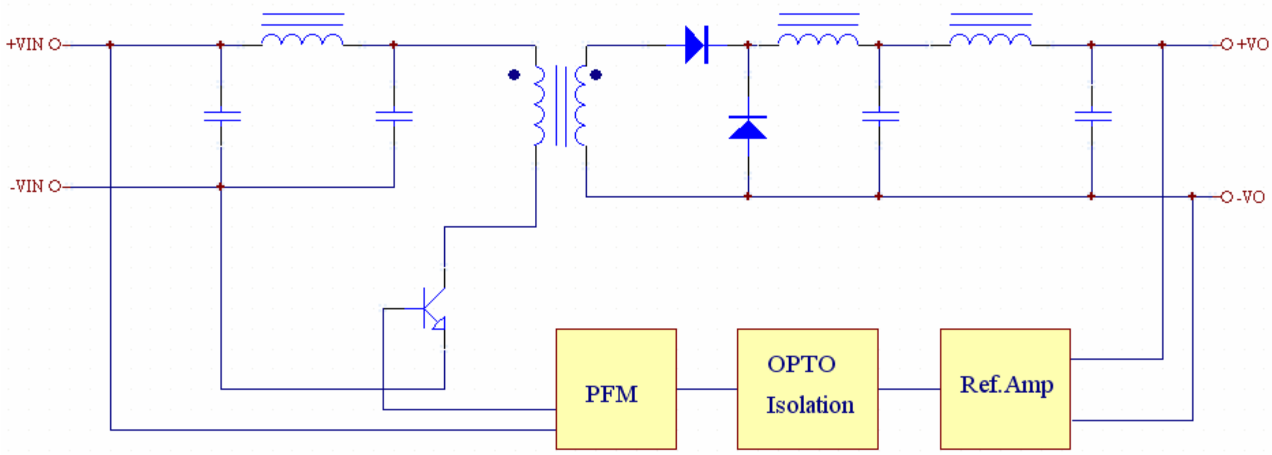


Figure 1 Electrical Block Diagram of single output module

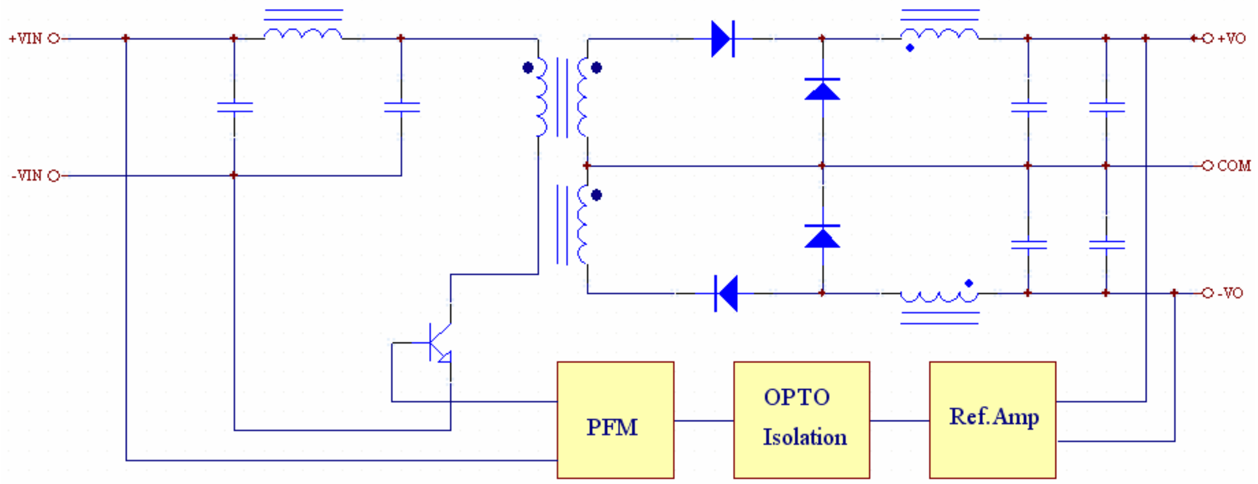


Figure 2 Electrical Block Diagram of dual output module

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	0	12	18	Vdc
		24Vin	0	24	36	
		48Vin	0	48	72	
Transient	100ms	12Vin			25	Vdc
		24Vin			50	
		48Vin			100	
Operating Ambient Temperature	With de-rating, above 71℃	All	-25		+71	℃
Case Temperature	Plastic Case	All			95	℃
	Copper Case				100	
Storage Temperature		All	-40		+100	℃
Input/Output Isolation Voltage	1 minute	EC4AXX (M/MS)	500			Vdc
		EC4AXX (H)	3K			
		EC4AXX (HM/HMS)	1.5K			

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	72	
Maximum Input Current	Full load, Vin= 9V	12Vin		800		mA
	Full load, Vin=18V	24Vin		400		
	Full load, Vin=36V	48Vin		200		
No-Load Input Current	Vin=12V	Vo=3.3Vdc		7.5		mA
		Vo=5Vdc		7.5		
		Vo=12Vdc		7.5		
		Vo=15Vdc		7.5		
		Vo=±5Vdc		12		
		Vo=±12Vdc		12		
		Vo=±15Vdc		12		
	Vin=24V	Vo=3.3Vdc		5		
		Vo=5Vdc		5		
		Vo=12Vdc		5		
		Vo=15Vdc		5		
		Vo=±5Vdc		7.5		
		Vo=±12Vdc		7.5		
		Vo=±15Vdc		7.5		
	Vin=48V	Vo=3.3Vdc		2		
		Vo=5Vdc		2		
		Vo=12Vdc		2		
		Vo=15Vdc		2		
		Vo=±5Vdc		3		
		Vo=±12Vdc		3		
		Vo=±15Vdc		3		
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		TBD		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	3.234	3.3	3.366	Vdc
		Vo=5Vdc	4.9	5	5.1	
		Vo=12Vdc	11.76	12	12.24	
		Vo=15Vdc	14.7	15	15.3	
		Vo=±5Vdc	±4.9	±5	±5.1	
		Vo=±12Vdc	±11.76	±12	±12.24	
		Vo=±15Vdc	±14.7	±15	±15.3	
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			±0.5	%
		Dual				
Temperature Coefficient	Ta=-25℃ to 71℃	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			100	mV
		Vo=5Vdc				
		Vo=±5Vdc				
		Vo=12Vdc			120	
		Vo=±12Vdc				
		Vo=15Vdc			150	
		Vo=±15Vdc				
Operating Output Current Range		Vo=3.3Vdc			1000	mA
		Vo=5Vdc			1000	
		Vo=12Vdc			470	
		Vo=15Vdc			400	
		Vo=±5Vdc			±500	
		Vo=±12Vdc			±230	
		Vo=±15Vdc			±190	
Output DC Current-Limit Inception	Vo=90% $V_{O,\ nominal}$	All	120			%
Maximum Output Capacitance	Full load (resistive)	Vo=3.3Vdc	0		TBD	uF
		Vo=5Vdc	0		TBD	
		Vo=12Vdc	0		TBD	
		Vo=15Vdc	0		TBD	
		Vo=±5Vdc	0		TBD	
		Vo=±12Vdc	0		TBD	
		Vo=±15Vdc	0		TBD	
DYNAMIC CHARACTERISTICS						
PARAMETER	**NOTES and CONDITIONS**	Device	Min.	Typical	Max.	Units
Turn-On Delay and Rise Time						
Turn-On Delay Time, From Input	Vin, Nominal. to 90%Vo,set	All		6	10	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=12V	EC4A01		77		%
		EC4A02		82		
		EC4A03		80		
		EC4A04		83		
		EC4A05		81		
		EC4A06		77		
		EC4A07		72		
	Vin=24V	EC4A11		80		
		EC4A12		84		
		EC4A13		84		
		EC4A14		82		
		EC4A15		81		
		EC4A16		80		
		EC4A17		74		
	Vin=48V	EC4A21		79		
		EC4A22		83		
		EC4A23		81		
		EC4A24		81		
		EC4A25		81		
		EC4A26		80		
		EC4A27		74		

