



CFB800 Series Application Note V10

ISOLATED DC-DC CONVERTER CFB800 SERIES APPLICATION NOTE



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1. Introduction

The CFB800 series of DC-DC converters offers 800 watts of output power @ single output voltages of 28VDC with standard Full-brick. It has a wide input voltage range of 18 to 36VDC (24VDC nominal) and 1500VDC isolation.

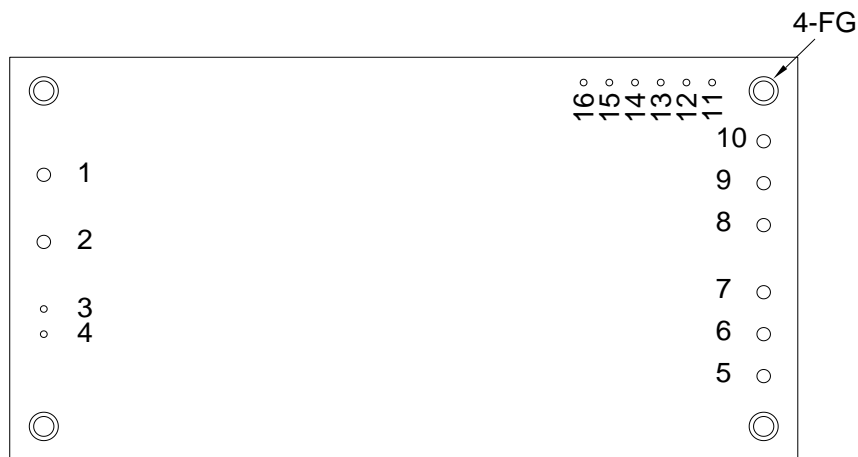
Meets EN62368-1, EN45545, High efficiency up to 90%, allowing case operating temperature range of -40°C to 100°C . An optional heat sink is available to extend the full power range of the unit.

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.

CFB800 series of isolated DC-DC Converters. These are highly efficient, reliable and compact, high power density, single output DC/DC converters. The modules can be used in the field of telecommunications, data communications, wireless communications, servers, base station, etc.

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

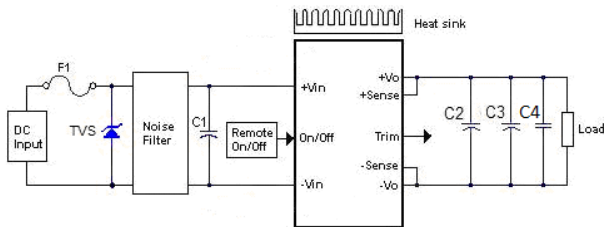
Note: Base plate can be connected to FG through M3 threaded mounting insert. Recommended torque 3Kgf-cm.



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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. The output terminal required a capacitor (C2) 470uF to maintain specified regulation. External output capacitors (C3, C4) are recommended to reduce output ripple and noise, 10uF tantalum and 1uF ceramic capacitor. The CFB800-24S series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a 70A 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, C4	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°C.

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:

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

Where:

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

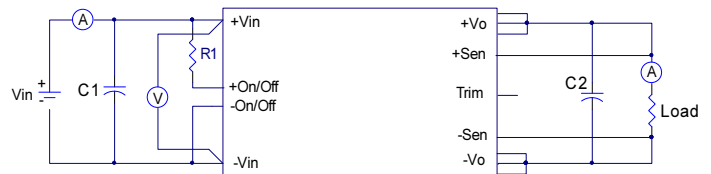
The value of line regulation is defined as:

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

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



CFB800 Series Test Setup

C1: 220uF/100V ESR<0.084Ω

C2: 470uF/50V ESR<0.045Ω

For CFB800 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.

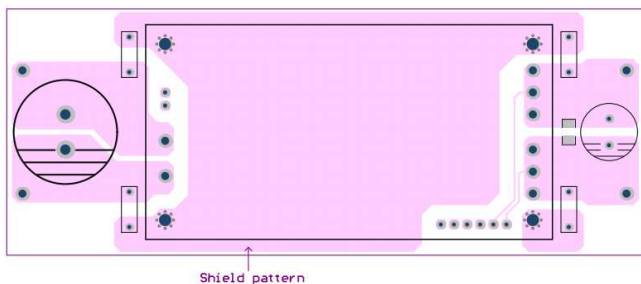
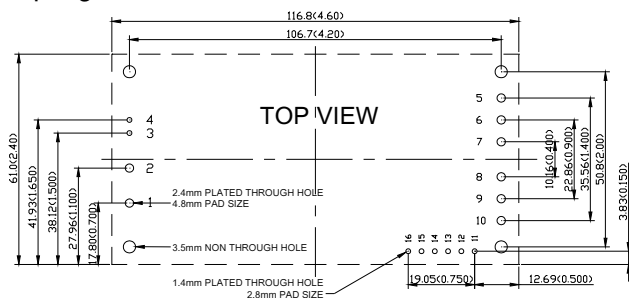
For stable operation, connect a low impedance electrolytic capacitor C2 in the output terminals. When operated at lower temperature than -20°C, increasing the C2 capacitance with three or four times more than the recommended value.



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5. Recommend Layout, PCB Footprint and Soldering Information

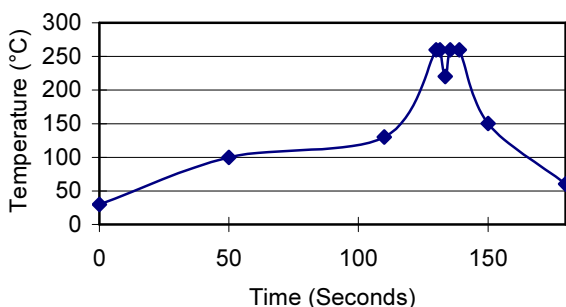
The system designer or end user must ensure that metal and other components in the vicinity of the converter meet the spacing requirements for which the system is approved. Low resistance and inductance PCB layout traces are the norm and should be used where possible. Due consideration must also be given 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°C for up to 5 seconds (less than 50W). Furthermore the recommended soldering profile and PCB layout are shown below.

