ECLB60 49.5-60 Watt Isolated DC-DC Converters

Application Note V12 November 2018

ISOLATED DC-DC CONVERTER
ECLB60 SERIES
APPLICATION NOTE

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Content

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1. Introduction

The ECLB60 series offer 60 watts of output power in a 2.05x1.20x0.4 inches copper packages. The ECLB60 series has a 2:1 wide input voltage range of 9-18、18-36 and 36-75VDC, 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 (de-rating above 45 °C). The modules are fully protected against input UVLO (under voltage lock out), output over-current, over-voltage and over-temperature 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

* 60W Isolated Output
* Efficiency to 93.5%
* 2.05" X1.2 X0.4" Six-Sided Shield Metal Case
* 2:1 Input Range
* Regulated Outputs
* Fixed Switching Frequency
* Input Under Voltage Protection
* Over Current Protection
* Remote On/Off
* Continuous Short Circuit Protection
* No Tantalum Capacitor Inside
* Safety Meets UL60950-1, EN60950-1, and IEC60950-1
* Full Load Operation Up to 60℃ with Heat-Sink M-C655 Natural Convection

3. Electrical Block Diagram

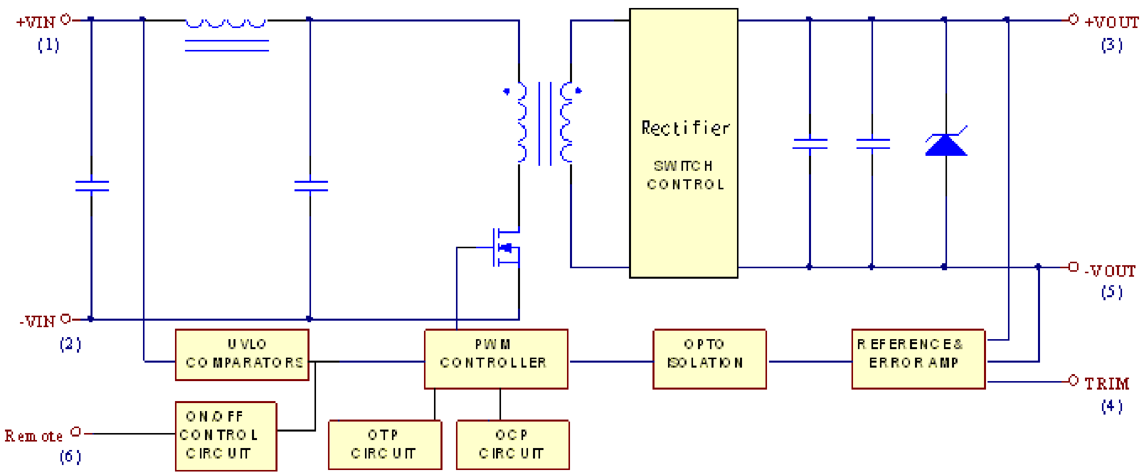


Figure 1 Electrical Block Diagram for Single Output Modules

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		12Vin 24Vin 48Vin	-0.3 -0.3 -0.3		18 36 75	Vdc
Transient	100ms	12Vin 24Vin 48Vin			25 50 100	Vdc
Operating Ambient Temperature	Derating, above 45℃	All	-40		+85	℃
Case Temperature		All			105	℃
Storage Temperature		All	-55		+125	℃
Input/Output Isolation Voltage	1 minute	All			1500	Vdc

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 75	Vdc
Input UnderVoltage Lockout						
Turn-On Voltage Threshold		12Vin 24Vin 48Vin	8 16.5 33	8.5 17 34	8.8 17.5 34.5	V_{dc}
Turn-Off Voltage Threshold		12Vin 24Vin 48Vin	7.7 15.5 31.5	8 16 32.5	8.3 16.5 33	V_{dc}
Lockout Hysteresis Voltage		12Vin 24Vin 48Vin		0.5 1 1.8		V_{dc}
Maximum Input Current	100% Load, Vin=9V	12Vin		7500		mA
	100% Load, Vin=18V	24Vin		3800		
	100% Load, Vin=36V	48Vin		1900		
No-Load Input Current	Vin=12V	12S33 12S05 12S12 12S15		10 10 10 10		mA
	Vin=24V	24S33 24S05 24S12 24S15		8 8 8 8		
	Vin=48V	48S33 48S05 48S12 48S15		5 5 5 5		

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Inrush Current (I^2t)	As per ETS300 132-2	All			0.1	A^2s
Input Reflected-Ripple Current	P-P thru 1.2uH inductor, 5Hz to 20MHz	12SXX 24SXX 48SXX			30 30 30	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 Vo=5.0V Vo=12V Vo=15V	3.2505 4.925 11.82 14.775	3.3 5 12 15	3.3495 5.075 12.18 15.225	Vdc
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			±0.2	%
Temperature Coefficient	Tc=-40℃ to 85℃	All			±0.02	%/℃
Output Voltage Ripple and Noise	5Hz to 20MHz bandwidth					
Peak-to-Peak	Full Load, Measured with 1uF MLCC	Vo=3.3V Vo=5.0V Vo=12V Vo=15V			100 100 150 150	mV
Operating Output Current Range		Vo=3.3V Vo=5.0V Vo=12V Vo=15V	0 0 0 0		15000 12000 5000 4000	mA
Output DC Current-Limit Inception	Vo=90% $V_{O,\ nominal}$	All	110	130	150	%
Maximum Output Capacitance	Full load (resistive)	Vo=3.3V Vo=5.0V Vo=12V Vo=15V			15000 12000 5000 4000	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. di/dt=0.1A/us	All			±5	%
Setting Time (within 1% Vonominal)		All			250	us
Turn-On Delay and Rise Time						
Turn-On Delay Time, From On/Off Control	Von/off to 10%Vo, set	All		15		ms
Turn-On Delay Time, From Input	Vin, min. to 10%Vo, set	All		15		ms
Output Voltage Rise Time	10%Vo, set to 90%Vo, set	All		15		ms

EFFICIENCY

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
100% Load	Vin=12V	12S33 12S05 12S12 12S15		90.5 91.5 92.5 92.5		%
	Vin=24V	24S33 24S05 24S12 24S15		91 92.5 93.5 93.5		
	Vin=48V	48S33 48S05 48S12 48S15		91 92 93 93		

ISOLATION CHARACTERISTICS

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

FEATURE CHARACTERISTICS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
Switching Frequency		All		260		KHz
On/Off Control, Positive Remote On/Off logic						
Logic Low (Module Off)	Von/off at Ion/off=1.0mA	All	0		1.2	V
Logic High (Module On)	Von/off at Ion/off=0.1uA	All	3.5 or Open Circuit		75	V
On/Off Control, Negative Remote On/Off logic						
Logic Low (Module Off)	Von/off at Ion/off=1.0mA	All	3.5 or Open Circuit 0		75	V
Logic High (Module On)	Von/off at Ion/off=0.1uA	All	0		1.2	V
On/Off Current (for both remote on/off logic)	Ion/off at Von/off=0.0V	All		0.3	1	mA
Leakage Current (for both remote on/off logic)	Logic high, Von/off=15V	All			30	uA
Off Converter Input Current	Shutdown input idle current	All		4	10	mA
Output Voltage Trim Range	Pout=maximum rated power	All	-10		+10	%
Output Over Voltage Protection	Zener or TVS clamp	Vo=3.3V Vo=5.0V Vo=12V Vo=15V		3.9 6.2 15 18		Vdc
Over-Temperature Shutdown		All		110		°C

