ECLB40W-110 Series
Application Note V14

ISOLATED DC-DC CONVERTER
ECLB40W-110 SERIES
APPLICATION NOTE

Approved By:

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Contents

1. Introduction

The ECLB40W-110 series of DC-DC converters offers 40 watts of output power @ output voltages of 3.3, 5, 12, 15, ±12, ±15VDC, ±24VDC with industry 2.05"x1.20"x0.4" package. It has a wide (4:1) input voltage range of 43 to 160VDC (110VDC nominal) and 3000VDC basic isolation.

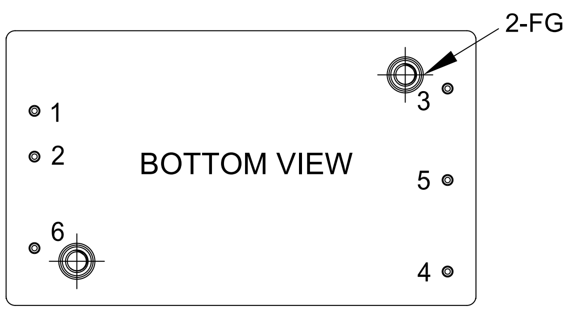
Compliant with EN 50155, EN 45545, EN 50121-3-2. High efficiency up to 91%, allowing case operating temperature range of -40℃ to 105℃. Very low no load power consumption (3mA), an ideal solution for energy critical systems.

Fully protected against input UVLO (under voltage lock out), output over-current, output over-voltage and over-temperature and continuous short circuit conditions.

The standard control functions include remote on/off (positive or negative) and +10%, -10% adjustable output voltage (single output only).

ECLB40W-110 series is designed primarily for common railway applications of 72V, 96V, 110V nominal voltage and also suitable for distributed power architectures, telecommunications, battery operated equipment and industrial applications.

2. Pin Function Description



Single Output

No	Label	Function	Description	Reference
1	+Vin	+V Input	Positive Supply Input	**Section 7.1/7.2**
2	-Vin	-V Input	Negative Supply Input	**Section 7.1/7.2**
3	+Vout	+V Output	Positive Power Output	**Section 7.3/7.4**
4	Trim	Trim	External Output Voltage Adjustment	**Section 6.6**
5	-Vout	-V Output	Negative Power Output	**Section 7.3/7.4**
6	Remote ON/OFF	Remote On/Off	External Remote On/Off Control	**Section 6.5**
--	--	Mounting Insert	Mounting Insert (FG)	**Section 8.5**

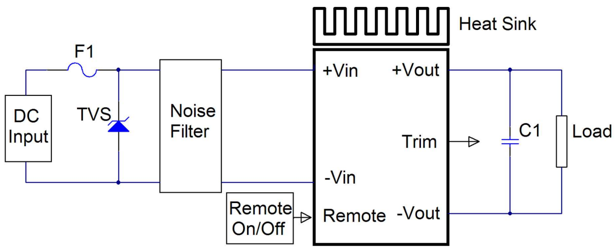
Dual Output

No	Label	Function	Description	Reference
1	+Vin	+V Input	Positive Supply Input	**Section 7.1/7.2**
2	-Vin	-V Input	Negative Supply Input	**Section 7.1/7.2**
3	+Vout	+V Output	Positive Power Output	**Section 7.3/7.4**
4	-Vout	-V Output	Negative Power Output	**Section 7.3/7.4**
5	Common	Common	Common Power Output	**Section 7.3/7.4**
6	Remote ON/OFF	Remote On/Off	External Remote On/Off Control	**Section 6.5**
--	--	Mounting Insert	Mounting Insert (FG)	**Section 8.5**

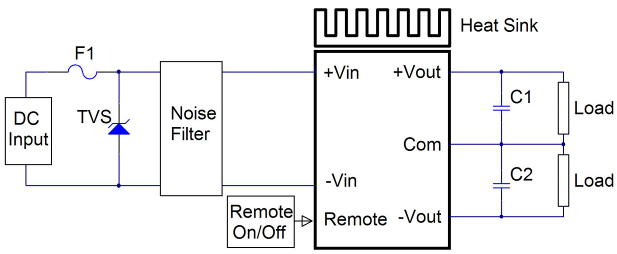
Note: Base plate can be connected to FG through M2.5 threaded mounting insert. Recommended torque 3-7Kgf-cm

3. Connection for Standard Use

The connection for standard use is shown below. External output capacitors (C1, C2) are recommended to reduce output ripple and noise, 1uF ceramic capacitor for all models.



ECLB40W-110 single output module



ECLB40W-110 dual output module

Symbol	Component	Reference
F1, TVS	Input fuse, TVS	**Section 9.1**
C1, C2	External capacitor on the output side	**Section 7.3**
Noise Filter	External input noise filter	**Section 9.2**
Remote On/Off	External remote on/off control	**Section 6.5**
Trim	External output voltage adjustment	**Section 6.6**
Heat Sink	External heat sink	**Section 8.2/8.3/8.4/8.5**

4. Test Set-Up

The basic test set-up to measure parameters such as efficiency and load regulation is shown below. 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:

- 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

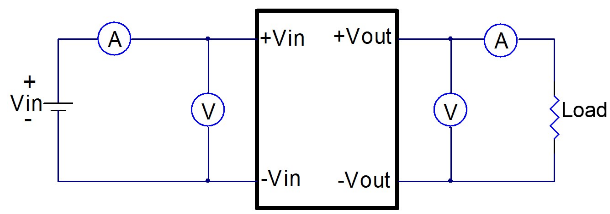
The value of line regulation is defined as:

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

Where:

V_{HL} is the output voltage of maximum input voltage at full load

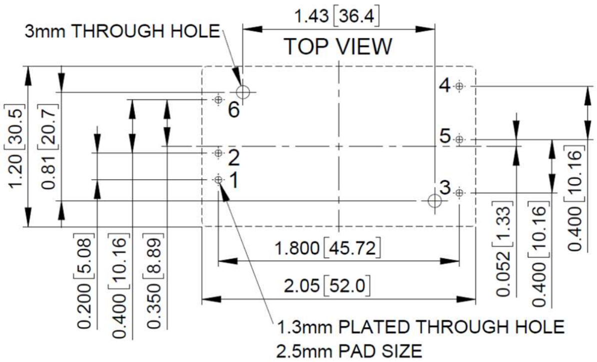
V_{LL} is the output voltage of minimum input voltage at full load



ECLB40W-110 Series Test Setup

5. Recommend Layout, PCB Footprint and Soldering Information

The system designer or end user must ensure that metal and other components in the vicinity of the converter meet the spacing requirements for which the system is approved. Low resistance and 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.

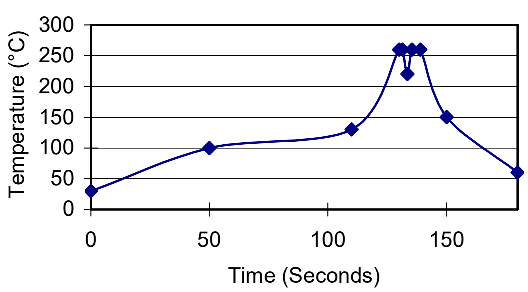


Note: Dimensions are in inches (millimeters)

Clean the soldered side of the module with a brush, prevent liquid from getting into the module. Do not clean by soaking the module into liquid. Do not allow solvent to come in contact with product labels or resin case as this may changed the color of the resin case or cause deletion of the letters printed on the product label. After cleaning, dry the modules well.

The suggested soldering iron is 420±10℃ for up to 4-10 seconds (less than 90W) used in double PCB and multilayer PCB, The other one is used in the single PCB is 385±10℃ for up to 2-6 seconds (less than 90W). Furthermore the recommended soldering profile is shown below.

