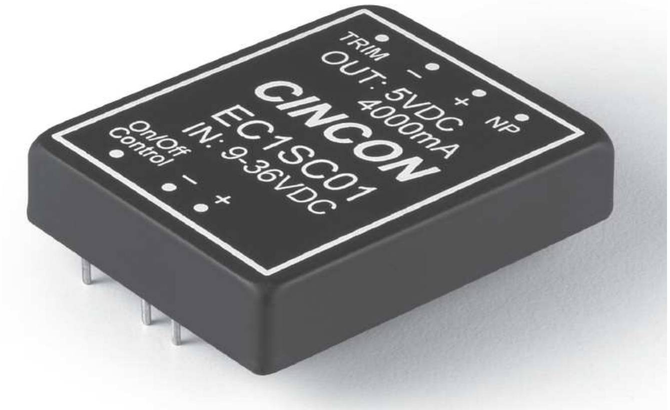
ISOLATED DC-DC Converter
EC1SC SERIES
APPLICATION NOTE



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Content

EC1SC 20W Isolated DC-DC Converters

Application Note V11 November 2020

1. Introduction

The EC1SC series offer 13.2-20 watts of output power in a 2.00x1.60x0.45 inches copper packages. The EC1SC series has a 4:1 wide input voltage range of 9-36 and 18-72VDC 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 –25°C to 71°C (de-rating above 60 °C). The modules are fully protected against output over-current and short circuit conditions. Furthermore, the standard control functions include remote on/off and adjustable output voltage. All models are very suitable for distributed power architectures, telecommunications, battery operated equipment and industrial applications.

2. DC-DC Converter Features

- 13.2-20W Isolated Output
- 2" X1.6" Six-Sided Shield Metal Case
- High Efficiency to 84%
- 4:1 Input Range
- Pi Input Filter
- Continuous Short Circuit Protection
- Meets EN55032 Class A, Conducted
- Remote On/Off Control
- Approval UL60950-1
- Safety Meets IEC/EN/UL 62368-1