GENERAL SPECIFICATIONS

PARAMETER	NOTES and CONDITIONS	Device	Min.	Typical	Max.	Units
MTBF	Io=100%of Io.max.; Ta=25℃ per MIL-HDBK-217F	Vo=3.3V		1100		K hours
		Vo=5.0V		900		
		Vo=12V		950		
		Vo=15V		1250		
Weight		All		39		grams

5. Main Features and Functions

5.1 Operating Temperature Range

The ECLB60 series converters can be operated by a wide ambient temperature range from -40℃ to 85℃ (de-rating above 45℃). The standard model has a copper case and case temperature can not over 105℃ at normal operating.

5.2 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 high (>3.5Vdc to 75 or open circuit). Setting the pin low (0 to <1.2Vdc) will turn the converter 'Off'. The signal level of the remote on/off input is defined with respect to "-Vin". If not using the remote on/off pin, leave the pin open (module will be on).

5.3 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the ECLB60 unit. The unit will shut down when the input voltage drops below a threshold, and the unit will operate when the input voltage goes above the upper threshold.

5.4 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 hiccup mode protection.

5.5 Over Voltage Protection

The over-voltage protection consists of a zener diode to limiting the out voltage.

5.6 Over-Temperature Protection (OTP)

The ECLB60 series converters are equipped with non-latching over-temperature protection. If the temperature exceeds a threshold of 110°C (typical) the converter will shut down, disabling the output. When the temperature has decreased the converter will automatically restart. The over-temperature condition can be induced by a variety of reasons such as external overload condition or a system fan failure.

5.7 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%. (Single output models only)

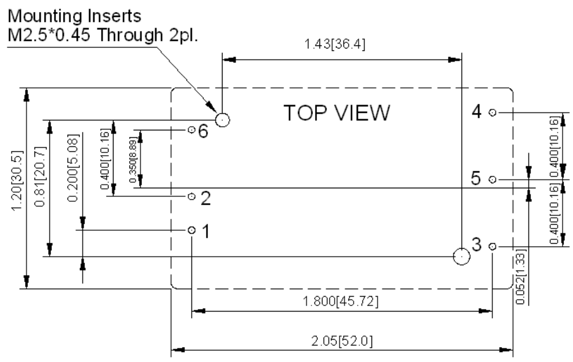
6. Applications

6.1 Recommended Layout PCB Footprints and Soldering Information

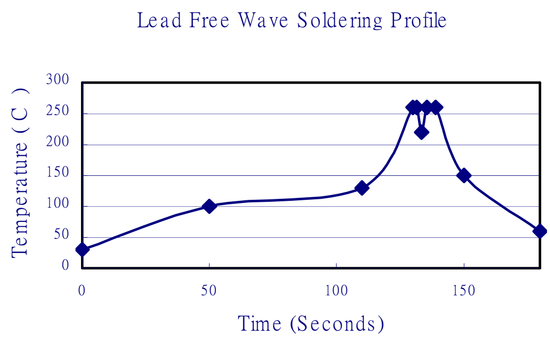
The system designer or the end user must ensure that other components and metal in the vicinity of the converter meet the spacing requirements to which the system is approved. Low resistance and low inductance PCB layout traces are the norm and should be used where possible. Due consideration must also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

1.3mm PLATED THROUGH HOLE

2.0mm PAD SIZE



Note: Dimensions are in inches (millimeters)



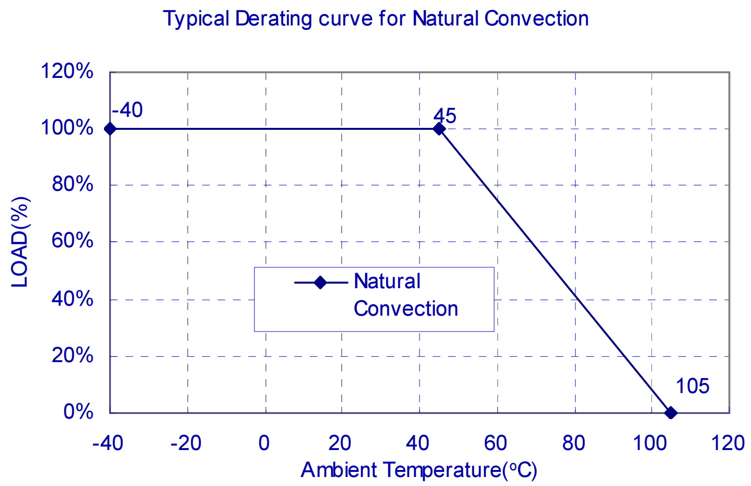
Note：

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℃)

6.2 Power De-Rating Curves for ECLB60 Series

Operating Ambient temperature Range: -40℃ ~ 85℃ (derating above 45℃).

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



De-rating measured with nominal line. Output power 60W and converter mounted test board (86x50x1.6mm, 2Oz).by M2.5 screw

Example (without heatsink):

What is the minimum airflow necessary for a ECLB60-24S05 operating at nominal line voltage, an output current of 12A, and a maximum ambient temperature of 45℃?

Solution:

Given: Vin=24V_{dc}, Vo=5V_{dc}, Io=12A

Determine Power dissipation (P_d):

$P_d=P_i-P_o=P_o(1-\eta)/\eta$

$P_d=5.0\times10\times(1-0.925)/0.925=4.86$Watts

Determine airflow:

Given: P_d=4.86W and T_a=45℃

Check above Power de-rating curve:

Airflow: Natural Convection

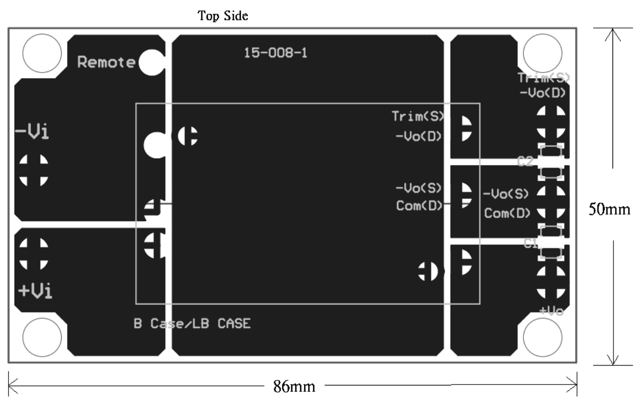
Verifying: The maximum temperature rise $\triangle T = P_d \times R_{ca}=4.86\times11.25=54.73$℃

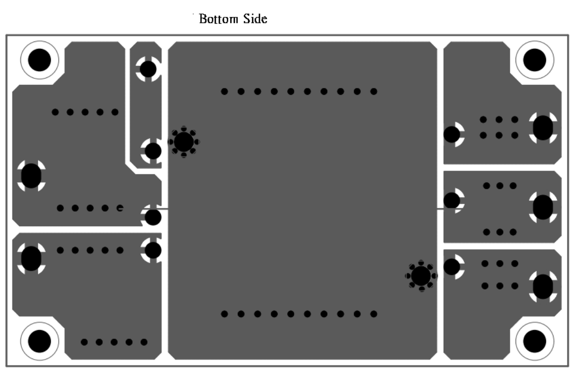
The maximum case temperature $T_c=T_a+\triangle T=99.73$℃ <105℃

Where: The R_{ca} is thermal resistance from case to ambience.

