ISOLATED DC-DC CONVERTER
CFB600W-110S SERIES
APPLICATION NOTE

Approved By:

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Contents

1. Introduction

The CFB600W-110S series of DC-DC converters offers 600 watts of output power @ single output voltages of 12, 24, 28, 48VDC with standard full-brick. It has a wide (4:1) input voltage range of 43 to 160VDC (110VDC nominal) and 2250VDC isolation.

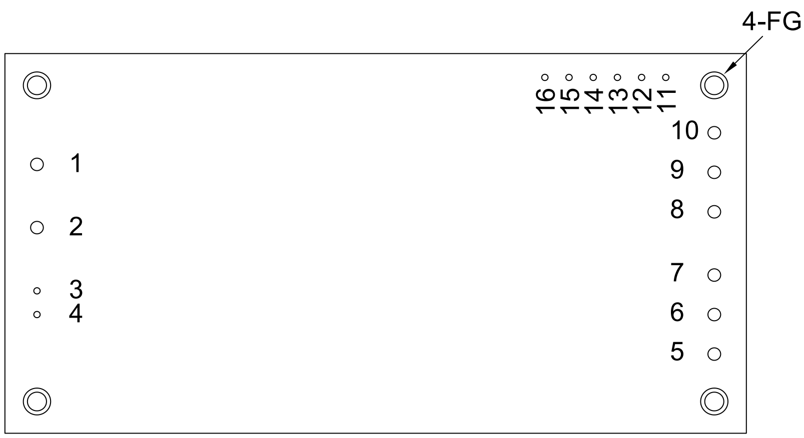
Compliant with EN 50155, EN 45545, EN 50121-3-2. High efficiency up to 88%, allowing case operating temperature range of -40℃ to 100℃. An optional heat sink is available to extend the full power range of the unit.

The standard control functions include remote **on/off** (positive or negative) and +10%, -40% adjustable output voltage.

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

CFB600W-110S 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



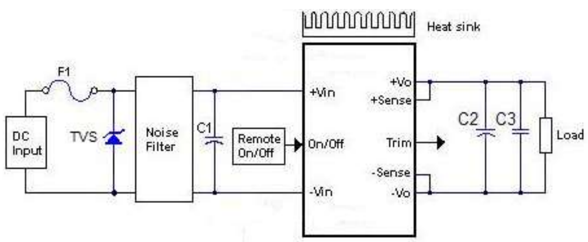
No	Label	Function	Description	Reference
1	-Vin	-V Input	Negative Supply Input	**Section 7.1**
2	+Vin	+V Input	Positive Supply Input	**Section 7.1**
3	-ON/OFF	On/Off	External Remote On/Off Control	**Section 6.5**
4	+ON/OFF	On/Off	External Remote On/Off Control	**Section 6.5**
5~7	+Vo	+V Output	Positive Power Output	**Section 7.2/7.3**
8~10	-Vo	-V Output	Negative Power Output	**Section 7.2/7.3**
11	-S	-Sense	Negative Output Remote Sense	**Section 6.6**
12	+S	+Sense	Positive Output Remote Sense	**Section 6.6**
13	Trim	Trim	External Output Voltage Adjustment	**Section 6.7**
14	PC	Parallel Control	Parallel Operation Control	**Section 8.2**
15	IOG	IOG	Inverter Operation Good Signal	**Section 6.8**
16	AUX	Auxiliary Power	Auxiliary Power for Output Signal	**Section 6.9**
17	--	Mounting Insert	Mounting Insert (FG)	**Section 9.5/10.2**

Note: Base plate can be connected to FG through M3 threated mounting insert. Recommended torque 5Kgf-cm.

3. Connection for Standard Use

The connection for standard use is shown below. An external input capacitor (C1) 220uF for all models is recommended to reduce input ripple voltage. External output capacitors (C2, C3) are recommended to reduce output ripple and noise, 10uF tantalum and 1uF ceramic capacitor.

The CFB600W-110S series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a 20A fast acting fuse 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).



Symbol	Component	Reference
F1	Input fuse	**Section 10.1**
C1	External capacitor on input side	**Section 7.1**
C2, C3	External capacitor on the output side	**Section 7.2/7.3**
Noise Filter	External input noise filter	**Section 10.2**
Remote On/Off	External remote **on/off** control	**Section 6.5**
Trim	External output voltage adjustment	**Section 6.7**
Heat Sink	External heat sink	**Section 9.2/9.3/9.4/9.5**
+Sense/-Sense	--	**Section 6.6**

Note:
If the impedance of input line is high, C1 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20℃.

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:

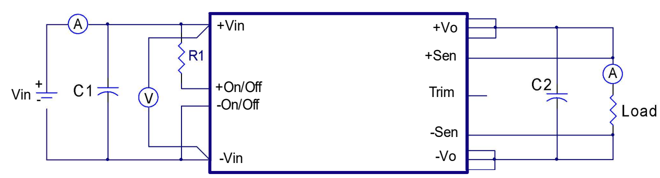
V_{FL} is the output voltage at full load
V_{NL} is the output voltage at no load

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



CFB600W-110S Series Test Setup

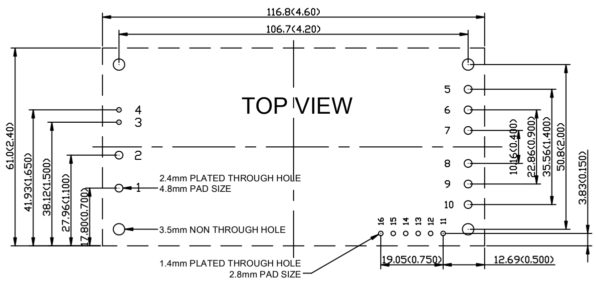
C1: 220uF/200V ESR<0.14Ω
C2: 470uF/100V ESR<0.14Ω

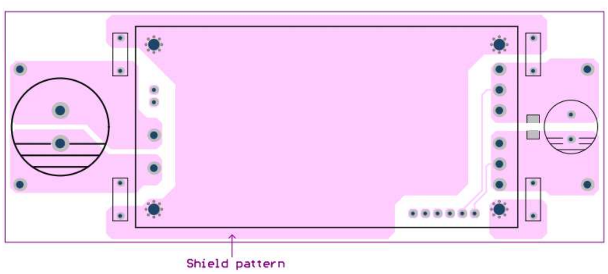
For CFB600W-110S series it's necessary to connect the input electrolytic capacitor C1 with low ESR to prevent the effective of input line inductance to the DC/DC converter.

For stable operation, connect a low impedance electrolytic capacitor C2 in the output terminals. When operated at lower temperature than -20℃, increasing the C2 capacitance with three or four times more than the recommended value.

5. Recommend Layout, PCB Footprint and Soldering Information

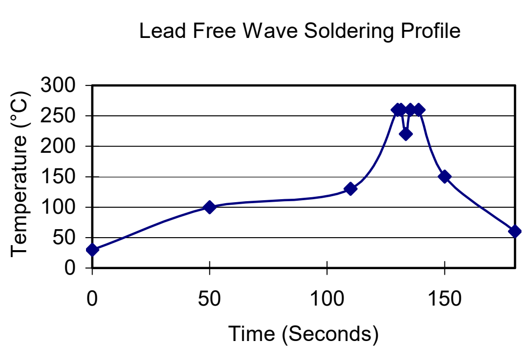
The system designer or end user must ensure that metal and other components in the vicinity of the converter meet the spacing requirements for which the system is approved. Low resistance and inductance PCB layout traces are the norm and should be used where possible. Due consideration must also be given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





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 change 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 450℃ for up to 5seconds (less than 90W). Furthermore the recommended soldering profile and PCB layout are shown below.



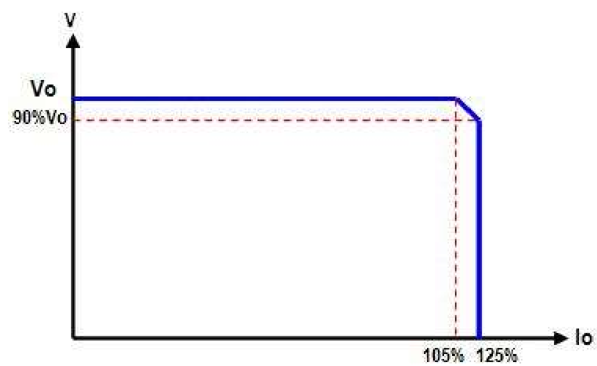
6. Features and Functions

6.1 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the CFB600W-110S 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

The converter is protected against over current or short circuit conditions. At the instance of current-limit inception, the module enters a constant current mode of operation. While the fault condition exists, the module will remain in this constant current mode, and can remain in this mode until the fault is cleared. The unit operates normally once the output current is reduced back into its specified range.