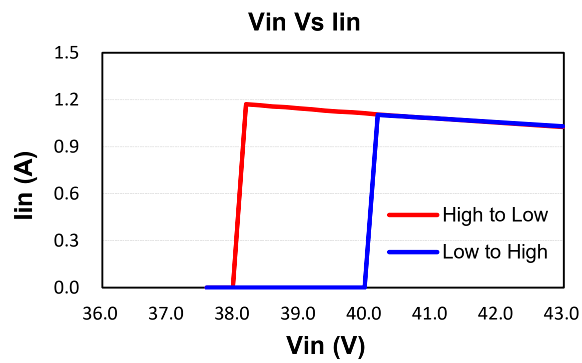
Lead Free Wave Soldering Profile



6. Features and Functions

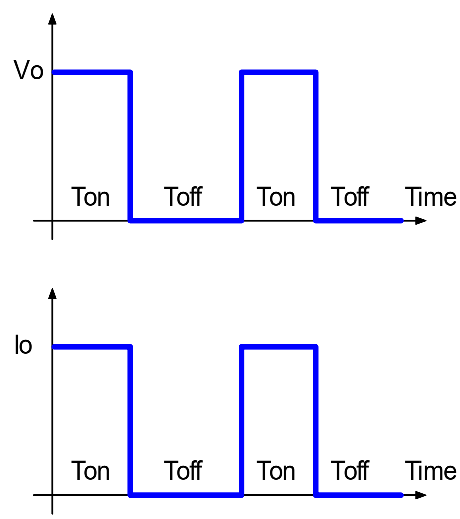
6.1 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the ECLB40W-110 series unit. The unit will shut down when the input voltage drops below a lower threshold, and the unit will operate when the input voltage goes above the upper threshold.



6.2 Over Current/Short Circuit 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.

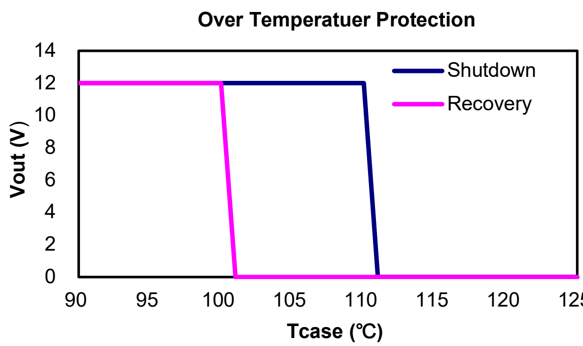


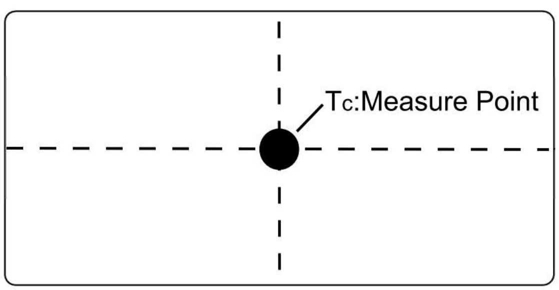
6.3 Output Over Voltage Protection

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

6.4 Over Temperature Protection

These modules have an over temperature protection circuit to safeguard against thermal damage. Shutdown occurs with the maximum case reference temperature is exceeded. The module will restart when the case temperature falls below over temperature recovery threshold. Different input voltage the over temperature protection turn on/off points will drift. Please measure temperature of the center part of metal case.





TOP VIEW

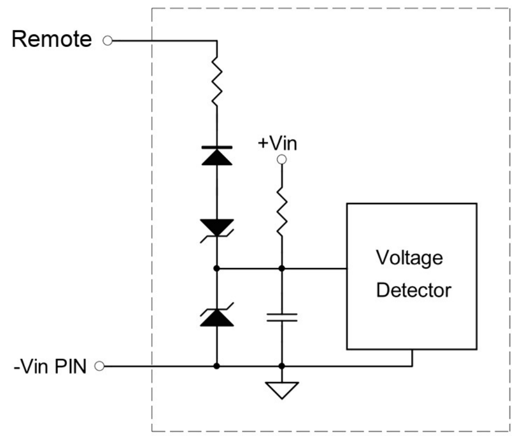
6.5 Remote On/Off

The ECLB40W-110 series allows the user to switch the module on and off electronically with the remote **on/off** feature. All models are available in “positive logic” and “negative logic” (optional) versions. The converter turns on if the remote **on/off** pin is high (>3.5Vdc to 75Vdc 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 ground.
If not using the remote **on/off** pin, leave the pin open (converter will be on). Converter will be turn on in positive mode.

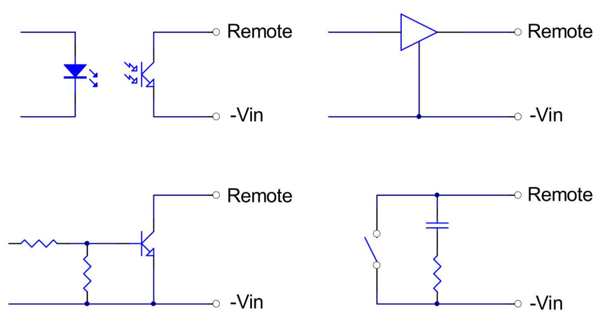
Models with part number suffix “N” are the “negative logic” remote **on/off** version. The unit turns off if the remote **on/off** pin is high (>3.5Vdc to 75Vdc or open circuit). The converter turns on if the **on/off** pin input is low (0 to<1.2Vdc). Note that the converter is off by default.

Logic State (Pin 6)	Negative Logic	Positive Logic
Logic Low	Module on	Module off
Logic High	Module off	Module on

The converter remote **on/off** circuit built-in on input side. The ground pin of input side remote **on/off** circuit is -Vin pin. Inside connection sees below.



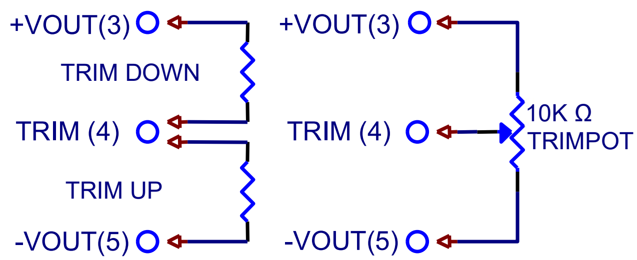
Connection examples see below.



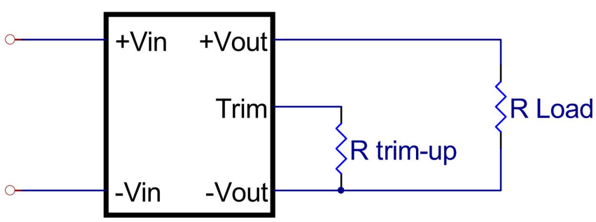
Remote On/Off Connection Examples

6.6 Output Voltage Adjustment

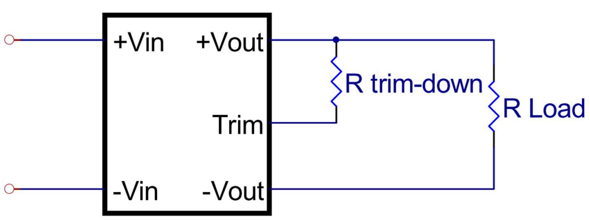
Output may be externally trimmed +10% to -10% (single output models only) with a fixed resistor or an external trim pot as shown (optional). Model specific formulas for calculating trim resistors are available upon request as a separate document.



In order to trim the voltage up or down, one needs to connect the trim resistor either between the trim pin and -Vout for trim-up or between trim pin and +Vout for trim-down. The output voltage trim range is +10% to -10%. This is shown:



Trim-up Voltage Setup



Trim-down Voltage Setup

The value of $R_{trim\text{-}up}$ defined as:

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

Table 1 – Trim up and Trim down Resistor Values

Model Number	Output Voltage(V)	R1 (KΩ)	R2 (KΩ)	R3 (KΩ)	Rt (KΩ)	Vr (V)
ECLB40W-110S33	3.3	2.74	1.8	0.27	9.1	1.24
ECLB40W-110S05	5.0	2.32	2.32	0	8.2	2.5
ECLB40W-110S12	12.0	6.8	2.4	2.32	22	2.5
ECLB40W-110S15	15.0	8.06	2.4	3.9	27	2.5

Where

$R_{trim\text{-}up}$ 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 V_r are internal to the unit and are defined in Table 1

For example, to trim-up the output voltage of 5.0V module (ECLB40W-110S05) 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
R_t = 8.2 KΩ
V_r= 2.5 V