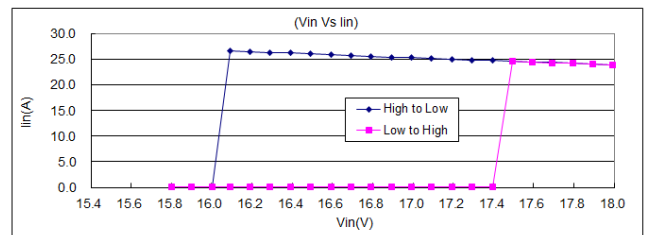
Lead Free Wave Soldering Profile



6. Features and Functions

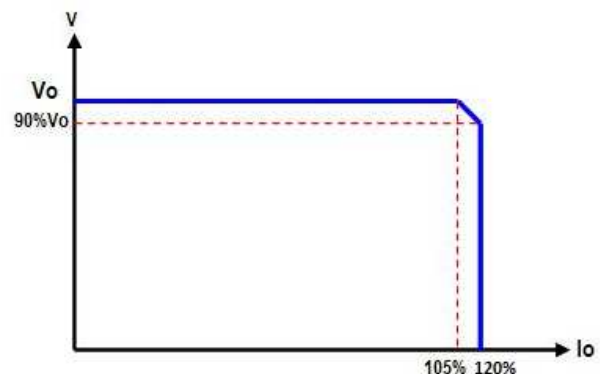
6.1 UVLO (Under Voltage Lock Out)

Input under voltage lockout is standard on the CFB800 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.

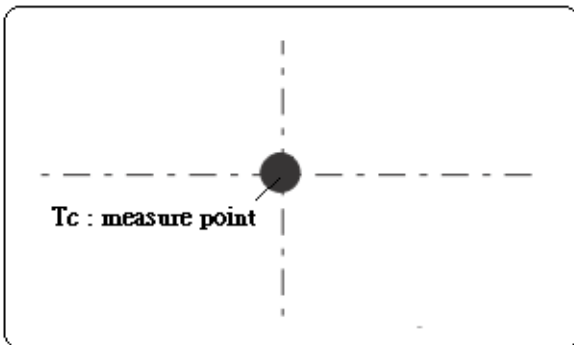
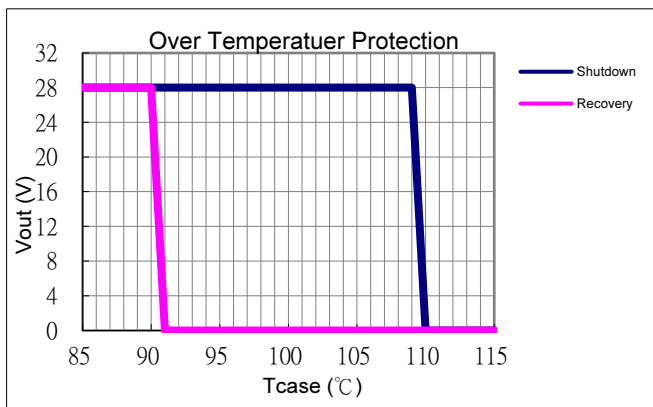
Note: Please note that device inside the power supply might fail when voltage more than rate output voltage is applied to output pin. This could happen when the customer tests the over voltage protection of unit.



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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.



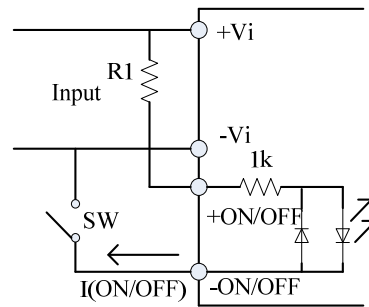
6.5 Remote On/Off

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.

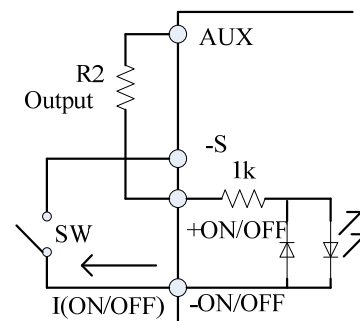
The converter's On/Off can be controlled from the input side or the output side.

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 15K (0.25W) for 24Vin.



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



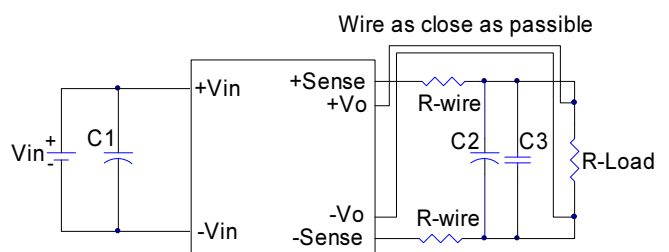
6.6 Output Remote Sensing

The CFB800-24S 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 CFB800-24S 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:

$$[(+V_{out}) - (-V_{out})] - [(+Sense) - (-Sense)] \leq 10\% \text{ of } V_{o_nominal}$$

When remote sense is in use, the sense should be connected by twisted-pair wire or shield wire. If the sensing patterns short, heavy 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.

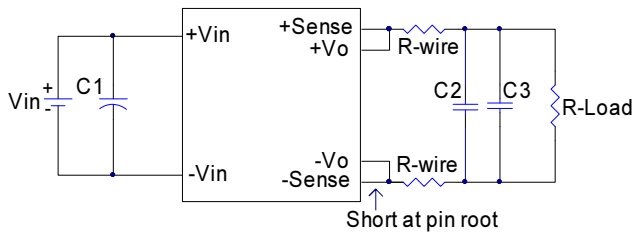
This is shown in the schematic below.