ISOLATION CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Isolation Voltage	Input to Output, 1 minutes	EC4AXX (M/MS)	500			Vdc
		EC4AXX (H)	3K			
		EC4AXX (HM/HMS)	1.5K			
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	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		2		M hours
Weight		All		12.5		grams

5. Main Features and Functions

5.1 Operating Temperature Range

The EC4A series converters can be operated by a wide ambient temperature range from -25℃ to 71℃ (de-rating above 71°C). The standard models case temperature should not be exceeded 100℃ at normal operating (Detail see content 6.2).

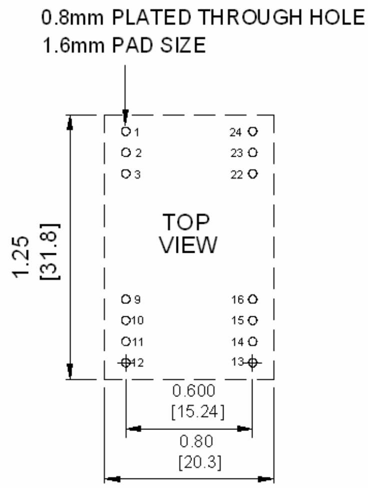
5.2 Over Current Protection

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

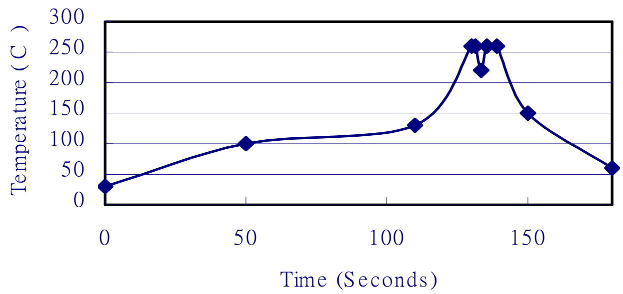
6.1 Recommended Layout PCB Footprints and Soldering Information

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.

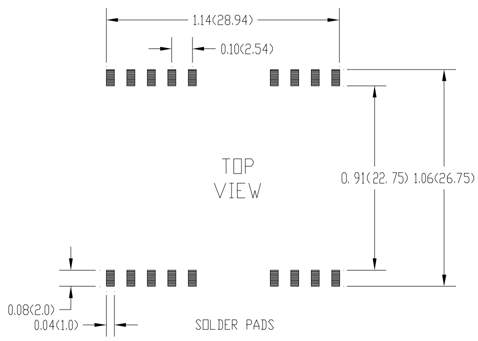


Note: Dimensions are in inches (millimeters)

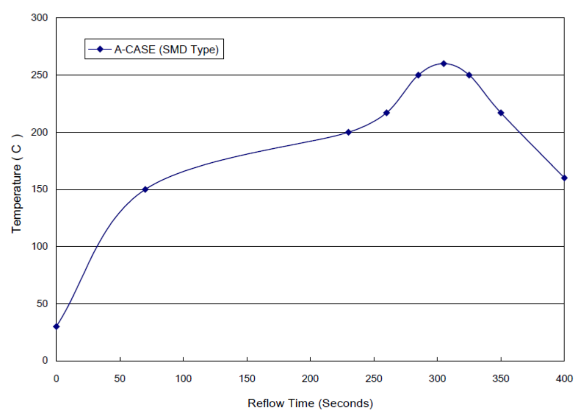
Lead Free Wave Soldering Profile



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



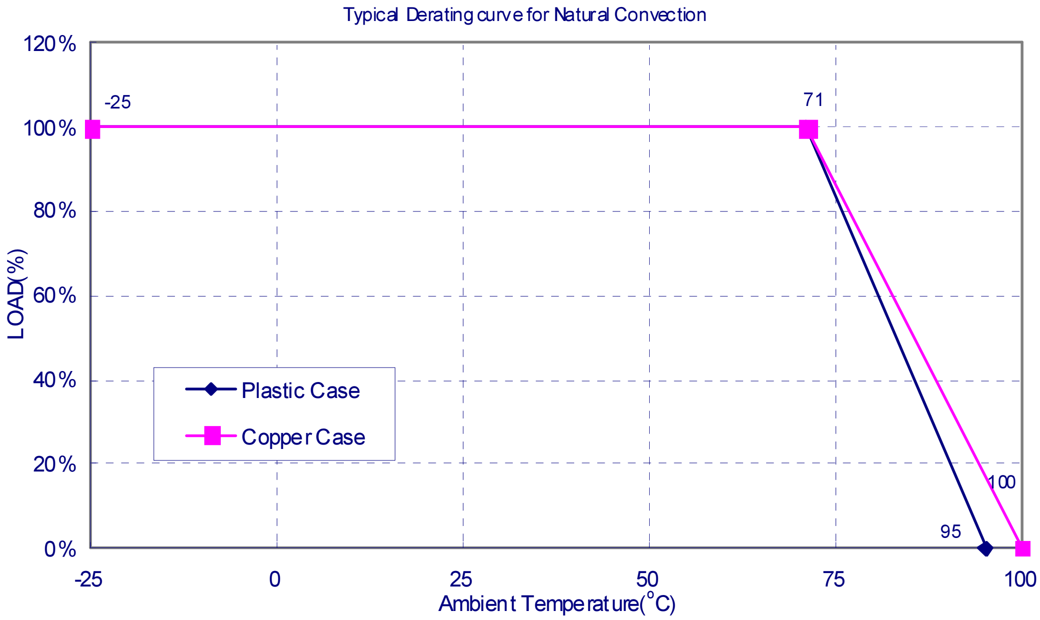
Note：
1. Soldering Paste: SHENMAO PF610-P (Sn/Ag/Cu)
2. Ramp up rate during preheat: 1.71 ℃/Sec (From 30℃ to 150℃)
3. Soaking temperature: 0.31 ℃/Sec (From 150℃ to 200℃), 160±10 seconds
4. Ramp up rate during reflow: 0.96 ℃/Sec (From 217℃ to 260℃)
5. Peak temperature: 260℃, above 217℃ 90 Seconds
6. Ramp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