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

The typical value of R_{trim_up}

Trim up %	3.3V	5V	12V	15V
	R_{trim_up} (KΩ)			
1%	109.301	107.800	256.611	325.625
2%	50.101	49.800	117.306	149.313
3%	30.367	30.467	70.870	90.542
4%	20.500	20.800	47.653	61.156
5%	14.580	15.000	33.722	43.525
6%	10.634	11.133	24.435	31.771
7%	7.814	8.371	17.802	23.375
8%	5.700	6.300	12.826	17.078
9%	4.056	4.689	8.957	12.181
10%	2.740	3.400	5.861	8.263

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

$$Rtrim-down = R1 \times (\frac{Vr \times R1}{(Vo,nom - Vo) \times R2} - 1) - Rt\ (K\Omega)$$

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 (ECLB40W-110S05) by 10% to 4.5V, R trim-down is calculated as follows:

$V_{o,nom} - V_o = 5.0 - 4.5 = 0.5V$

R1 = 2.32 KΩ

R2 = 2.32 KΩ

R3 = 0 KΩ

Rt = 8.2 KΩ

Vr= 2.5 V

$$Rtrim-down = 2.32 \times (\frac{(2.5 \times 2.32)}{0.5 \times 2.32} - 1) - 8.2 = 1.08\ (K\Omega)$$

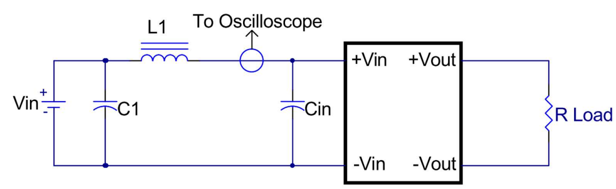
The typical value of R_{trim_down}

Trim down %	3.3V	5V	12V	15V
	R_{trim_down} (KΩ)			
1%	144.884	105.480	372.589	416.076
2%	66.522	47.480	171.894	190.508
3%	40.401	28.147	104.996	115.319
4%	27.341	18.480	71.547	77.724
5%	19.505	12.680	51.478	55.167
6%	14.281	8.813	38.098	40.129
7%	10.549	6.051	28.541	29.388
8%	7.751	3.980	21.374	21.332
9%	5.574	2.369	15.799	15.066
10%	3.832	1.080	11.339	10.054

7. Input / Output Considerations

7.1 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 as below represents typical measurement methods for reflected ripple current. C1 and L1 simulate a typical DC source impedance. The input reflected-ripple current is measured by current probe to oscilloscope with a simulated source Inductance (L1).



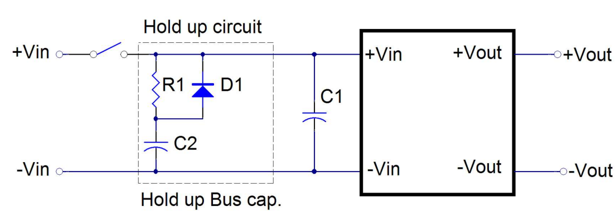
L1: 12uH

C1: None

Cin: 33uF ESR<0.7ohm @100KHz

7.2 Hold Up Time

Hold up time is defined as the duration of time that the DC/DC converter output will remain active following a loss of input power. To meet power supply interruptions, an external circuit is required, shown below.



D1:200V/10A

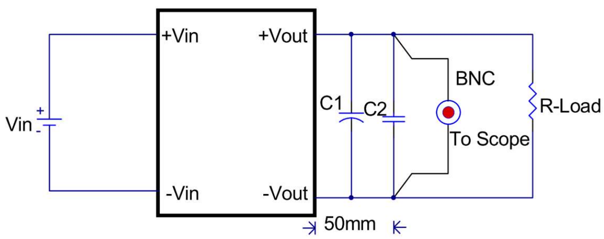
R1:100Ω/10W

C1: None

C2 (Hold up Bus cap.): See below table

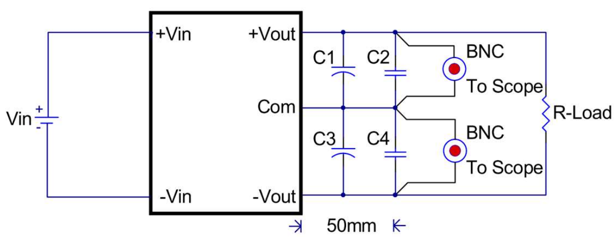
Input Voltage	72Vdc	96Vdc	110Vdc
Hold up time for 10ms	270uF	150uF	120uF
Hold up time for 30ms	820uF	470uF	390uF

7.3 Output Ripple and Noise



Note:
C1: None
C2: 1uF ceramic capacitor

ECLB40W-110 single output module

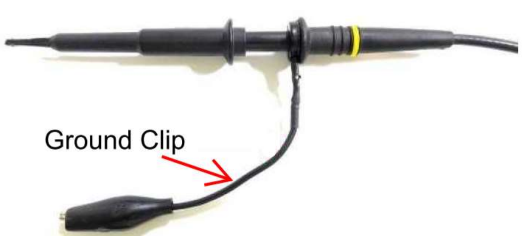


Note:
C1 & C3: None
C2 & C4: 1uF ceramic capacitor

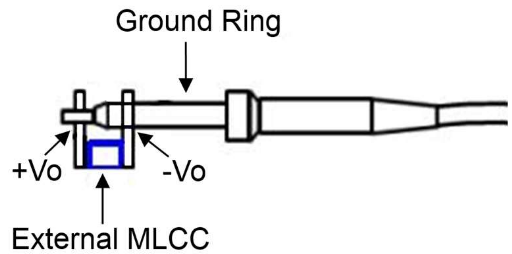
ECLB40W-110 dual output module

Output ripple and noise measured with 1uF ceramic capacitor across output, A 20 MHz bandwidth oscilloscope is normally used for the measurement.

The conventional ground clip on an oscilloscope probe should never be used in this kind of measurement. This clip, when placed in a field of radiated high frequency energy, acts as an antenna or inductive pickup loop, creating an extraneous voltage that is not part of the output noise of the converter.



Another method is shown in below, in case of coaxial-cable/BNC is not available. The noise pickup is eliminated by pressing scope probe ground ring directly against the -Vout terminal while the tip contacts the +Vout terminal. This makes the shortest possible connection across the output terminals.



7.4 Output Capacitance

The ECLB40W-110 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 (<100mm). PCB design emphasizes low resistance and inductance tracks in consideration of high current applications. Output capacitors with their associated ESR values have an impact on loop stability and bandwidth. Cincon's converters are designed to work with load capacitance to see technical specifications.

8. Thermal Design

8.1 Operating Temperature Range

The ECLB40W-110 series converters can be operated within a wide case temperature range of -40℃ to 105℃. Consideration must be given to the derating curves when ascertaining maximum power that can be drawn from the converter. The maximum power drawn from models is influenced by usual factors, such as:

- Input voltage range
- Output load current
- Forced air or natural convection
- Heat sink optional

8.2 Convection Requirements for Cooling

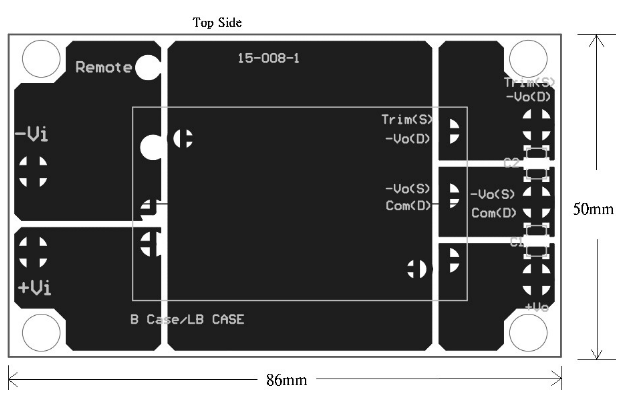
To predict the approximate cooling needed for the 2”×1” module, refer to the power derating curves in **section 8.4**. These derating curves are approximations of the ambient temperatures and airflows required to keep the power module temperature below its maximum rating. Once the module is assembled in the actual system, the module’s temperature should be monitored to ensure it does not exceed 105℃ as measured at the center of the top of the case (thus verifying proper cooling).