3. Electrical Block Diagram

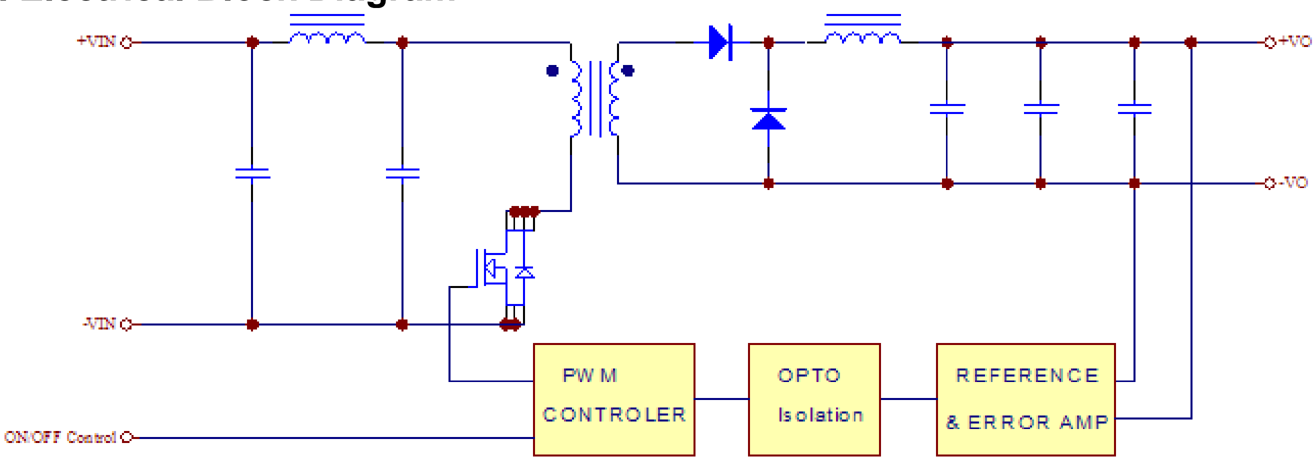


Figure 1 Electrical Block Diagram for Single Output Modules

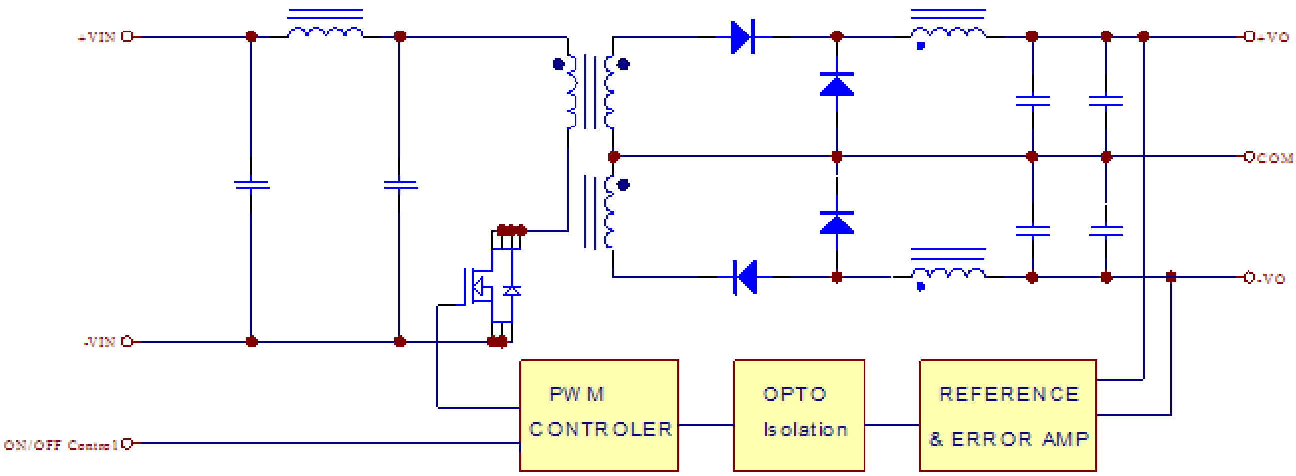


Figure 2 Electrical Block Diagram for Dual Output Modules

4. Technical Specifications

(All specifications are typical at nominal input, full load at 25℃ unless otherwise noted.)

ABSOLUTE MAXIMUM RATINGS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Input Voltage						
Continuous		24Vin	-0.3		36	Vdc
		48Vin	-0.3		72	
Transient	100ms	24Vin	`		50	Vdc
		48Vin			100	
Operating Ambient Temperature	Derating, above 60℃	All	-25		+71	℃
Case Temperature		All			+100	℃
Storage Temperature		All	-55		+105	℃
Input/Output Isolation Voltage	1 minute	All	1500			Vdc

INPUT CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Operating Input Voltage		24Vin	9	24	36	Vdc
		48Vin	18	48	72	
Maximum Input Current	100% Load, Vin=9V	24Vin		2780		mA
	100% Load, Vin=18V	48Vin		1390		
No-Load Input Current	Vin=24V	EC1SC01		15		mA
		EC1SC02		15		
		EC1SC03		15		
		EC1SC04		20		
		EC1SC05		20		
		EC1SC06		20		
		EC1SC07		15		
	Vin=48V	EC1SC11		10		
		EC1SC12		10		
		EC1SC13		10		
		EC1SC14		15		
		EC1SC15		15		
		EC1SC16		15		
		EC1SC17		10		
Inrush Current (I^2t)	As per ETS300 132-2	All			TBD	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=3.3V	3.267	3.3	3.333	Vdc
		Vo=5.0V	4.95	5	5.05	
		Vo=12V	11.89	12	12.12	
		Vo=15V	14.85	15	15.15	
		Vo=±5V	±4.9	±5	±5.05	
		Vo=±12V	±11.76	±12	±12.12	
		Vo=±15V	±14.7	±15	±15.15	
Output Voltage Balance	Vin=nominal input, Io= $Io_{max.}$	Dual			±1.0	%
Output Voltage Regulation						
Load Regulation	Io=full load to min. Load	Single			±0.5	%
Line Regulation	Vin=high line to low line, full Load	Single			±0.5	%
Temperature Coefficient	T_C=-25℃ to 71℃	All			±0.02	%/℃
Output Voltage Ripple and Noise (5Hz to 20MHz bandwidth)						
Peak-to-Peak	Vin=nominal input, Io=full load.	All			75	mV
RMS	Vin=nominal input, Io=full load.	All			20	mV
Operating Output Current Range		Vo=3.3V			4000	mA
		Vo=5.0V			4000	
		Vo=12V			1670	
		Vo=15V			1330	
		Vo=±5V			±2000	
		Vo=±12V			±833	
		Vo=±15V			±666	
Output DC Current-Limit Inception	Vo=90% $V_{O,\ nominal}$	All	120			%
Maximum Output Capacitance	Full load (resistive)	Vo=3.3V			4000	uF
		Vo=5.0V			4000	
		Vo=12V			1670	
		Vo=15V			1330	
		Vo=±5V			833	
		Vo=±12V			666	
		Vo=±15V			2000	

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			±5	%
Setting Time (within 1% Vo nominal)	di/dt=0.1A/us	All			500	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	EC1SC0X		180		ms
		EC1SC1X		140		
Output Voltage Rise Time	10%Vo, set to 90%Vo, set	EC1SC0X		90		ms
		EC1SC1X		10		

EFFICIENCY

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
100% Load	Vin=24V	EC1SC01		81		%
		EC1SC02		83		
		EC1SC03		83		
		EC1SC04		83		
		EC1SC05		83		
		EC1SC06		83		
		EC1SC07		78		
	Vin=48V	EC1SC11		82		
		EC1SC12		84		
		EC1SC13		84		
		EC1SC14		84		
		EC1SC15		84		
		EC1SC16		84		
		EC1SC17		78		

ISOLATION CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Input to Output	Input to Output, 1 minutes	All			1500	Vdc
Isolation Resistance	Input to Output	All	100			MΩ
Isolation Capacitance	Input to Output	All		1000		pF

FEATURE CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Switching Frequency		All		300		KHz
On/Off Control, Positive Remote On/Off logic						
Logic Low (Module Off)	Von/off at Ion/off=1.0mA	All	0		1.8	V
Logic High (Module On)	Von/off at Ion/off=0.1uA	All	5.5 or Open Circuit		75	V
Output Voltage Trim Range	Pout=maximum rated power	All	-10		+10	%

GENERAL SPECIFICATIONS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
MTBF	Io=100%of Io.max. Ta=25℃ per MIL-HDBK-217F	All		1500		K hours
Weight		All		53		grams

5. Main Features and Functions

5.1 Operating Temperature Range

The EC1SC series converters can be operated by a wide ambient temperature range from -25℃ to 71℃ (de-c above 60℃). The standard model has a copper case and case temperature can not over 100℃ at normal operating.

