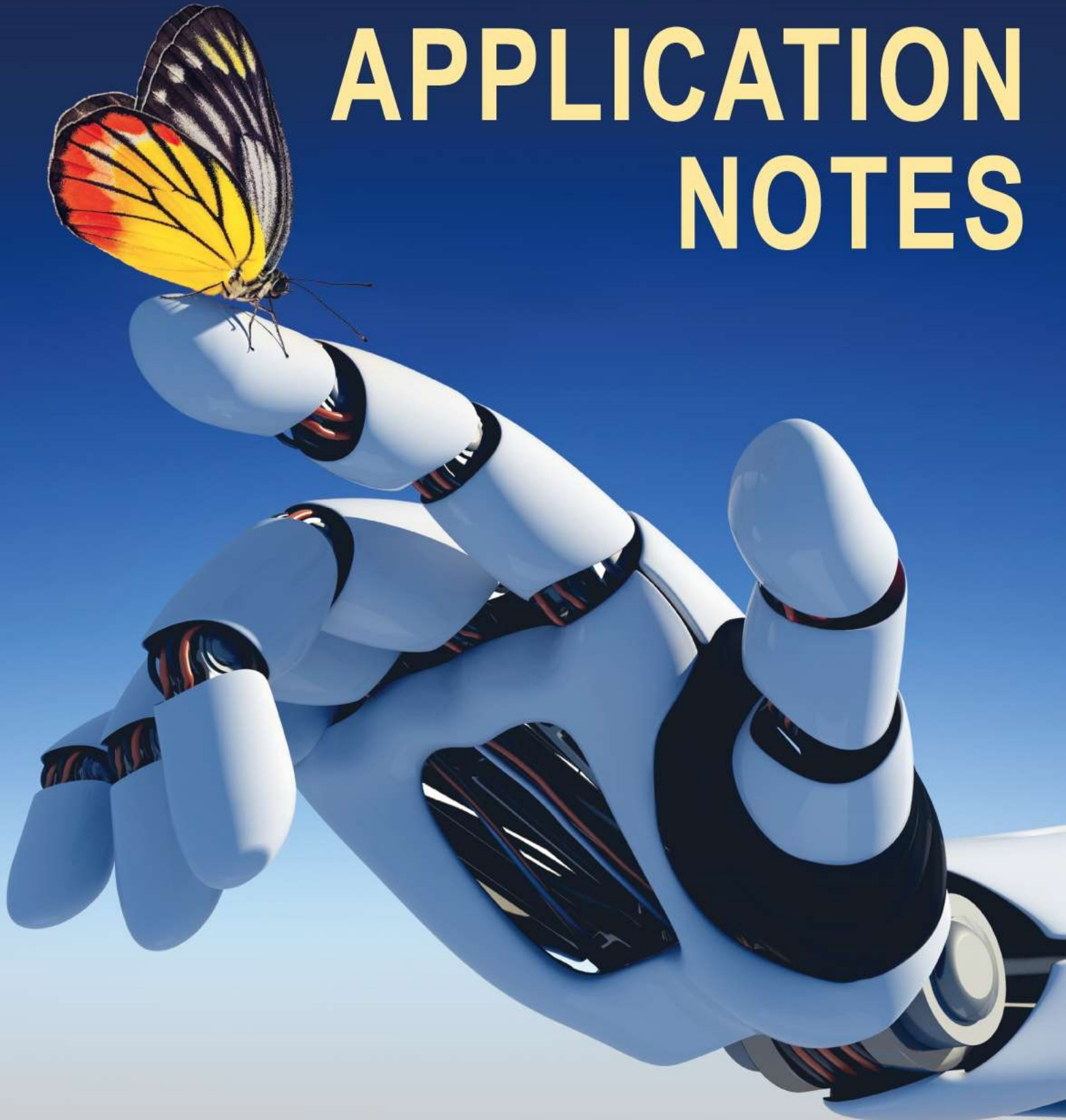# POWERGOOD

DC DC Converters
APPLICATION NOTES

ISO CE REACH COMPLIANT RoHS COMPLIANT UL

POWERGOOD Develops a Reliable Power Modules.

Absolute Maximum Rating

The absolute maximum ratings indicate limits beyond which damage to the device may occur.