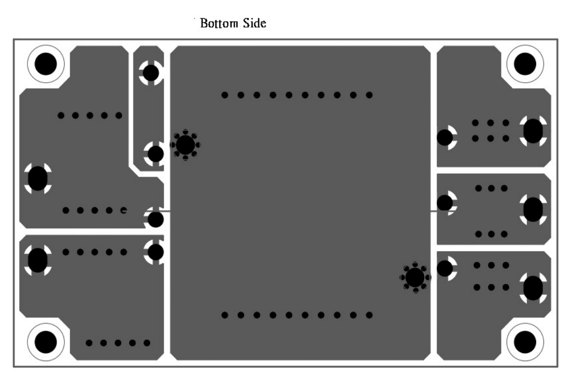
8.3 Thermal Considerations

The power module operates in a variety of thermal environments; however, sufficient cooling should be provided to help ensure reliable operation of the unit. Heat is removed by conduction, convection, and radiation to the surrounding environment. The example is presented in **section 8.4**. The power output of the module should not be allowed to exceed rated power (V_{o_set} x $I_{o\_max.}$).

8.4 Power Derating

The operating case temperature range of ECLB40W-110 series is -40℃ to +105℃. When operating the ECLB40W-110 series, proper derating or cooling is needed. The maximum case temperature under any operating condition should not exceed 105℃ (refer to datasheet).
The following de-rating curve of ECLB40W-110S12 with heat sink and recommended PCB Layout with de-rating. (86x50x1.6mm, 2Oz.)





Example (without heatsink):

The ECLB40W-110S12 operating at nominal line voltage, an output current of 3.333A, and a maximum ambient temperature of 45℃.

Solution:

Given: V_{in}=110V_{dc}, V_o=12V_{dc}, I_o=3.333A

Determine Power dissipation (P_d):

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

P_d=12×3.333×(1-0.9)/0.9=4.44Watts

Determine airflow:

Airflow: Natural Convection

Check above Power de-rating curve:

Given: P_d=4.44W and T_a=45℃

Verifying:

The maximum temperature rise △T=Pd × R_{ca}=4.44×11.25=49.95℃

The maximum case temperature $T_c=T_a$+△T=94.95℃ <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

Example (with heatsink M-C655):

The ECLB40W-110D24 with thermal pad SZ 29.5x49.8x0.25mm and heat sink MC-655 operating at nominal line voltage, an output current of 0.833A, and a maximum ambient temperature of 60℃.

Solution:

Given: V_{in}=4V_{dc}, V_o=5V_{dc}, I_o=12A

Determine Power dissipation (P_d):

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

P_d=48×0.833×(1-0.89)/0.89=4.94Watts

Determine airflow:

Airflow: Natural Convection

Check above Power de-rating curve:

Given: P_d=4.94W and T_a=60℃

Verifying:

The maximum temperature rise △T=P_d × R_{ca}=4.94×8.99=44.41℃

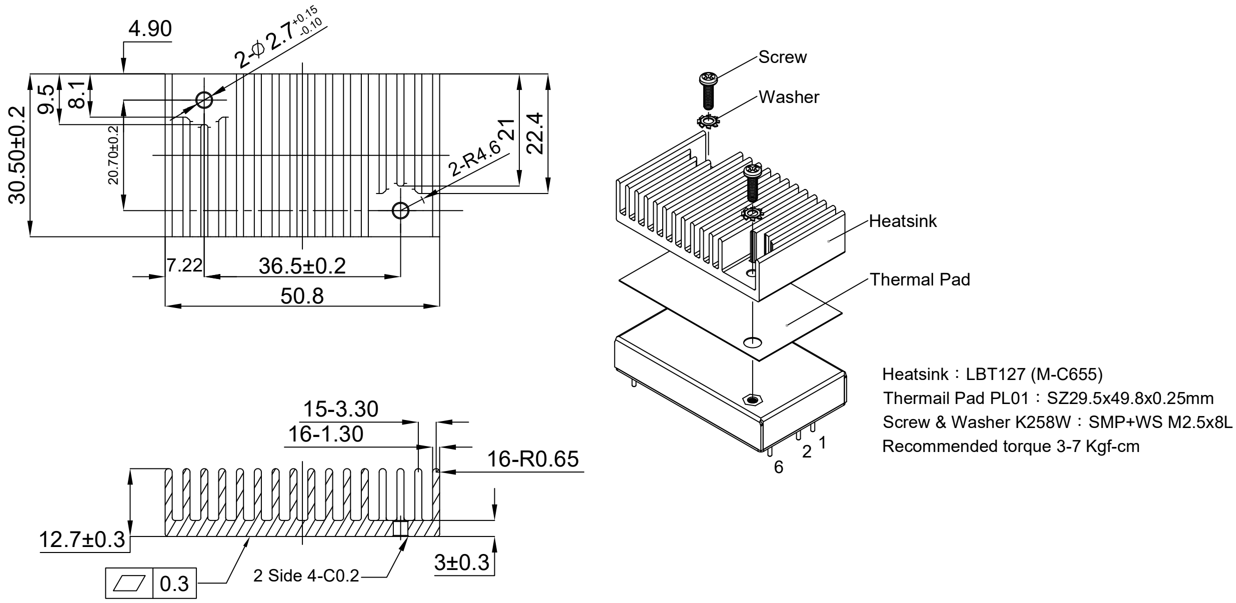
The maximum case temperature $T_c=T_a$+△T=104.41℃ <105℃

Where:

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

The T_a is ambient temperature and the T_c is case temperature

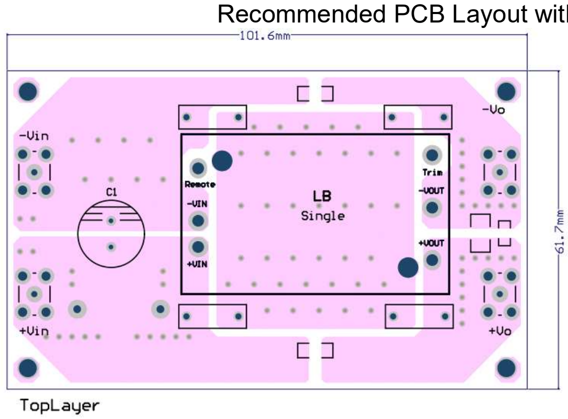
8.5 LB Heat Sinks:

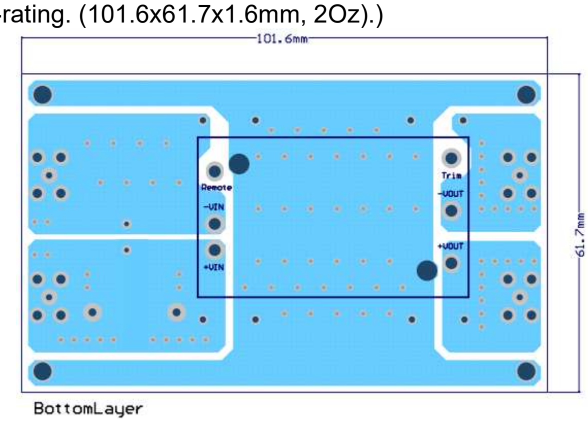


M-C655 (G6620790202)
Transverse Heat Sink
All Dimensions in mm
Thermal Pad: SZ29.5x49.8x0.25mm (G6135041753)
Screw: M2.5x8mm (G75A3300922)
Washer: (G75A5750052)

Rca: 8.99°C/W (typ.), At natural convection
Rca: 8.36°C/W (typ.), At natural convection, mounted 101.6x61.7x1.6mm 2Oz test board.

Recommended PCB Layout with de-rating. (101.6x61.7x1.6mm, 2Oz).)