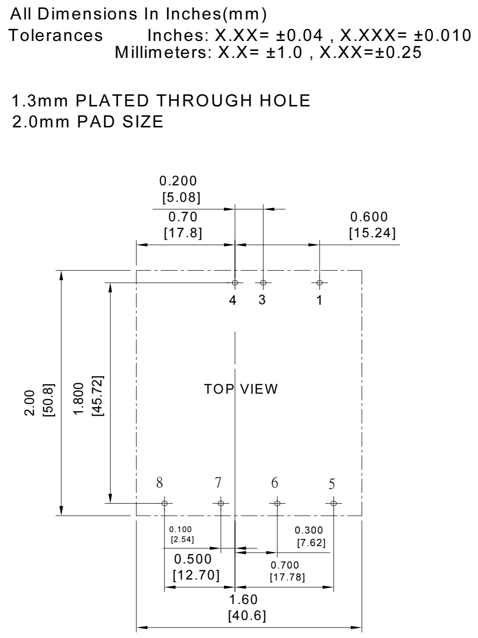
5.2 Output Voltage Adjustment

Section 6.6 describes in detail how to trim the output voltage with respect to its set point. The output voltage on all models is adjustable within the range of +10% to –10%.

6. Applications

6.1 Recommended Layout PCB Footprints and Soldering Information

The system designer or the end user must ensure that other components and metal in the vicinity of the converter meet the spacing requirements to which the system is approved. Low resistance and low inductance PCB layout traces are the norm and should be used where possible. Due consideration must also be given to proper low impedance tracks between power module, input and output grounds. The recommended footprints and soldering profiles are shown as Figure 3.



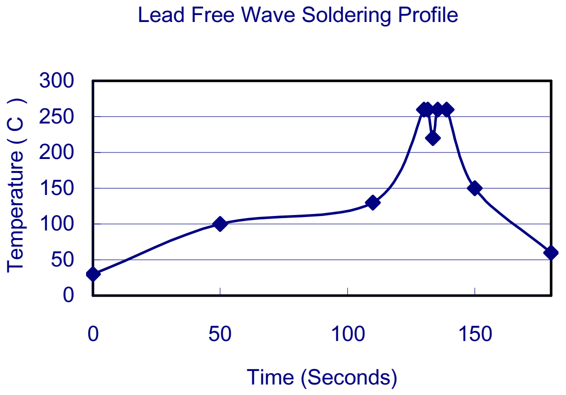


Figure3 Recommended PCB Layout Footprint and Soldering Profile

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℃)

6.2 Power De-Rating Curves for EC1SC Series

Operating Ambient temperature Range: -25℃ ~ 71℃ (derating above 60℃). Maximum case temperature under any operating condition should not exceed 100℃.