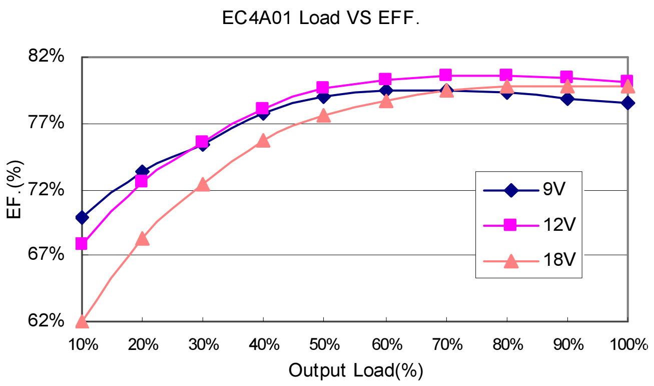
6.2 Power De-Rating Curves for EC4A Series

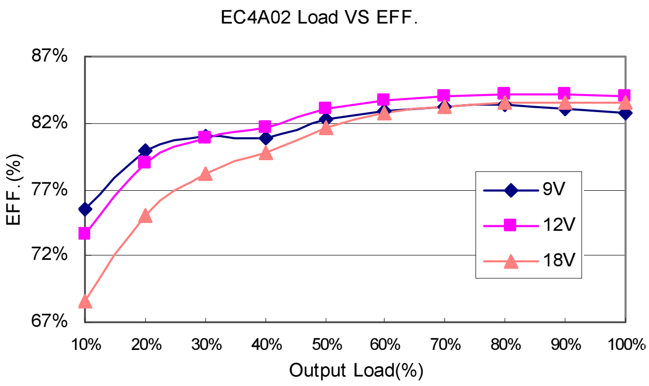
Operating Ambient temperature Range: -25℃ ~ 71℃ with de-rating above 71℃.

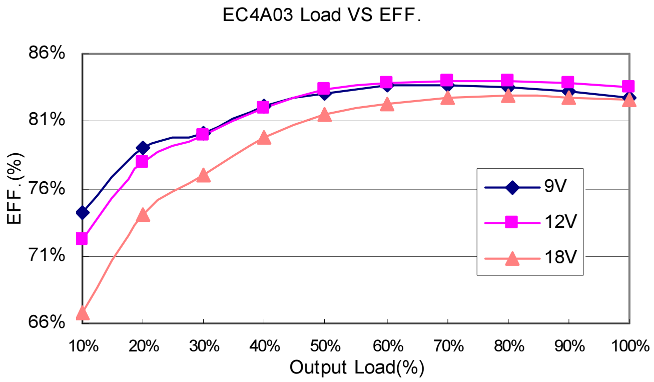
Maximum case temperature under any operating condition should not exceed 95℃(Plastic Case), 100℃(Copper Case).