6.3 Output Over Voltage Protection

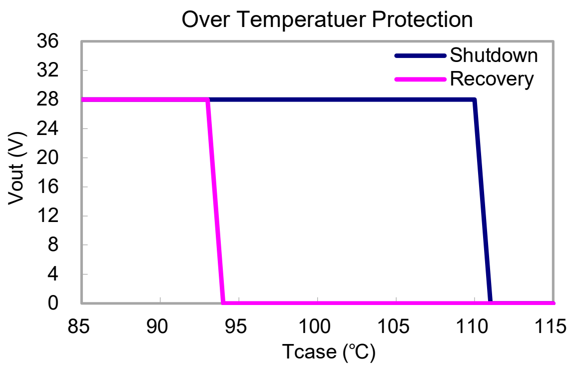
The output over voltage protection consists of circuitry that internally limits the output voltage. If more accurate output over voltage protection is required then an external circuit can be used via the remote on/off pin.

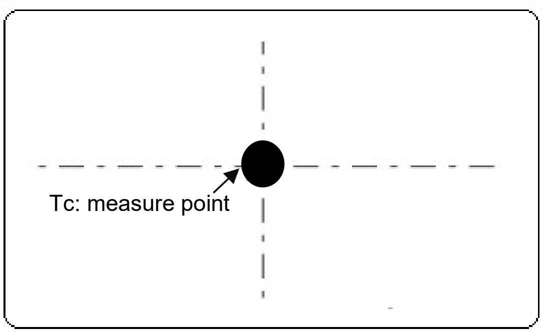
Note:

Please note that device inside the power supply might fail when voltage more than rate output voltage is applied to output pin. This could happen when the customer tests the over voltage protection of unit.

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. Please measure case temperature of the center part of aluminum baseplate.





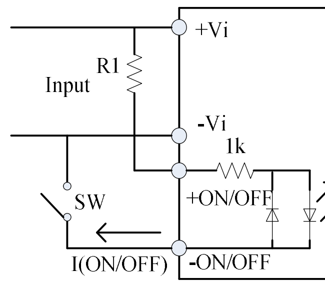
6.5 Remote On/Off

The **on/off** input pins permit the user to turn the power module on or off via a system signal from the primary side or the secondary side. Two remote **on/off** options are available. Negative logic turns the module on as long as a current (1-10mA) is flowing between **+on/off** and **–on/off** and inactive when no current is flowing. Positive logic turns the module off as long as a current (1-10mA) is flowing between **+on/off** and **–on/off** and active when no current is flowing.

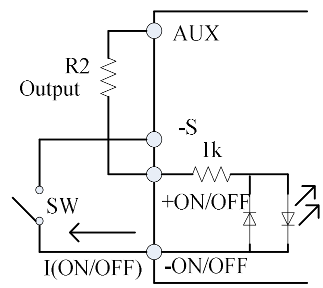
The converter's **on/off** can be controlled from the input side or the output side.

Output voltage turns on when current is made to through **on/off** terminals which can be reached by opening or closing the switches. The maximum current through the **on/off** pin is 10mA, setting the resistor value to avoid the maximum current through the **on/off** pins.

(A) Controlling the **on/off** terminal from the input side, recommend R1 value is 42K (0.5W) for 110Vin.



(B) Controlling the **on/off** terminal from the output side, Recommend R2 value is 5.1k (0.1W).

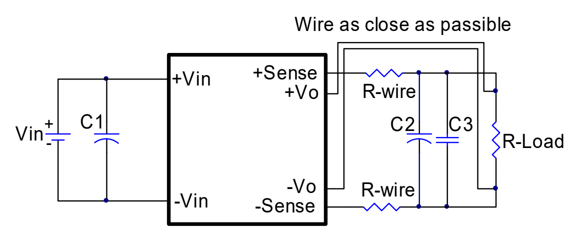


6.6 Output Remote Sensing

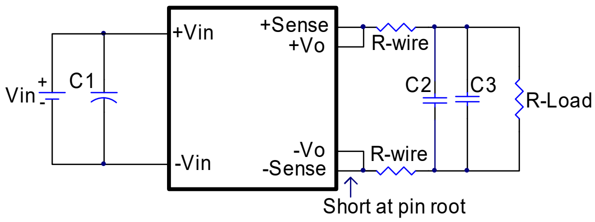
The CFB600W-110S series converter has the capability to remotely sense both lines of its output. This feature moves the effective output voltage regulation point from the output of the unit to the point of connection of the remote sense pins. This feature automatically adjusts the real output voltage of the CFB600W-110S series in order to compensate for voltage drops in distribution and maintain a regulated voltage at the point of load. The remote-sense voltage range is:

$[(+V_{out}) - (-V_{out})] - [(+Sense) - (-Sense)] \leqq 10\%$ of $V_{o\_nominal}$

When remote sense is in use, the sense should be connected by twisted-pair wire or shield wire. If the sensing patterns short, heave current flows and the pattern may be damaged. Output voltage might become unstable because of impedance of wiring and load condition when length of wire is exceeding 400mm. This is shown in the schematic below. This is shown in the schematic below.



If the remote sense feature is not to be used, the sense pins should be connected locally. The +Sense pin should be connected to the $+V_{out}$ pin at the module and the -Sense pin should be connected to the $-V_{out}$ pin at the module. Wire between +Sense and $+V_{out}$ and between -Sense and $-V_{out}$ as short as possible. Loop wiring should be avoided. The converter might become unstable by noise coming from poor wiring. This is shown in the schematic below.

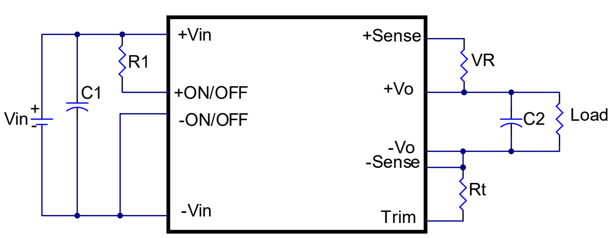


Note:

Although the output voltage can be varied (increased or decreased) by both remote sense and trim, the maximum variation for the output voltage is the larger of the two values not the sum of the values. The output power delivered by the module is defined as the voltage at the output terminals multiplied by the output current. Using remote sense and trim can cause the output voltage to increase and consequently increase the power output of the module if output current remains unchanged. Always ensure that the output power of the module remains at or below the maximum rated power. Also be aware that if $V_{o.set}$ is below nominal value, $P_{out.max.}$ will also decrease accordingly because $I_{o.max}$ is an absolute limit. Thus, $P_{out.max.} = V_{o.set} \times I_{o.max.}$ is also an absolute limit.

6.7 Output Voltage Adjustment

The Trim input permits the user to adjust the output voltage up or down according to the trim range specification (60% to 110% of nominal output). This is accomplished by connecting an external resistor between the +Vout and +Sense pin for trim up and between the TRIM and -Sense pin for trim down, see Figure.



Output voltage trim circuit configuration

The Trim pin should be left open if trimming is not being used. The output voltage can be determined by the following equations:

$$Vf = \frac{1.24 \times \left(\frac{Rt \times 33}{Rt + 33}\right)}{7.68 + \frac{Rt \times 33}{Rt + 33}}$$

$$Vout = (Vo + VR) \times Vf$$

Unit: KΩ

Vo: Nominal Output Voltage

Recommend Rt=6.8KΩ

For example, to trim-up the output voltage of 24V module (CFB600W-110S24) by 5% to 25.2V, to trim-down by 20% to 19.2V.