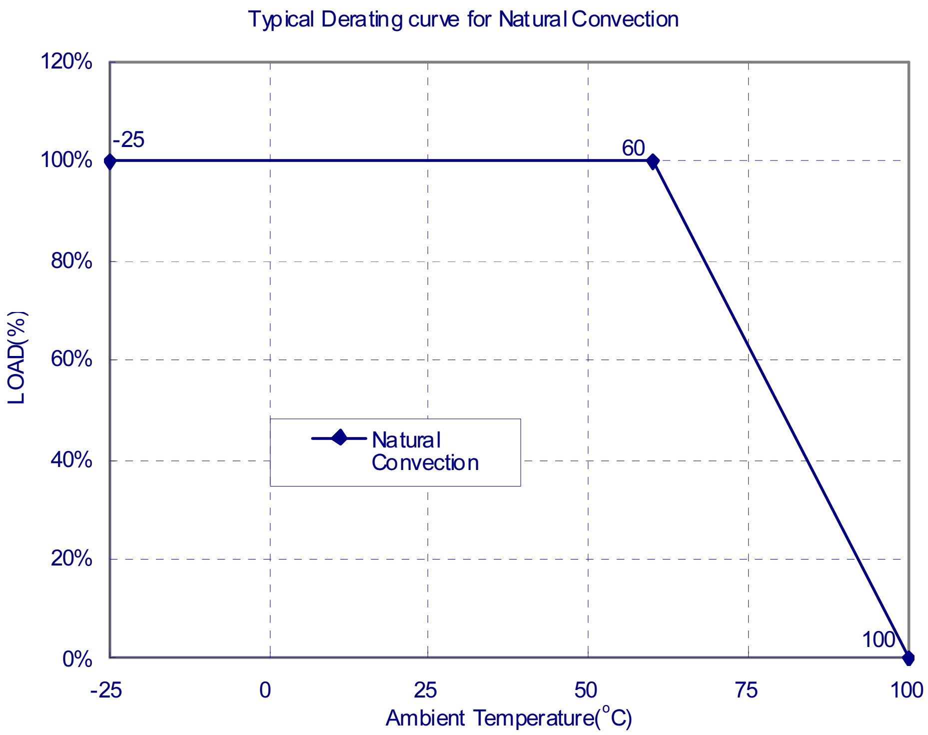
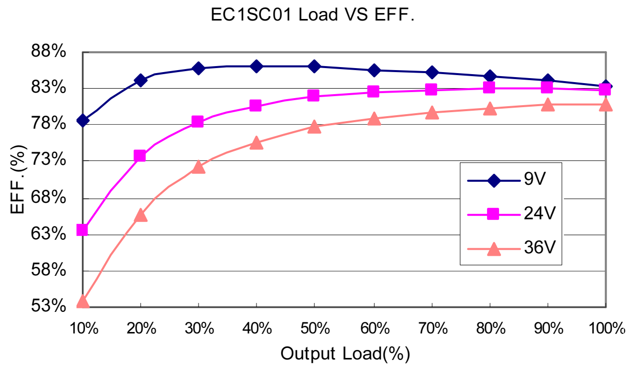
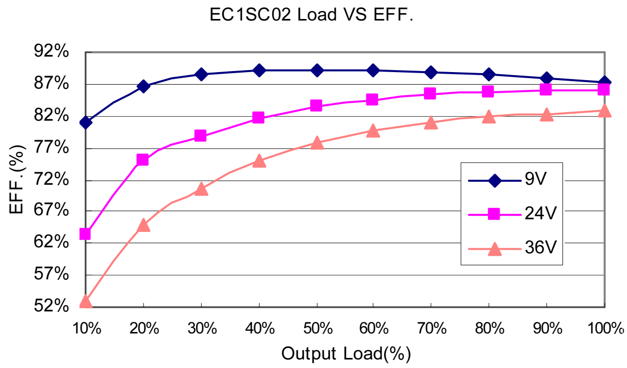
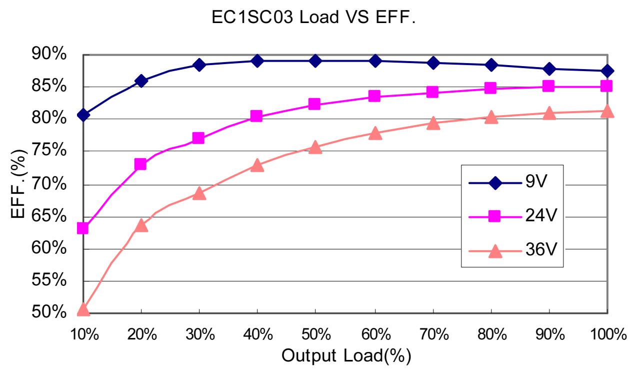


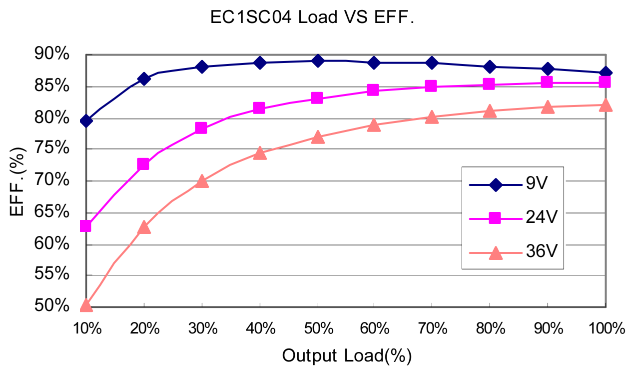
Figure4 Typical Power De-rating Curve for EC1SC Series