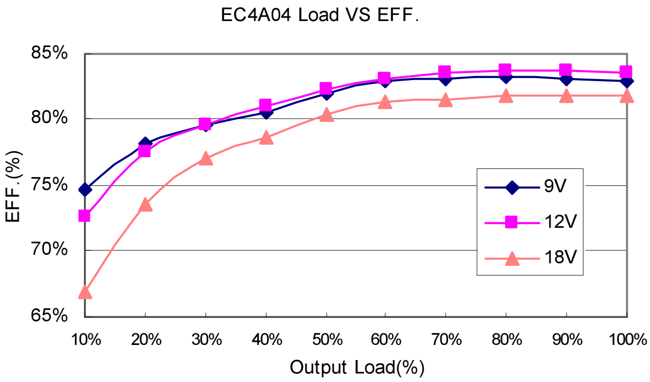


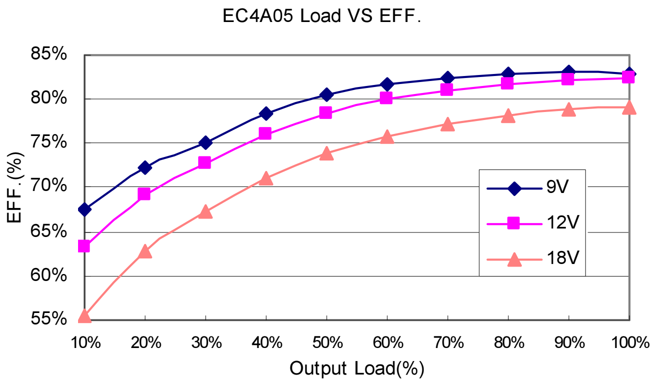
6.3 Efficiency vs. Load Curves

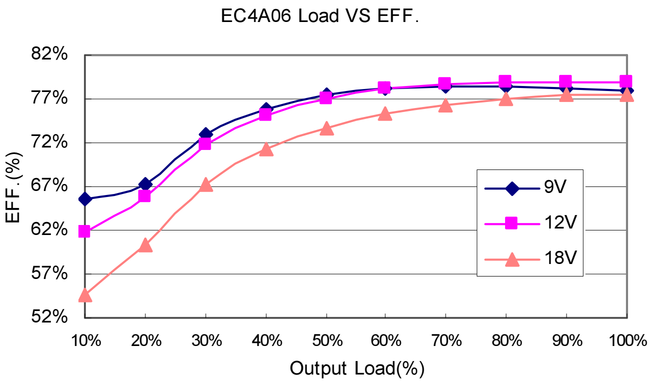


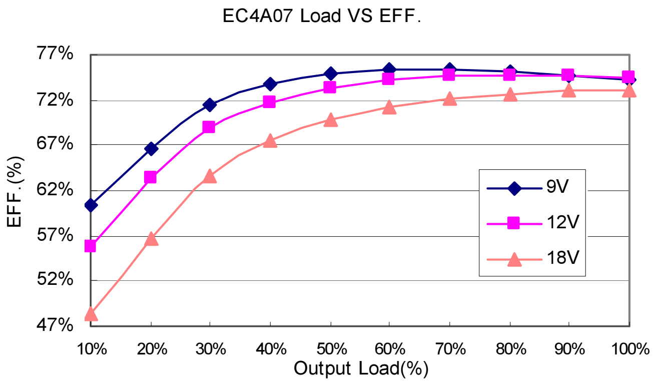




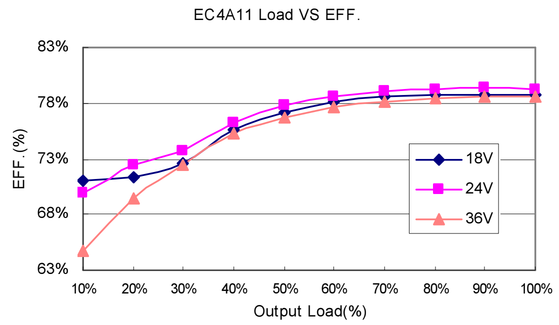




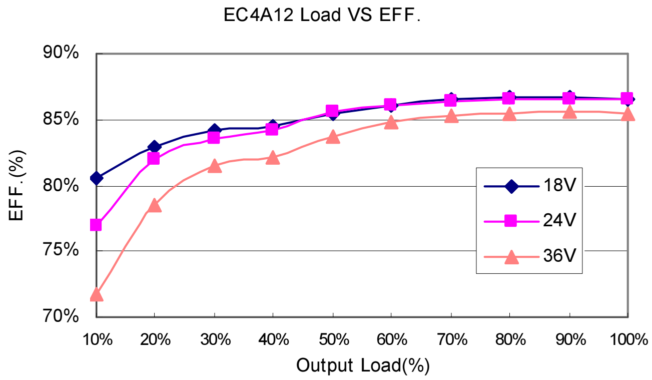




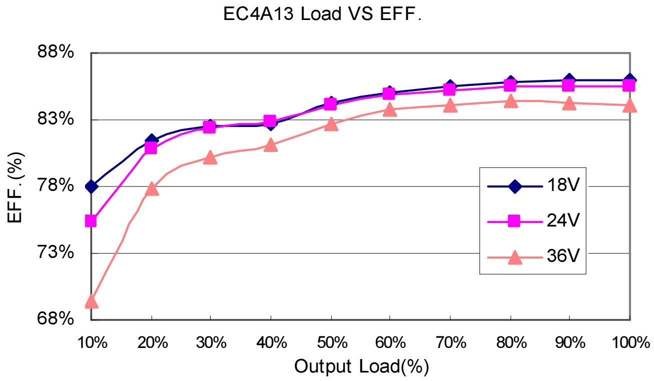
EC4A07 Load VS EFF.
EFF.(%)
77%
72%
67%
62%
57%
52%
47%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)
9V
12V
18V



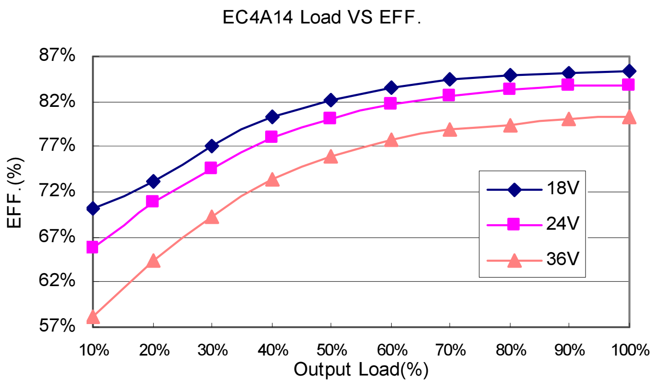
EC4A11 Load VS EFF.
EFF.(%)
83%
78%
73%
68%
63%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)
18V
24V
36V



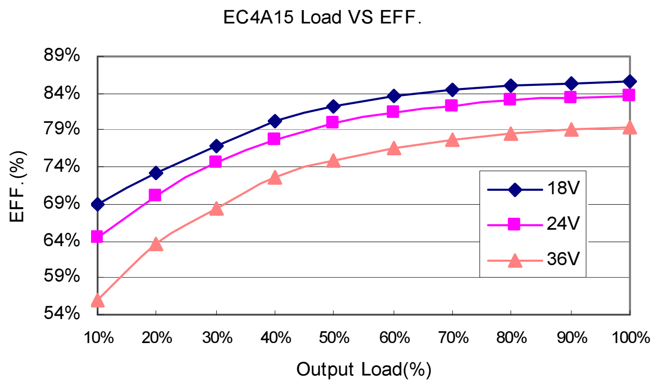
EC4A12 Load VS EFF.
EFF.(%)
90%
85%
80%
75%
70%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)
18V
24V
36V



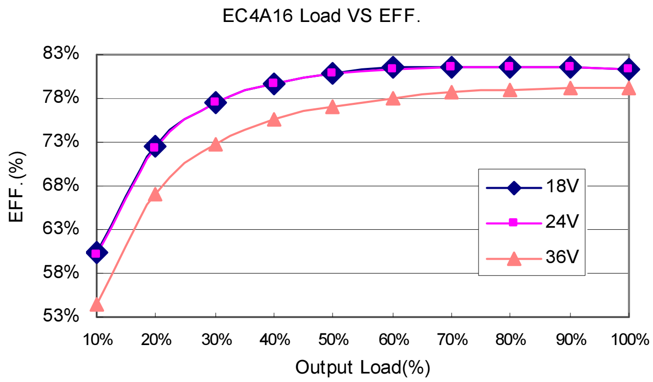
EC4A13 Load VS EFF.
EFF.(%)
88%
83%
78%
73%
68%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)
18V
24V
36V

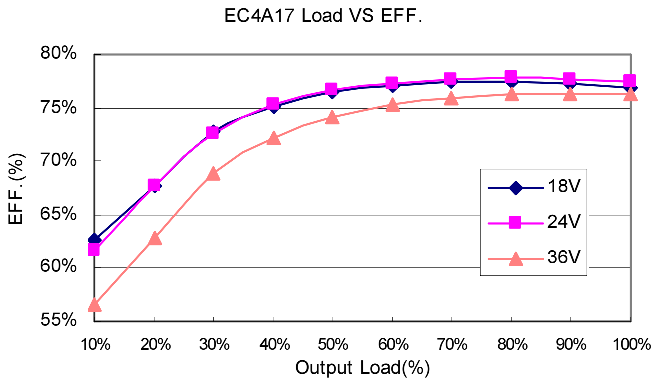


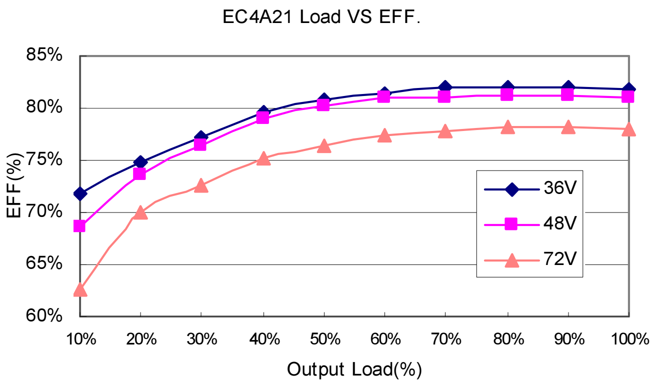
EC4A14 Load VS EFF.
EFF.(%)
87%
82%
77%
72%
67%
62%
57%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)
18V
24V
36V