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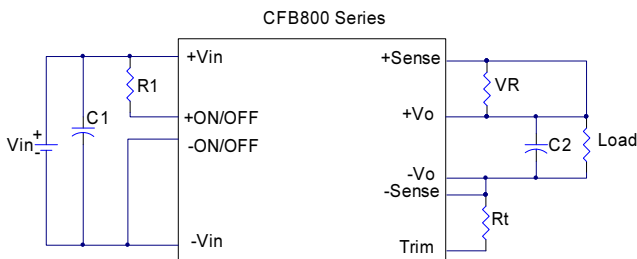
If the remote sense feature is not to be used, the sense pins should be connected locally. The +Sense pin should be connected to the +Vout pin at the module and the -Sense pin should be connected to the -Vout pin at the module. Wire between +Sense and +Vout and between -Sense and -Vout as short as possible. 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:

$$V_f = \frac{1.24 \times \left(\frac{R_t \times 33}{R_t + 33} \right)}{7.68 + \frac{R_t \times 33}{R_t + 33}}$$

$$V_{out} = (V_o + VR) \times V_f$$

Unit: K Ω

V_o : Nominal Output Voltage

Recommend $R_t=6.8K\Omega$

For example, to trim-up the output voltage of 28V module (CFB800-24S28) by 5% to 29.4V, to trim-down by 20% to 22.4V.

The value VR_{trim_up} is calculated as follows:
 $R_t=6.8K\Omega$, $V_f=0.525V$,

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

$$29.4 = (28 + VR) \times 0.525,$$

$$VR = 28K\Omega$$

The value of VR_{trim_down} defined as:

$$22.4 = (28 + VR) \times 0.525,$$

$$VR = 14.67K\Omega$$

The typical value of VR_{trim_up}

Trim up %	28V
	VR_{trim_up} (K Ω); $R_t=6.8K\Omega$
1%	25.87
2%	26.40
3%	26.93
4%	27.47
5%	28.00
6%	28.53
7%	29.07
8%	29.60
9%	30.13
10%	30.67

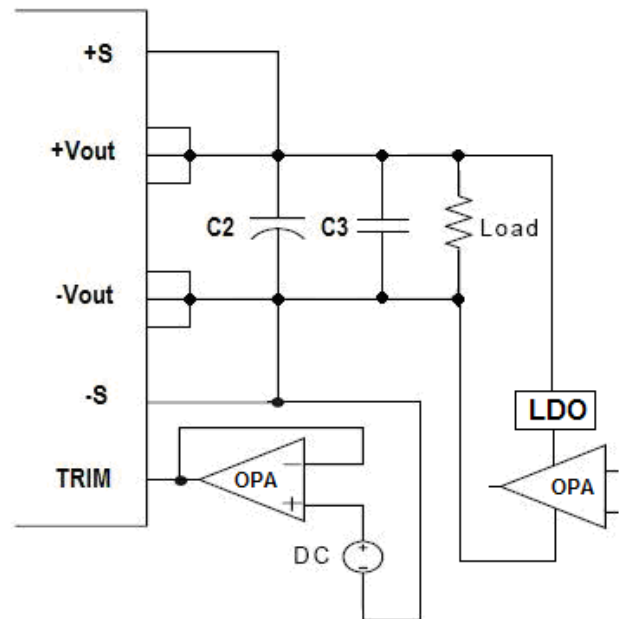


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The typical value of VR_{trim_down}

Trim down %	28V
	VR_{trim_down} (K Ω); $R_t=6.8K\Omega$
1%	24.80
2%	24.27
3%	23.73
4%	23.20
5%	22.67
6%	22.13
7%	21.60
8%	21.07
9%	20.53
10%	20.00
11%	19.47
12%	18.93
13%	18.40
14%	17.87
15%	17.33
16%	16.80
17%	16.27
18%	15.73
19%	15.20
20%	14.67
21%	14.13
22%	13.60
23%	13.07
24%	12.53
25%	12.00
26%	11.47
27%	10.93
28%	10.40
29%	9.867
30%	9.333
31%	8.800
32%	8.267
33%	7.733
34%	7.200
35%	6.667
36%	6.133
37%	5.600
38%	5.067
39%	4.533
40%	4.000

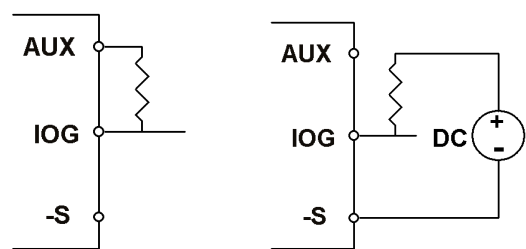
The output voltage can also be adjustment by using external DC voltage.



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.

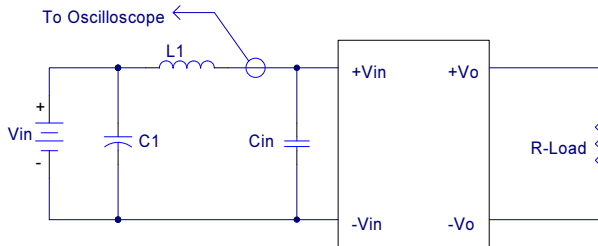


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7. Input / Output Considerations

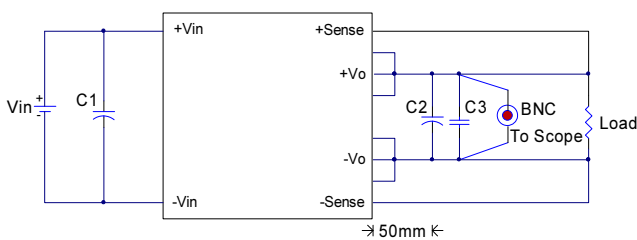
7.1 Input Capacitance at the Power Module

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 (C_{in}) should be placed close to the converter input pins to decouple 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 ($L1$).