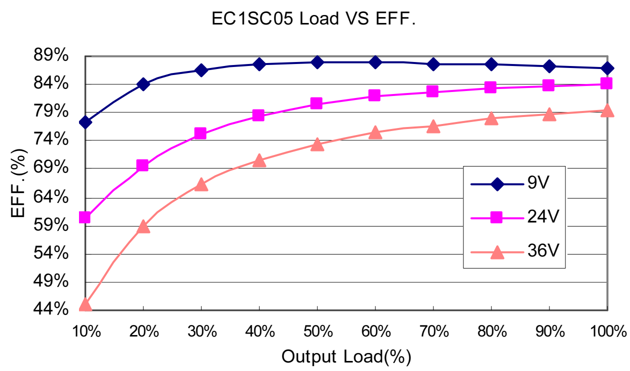
6.3 Efficiency vs. Load Curves

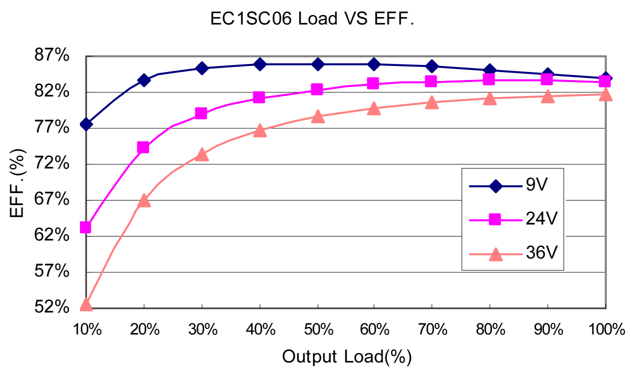


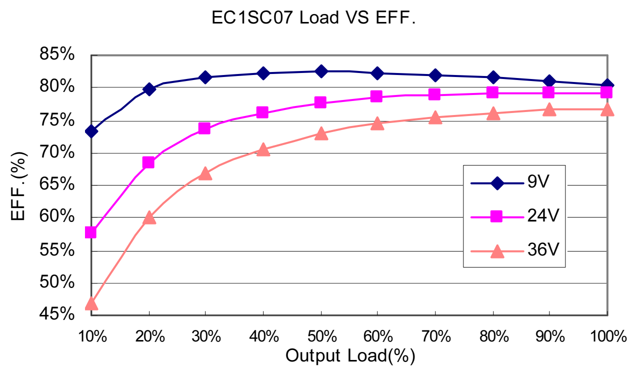


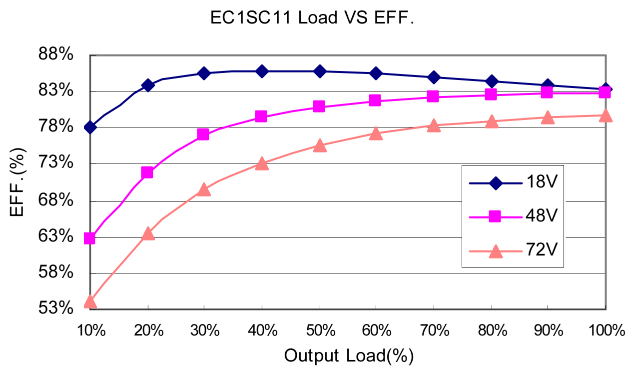


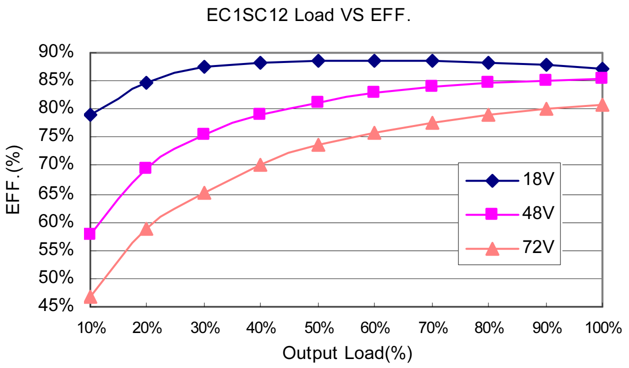


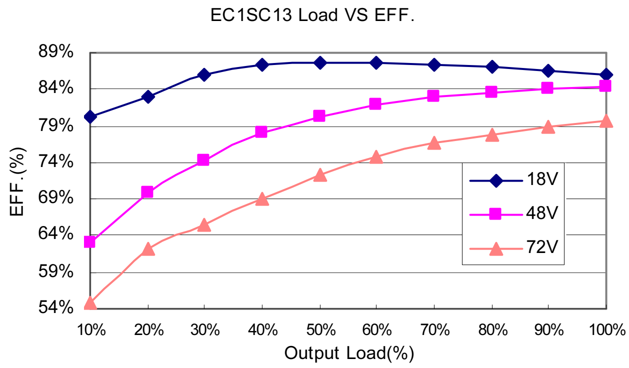


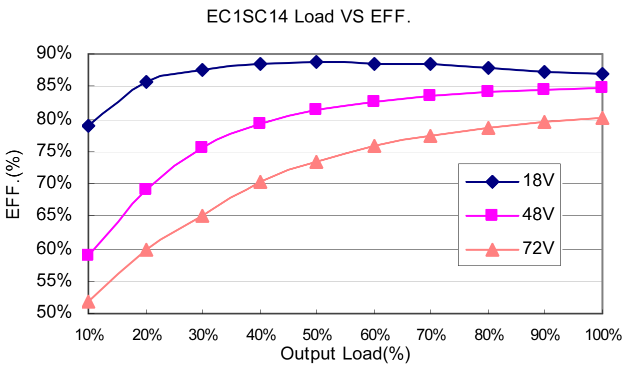


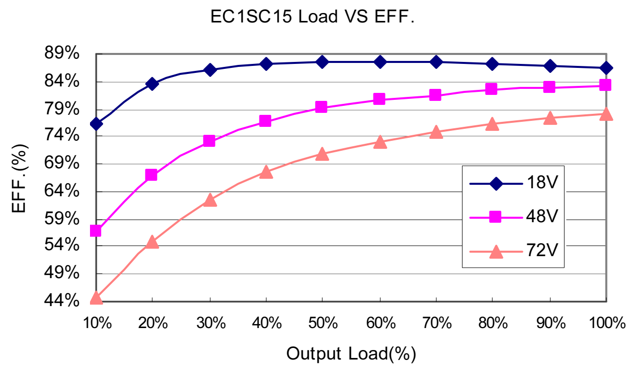


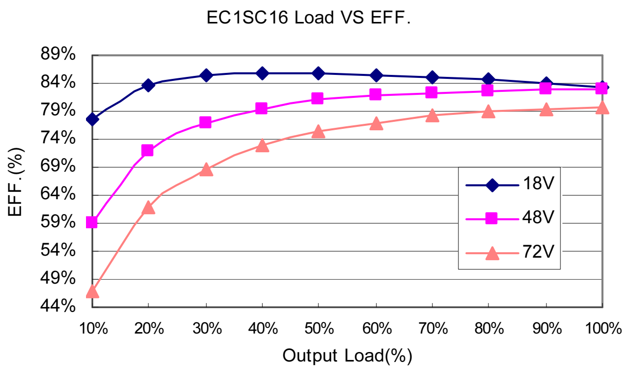


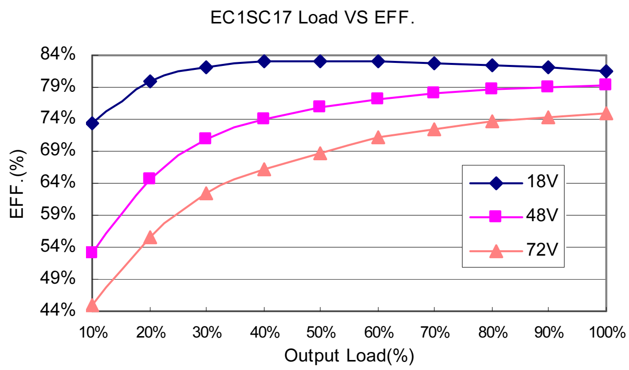

EC1SC12 Load VS EFF.
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
EFF.(%)
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Output Load(%)
18V
48V
72V


EC1SC13 Load VS EFF.
89%
84%
79%
74%
69%
64%
59%
54%
EFF.(%)
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Output Load(%)
18V
48V
72V


EC1SC14 Load VS EFF.
90%
85%
80%
75%
70%
65%
60%
55%
50%
EFF.(%)
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Output Load(%)
18V
48V
72V

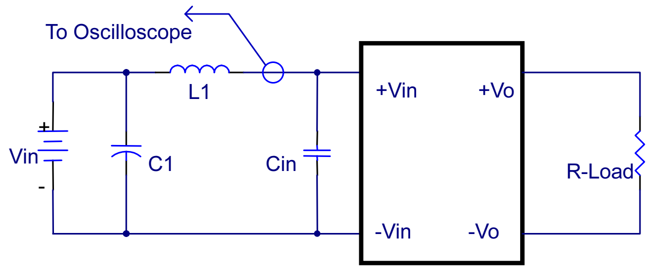

EC1SC15 Load VS EFF.
89%
84%
79%
74%
69%
64%
59%
54%
49%
44%
EFF.(%)
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Output Load(%)
18V
48V
72V


EC1SC16 Load VS EFF.
89%
84%
79%
74%
69%
64%
59%
54%
49%
44%
EFF.(%)
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Output Load(%)
18V
48V
72V


EC1SC17 Load VS EFF.
84%
79%
74%
69%
64%
59%