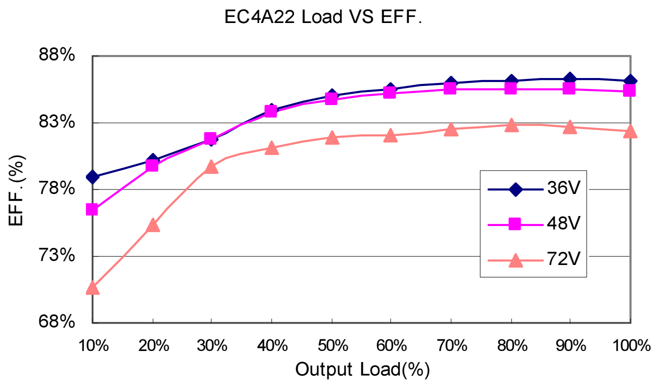


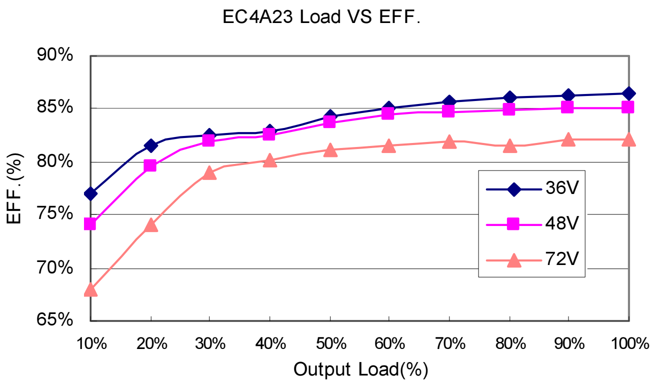
EC4A15 Load VS EFF.
EFF.(%)
89%
84%
79%
74%
69%
64%
59%
54%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)
18V
24V
36V

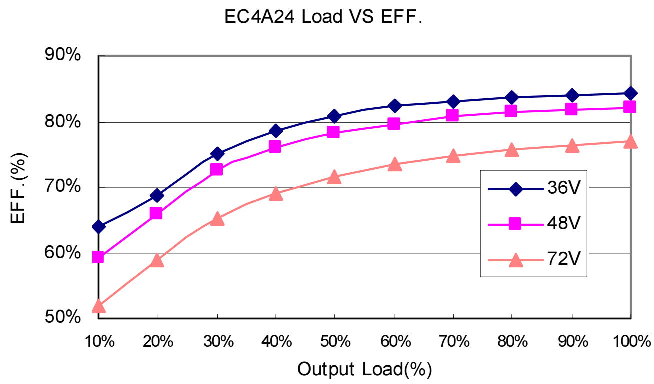

EC4A16 Load VS EFF.
83%
78%
73%
68%
63%
58%
53%
EFF.(%)
18V
24V
36V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)

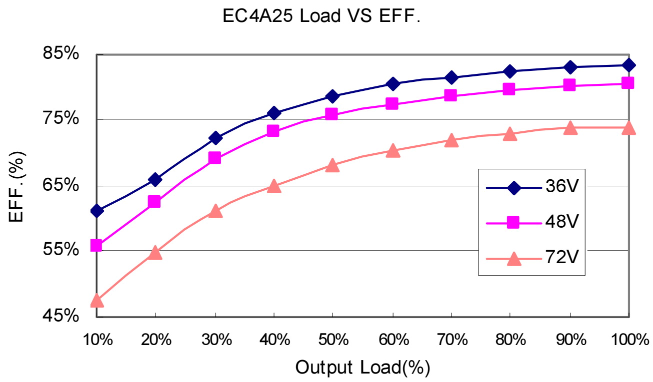

EC4A17 Load VS EFF.
80%
75%
70%
65%
60%
55%
EFF.(%)
18V
24V
36V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)

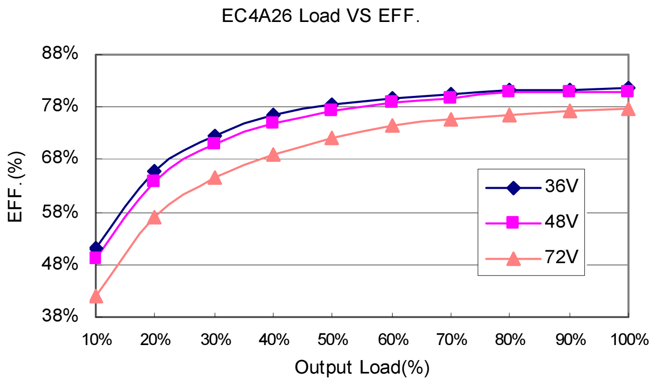

EC4A21 Load VS EFF.
85%
80%
75%
70%
65%
60%
EFF(%)
36V
48V
72V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)

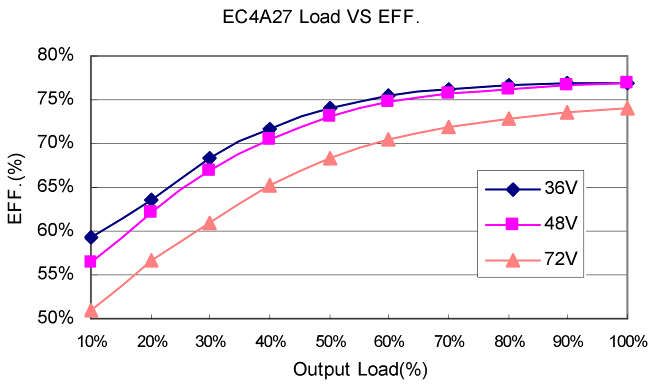

EC4A22 Load VS EFF.
88%
83%
78%
73%
68%
EFF.(%)
36V
48V
72V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)


EC4A23 Load VS EFF.
90%
85%
80%
75%
70%
65%
EFF.(%)
36V
48V
72V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)


EC4A24 Load VS EFF.
90%
80%
70%
60%
50%
EFF.(%)
36V
48V
72V
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)

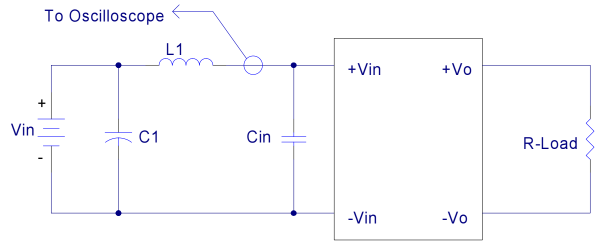

EC4A25 Load VS EFF.
85%
75%
65%
55%
45%
EFF.(%)
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)
36V
48V
72V


EC4A26 Load VS EFF.
88%
78%
68%
58%
48%
38%
EFF.(%)
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)
36V
48V
72V


EC4A27 Load VS EFF.
80%
75%
70%
65%
60%
55%
50%
EFF.(%)
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Output Load(%)
36V
48V
72V

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 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 to oscilloscope with a simulated source Inductance (L1).