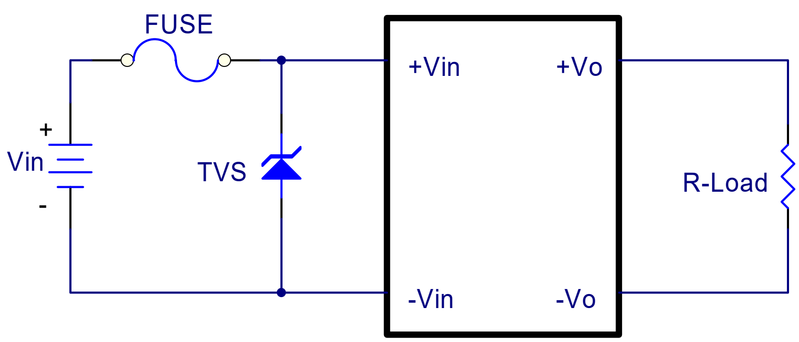




9. Safety & EMC

9.1 Input Fusing and Safety Considerations

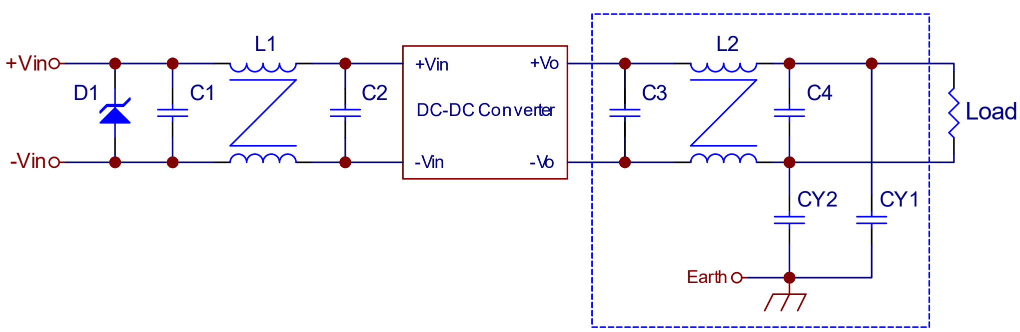
The ECLB40W-110 series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a time delay fuse 2A for all models. It is recommended that the circuit have a transient voltage suppressor diode (TVS) across the input terminal to protect the unit against surge or spike voltage and input reverse voltage (as shown).



The external input TVS is required if ECLB40W-110 series has to meet EN61000-4-4, EN61000-4-5.
The ECLB40W-110 series recommended a TVS (1.5KE180A Littelfuse) to connect parallel.

9.2 EMC Considerations

(1) EMI Test standard: EN 50121-3-2 Conducted, EN 55032 Class A Radiated Emission
Test Condition: Input Voltage: Nominal, Output Load: Full Load



Model No.	D1	C1,C2	C3,C4	CY1,CY2	L1	L2
ECLB40W-110S33	P6KE180A Littelfuse	47uF/200V Aluminum KXJ Series Capacitors	1uF/250V MLCC	4.7uF/100V MLCC	2.25mH	0.145mH
ECLB40W-110S05						
ECLB40W-110S12						
ECLB40W-110S15						
ECLB40W-110D12						
ECLB40W-110D15						
ECLB40W-110D24						

Note:

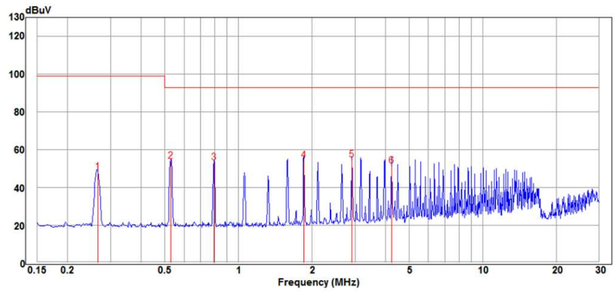
L1: Winding:0.55mm*2/ 15Turns, Core: P/N: T60006-L2012-W498, VACUUMSCHMELZE or equivalent

L2: Winding: 0.8mm*2/ 5Turns, Core: P/N: T18*12*6C, VAKOS or equivalent

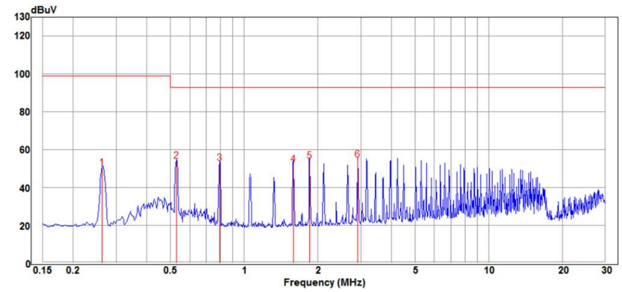
Input Conducted Emission (EN 50121-3-2):