The value VR_{trim_up} is calculated as follows:
Rt=6.8KΩ, Vf=0.525V,

$$Vf = \frac{1.24 \times \left(\frac{6.8 \times 33}{6.8 + 33}\right)}{7.68 + \frac{6.8 \times 33}{6.8 + 33}} = 0.525$$

$$25.2 = (24 + VR) \times 0.525,$$

$$VR = 24K\Omega$$

The value of VR_{trim_down} defined as:

$$19.2 = (24 + VR) \times 0.525,$$

$$VR = 12.57K\Omega$$

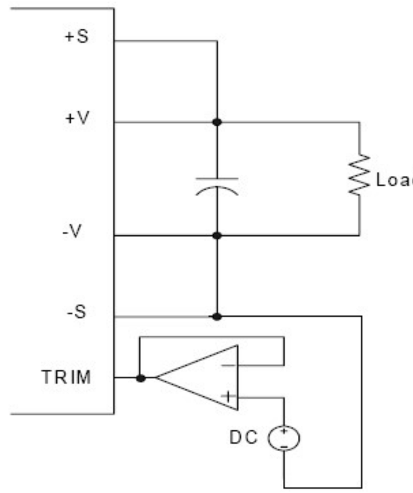
The typical value of VR_{trim_up}

Trim up %	12V	24V	28V	48V
	R_{trim_up} (KΩ)			
1%	11.086	22.171	25.867	44.343
2%	11.314	22.629	26.400	45.257
3%	11.543	23.086	26.933	46.171
4%	11.771	23.543	27.467	47.086
5%	12.000	24.000	28.000	48.000
6%	12.229	24.457	28.533	48.914
7%	12.457	24.914	29.067	49.829
8%	12.686	25.371	29.600	50.743
9%	12.914	25.829	30.133	51.657
10%	13.143	26.286	30.667	52.571

The typical value of VR_{trim_down}

Trim down %	12V	24V	28V	48V
	R_{trim_down} (KΩ)			
1%	10.629	21.257	24.800	42.514
2%	10.400	20.800	24.267	41.600
3%	10.171	20.343	23.733	40.686
4%	9.943	19.886	23.200	39.771
5%	9.714	19.429	22.667	38.857
6%	9.486	18.971	22.133	37.943
7%	9.257	18.514	21.600	37.029
8%	9.029	18.057	21.067	36.114
9%	8.800	17.600	20.533	35.200
10%	8.571	17.143	20.000	34.286
11%	8.343	16.686	19.467	33.371
12%	8.114	16.229	18.933	32.457
13%	7.886	15.771	18.400	31.543
14%	7.657	15.314	17.867	30.629
15%	7.429	14.857	17.333	29.714
16%	7.200	14.400	16.800	28.800
17%	6.971	13.943	16.267	27.886
18%	6.743	13.486	15.733	26.971
19%	6.514	13.029	15.200	26.057
20%	6.286	12.571	14.667	25.143
21%	6.057	12.114	14.133	24.229
22%	5.829	11.657	13.600	23.314
23%	5.600	11.200	13.067	22.400
24%	5.371	10.743	12.533	21.486
25%	5.143	10.286	12.000	20.571
26%	4.914	9.829	11.467	19.657
27%	4.686	9.371	10.933	18.743
28%	4.457	8.914	10.400	17.829
29%	4.229	8.457	9.867	16.914
30%	4.000	8.000	9.333	16.000
31%	3.771	7.543	8.800	15.086
32%	3.543	7.086	8.267	14.171
33%	3.314	6.629	7.733	13.257
34%	3.086	6.171	7.200	12.343
35%	2.857	5.714	6.667	11.429
36%	2.629	5.257	6.133	10.514
37%	2.400	4.800	5.600	9.600
38%	2.171	4.343	5.067	8.686
39%	1.943	3.886	4.533	7.771
40%	1.714	3.429	4.000	6.857

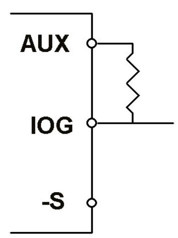
The output voltage can also be adjustment by using external DC voltage.



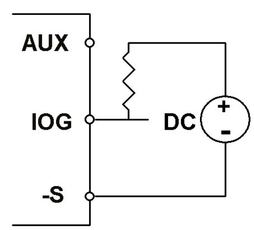
Output Voltage = TRIM Terminal Voltage * Nominal Output Voltage

6.8 IOG Signal

Normal and abnormal operation of the converter can be monitored by using the I.O.G signal. Output of this signal monitor is located at the secondary side and is open collector output, you can use the signal by the internal aux power supply or the external DC supply as the following figures. the ground reference is the -sense.



By internal AUX



By external DC supply

This signal is low when the converter is normally operating and high when the converter is disabled or when the converter is abnormally operating.

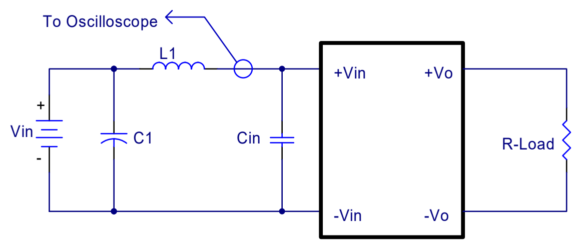
6.9 Auxiliary Power for Output Signal

The auxiliary power supply output is within 7-13V with maximum current of 20 mA. Ground reference is the -sense pin.

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).

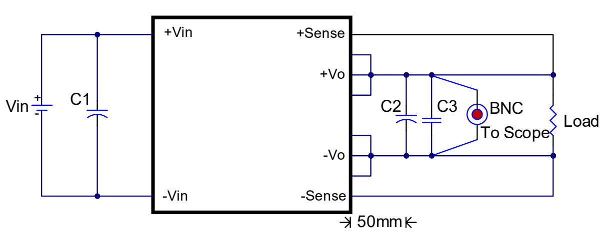


L1: 12uH

C1: 220uF ESR<0.14ohm @100KHz

Cin: 220uF ESR<0.14hm @100KHz

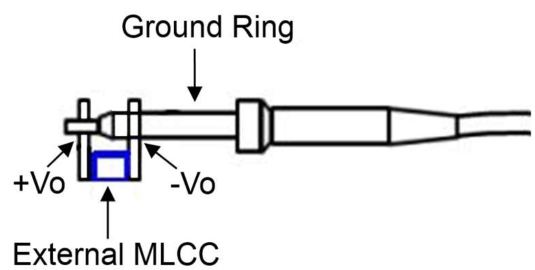
7.2 Output Ripple and Noise



Output ripple and noise is measured with 1.0uF ceramic and 10uF solid tantalum capacitor($48V_o$:10uF aluminum capacitor) across the 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 $-V_{out}$ terminal while the tip contacts the $+V_{out}$ terminal. This makes the shortest possible connection across the output terminals.



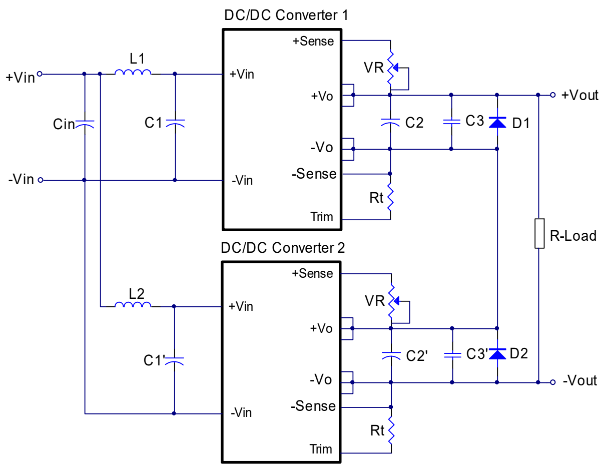
7.3 Output Capacitance

The CFB600W-110S 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. Series and Parallel Operation

8.1 Series Operation

Series operation is possible by connecting the outputs two or more units. Connection is shown in below. The output current in series connection should be lower than the lowest rate current in each power module.



Simple Series Operation Connect Circuit

L1, L2: 1.0uH

Cin, C1, C1’: 220uF/200V ESR<0.14Ω

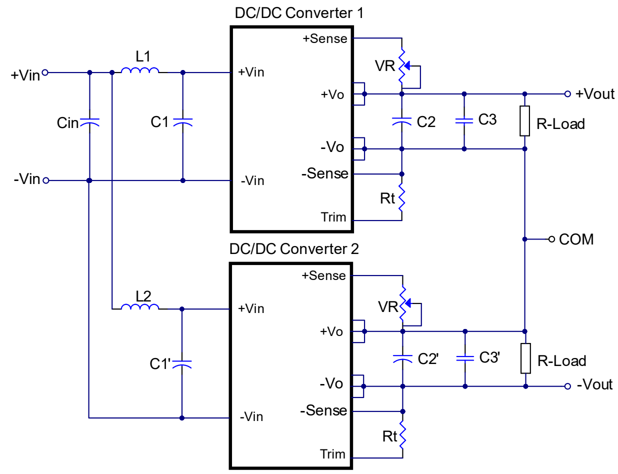
C2, C2’: 470uF

C3, C3’: 1uF MLCC

Note:

1. If the impedance of input line is high, Cin, C1 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20℃.
2. Recommend Schottky diode (D1, D2) be connected across the output of each series connected converter, so that if one converter shuts down for any reason, then the output stage won’t be thermally overstressed. Without this external diode, the output stage of the shut-down converter could carry the load current provided by the other series converters, with its MOSFETs conducting through the body diodes. The MOSFETs could then be overstressed and fail. The external diode should be capable of handling the full load current for as long as the application is expected to run with any unit shut down.

Series for ±output operation is possible by connecting the outputs two units, as shown in the schematic below.