54%
49%
44%
EFF.(%)
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Output Load(%)
18V
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 5 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 <0.1ohm @100KHz.
Cin: NC

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 Figure 6. 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:

$$\eta = \frac{V_O \times I_O}{V_{IN} \times I_{IN}} \times 100\%$$

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

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.

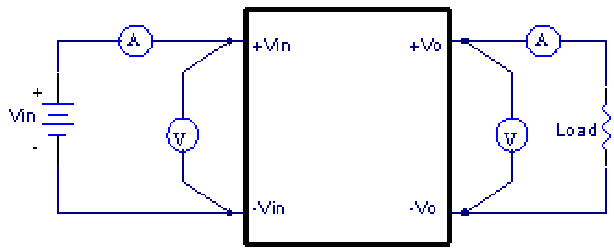


Figure 6 EC1SC Series Test Setup

6.6 Output Voltage Adjustment

In order to trim the voltage up or down one needs to connect the trim resistor either between the trim pin and -Vo for trim-up and between trim pin and +Vo for trim-down. The output voltage trim range is ±10%. This is shown in Figure 7 and 8:

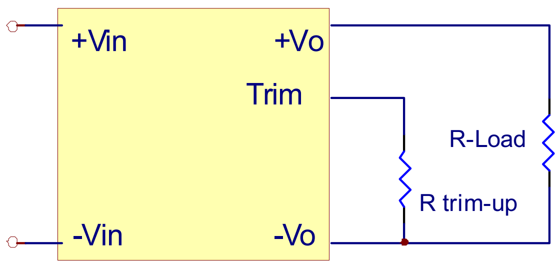


Figure 7 Trim-up Voltage Setup

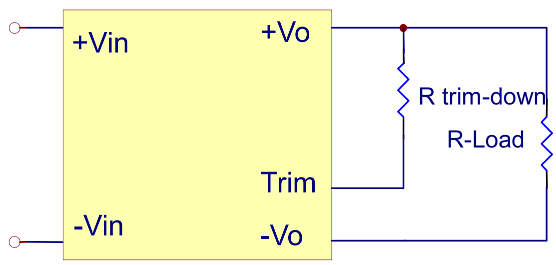


Figure 8 Trim-down Voltage Setup

1. The value of $R_{trim-up}$ defined as:

$$R_{trim-up} = \frac{(R1 - R2 \times (Vo - V_{o,nom}))}{(Vo - V_{o,nom})} \quad (K\Omega)$$

Where

$R_{trim-up}$ is the external resistor in Kohm.
$V_{O,nom}$ is the nominal output voltage.
V_O is the desired output voltage.