ECLB40W-110S33

Line

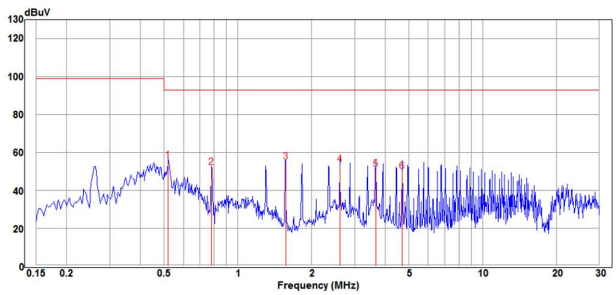


Neutral

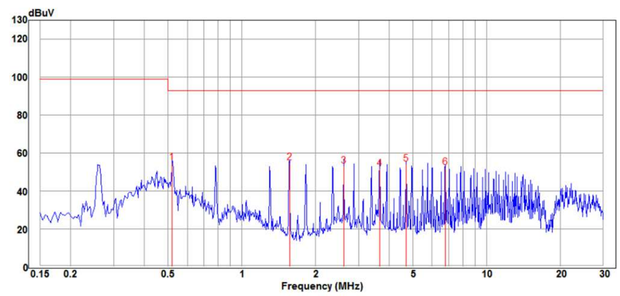


ECLB40W-110S05

Line

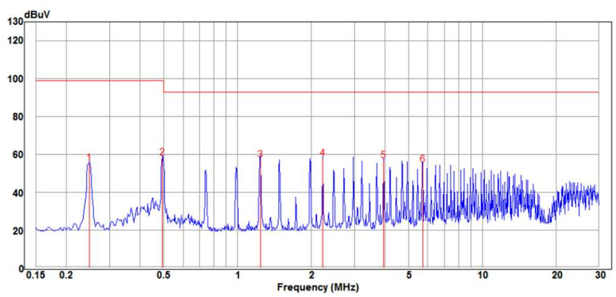


Neutral

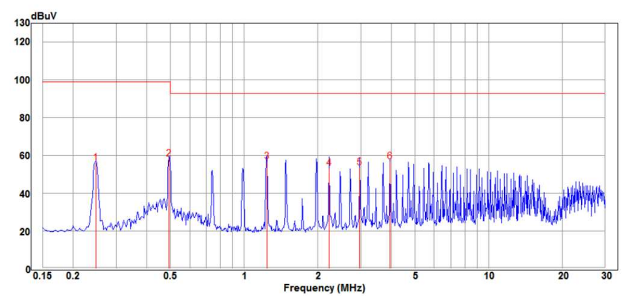


ECLB40W-110S12

Line

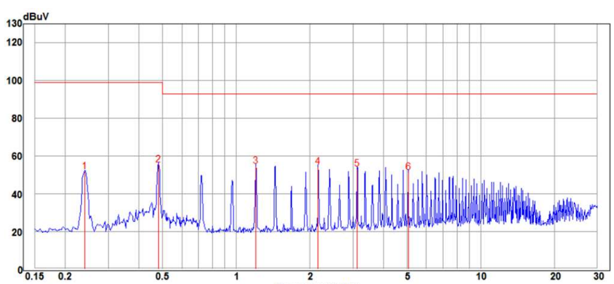


Neutral

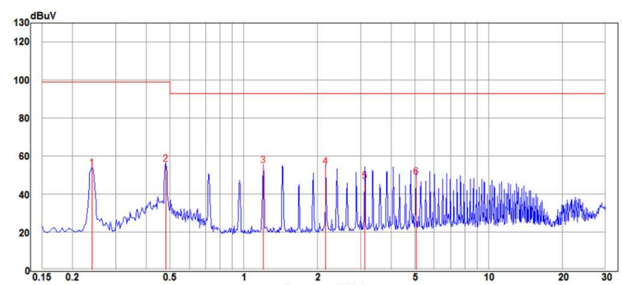


ECLB40W-110S15

Line

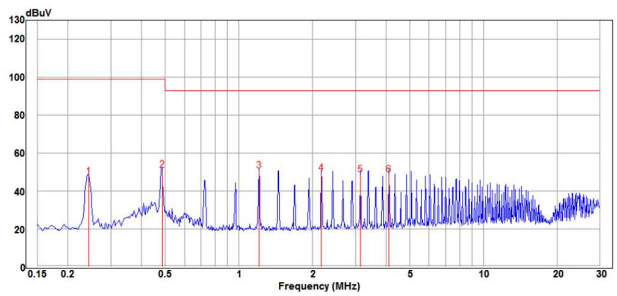


Neutral

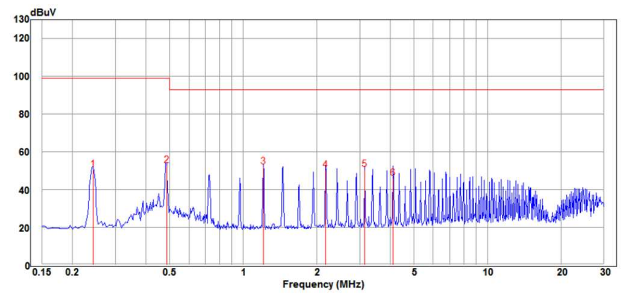


ECLB40W-110D12

Line

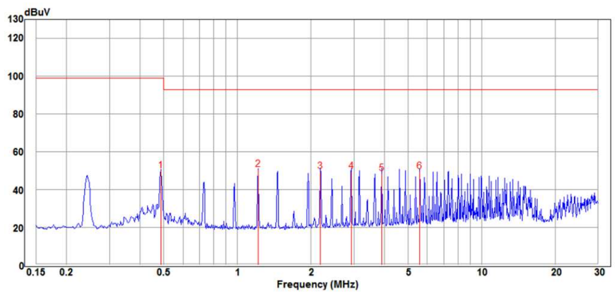


Neutral

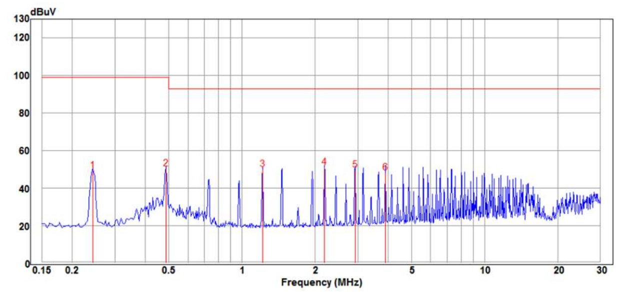


ECLB40W-110D15

Line

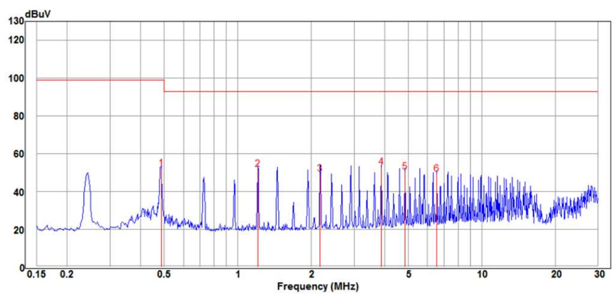


Neutral

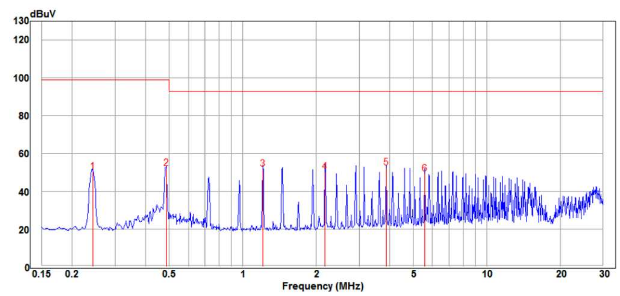


ECLB40W-110D24

Line



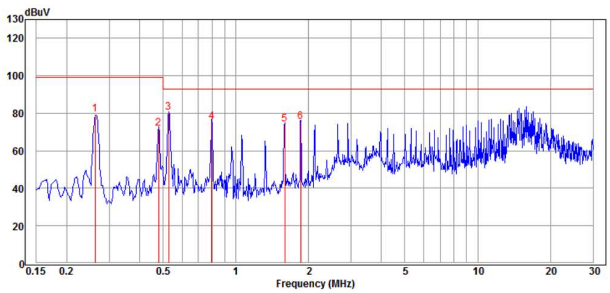
Neutral



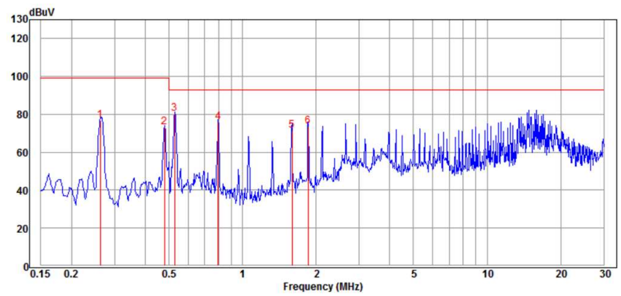
Output Conducted Emission (EN 50121-3-2):