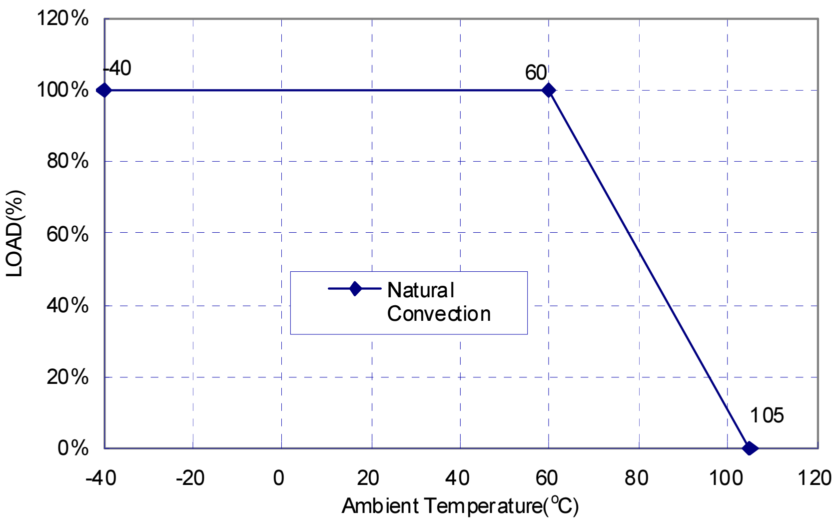
The T_a is ambient temperature and the T_c is case temperature

Recommended PCB Layout with de-rating. (86x50x1.6mm, 2Oz.)





Typical Derating curve for Natural Convection with heatsink M-C655



De-rating measured with nominal line. Output power 60W and converter with thermal pad SZ 29.5x49.8x0.25mm and heat sink M-C655. Mounted test board (86x50x1.6mm, 2Oz)by M2.5 screw

Example (with heatsink M-C655):

What is the minimum airflow necessary for a ECLB60-24S12 operating at nominal line voltage, an output current of 5A, and a maximum ambient temperature of 60℃?

Solution:

Given: Vin=24V_{dc}, Vo=12V_{dc}, Io=5A

Determine Power dissipation (P_d):

$P_d = P_i - P_o = P_o(1-\eta)/\eta$

$P_d = 5.0 \times 10 \times (1-0.935)/0.935 = 4.17$Watts

Determine airflow:

Given: P_d=4.86W and T_a=60℃

Check above Power de-rating curve:

Airflow: Natural Convection

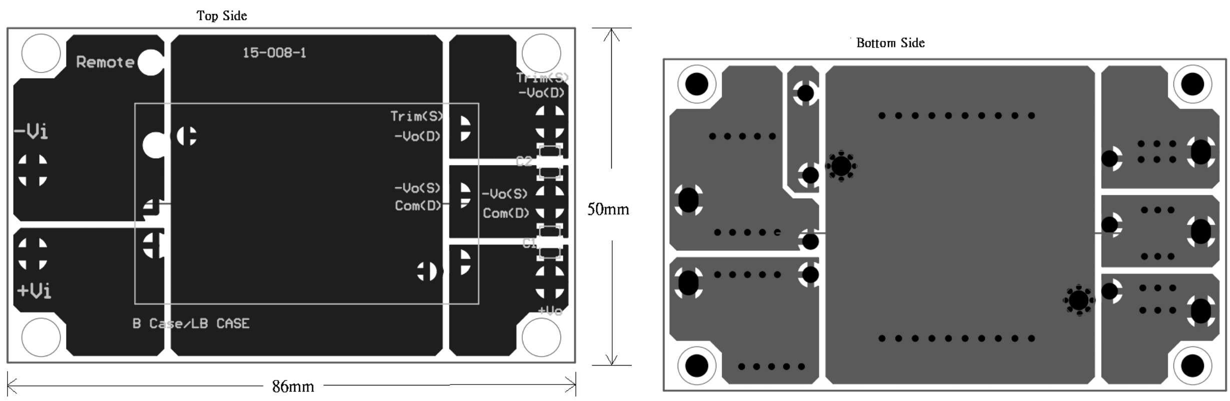
Verifying: The maximum temperature rise $\triangle T = P_d \times R_{ca} = 4.17 \times 8.99 = 37.5$℃

The maximum case temperature $T_c = T_a + \triangle T = 97.5$℃ <105℃

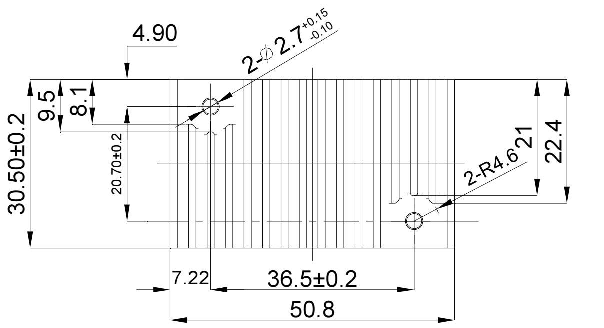
Where: The R_{ca} is thermal resistance from case to ambience.

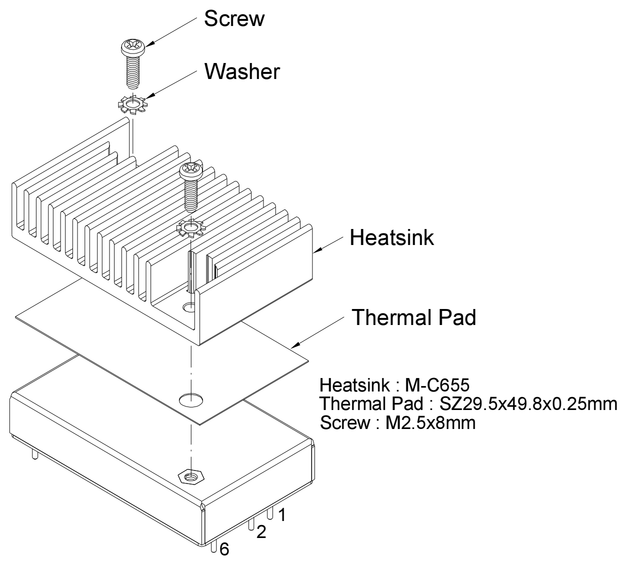
The T_a is ambient temperature and the T_c is case temperature

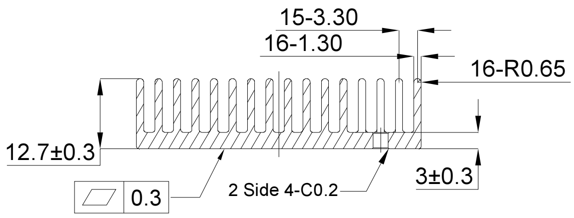
Recommended PCB Layout with de-rating. (86x50x1.6mm, 2Oz.)