$L1$: 12 μ H
 $C1$: 220 μ F ESR<0.084ohm @100KHz
 C_{in} : 220 μ F ESR<0.084ohm @100KHz

7.2 Output Ripple and Noise

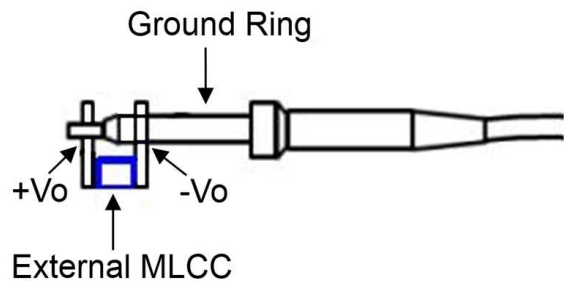


Output ripple and noise is measured with 1.0 μ F ceramic and 10 μ F solid tantalum capacitors across the output. A 20 MHz bandwidth oscilloscope is normally used for the measurement.

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 CFB800 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.

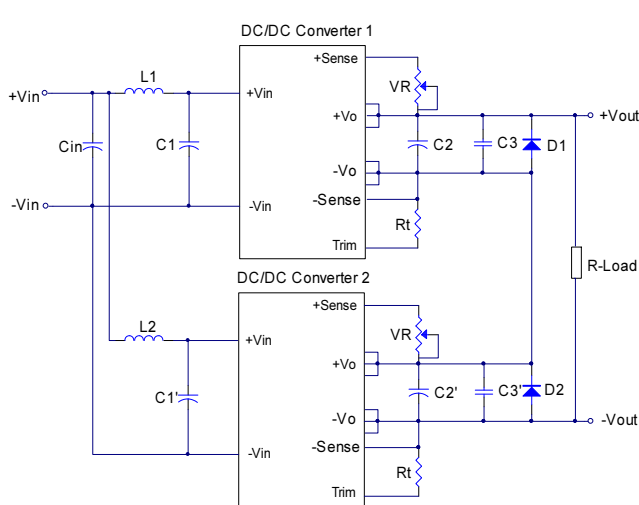
8. Series and Parallel Operation

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.



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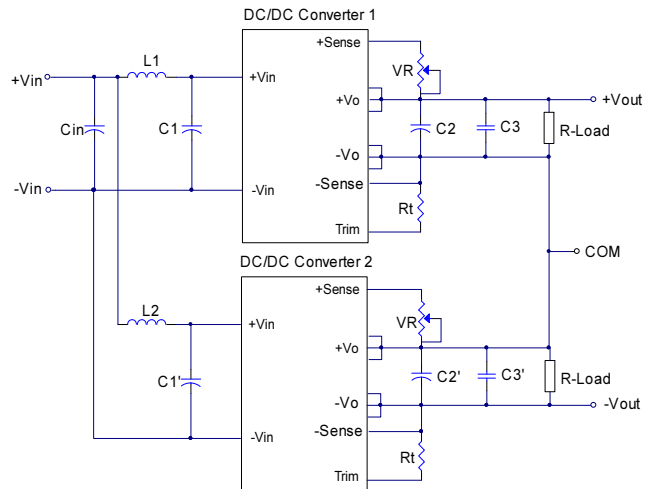
Simple Series Operation Connect Circuit

L1, L2: 1.0uH
 Cin, C1, C1': 220uF/100V ESR<0.084Ω
 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°C.
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/100V ESR<0.084Ω
 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°C.

8.2 Parallel/Redundant Operation

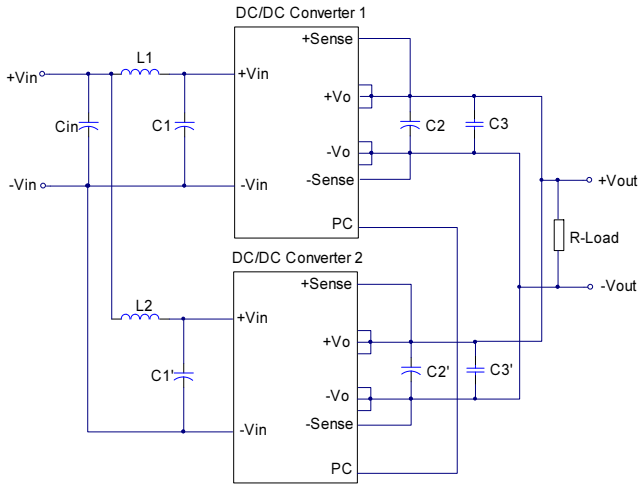
The CFB800 series are also designed for parallel operation. When paralleled, the load current can be equally shared between the modules by connecting the PC pins together.

There are two different parallel operations for CFB800 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.