ECLB40W-110S33

Positive

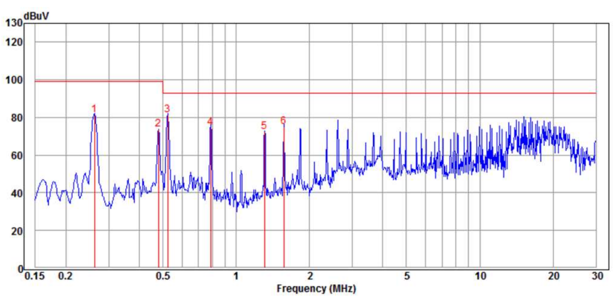


Negative

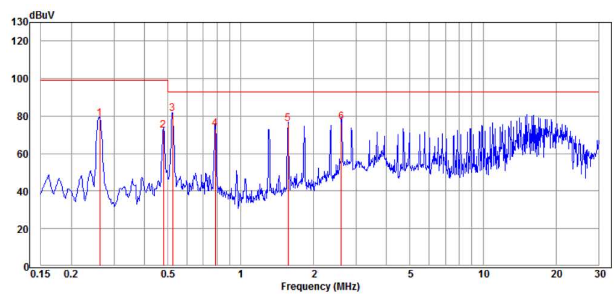


ECLB40W-110S05

Positive

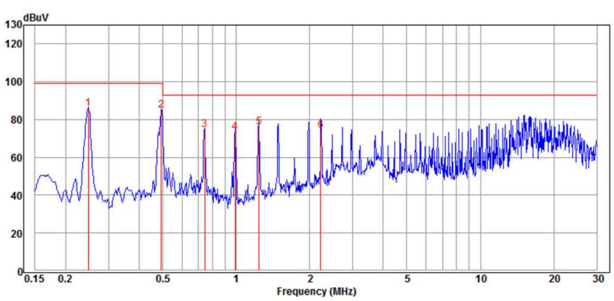


Negative

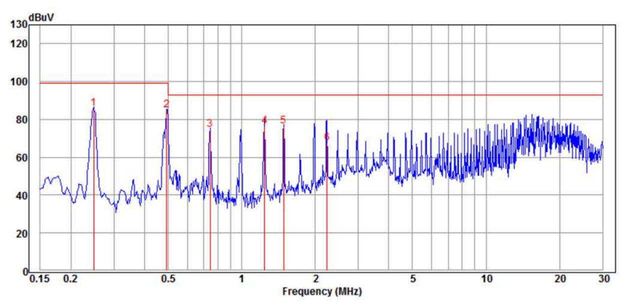


ECLB40W-110S12

Positive

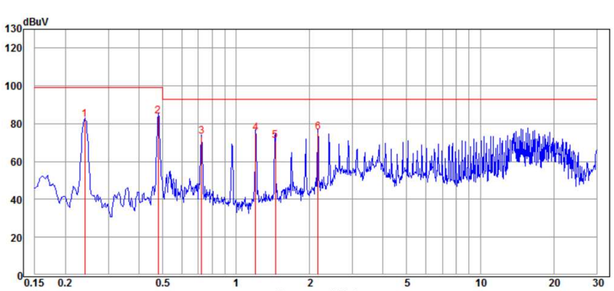


Negative

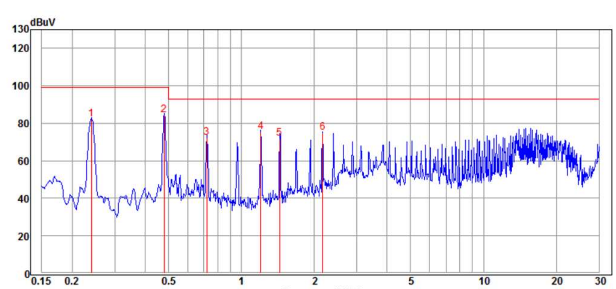


ECLB40W-110S15

Positive

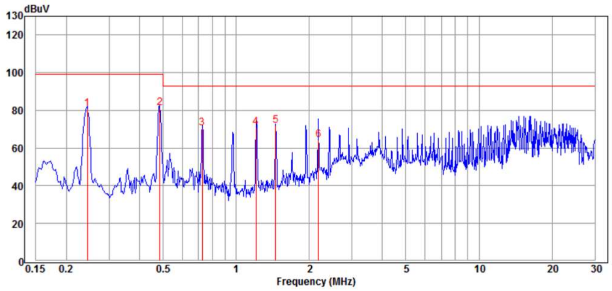


Negative

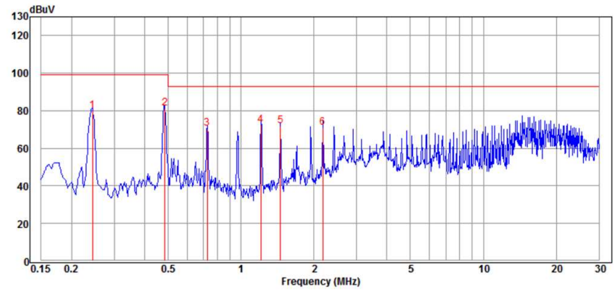


ECLB40W-110D12

Positive

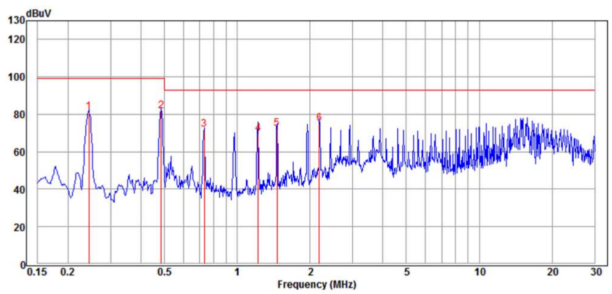


Negative

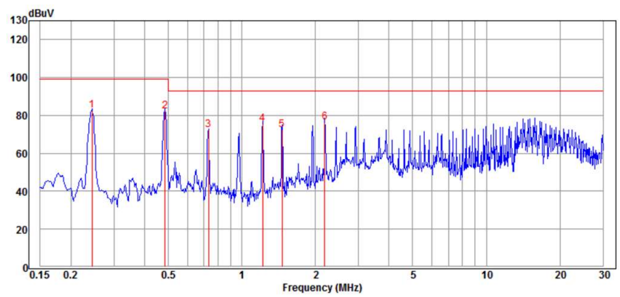


ECLB40W-110D15

Positive

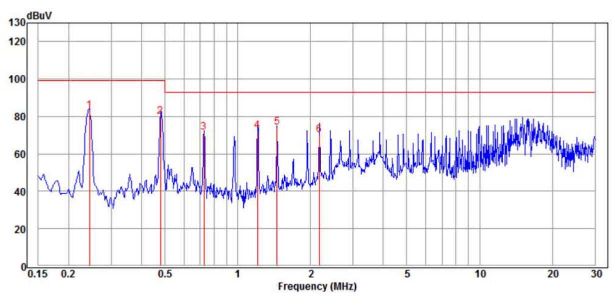


Negative

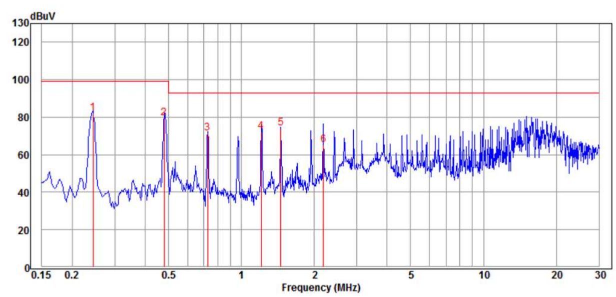


ECLB40W-110D24

Positive



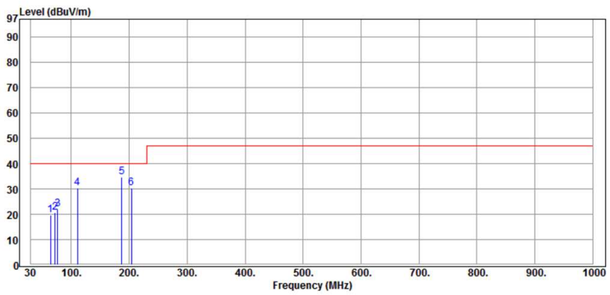
Negative



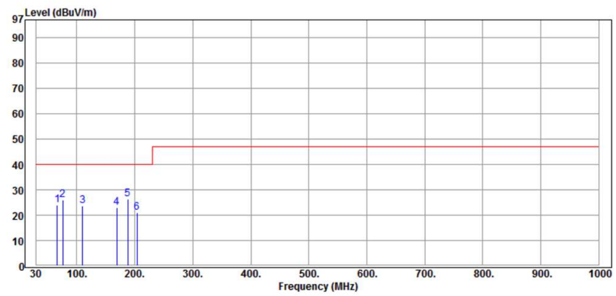
Radiated Emission (EN 50121-3-2):