6.3 LB Heat Sinks:

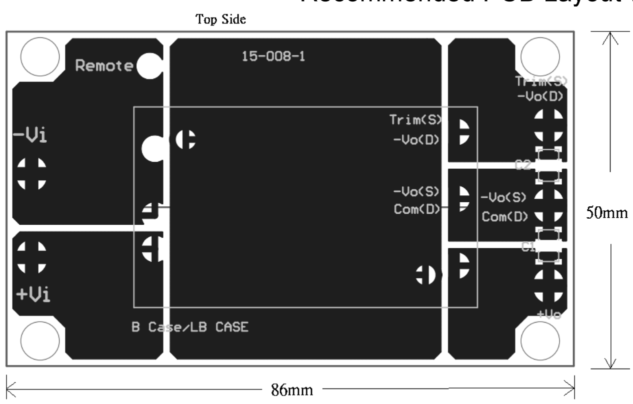


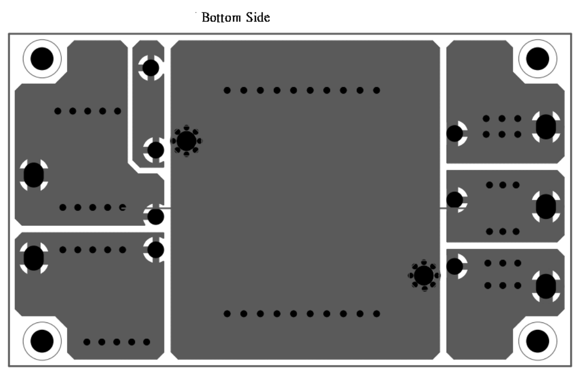




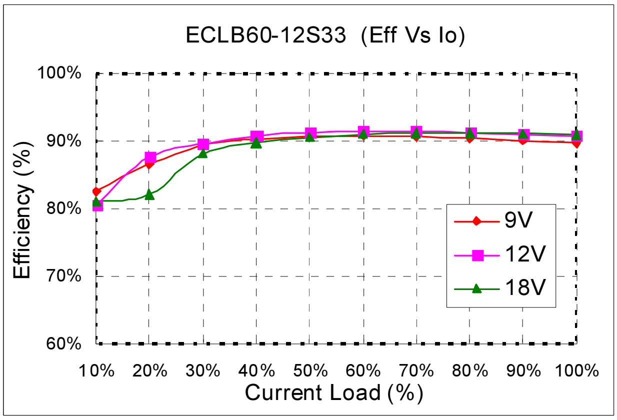
M-C655 (G6620790202)
Transverse Heat Sink
All Dimensions in mm
Thermal Pad: SZ29.5x49.8x0.25mm (G6135041753)
Screw: M2.5x8mm (G75A3300922)
Washer: (G75A5750052)
Rca: 8.99°C/W (typ.), At natural convection
Rca: 8.3°C/W (typ.), At natural convection, mounted 85x50x1.6mm 2Oz test board.

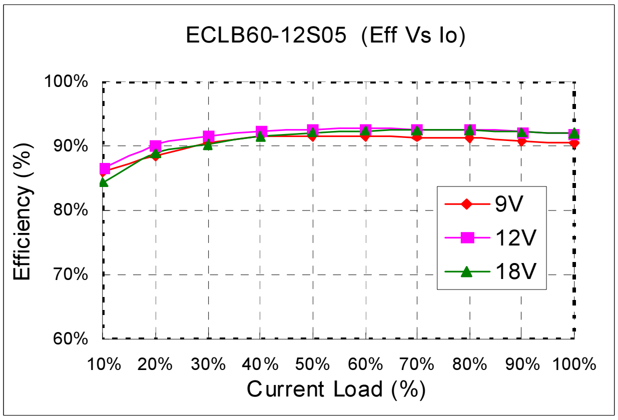
Recommended PCB Layout with de-rating. (86x50x1.6mm, 2Oz.)