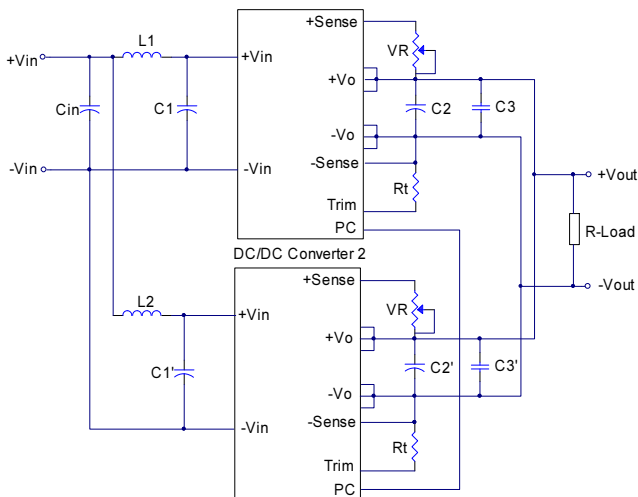


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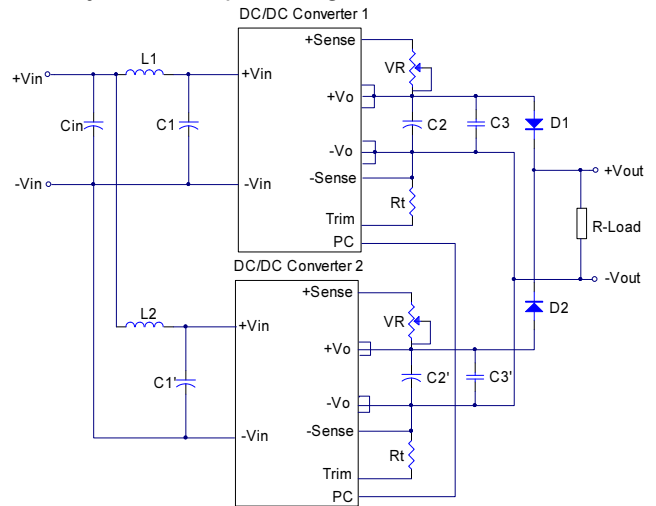
(a) parallel operation



(b) Parallel operation with programmed and adjustable output



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



L1, L2: 1.0uH

Cin, C1, C1': 220uF/100V ESR<0.084Ω

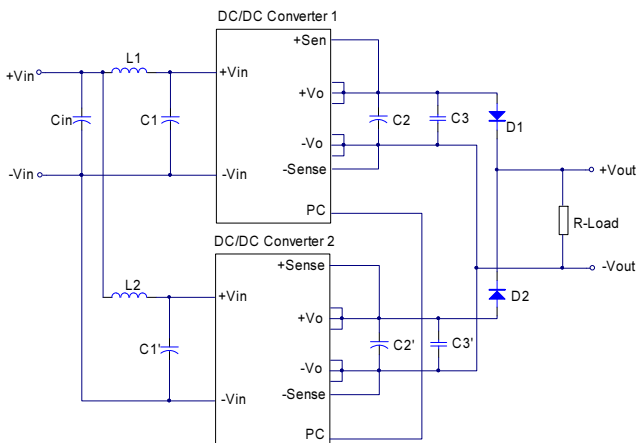
C2, C2': 470uF

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°C.

(c) N+1 redundant connection





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9. Thermal Design

9.1 Operating Temperature Range

The CFB800 series converters can be operated within a wide case temperature range of -40°C to 100°C . 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°C as measured at the center of the top of the case (thus verifying proper cooling).

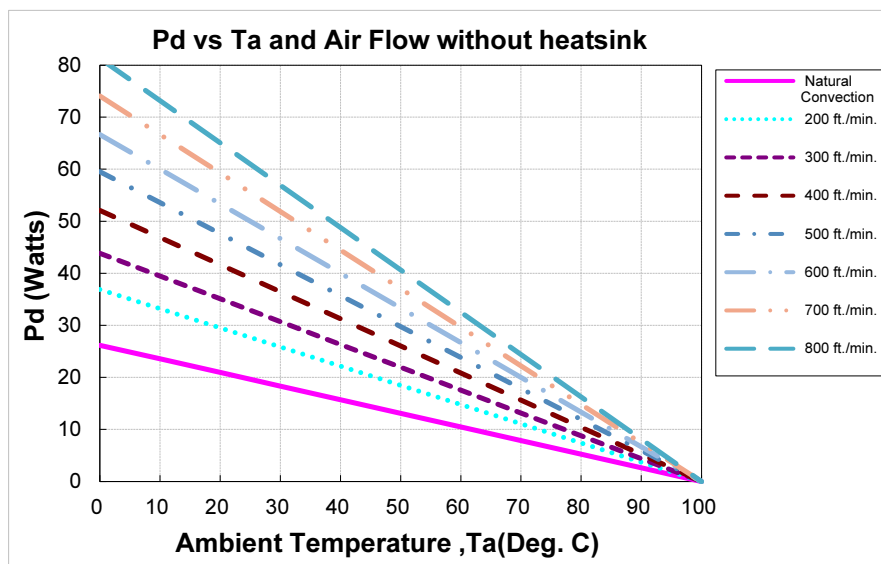
9.3 Thermal Considerations

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 ($V_{o_set} \times I_{o_max}$).

9.4 Power Derating

The operating case temperature range of CFB800 series is -40°C to $+100^{\circ}\text{C}$. When operating the CFB800 series, proper derating or cooling is needed. The maximum case temperature under any operating condition should not exceed 100°C .

The following curve is the de-rating curve of CFB800 series without heat sink.



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



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Example:

What is the minimum airflow necessary for a CFB800-24S28 operating at nominal line voltage, an output current of 21.5A and a maximum ambient temperature of 10°C?

Solution:

Given: $V_{in}= 24V_{dc}$, $V_o= 28V_{dc}$, $I_o= 21.5A$

Determine Power dissipation (P_d): $P_d= P_i-P_o= P_o(1-\eta)/\eta$, $P_d= 28 \times 21.5 \times (1-0.90)/0.90= 66.89Watts$

Determine airflow: Given: $P_d= 66.89W$ and $T_a= 10^\circ C$

Check Power Derating curve: Minimum airflow= 800 ft./min.