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

Figure 4 Input Reflected-Ripple Test Setup

6.6 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

V_o is output voltage,

I_o is output current,

V_{in} is input voltage,

I_{in} is input current.

The value of load regulation is defined as:

$$Load.reg = \frac{V_{FL} - V_{NL}}{V_{NL}} \times 100\%$$

Where

V_{FL} is the output voltage at full load

V_{NL} is the output voltage at 10% load (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

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.

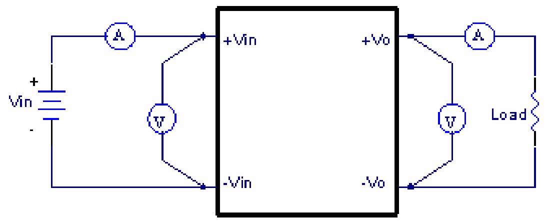
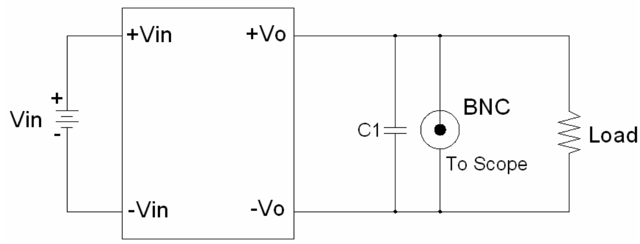


Figure 5 EC4A Series Test Setup

6.7 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

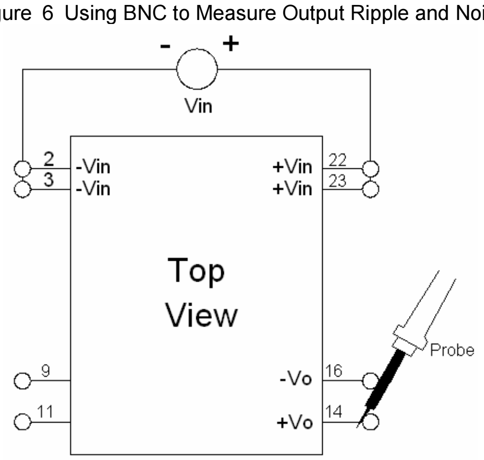


Figure 7 Using Probe to Measure Output Ripple and Noise

6.8 Output Capacitance

The EC4A 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 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 8 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.

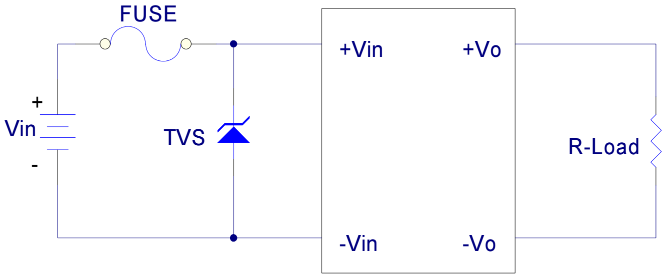


Figure 8 Input Protection

7.2 EMC Considerations

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

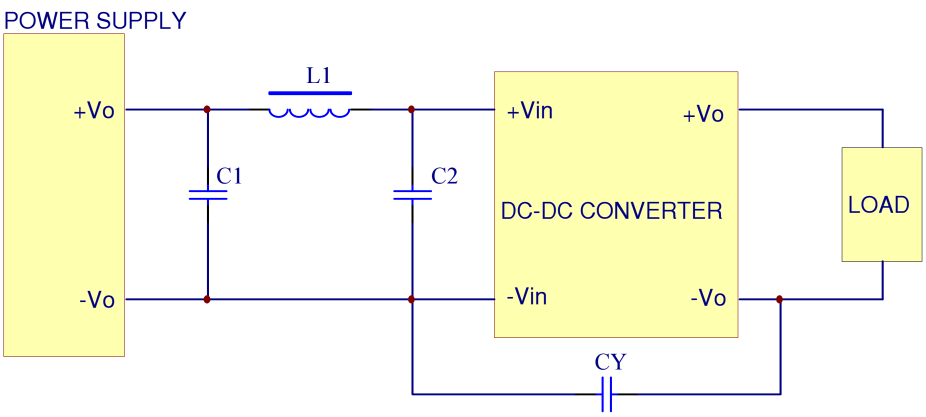
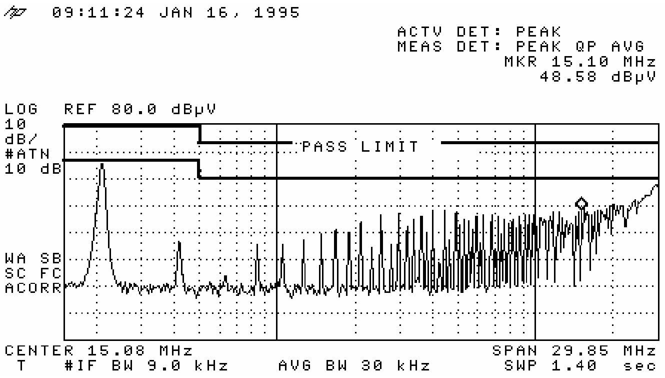


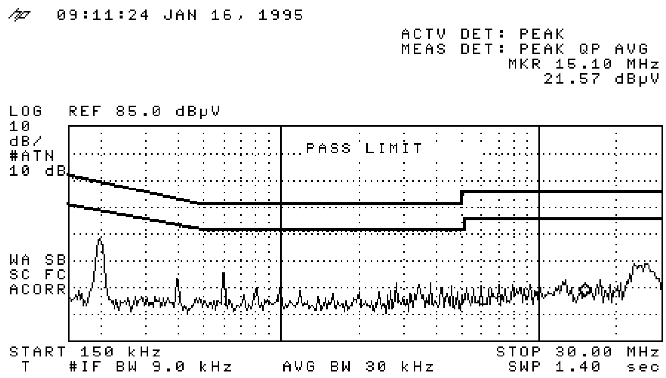
Figure 9 Connection circuit for conducted EMI testing