Simple ±Output Operation Connect Circuit

L1, L2: 1.0uH

Cin, C1, C1’: 220uF/200V ESR<0.14Ω

C2, C2’: 470uF

C3, C3’: 1uF MLCC

Note:

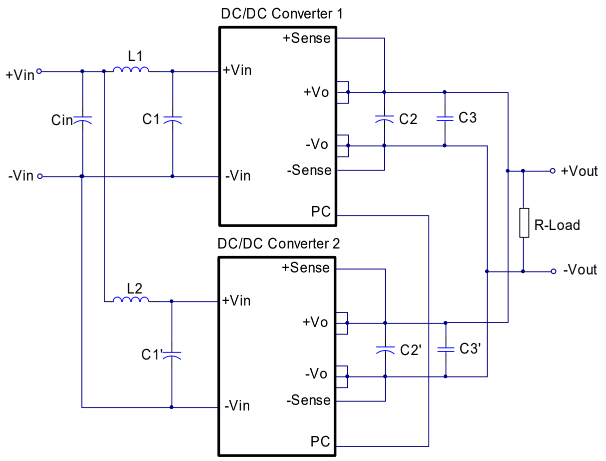
If the impedance of input line is high, Cin, C1 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20℃.

8.2 Parallel/Redundant Operation

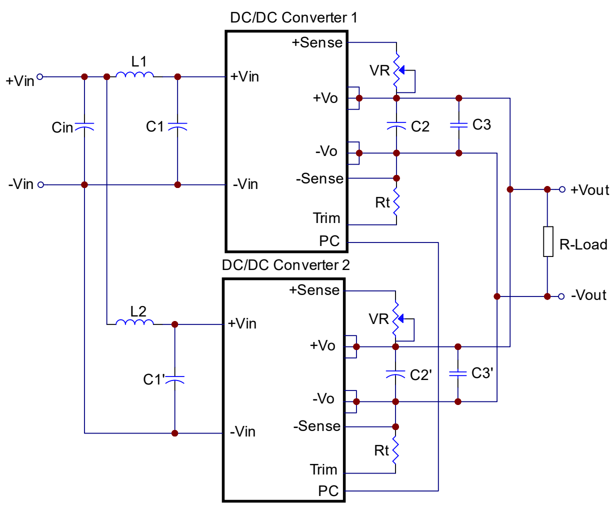
The CFB600W-110S series are also designed for parallel operation. When paralleled, the load current can be equally shared between the modules by connecting the PC pins together.

There are two different parallel operations for CFB600W-110S series, one is parallel operation when load can’t be supplied by only one power unit; the other is the N+1 redundant operation which is high reliable for load of N units by using N+1 units.

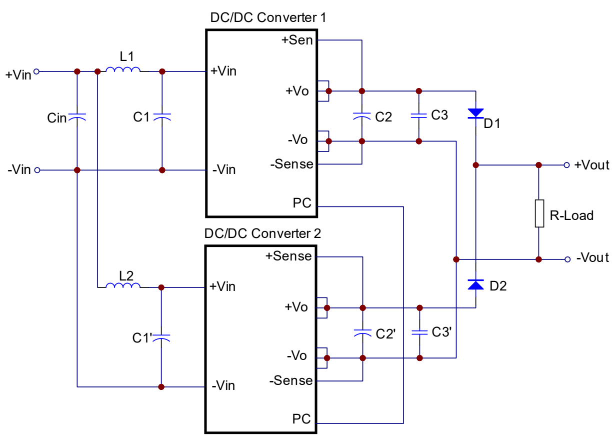
(a) parallel operation



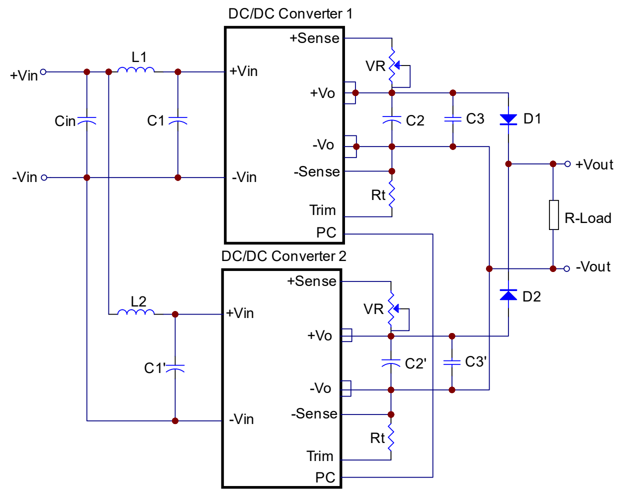
(b) Parallel operation with programmed and adjustable output



(c) N+1 redundant connection



(d) N+1 redundant connection with programmed output and adjustable output voltage



L1, L2: 1.0uH
Cin, C1, C1': 220uF/200V ESR<0.14Ω
C2, C2': 470uF
C3, C3': 1uF MLCC

Note:

If the impedance of input line is high, Cin, C1 capacitance must be more than above. Use more than two recommended capacitor above in parallel when ambient temperature becomes lower than -20℃.

9. Thermal Design

9.1 Operating Temperature Range

The CFB600W-110S series converters can be operated within a wide case temperature range of -40℃ to 100℃. Consideration must be given to the derating curves when ascertaining maximum power that can be drawn from the converter. The maximum power drawn from open full brick models is influenced by usual factors, such as:

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

9.2 Convection Requirements for Cooling

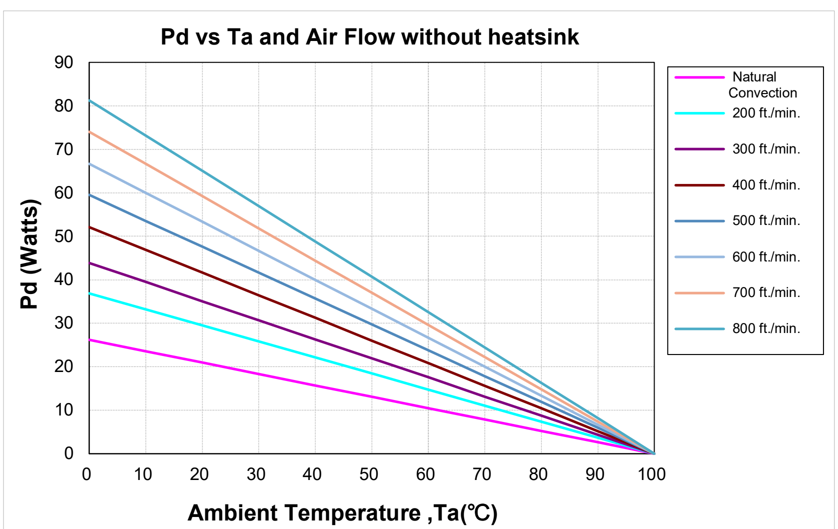
To predict the approximate cooling needed for the full brick module, refer to the power derating curves in **section 9.4**. These derating curves are approximations of the ambient temperatures and airflows required to keep the power module temperature below its maximum rating. Once the module is assembled in the actual system, the module's temperature should be monitored to ensure it does not exceed 100℃ as measured at the center of the top of the case (thus verifying proper cooling).

9.3 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 9.4**. The power output of the module should not be allowed to exceed rated power (V_{o_set} x $I_{o\_max.}$).

9.4 Power Derating

The operating case temperature range of CFB600W-110S series is -40℃ to +100℃. When operating the CFB600W-110S series, proper derating or cooling is needed. The maximum case temperature under any operating condition should not exceed 100℃.
The following curve is the de-rating curve of CFB600W-110S series without heat sink.



AIR FLOW RATE	TYPICAL R_{ca}
Natural Convection 20ft./min. (0.1m/s)	3.82℃/W
200 ft./min. (1.0m/s)	2.71℃/W
300 ft./min. (1.5m/s)	2.28℃/W
400 ft./min. (2.0m/s)	1.92℃/W
500 ft./min. (2.5m/s)	1.68℃/W
600 ft./min. (2.5m/s)	1.50℃/W
700 ft./min. (2.5m/s)	1.35℃/W
800 ft./min. (2.5m/s)	1.23℃/W

Example:

What is the minimum airflow necessary for a CFB600W-110S12 operating at nominal line voltage, an output current of 30A and a maximum ambient temperature of 30℃?

Solution:

Given: V_{in}=110V_{dc}, V_o=12V_{dc}, I_o=30A

Determine power dissipation (P_d): $P_d=P_i-P_o=P_o(1-\eta)/\eta$, P_d=12×30×(1-0.87)/0.87=53.79Watts

Determine airflow: Given: P_d=53.79W and T_a=30℃

Check power derating curve: Minimum airflow=800ft./min.