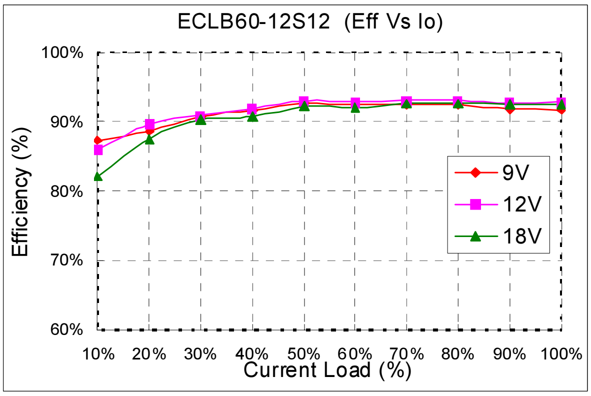


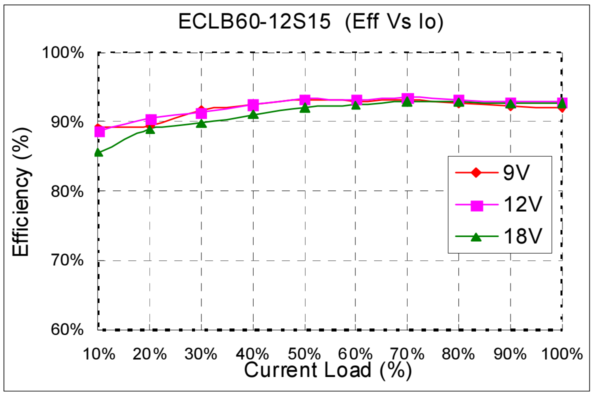


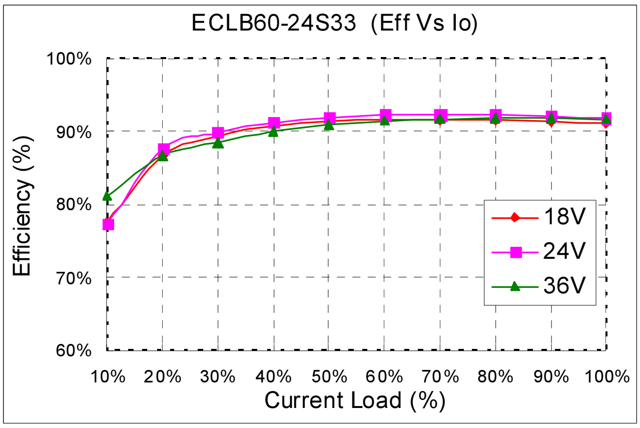
6.4 Efficiency vs. Load Curves

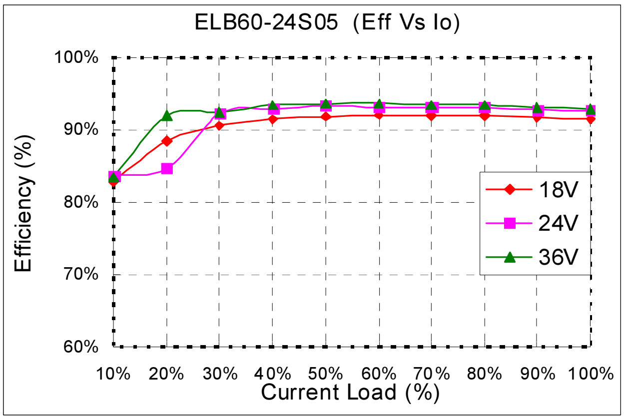


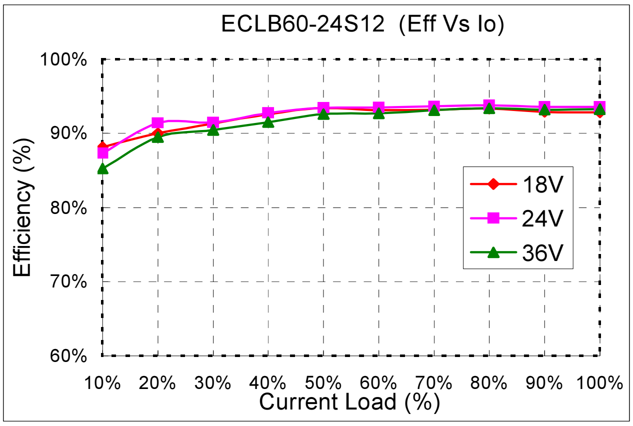


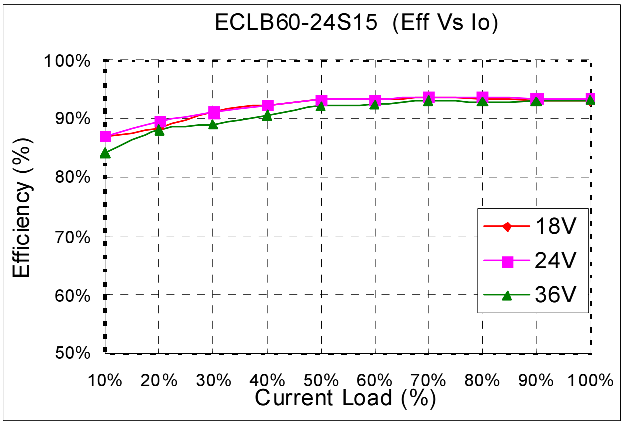


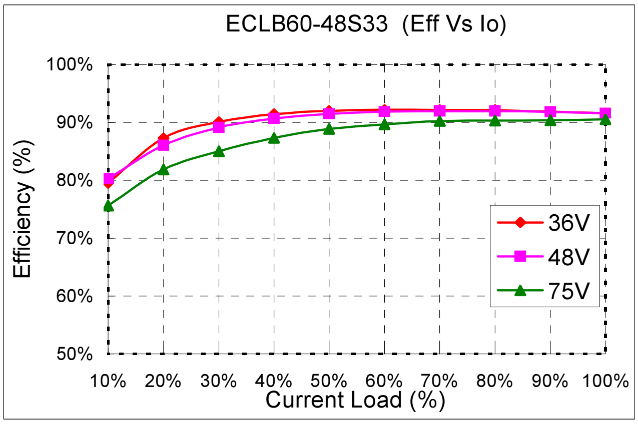


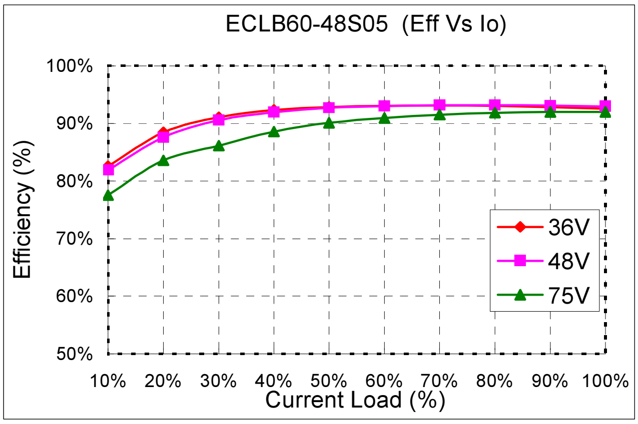


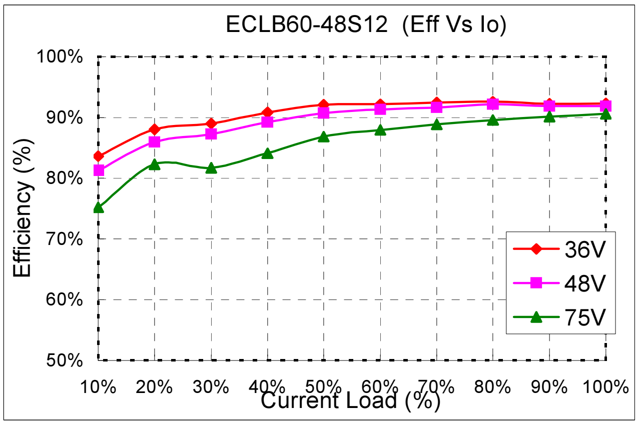


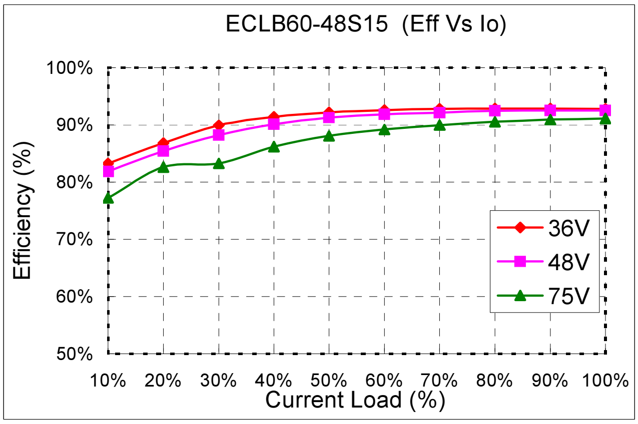

ECLB60-24S12 (Eff Vs Io)
Efficiency (%)
Current Load (%)
18V
24V
36V


ECLB60-24S15 (Eff Vs Io)
Efficiency (%)
Current Load (%)
18V
24V
36V


ECLB60-48S33 (Eff Vs Io)
Efficiency (%)
Current Load (%)
36V
48V
75V


ECLB60-48S05 (Eff Vs Io)
Efficiency (%)
Current Load (%)
36V
48V
75V

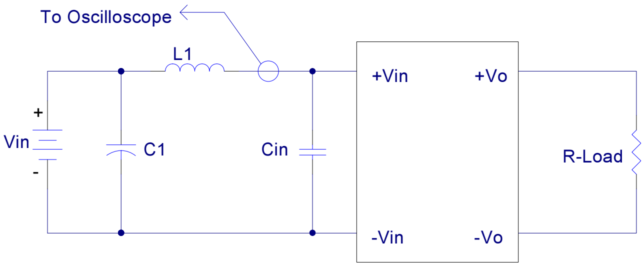

ECLB60-48S12 (Eff Vs Io)
Efficiency (%)
Current Load (%)
36V
48V
75V


ECLB60-48S15 (Eff Vs Io)
Efficiency (%)
Current Load (%)
36V
48V
75V

6.5 Input Capacitance at the Power Module

The converters must be connected to low AC source impedance. To avoid problems with loop stability source inductance should be low. Also, the input capacitors (Cin) should be placed close to the converter input pins to de-couple distribution inductance. However, the external input capacitors are chosen for suitable ripple handling capability. Low ESR capacitors are good choice. Circuit as shown in Figure 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).