Verify:

Maximum temperature rise is $\Delta T= P_d \times R_{ca} = 66.89 \times 1.23= 82.27^\circ C$

Maximum case temperature is $T_c = T_a + \Delta T= 92.27^\circ C < 100^\circ C$

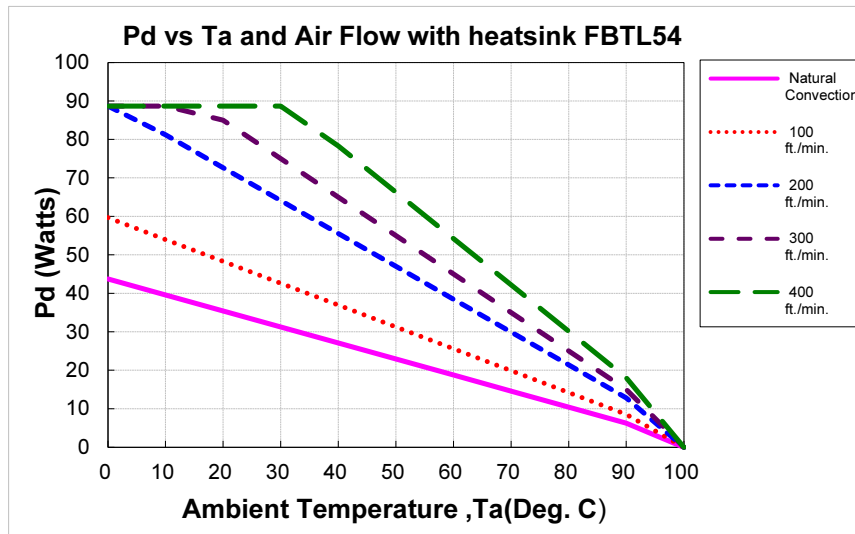
Where:

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 CFB800 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 °C/W
100 ft./min. (0.5m/s)	1.76 °C/W
200 ft./min. (1.0m/s)	1.17 °C/W
300 ft./min. (1.5m/s)	1.00 °C/W
400 ft./min. (2.0m/s)	0.83 °C/W

What is the minimum airflow necessary for a CFB800-24S28 operating at nominal line voltage, an output current of 28.5A and a maximum ambient temperature of 20°C?

Solution:

Given: $V_{in}= 24V_{dc}$, $V_o= 28V_{dc}$, $I_o= 28.5A$

Determine Power dissipation (P_d): $P_d= P_i-P_o= P_o(1-\eta)/\eta$, $P_d= 28 \times 28.5 \times (1-0.90)/0.90= 88.67Watts$

Determine airflow: Given: $P_d= 88.67W$ and $T_a = 20^\circ C$

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

Verify:

Maximum temperature rise is $\Delta T= P_d \times R_{ca}= 88.67 \times 0.83= 73.6^\circ C$

Maximum case temperature is $T_c= T_a + \Delta T= 93.6^\circ C < 100^\circ C$

Where:

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

T_a is ambient temperature and T_c is case temperature.

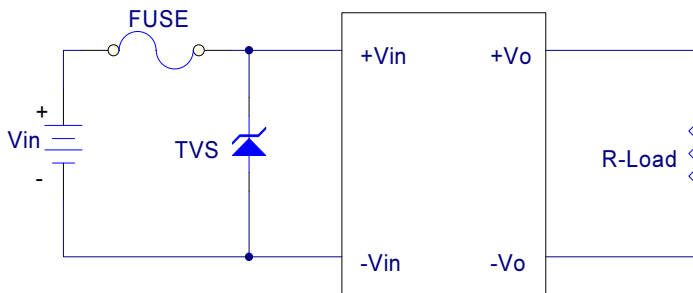


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10. Safety & EMC

10.1 Input Fusing and Safety Considerations

The CFB800 series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a 70A time delay fuse for 24V_{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: EN55022/EN55032 Class A Conducted Emission.

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

(1) Suggested Circuits for Conducted EMI meet EN55022/EN55032 Class A.