Verify:

Maximum temperature rise is $\Delta T=P_d\times R_{ca}$=53.79×1.23=66.16℃

Maximum case temperature is $T_c=T_a+\Delta T$=96.16℃<100℃

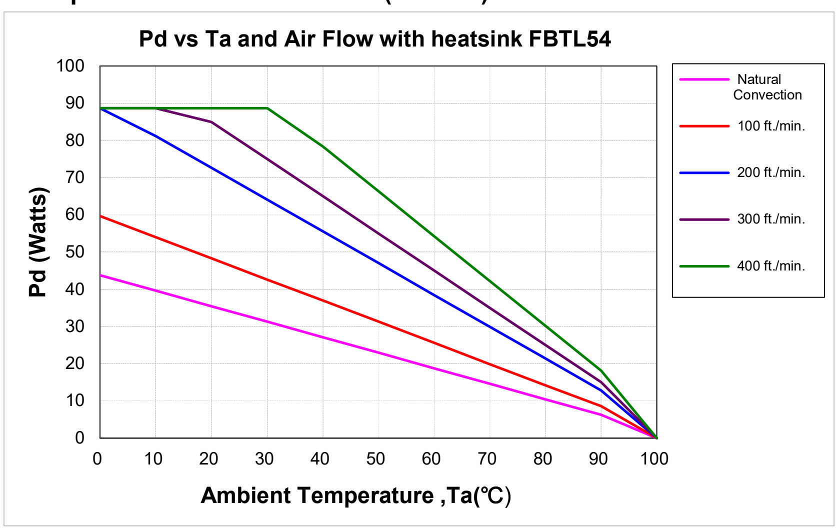
Where:

The R_{ca} is thermal resistance from case to ambient environment

T_a is ambient temperature and T_c is case temperature

The following curve is the de-rating curve of CFB600W-110S series with heat sink FBL254 (M-B012).

Example with heat sink FBL254 (M-B012):



AIR FLOW RATE	TYPICAL R_{ca}
Natural Convection 20ft./min. (0.1m/s)	2.4℃/W
100 ft./min. (0.5m/s)	1.76℃/W
200 ft./min. (1.0m/s)	1.17℃/W
300 ft./min. (1.5m/s)	1.00℃/W
400 ft./min. (2.0m/s)	0.83℃/W

What is the minimum airflow necessary for a CFB600W-110S12 operating at nominal line voltage, an output current of 30A and a maximum ambient temperature of 50℃?

Solution:

Given: V_{in}=110V_{dc}, V_o=12V_{dc}, I_o=30A

Determine power dissipation (P_d): $P_d=P_i-P_o=P_o(1-\eta)/\eta$, P_d=12×30(1-0.87)/0.87=53.79Watts

Determine airflow: Given: P_d=53.79W and T_a=50℃

Check above power de-rating curve: Minimum airflow=400ft./min

Verify:

Maximum temperature rise is $\Delta T=P_d\times R_{ca}$=53.79×0.83=44.65℃

Maximum case temperature is $T_c=T_a+\Delta T$=94.65℃<100℃

Where:

The R_{ca} is thermal resistance from case to ambient environment

T_a is ambient temperature and T_c is case temperature

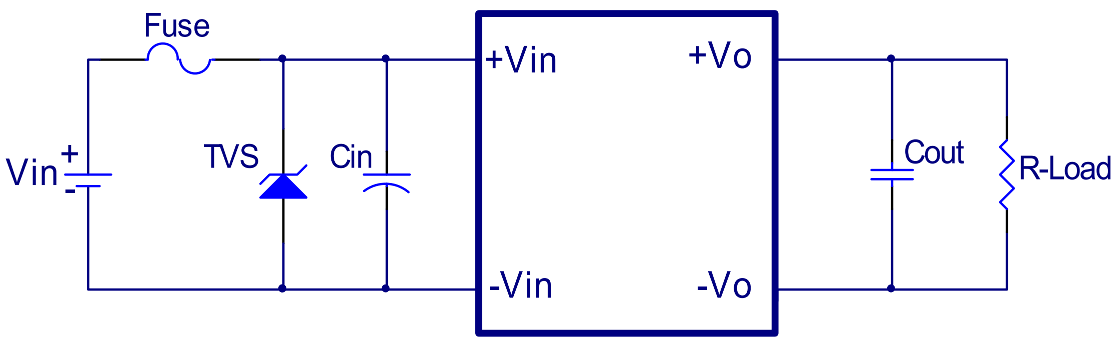
9.5 Full Brick Heat Sinks

Heat sinks assembly **refer to Datasheet-Thermal**

10. Safety & EMC

10.1 Input Fusing and Safety Considerations

The CFB600W-110S series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a 20A time delay fuse for 110V$_{in}$ 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).

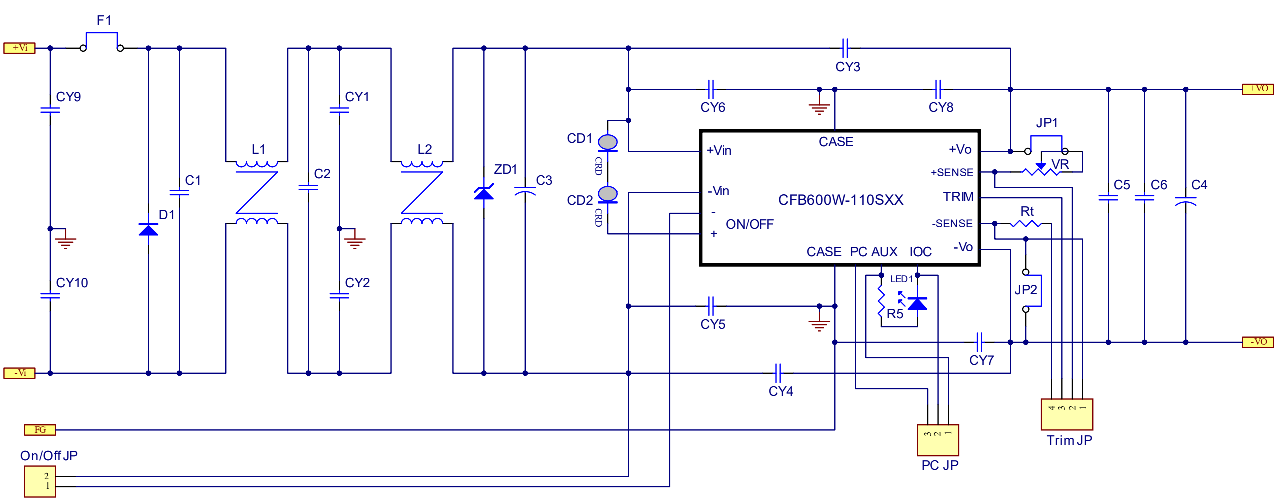


10.2 EMC Considerations

EMI Test standard: EN 50155 (EN 50121-3-2) Conducted Emission.