R1, R2, are internal to the unit and are defined in Table 1.

Table 1 – Trim up and Trim down Resistor Values

Model Number	Output Voltage(V)	R1 (KΩ)	R2 (KΩ)
EC1SC07 EC1SC17	3.3	3.484	7.511
EC1SC01 EC1SC11	5.0	5.788	8.25
EC1SC02 EC1SC12	12.0	19.763	14.366
EC1SC03 EC1SC13	15.0	25.585	14.516
EC1SC04 EC1SC14	±12.0	42.141	13.793
EC1SC05 EC1SC15	±15.0	56.644	17.647
EC1SC06 EC1SC16	±5.0	20.657	19.5

For example, to trim-up the output voltage of 5V module (EC1SC11) by 8% to 5.4V, R trim-up is calculated as follows:

$V_o - V_{o,\,nom} = 5.4 - 5 = 0.4V$
R1 = 5.788 KΩ
R2 = 8.25 KΩ

$$R_{trim-up} = \frac{5.788 - 8.25 \times 0.4}{0.4} = 6.22\ (K\Omega)$$

2. The value of $R_{trim-down}$ defined as:

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

Where

$R_{trim-down}$ is the external resistor in Kohm.
$V_{O,\,nom}$ is the nominal output voltage.
V_O is the desired output voltage.
R1, R2, are internal to the unit and are defined in Table 2

Table 2 –Trim down Resistor Values

Model Number	Output Voltage(V)	R1 (KΩ)	R2 (KΩ)
EC1SC07 EC1SC17	3.3	6.18	12.1
EC1SC01 EC1SC11	5.0	5.788	10.57
EC1SC02 EC1SC12	12.0	86.496	60.1
EC1SC03 EC1SC13	15.0	150	87
EC1SC04 EC1SC14	±12.0	430	120
EC1SC05 EC1SC15	±15.0	743	177
EC1SC06 EC1SC16	±5.0	68.296	48.1

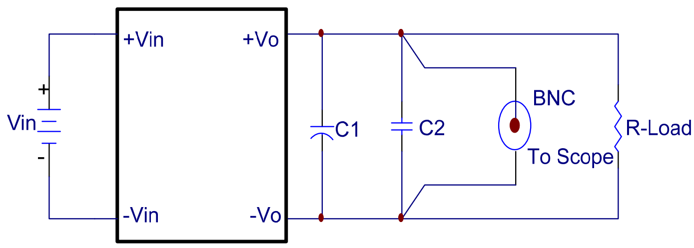
For example, to trim-down the output voltage of 5.0V module (EC1SC11) by 8% to 4.6V, R trim-down is calculated as follows:

$V_{O,nom} - Vo = 5.0 - 4.6 = 0.4V$
R1 = 5.788 KΩ
R2 = 10.57 KΩ

$$R_{trim-down} = \frac{5.788 - 10.57 \times 0.4}{0.4} = 3.9\ (K\Omega)$$

6.7 Output Ripple and Noise Measurement

The test set-up for noise and ripple measurements is shown in Figure 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 bandwidth.



Note: C1: none
C2: 0.1uF ceramic capacitor

Figure 9 Output Voltage Ripple and Noise Measurement Set-Up

6.8 Output Capacitance

The EC1SC 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 EC1SC 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 delay fuse 4A for 24Vin models and 2A for 48Vin modules. Figure 10 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.