ECLB60-12SXX and 24SXX Series
L1: 1.2uH
C1: None
Cin: 330uF ESR<0.7ohm @100KHz
ECLB60-48SXX Series
L1: 12uH
C1: None
Cin: 33uF ESR<0.7ohm @100KHz

Figure 5 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 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.

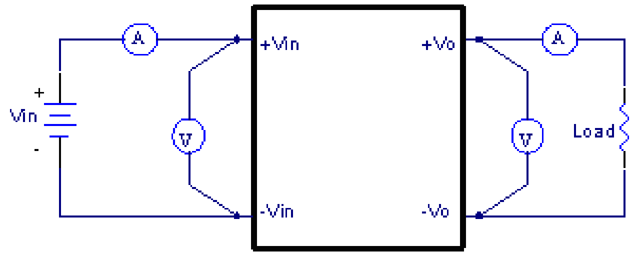


Figure 6 ECLB60 Series Test Setup

6.7 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%. (Single output models only) This is shown in Figure 7 and 8:

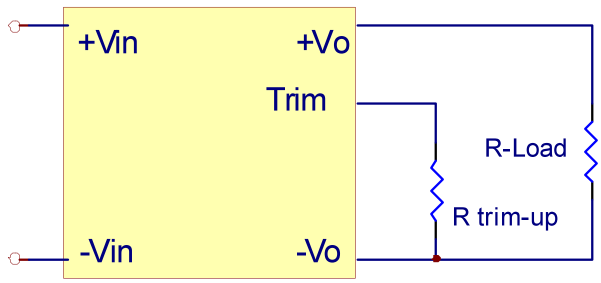


Figure 7 Trim-up Voltage Setup

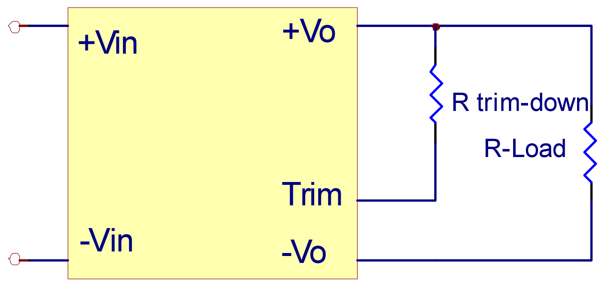


Figure 8 Trim-down Voltage Setup

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

$$R_{trim-up} = \left(\frac{Vr \times R1 \times (R2 + R3)}{(Vo - V_{o,nom}) \times R2}\right) - Rt \quad (K\Omega)$$

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, Rt, R2, R3 and Vr 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)	R3 (KΩ)	Rt (KΩ)	Vr (V)
ECLB60-XXS33	3.3	2.74	1.8	0.27	9.1	1.24
ECLB60-XXS05	5.0	2.32	2.32	0	8.2	2.5
ECLB60-XXS12	12.0	6.8	2.4	2.32	22	2.5
ECLB60-XXS15	15.0	8.06	2.4	3.9	27	2.5

For example, to trim-up the output voltage of 5.0V module (ECLB60-24S05) by 10% to 5.5V, R trim-up is calculated as follows:

$V_o - V_{o,\,nom} = 5.5 - 5.0 = 0.5V$
R1 = 2.32 KΩ
R2 = 2.32 KΩ
R3 = 0 KΩ
Rt = 8.2 KΩ,
Vr= 2.5 V

$$R_{trim-up} = \left(\frac{2.5 \times 2.32 \times (2.32 + 0)}{0.5 \times 2.32}\right) - 8.2 = 3.4(K\Omega)$$

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

$$R_{trim-down} = R1 \times \left(\frac{Vr \times R1}{(V_{o,nom} - Vo) \times R2} - 1\right) - Rt \quad (K\Omega)$$

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, Rt, R2, R3 and Vr are internal to the unit and are defined in Table 1

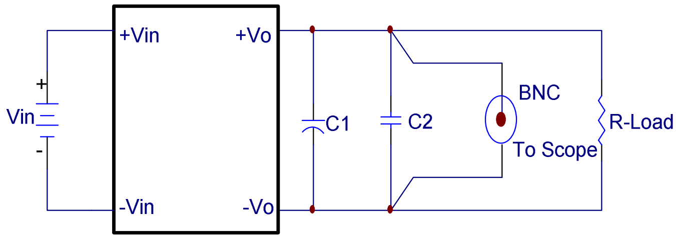
For example, to trim-down the output voltage of 5.0V module (ECLB60-12S05) by 10% to 4.5V, R trim-down is calculated as follows:

$V_{O,nom} - Vo = 5.0 - 4.5 = 0.5V$
R1 = 2.32 KΩ
R2 = 2.32 KΩ
R3 = 0 KΩ
Rt = 8.2 KΩ
Vr= 2.5 V

$$R_{trim-down} = 2.32 \times \left(\frac{(2.5 \times 2.32)}{0.5 \times 2.32} - 1\right) - 8.2 = 1.08 \quad (K\Omega)$$

6.8 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: 1uF ceramic capacitor

Figure 9 Output Voltage Ripple and Noise Measurement Set-Up

6.9 Output Capacitance

The ECLB60 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 ECLB60 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 10A for 12Vin models, 6A for 24Vin modules. and 3A 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.