Test Condition: Input Voltage: Nominal, Output Load: Full Load

(1) Suggested Circuits for Conducted EMI Meet EN 50155



Connection Circuit

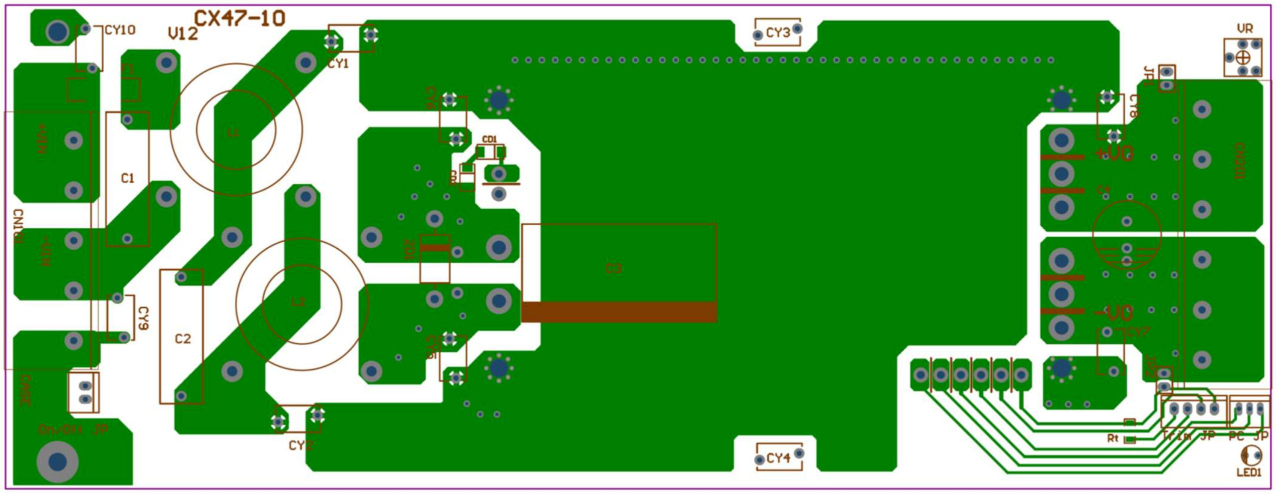


Figure1 EMI Test Board Top Side

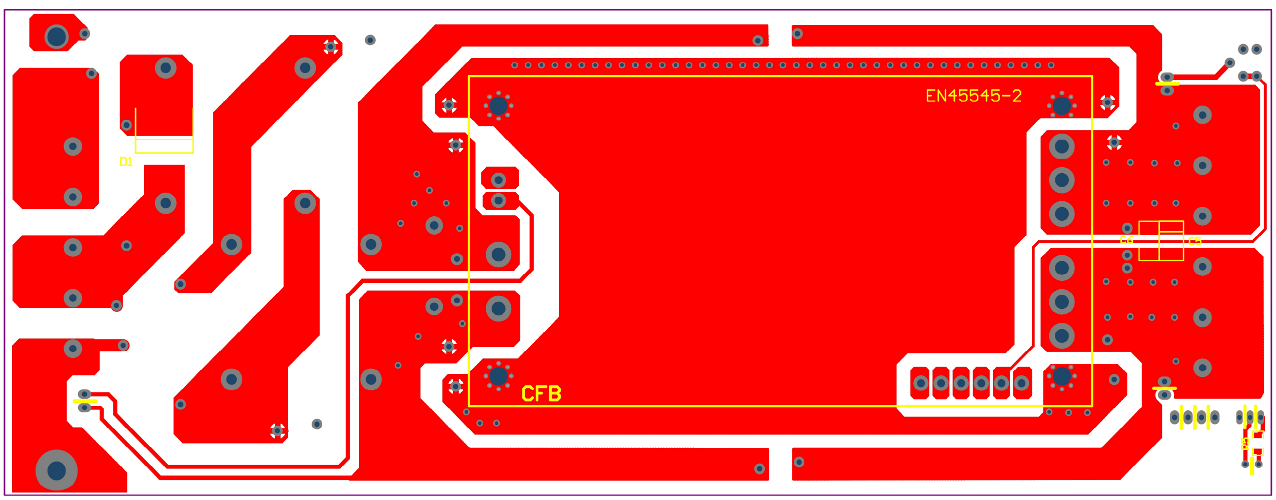


Figure2 EMI Test Board Bottom Side

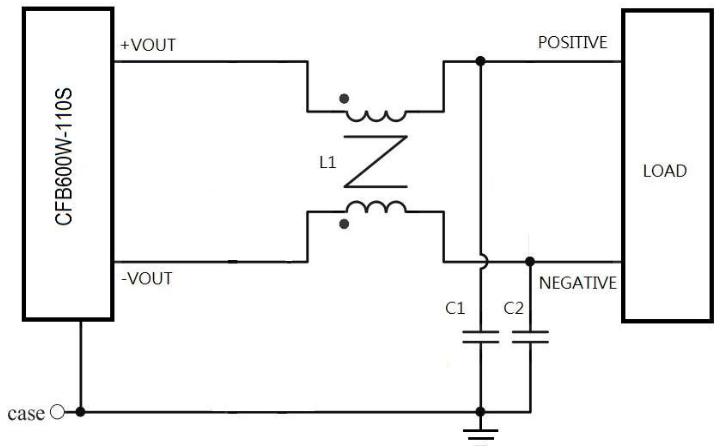
Components value:

<table>
<tr><th rowspan="2"></th><th colspan="4">Model Number</th></tr>
<tr><th>CFB600W-110S12</th><th>CFB600W-110S24</th><th>CFB600W-110S28</th><th>CFB600W-11S48</th></tr>
<tr><td>C1</td><td colspan="4" rowspan="2">X2 CAP. 0.47uF</td></tr>
<tr><td>C2</td></tr>
<tr><td>C3</td><td colspan="4">220uF/200V YXF</td></tr>
<tr><td>C4</td><td colspan="3">470uF/50V KY</td><td>470uF/63V KY</td></tr>
<tr><td>C5</td><td colspan="3">10uF/50V</td><td>4.7uF/100V</td></tr>
<tr><td>C6</td><td colspan="3">1uF/50V</td><td>1uF/100V</td></tr>
<tr><td>CY1</td><td colspan="4" rowspan="2">Y1 CAP. 470pF</td></tr>
<tr><td>CY2</td></tr>
<tr><td>CY3</td><td colspan="2" rowspan="2">Y1 CAP. 2200pF</td><td colspan="2" rowspan="2">Y1 CAP. 1000pF</td></tr>
<tr><td>CY4</td></tr>
<tr><td>CY5</td><td colspan="4" rowspan="2">Y1 CAP. 4700pF</td></tr>
<tr><td>CY6</td></tr>
<tr><td>CY7</td><td colspan="4" rowspan="2">Y1 CAP. 10000pF</td></tr>
<tr><td>CY8</td></tr>
<tr><td>CY9</td><td colspan="3">NC</td><td rowspan="2">Y1 CAP. 4700pF</td></tr>
<tr><td>CY10</td><td colspan="3">NC</td></tr>
<tr><td>CD1</td><td colspan="4" rowspan="2">S-152T</td></tr>
<tr><td>CD2</td></tr>
<tr><td>ZD1</td><td colspan="4">1.5KE180A</td></tr>
<tr><td>F1</td><td colspan="4">JP</td></tr>
<tr><td>L1</td><td colspan="4" rowspan="2">3.8mH</td></tr>
<tr><td>L2</td></tr>
</table>

Note:

C1, C2: PCX2337 0.47uF/275V or equivalent
C3, C4: Aluminum Cap. or equivalent
C5: VISHAY 293D Tantalum Chip Cap. D"<0.8R or equivalent
C6: CHIP CAP. 1812 or equivalent
CD1, CD2: Semitec Current Diode or equivalent
L1, L2: Ferrite Core Ferroxcube T29/19/15-3E6 Φ1.2mm*2/18T or equivalent
ZD1: Littelfuse TVS or equivalent

(2) The external filter is required for output conducted noise meet EN 50155: 2017



Components value:

	Model Number			
	CFB600W-110S12	CFB600W-110S24	CFB600W-110S28	CFB600W-11S48
C1	Y1 CAP. 10000pF			
C2				
L1	1.0mH			2.2mH

Note:

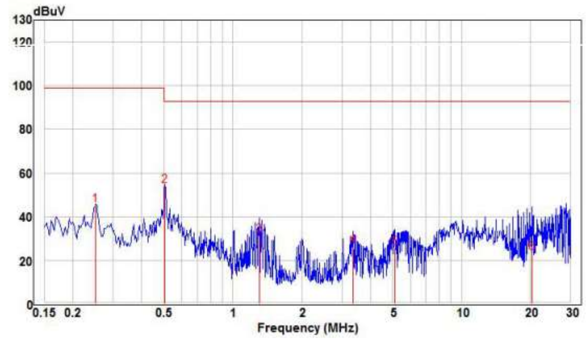
L1: 1.0mH Ferrite Core Ferroxcube T29/19/15-3E6 Φ1.0mm*3/9T or equivalent

2.2mH Ferrite Core Ferroxcube T29/19/15-3E6 Φ1.2mm*1/14T or equivalent

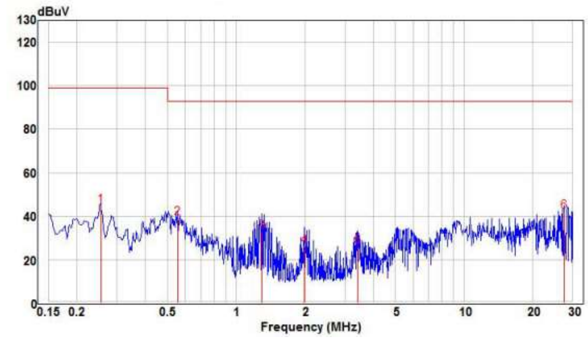
Conducted Emission (Input):

CFB600W-110S12

Line:

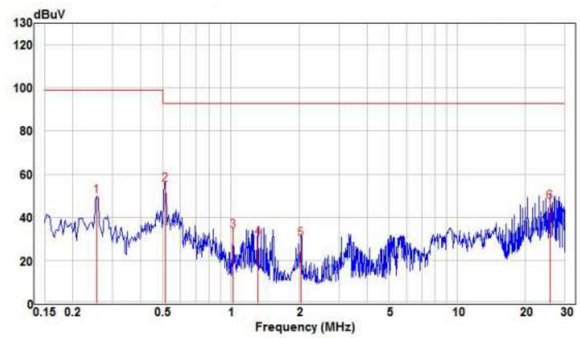


Neutral:

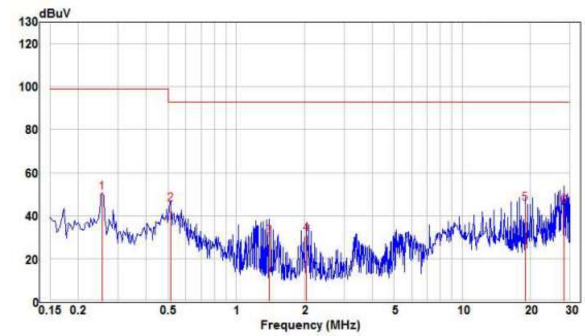


CFB600W-110S24

Line:

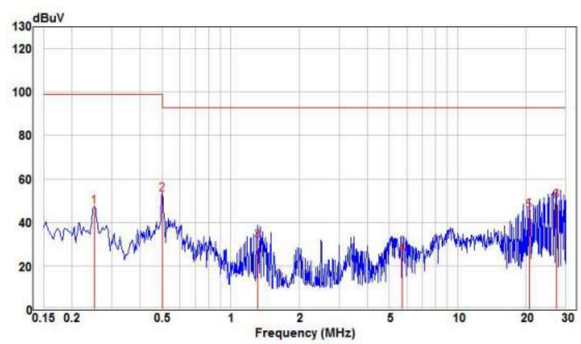


Neutral:

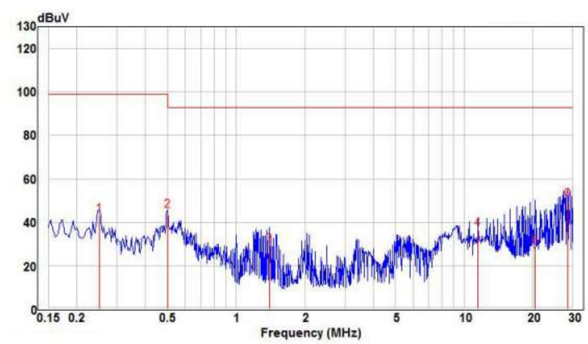


CFB600W-110S28

Line:

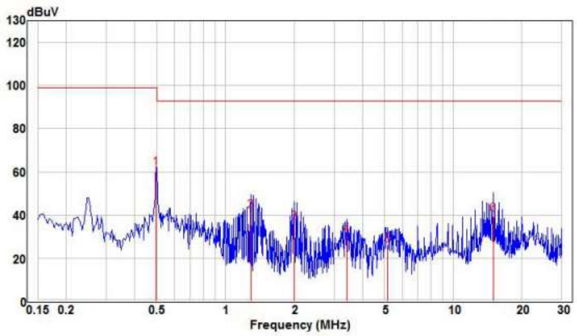


Neutral:

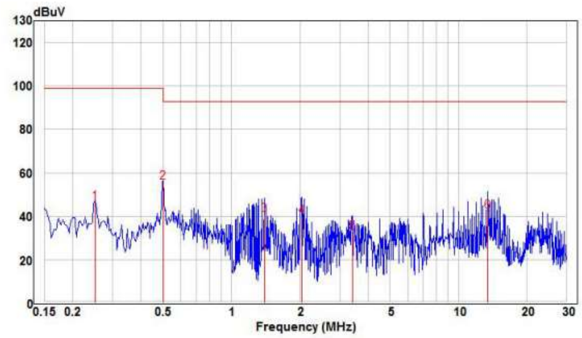


CFB600W-110S48

Line:



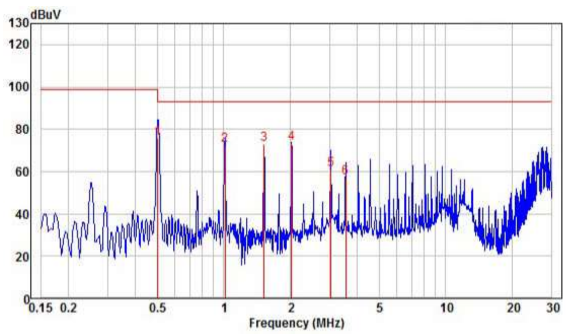
Neutral:



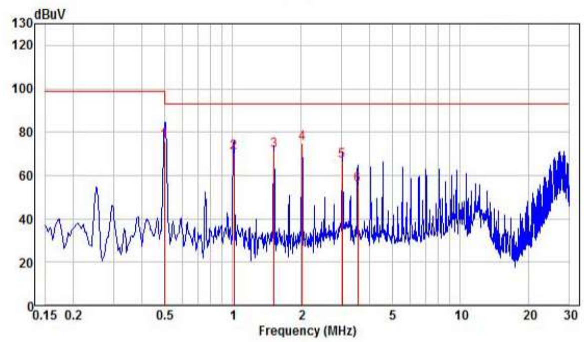
Conducted Emission (Output):

CFB600W-110S12

Positive:

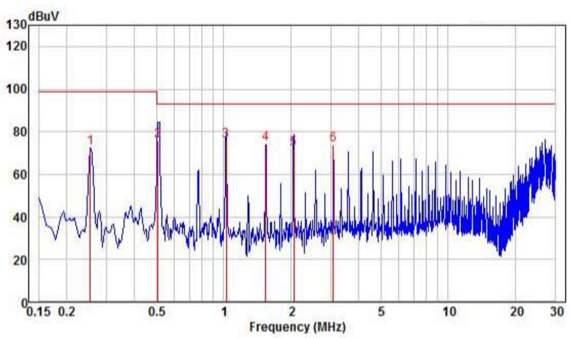


Negative:

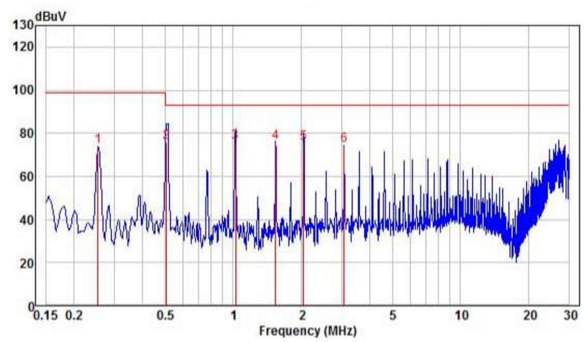


CFB600W-110S24

Positive:

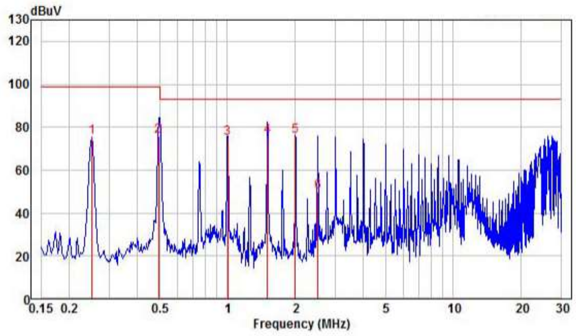


Negative:

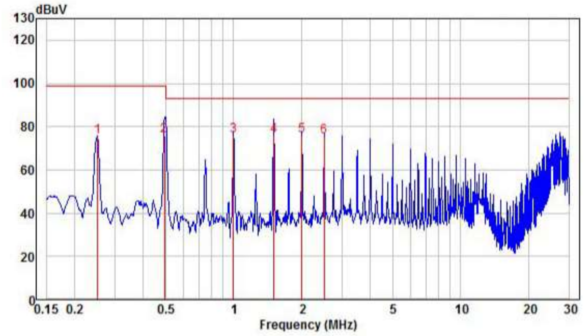


CFB600W-110S28

Positive:

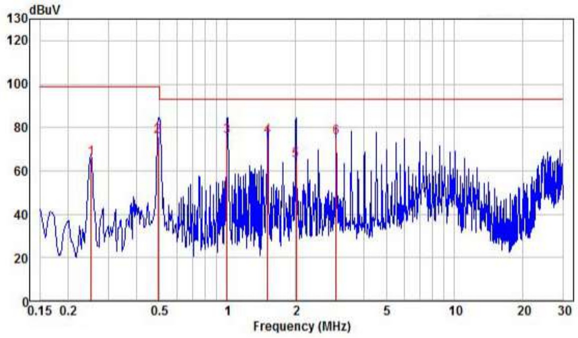


Negative:

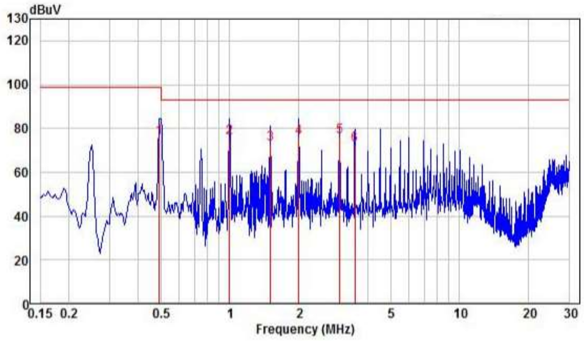


CFB600W-110S48

Positive:



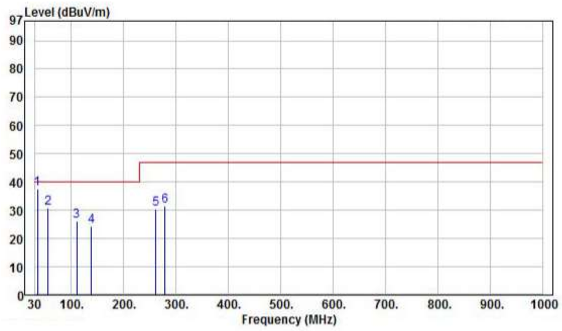
Negative:



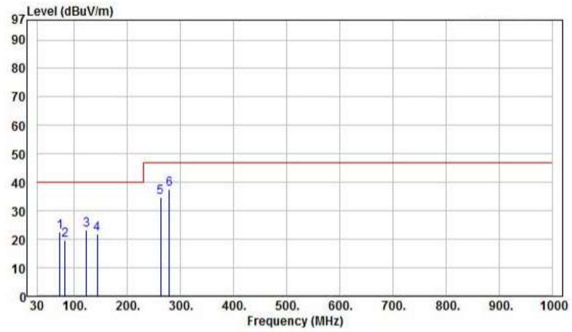
Radiated Emission:

CHB600W-110S12

Vertical

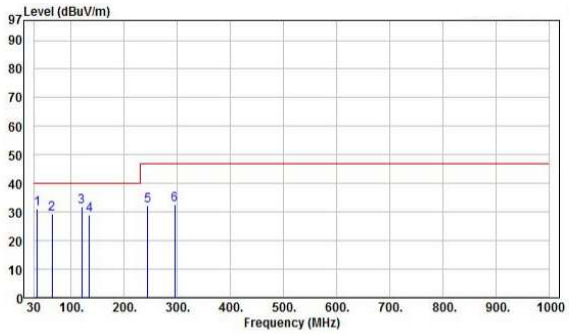


Horizontal

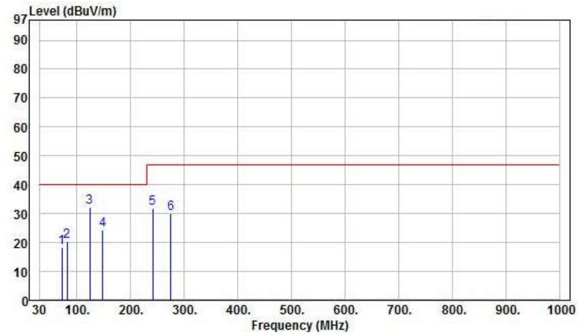


CHB600W-110S24

Vertical

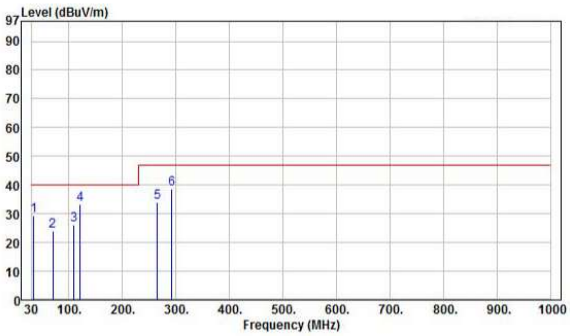


Horizontal



CHB600W-110S28

Vertical



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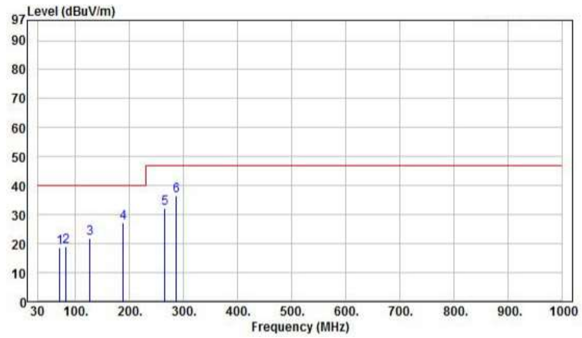
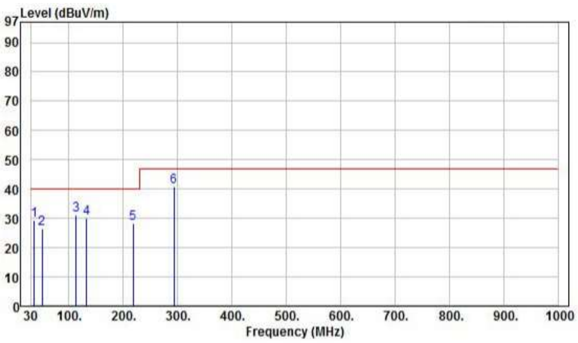
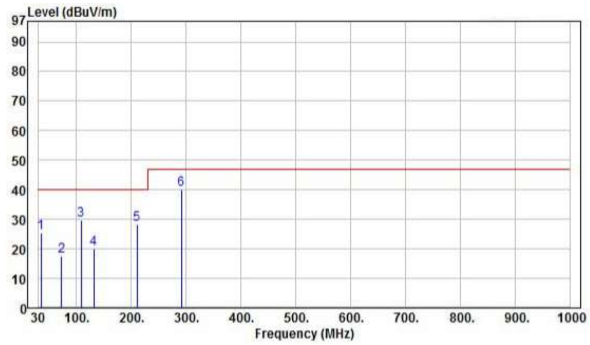


CHB600W-110S48

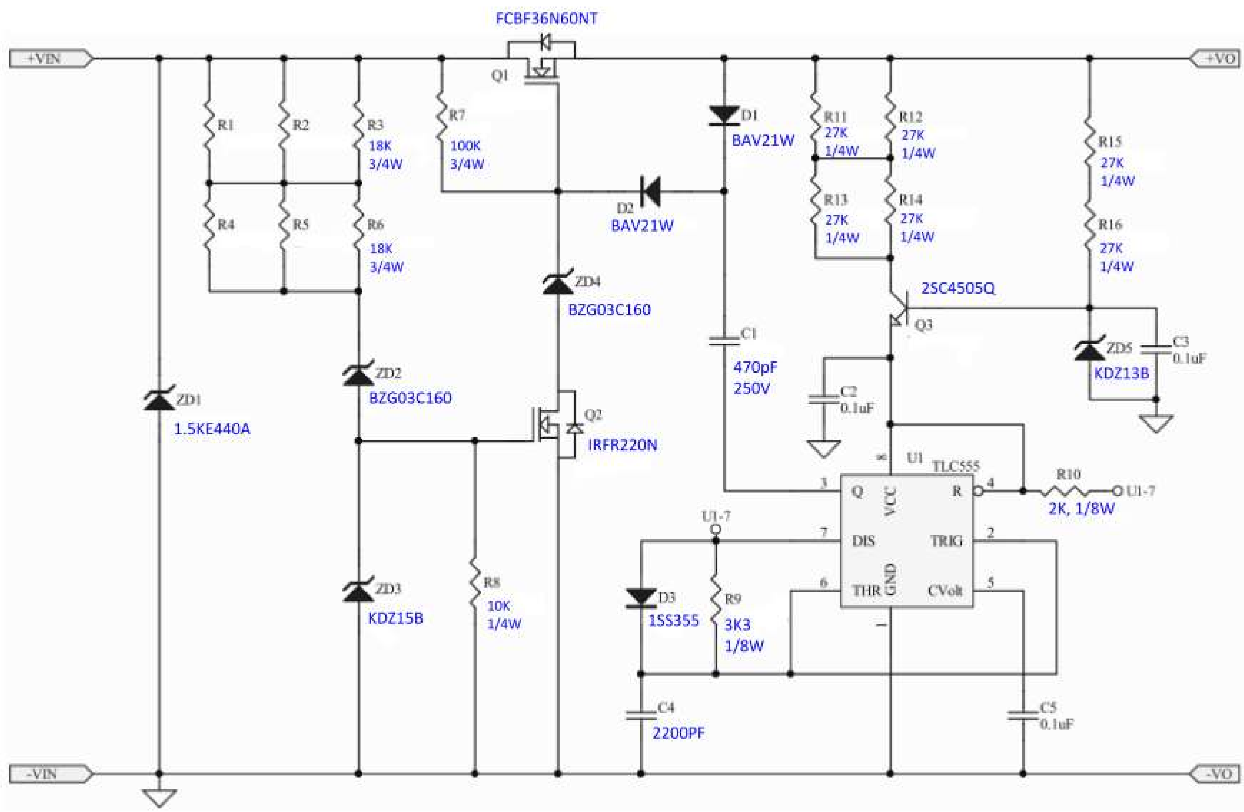
Vertical



Horizontal



10.3 Suggested Configuration for RIA12 Surge Test



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