ECLB40W-110S33

Horizontal

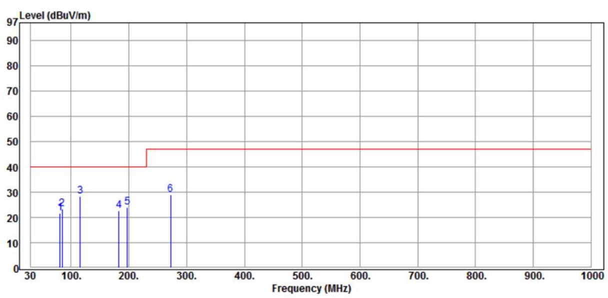


Vertical

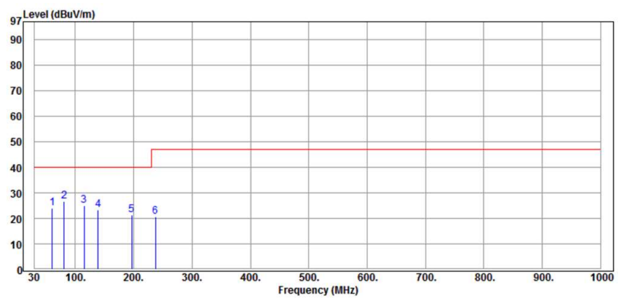


ECLB40W-110S05

Horizontal

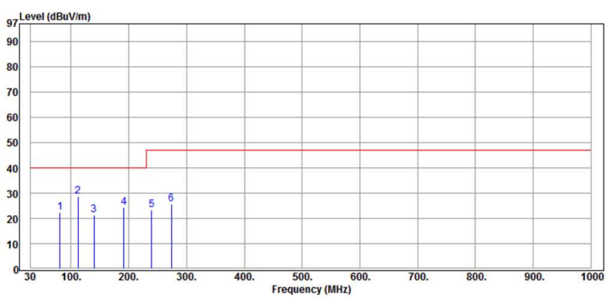


Vertical

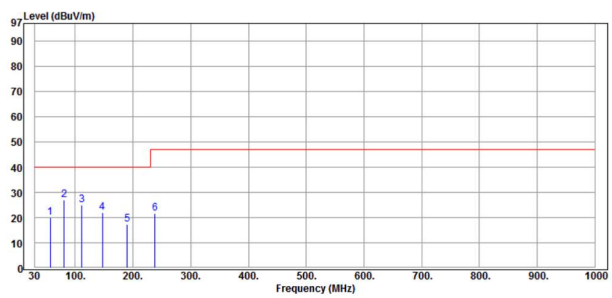


ECLB40W-110S12

Horizontal

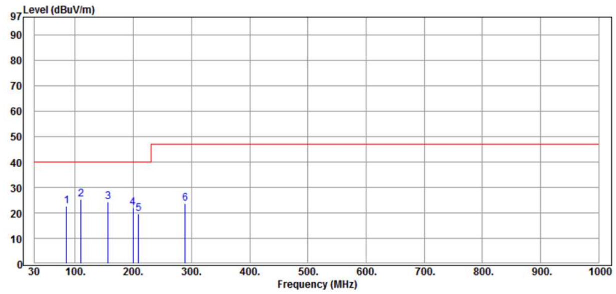


Vertical

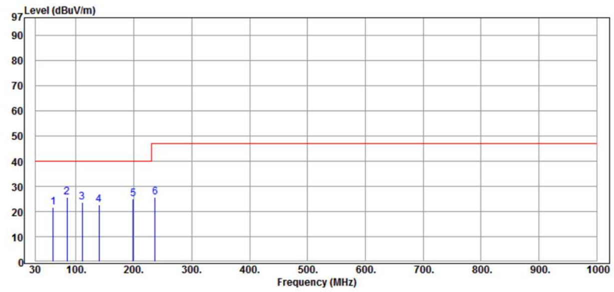


ECLB40W-110S15

Horizontal

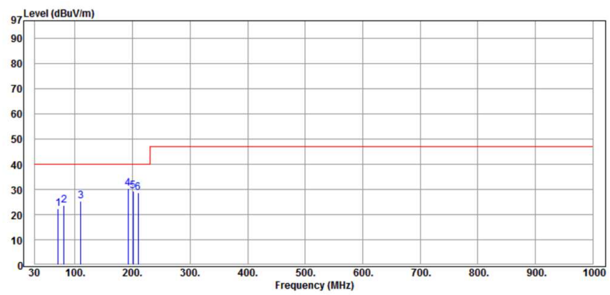


Vertical

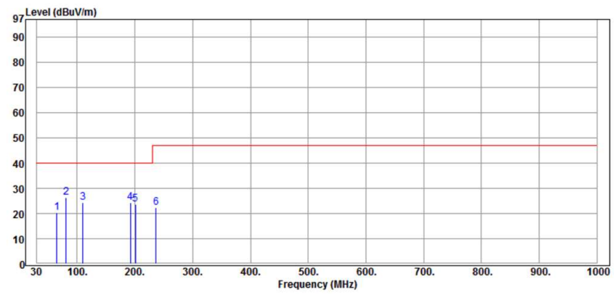


ECLB40W-110D12

Horizontal

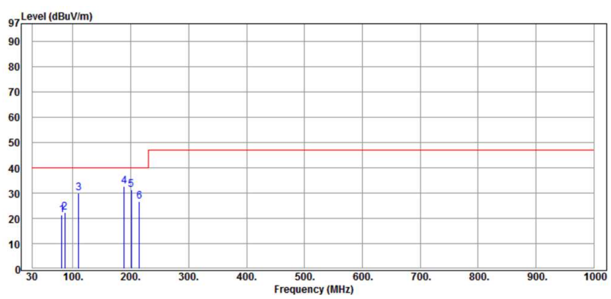


Vertical

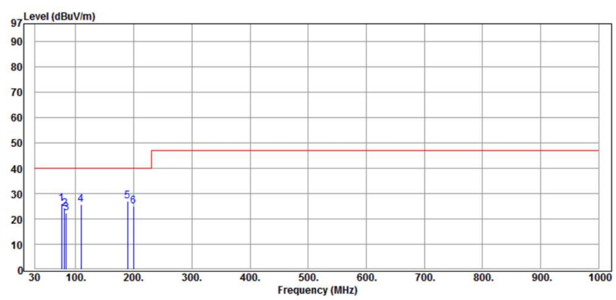


ECLB40W-110D15

Horizontal

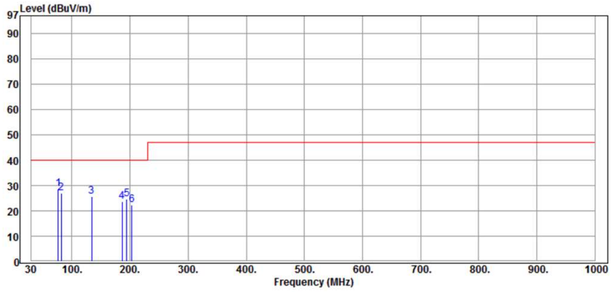


Vertical

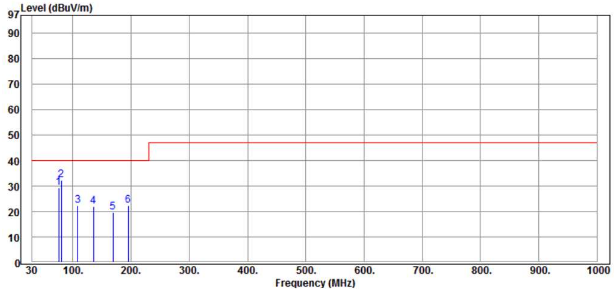


ECLB40W-110D24

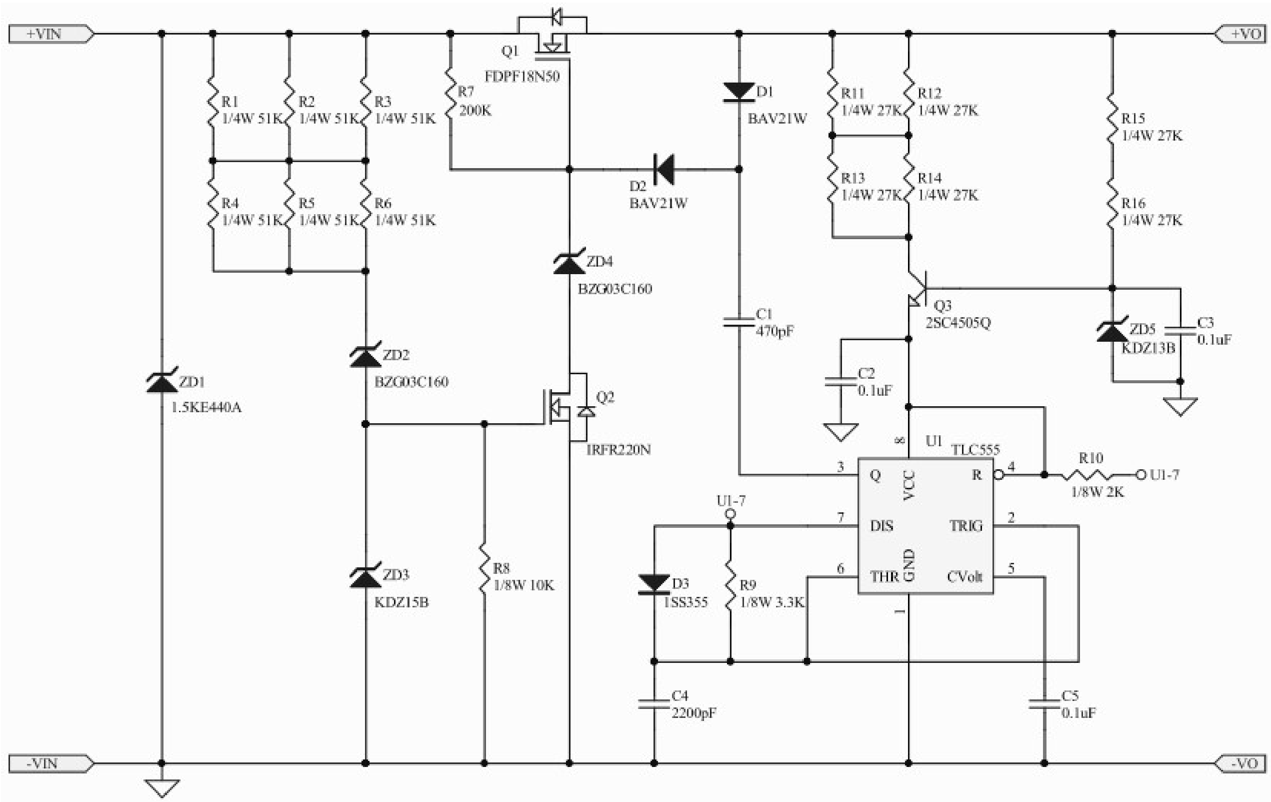
Horizontal



Vertical



9.3 Suggested Configuration for RIA12 Surge Test



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