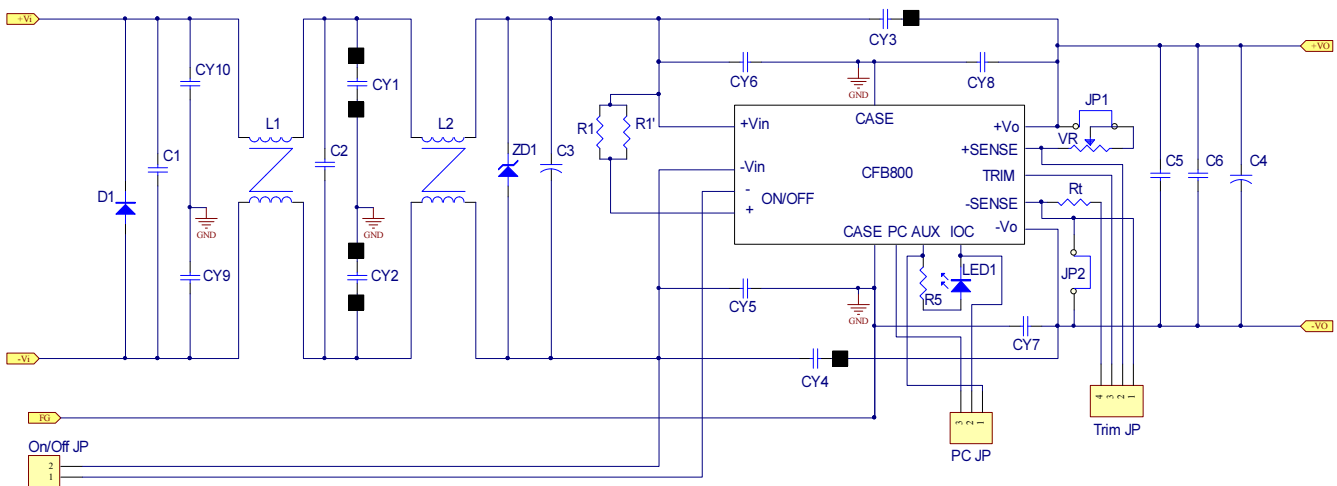


Figure1 Connection circuit



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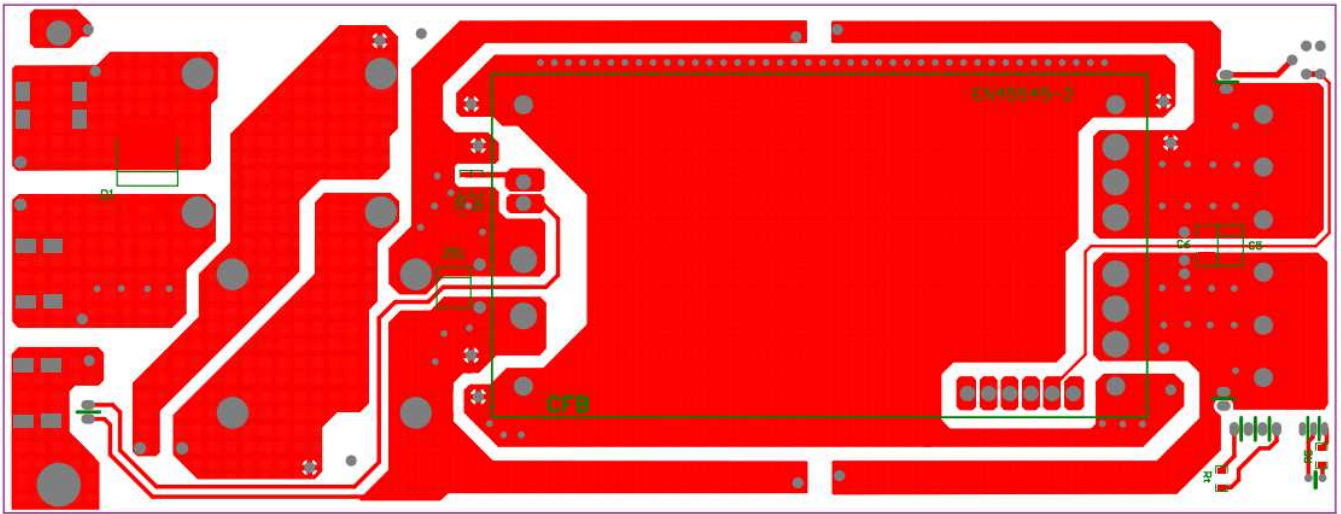


Figure2 EMI test board bottom side

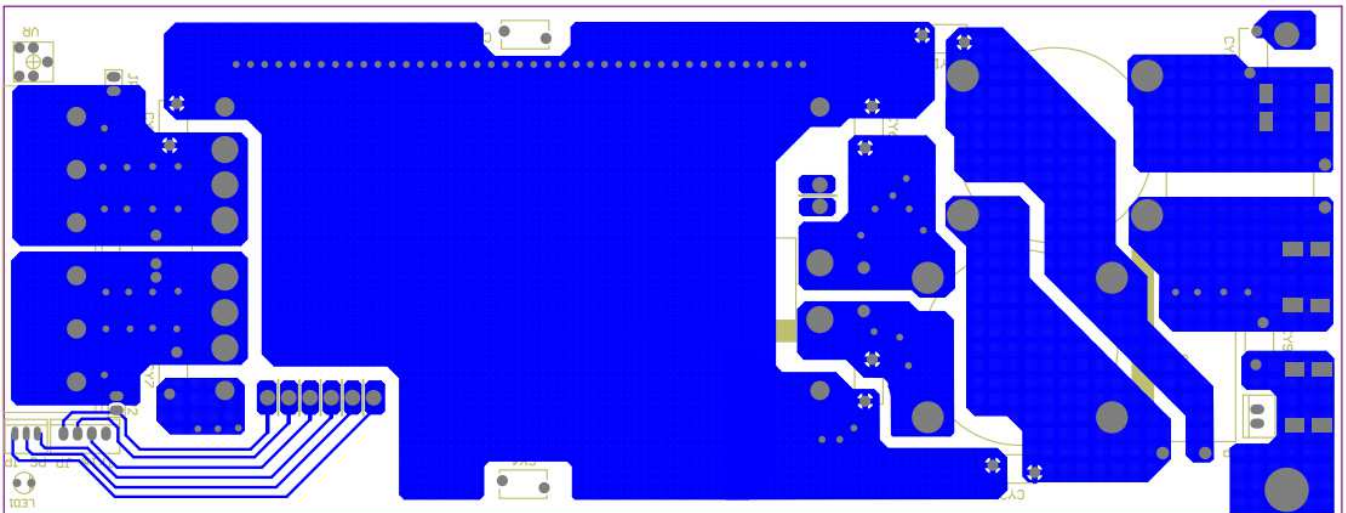


Figure3 EMI test board top side



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Components value:

Model No.	C1	C2, C3	C4	C5	C6	CY1, CY2	CY3, CY4, CY5, CY6
CFB800-24S28	1000uF/50V KY	2200uF/50V KY	470uF/50V KY	10uF/50V	1uF/50V	Y2 CAP 470pF	Y2 CAP 4700pF
	CY7, CY8	CY9	L1, L2	ZD1	R1, R1'	Bead Core	
	Y2 CAP 10000pF	Y2 CAP 220pF	2.9mH	SMDJ40A	30K 1206	CY1, CY2 CY3, CY4	

Note:

C1, C2, C3, C4: NIPPON CHEMI-CON KY series aluminum capacitor or equivalent.

C5: VISHAY 293D TANTALUM CHIP CAP. D"<0.8R or equivalent.

C6: 1812 X7R ceramic.