Model No.	EN55022 Class A				EN55022 Class B			
	C1	C2	L1	CY	C1	C2	L1	CY
EC4A01	NC	100uF/50V ESR<0.17Ω	Short	NC	100uF/50V ESR<0.17Ω	100uF/50V ESR<0.17Ω	2.2uH	1000pF/3KV
EC4A02	NC	100uF/50V ESR<0.17Ω	Short	NC	100uF/50V ESR<0.17Ω	100uF/50V ESR<0.17Ω	2.2uH	1000pF/3KV
EC4A03	NC	100uF/50V ESR<0.17Ω	Short	NC	100uF/50V ESR<0.17Ω	100uF/50V ESR<0.17Ω	2.2uH	1000pF/3KV
EC4A04	NC	100uF/50V ESR<0.17Ω	Short	NC	100uF/50V ESR<0.17Ω	100uF/50V ESR<0.17Ω	2.2uH	1000pF/3KV
EC4A05	NC	100uF/50V ESR<0.17Ω	Short	NC	100uF/50V ESR<0.17Ω	100uF/50V ESR<0.17Ω	2.2uH	1000pF/3KV
EC4A06	NC	100uF/50V ESR<0.17Ω	Short	NC	100uF/50V ESR<0.17Ω	100uF/50V ESR<0.17Ω	2.2uH	1000pF/3KV
EC4A07	NC	100uF/50V ESR<0.17Ω	Short	NC	100uF/50V ESR<0.17Ω	100uF/50V ESR<0.17Ω	2.2uH	1000pF/3KV
EC4A11	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A12	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A13	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A14	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A15	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A16	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A17	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A21	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A22	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A23	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A24	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A25	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A26	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC
EC4A27	NC	47uF/100V ESR<0.17Ω	Short	NC	47uF/100V ESR<0.17Ω	47uF/100V ESR<0.17Ω	2.2uH	NC

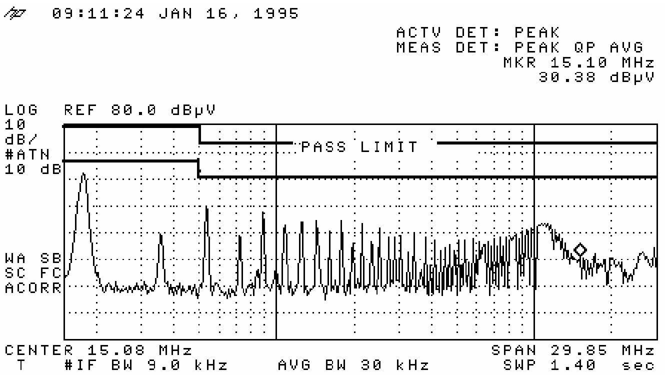
Note: The C1 and C2 are aluminum capacitors, C3 is ceramic capacitors.