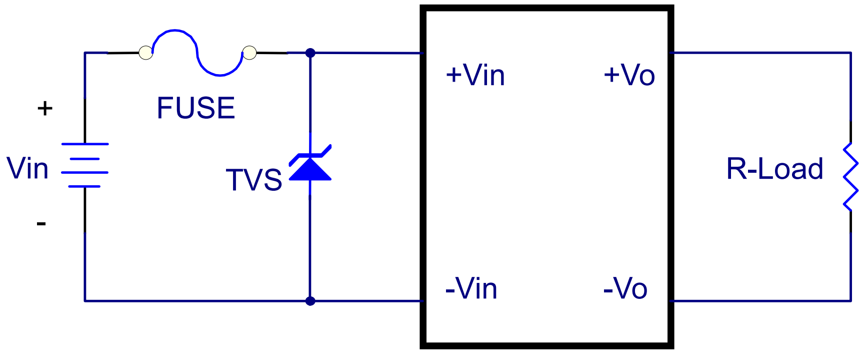


Figure 10 Input Protection

7.2 EMC Considerations

EMI Test standard: EN55032 Class B Conducted Emission

Test Condition: Nominal Input. Full Load at 25℃

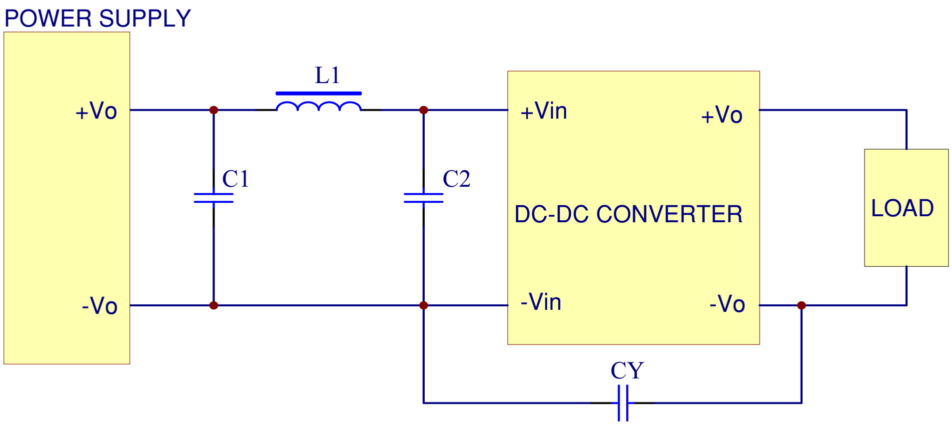
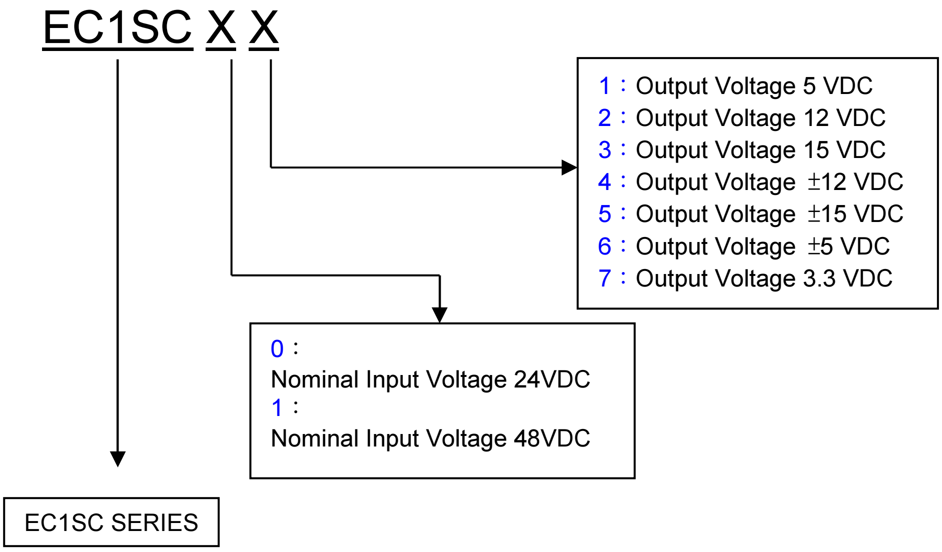


Figure 11 Connection circuit for conducted EMI testing

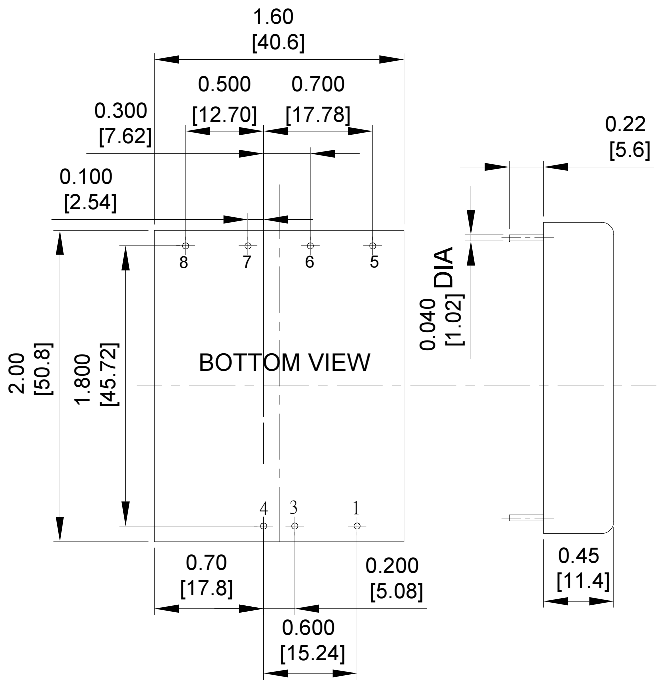
	EN55032 Class B			
Model No.	C1	C2	L1	CY
EC1SC0X	47uF/50V	47uF/50V	1.25uH	NC
EC1SC1X	22uF/100V	22uF/100V	3.5uH	NC

Note: The C1, C2 KY series aluminum capacitors

8. Part Number



9. Mechanical Specifications



PIN CONNECTIONS		
Pin	Single Output	Dual Output
1	On/Off Control	On/Off Control
3	-V Input	-V Input
4	+V Input	+V Input
5	Trim	Trim
6	-V Output	-V Output
7	+V Output	Common
8	No Pin	+V Output

NOTE: Pin Size is 0.04±0.004 Inch (1.0±0.1mm)DIA
All Dimensions In Inches(mm)
Tolerances Inches: X.XX= ±0.04 , X.XXX= ±0.010
Millimeters: X.X= ±1.0 , X.XX=±0.25

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