CY1, CY2, CY3, CY4, CY5, CY6, CY9: TDK Y2 CS Type capacitor or equivalent.

CY7, CY8: MURATA KY Series capacitor or equivalent.

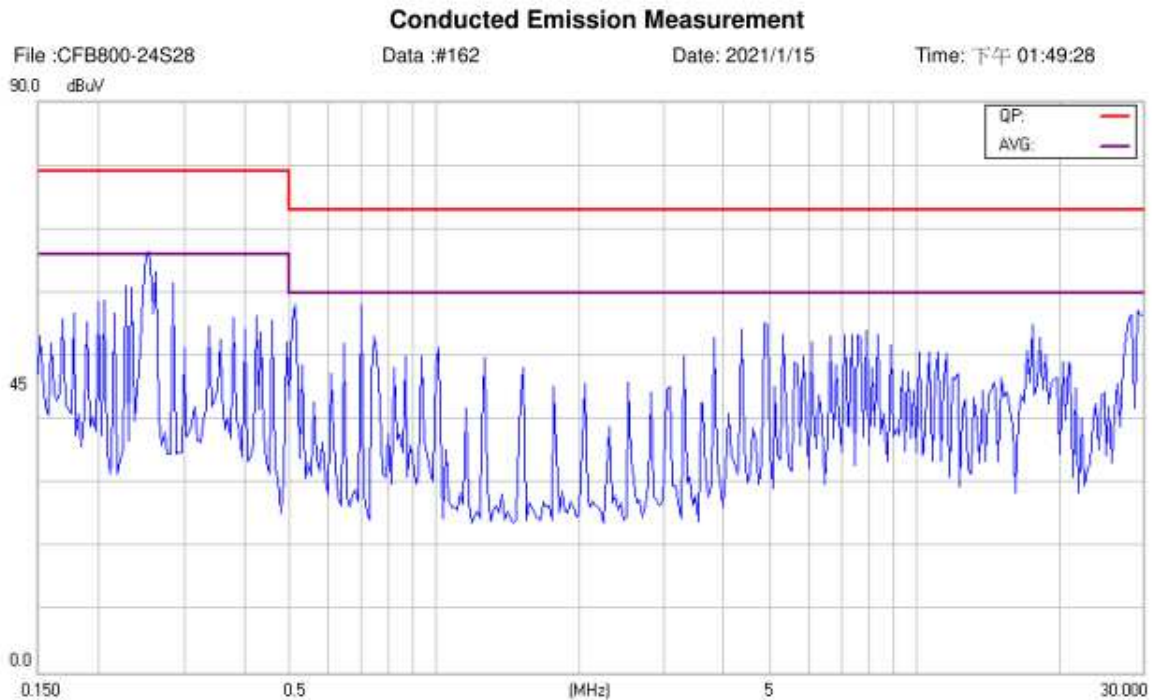
L1, L2: Nanocrystalline Material CORE GREDMANN T60006-L2030-P423 Φ 1.0mm*3/7T or equivalent.

ZD1: LITTELFUSE TVS or equivalent.

Bead Core: BRH 3.5*3.2*1.2 CHILISIN(G4032451007) for CY1, CY2, CY3, CY4

Conducted Emission:

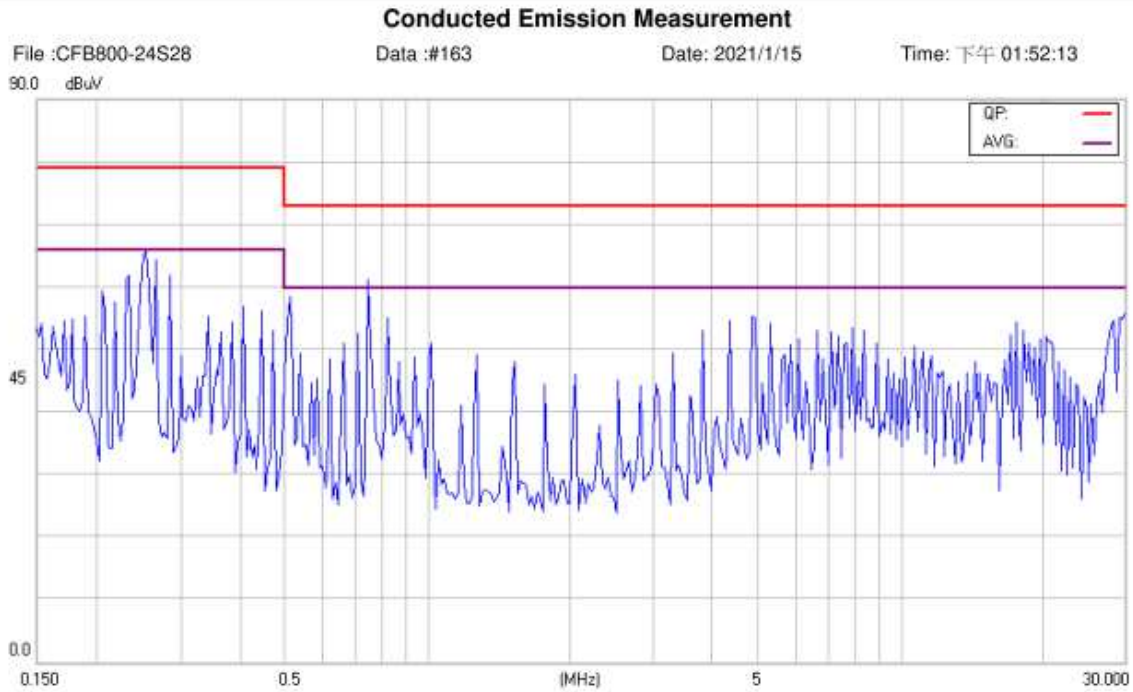
Line :





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