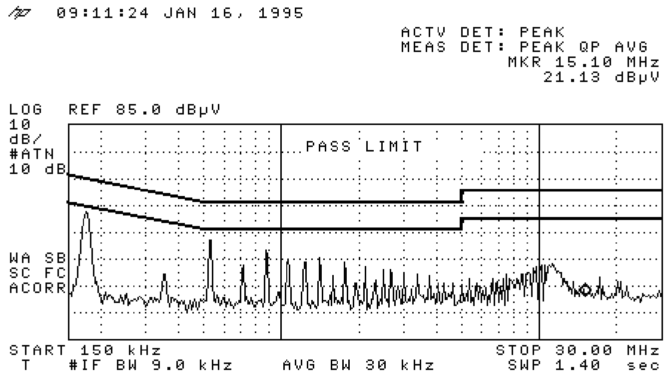
Conducted Class A of EC4A02



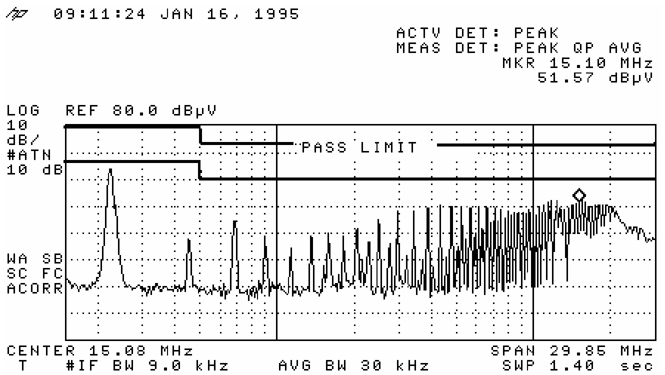
Conducted Class B EC4A02



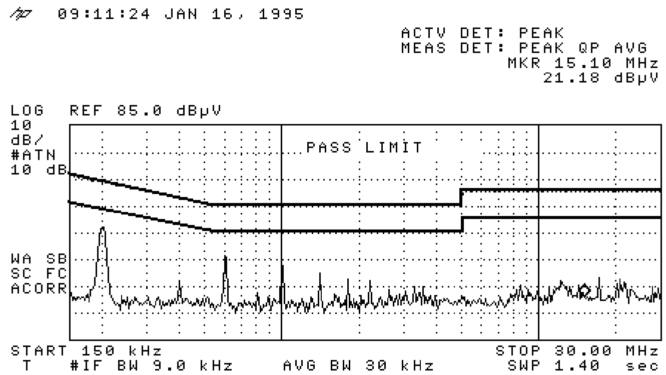
Conducted Class A EC4A04



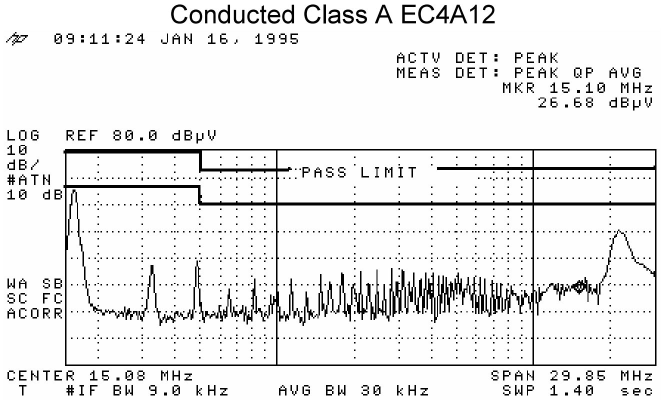
Conducted Class B EC4A04



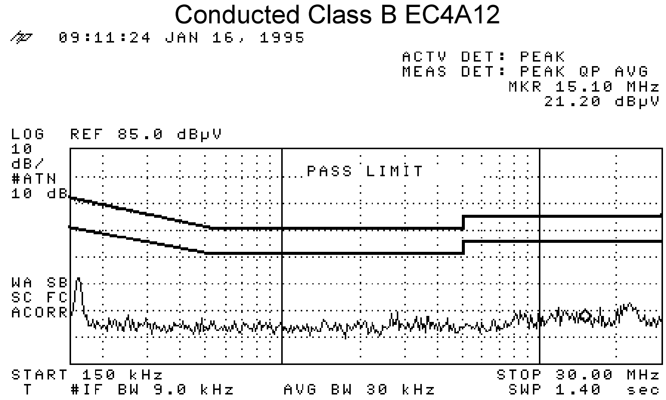
Conducted Class A EC4A12



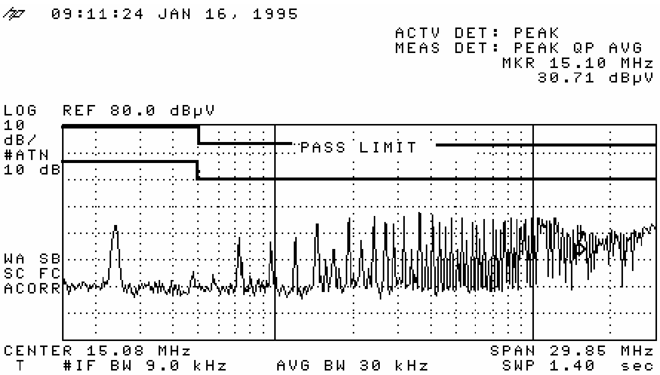
Conducted Class B EC4A12



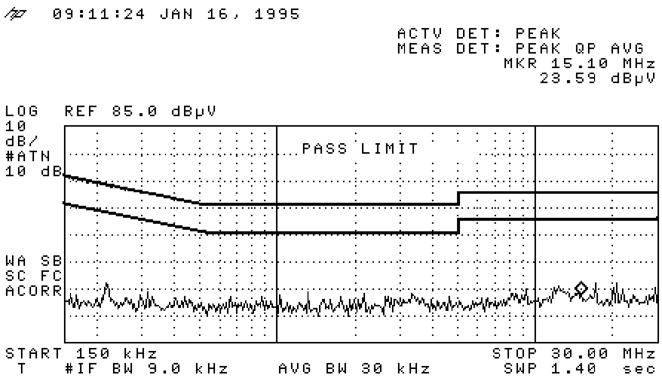
Conducted Class A EC4A15



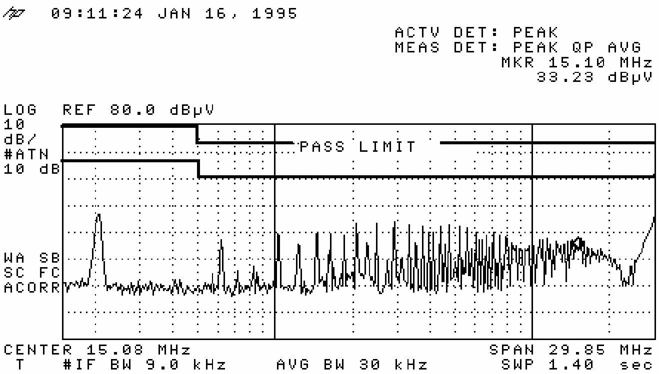
Conducted Class B EC4A15



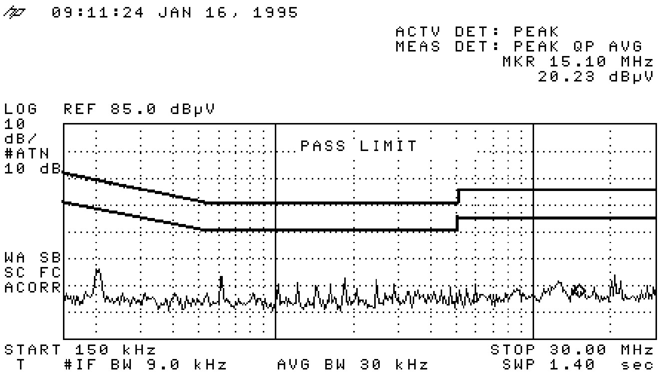
Conducted Class A of EC4A24



Conducted Class B of EC4A26

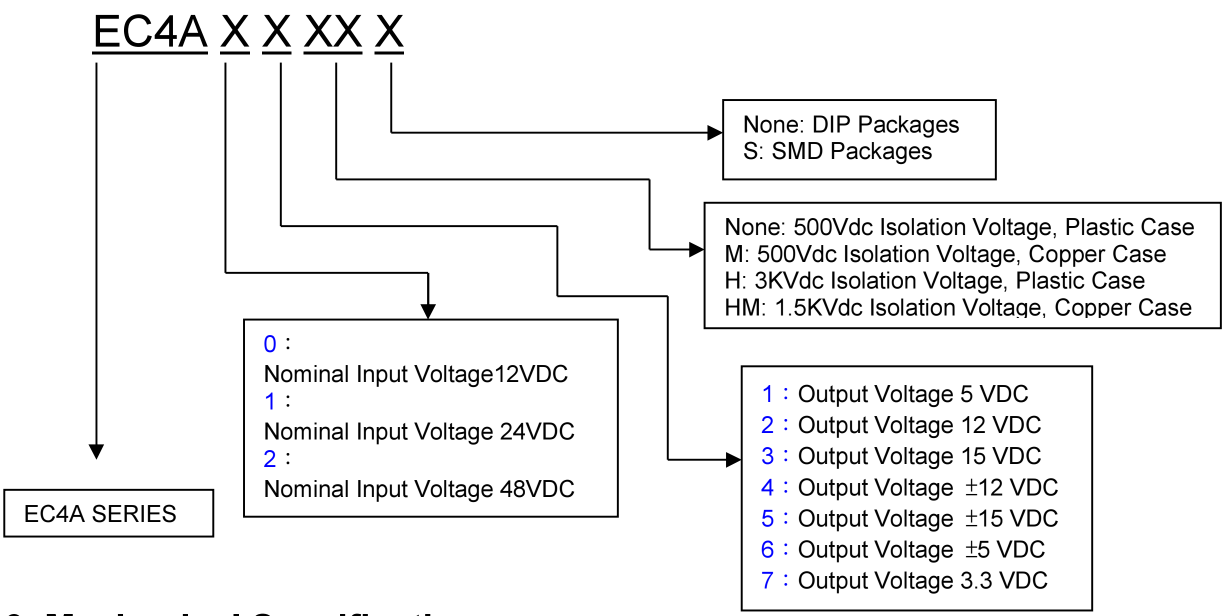


Conducted Class A of EC4A26

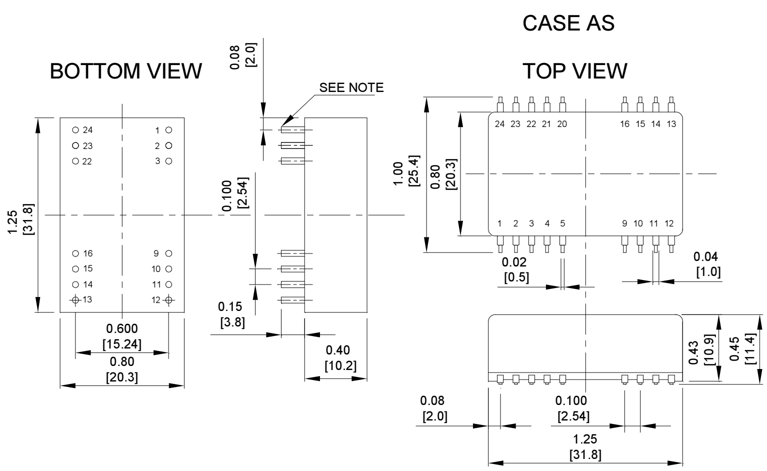


Conducted Class B of EC4A26

8. Part Number



9. Mechanical Specifications



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

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

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