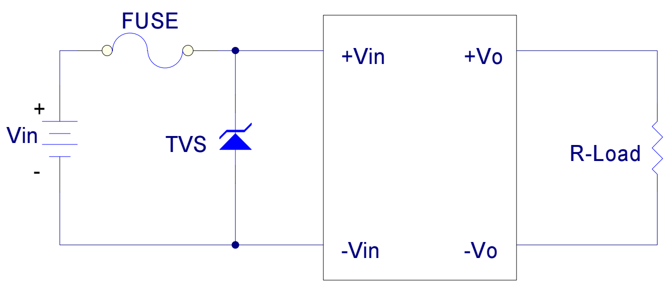


Figure 10 Input Protection

7.2 EMC Considerations

EMI Test standard: EN55022 Class A Conducted Emission
Test Condition: Input Voltage: Nominal, Output Load: Full Load

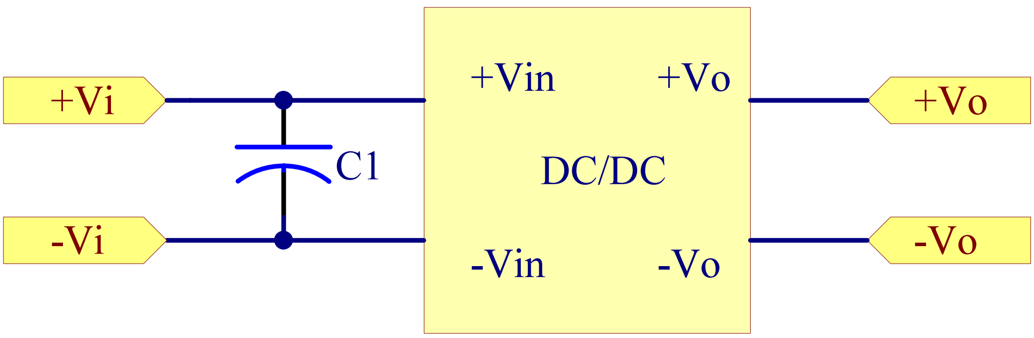


Figure 11 Connection circuit for conducted EMI testing

Model No.	C1	Model No.	C1	Model No.	C1
ECLB60-12S33	470uF/25V ESR<0.07	ECLB60-24S33	220uF/50V ESR<0.09	ECLB60-48S33	47uF/100V ESR<0.17
ECLB60-12S05		ECLB60-24S05		ECLB60-48S05	
ECLB60-12S12		ECLB60-24S12		ECLB60-48S12	
ECLB60-12S15		ECLB60-24S15		ECLB60-48S15	

Note: The C1 aluminum capacitors

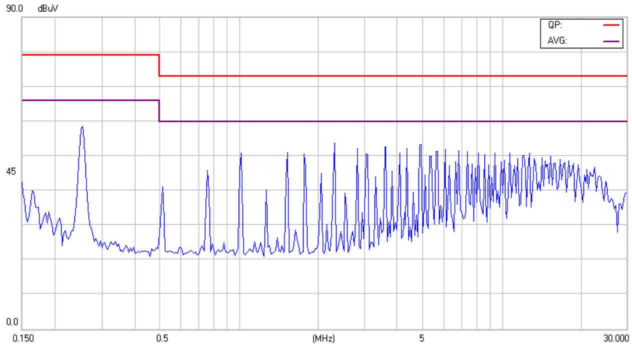


Figure 12 Conducted Class A of ECLB60-12S33

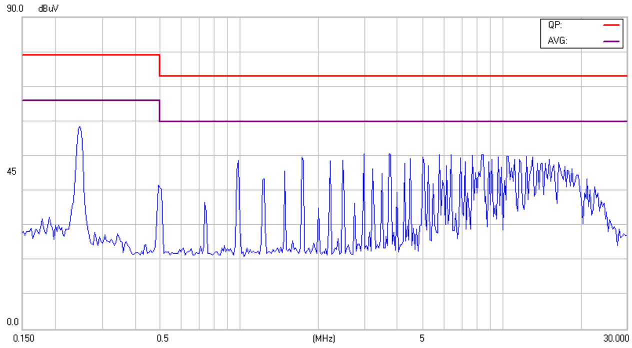


Figure 13 Conducted Class A of ECLB60-12S05

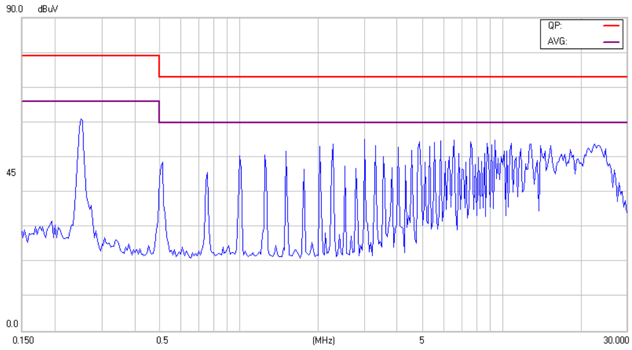


Figure 14 Conducted Class A of ECLB60-12S12

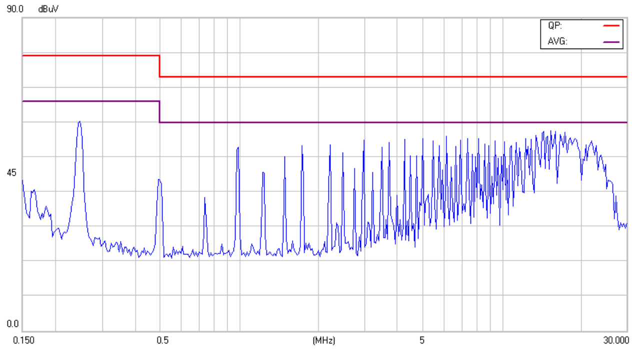


Figure 15 Conducted Class A ECLB60-12S15

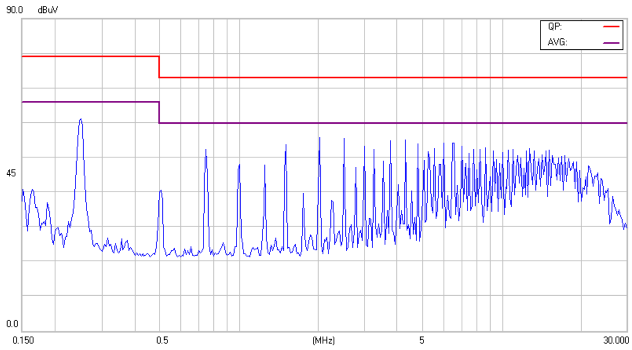


Figure 16 Conducted Class A of ECLB60-24S33

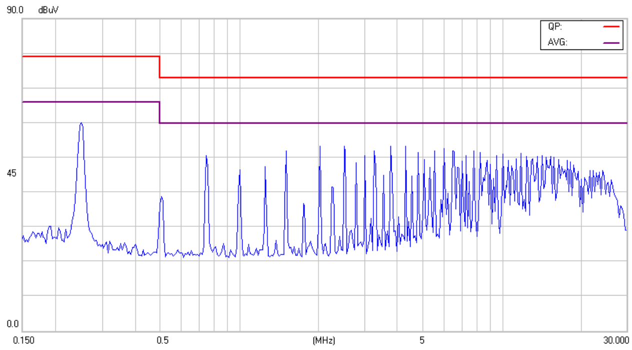


Figure 17 Conducted Class A of ECLB60-24S05

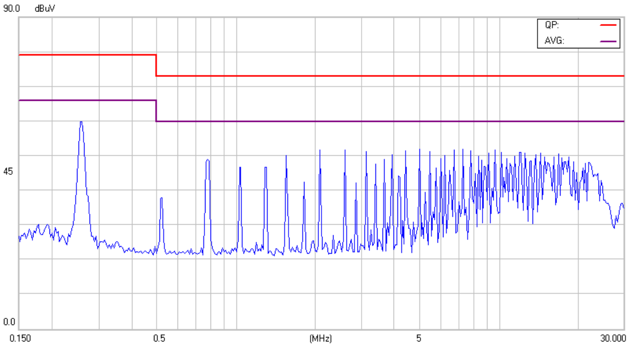


Figure 18 Conducted Class A of ECLB60-24S12

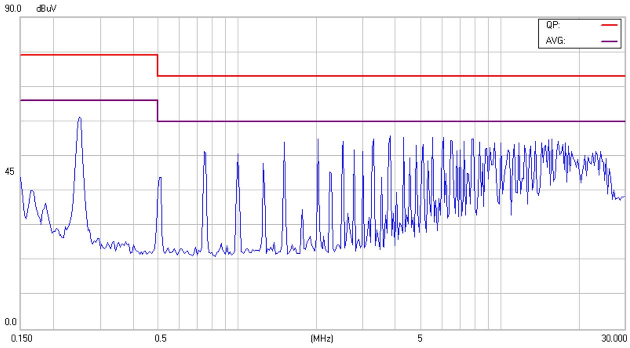


Figure 19 Conducted Class A of ECLB60-24S15

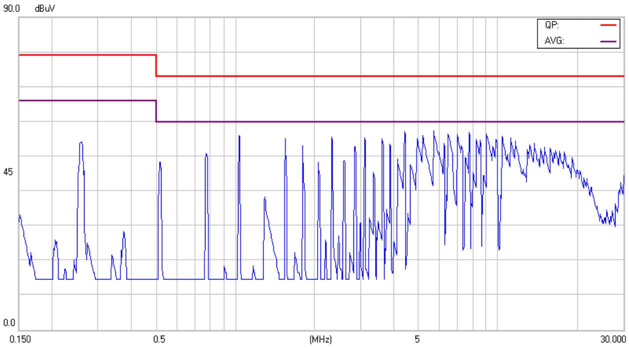


Figure 20 Conducted Class A of ECLB60-48S33

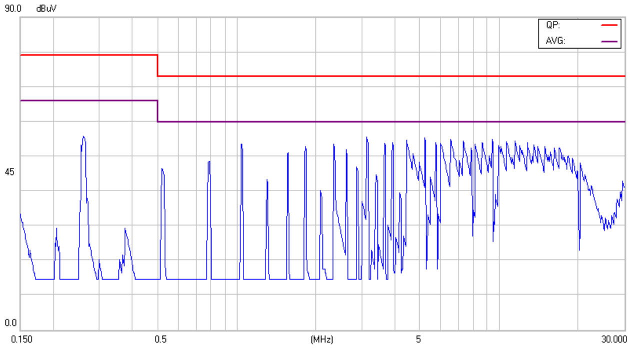


Figure 21 Conducted Class A of ECLB60-48S05

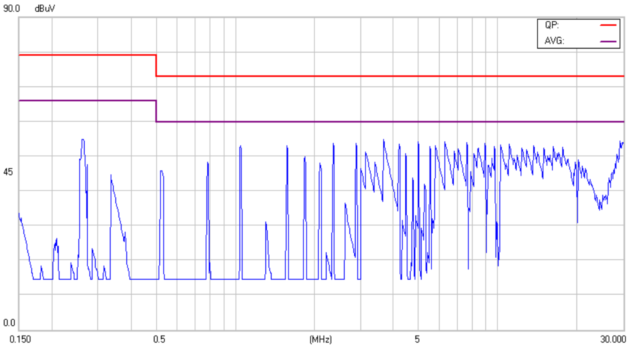


Figure 22 Conducted Class A of ECLB60-48S12

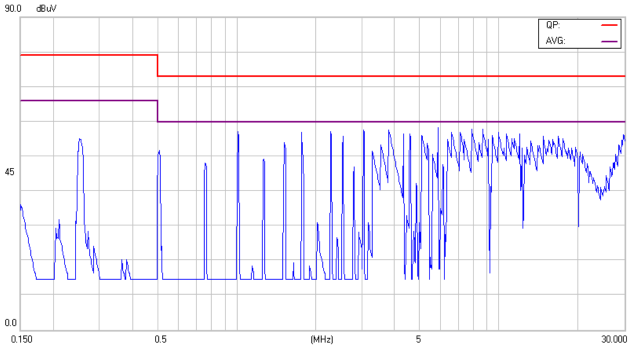


Figure 23 Conducted Class A of ECLB60-48S15

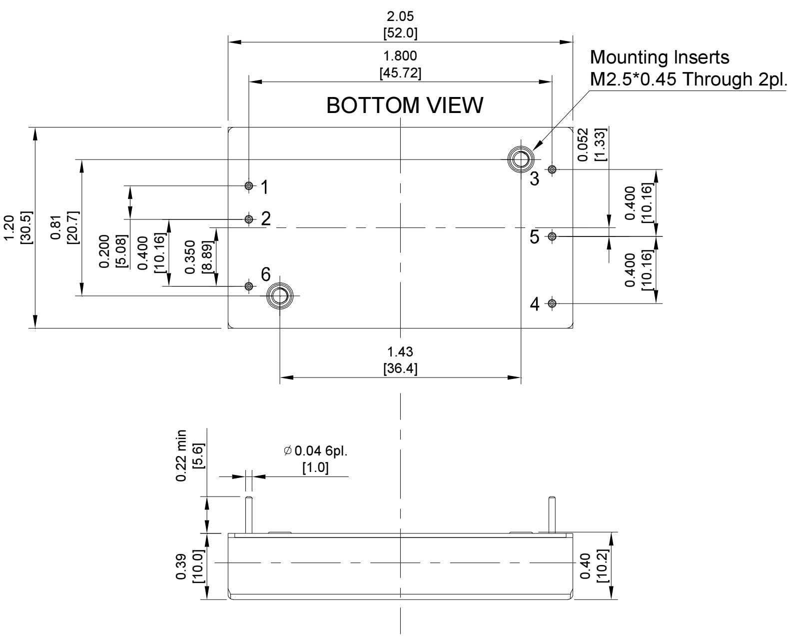
8. Part Number

ECLB60 – XX X XX X X

- ECLB60 Series
- 12 : Nominal Input Voltage 12VDC
- 24 : Nominal Input Voltage 24VDC
- 48 : Nominal Input Voltage 48VDC
- S : Single Output
- 33 : Output Voltage 3.3 VDC
- 05 : Output Voltage 5 VDC
- 12 : Output Voltage 12 VDC
- 15 : Output Voltage 15 VDC
- None : Positive Logic
- N : Negative Logic
- None: Mounting Insert M2.5*0.45 2pl.
- -C: Clear Mounting Insert 2.65mm DIA.

9. Mechanical Specifications

NOTE: Pin Size is 0.04±0.004 Inch (1.0±0.1 mm)DIA
All Dimensions in Inches[mm]
Tolerance Inches:x.xx=±0.02 ,x.xxx=±0.010
Millimeters:x.x=±0.5 , x.xx=±0.25



PIN CONNECTION		
PIN	Single Output	Dual Output
1	+V Input	+V Input
2	-V Input	-V Input
3	+V Output	+V Output
4	Trim	-V Output
5	-V Output	Common
6	Remote On/Off	Remote On/Off

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