Input supply voltage (voltage range 9-36V, 18-36 model) --- 50VDC
Input supply voltage (voltage range 18-75V, 36-75 model) -- 80VDC
Input supply voltage (voltage range 40-160 model) -------- 180VDC
Input supply voltage (voltage range 40-180 model) -------- 250VDC
Input supply voltage (voltage range 180-425 model) ------ 450VDC

Enable input voltage(referenced to –input pin ------------- 7VDC "See Enable Function Input,

Soldering methods for DC/DC Modules

1.The IPC-A-610 standard requires that solder fill at least 75% of the barrel to ensure a solid connection.
Ideally, all connections should have a 100% fill.
2. Hand-Soldering Guideline for Multi-layers PCB board
400ºC+/-10 ºC temperature on a 70W iron
(PINø1mm) 400℃ Soldering time <6S
(PINø2mm) 400℃ Soldering time <4S
3. Reflow soldering is not a suggested method for through-hole power modules due to many
process and reliability concerns. If you have this kind of application requirement, please contact
Power Good sales or FAE for further confirmation.

Removal of Soldered DC/DC Modules from PCB's

Should removal of the Powergood DC/DC's module from its soldered connection be needed, it is very important to thoroughly de-solder the pins using solder wicks or de-soldering tools. At no time should any prying or leverage be used to remove boards that have not been properly de-soldered first.

Input and Output Impedance

DC/DC's converters have been designed to be stable with no external capacitors when used in low ac-impedance input and output circuits. The DC/DC's performance and stability can be compromised by the use of highly inductive source impedances. The input circuit shown in Figure 1 is a practical solution that can be used to minimize the effects of inductance in the input traces. For optimum performance, components should be mounted close to the DC/DC converter.

I/O filtering, Input Ripple Current, and Output Noise

All models are tested/specified for input ripple current (also called input reflected ripple current) and output noise using the circuits and layout shown in .See Figures 1 and 2.
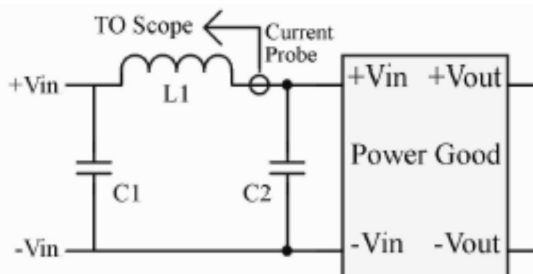

Figure 1. Measuring input Ripple Current

External input capacitors (C2) serve basically as energy-storage elements; they should be selected for bulk capacitance (at appropriate frequencies), low ESR, and high RMS ripple current ratings. The switching nature of DC/DC converters requires that DC voltage sources gave low AC impedance because highly inductive source impedance can affect system stability. In Figure 1, C1 and L1 simulate a typical DC BUS.

In critical application, output ripple/noise can be reduced below specified limits using filtering techniques, the simplest of which is the installation of additional external output capacitors. Output capacitors function as true filter elements and should be selected for bulk capacitance, low ESR, and appropriate frequency response.

In Figure 2, the two copper strips simulate real-world PCB impedances between the converter and its load. Scope measurements should be made using BNC connectors or the probe ground should be less than 1/2 inch and soldered directly to the fixture.
All external capacitors should have appropriate voltage ratings and be located as close to the converter as possible. Temperature variations for all relevant parameters should be taken into consideration.

The most effective combination of external I/O capacitors will be a function of line voltage and source impedance, as well as particular load and layout conditions.
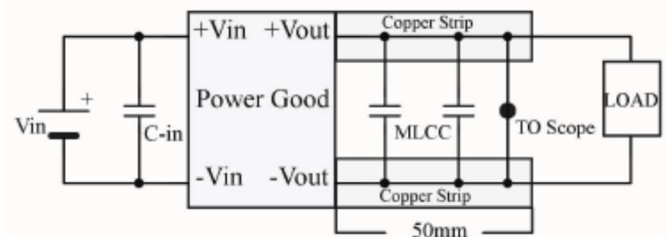

**Figure 2. Measuring Output Ripple/Noise
(20MHz bandwidth)**

Start-up Threshold and Under Voltage Lock Off

Under normal start-up conditions, DC/DC's converters will not begin to start until the ramping input voltage exceeds the Start-up Threshold. Once operating, devices will turn off when the applied voltage drops below the Under Voltage Lock Off point. Devices will remain off as long as the under voltage condition continues. Units will automatically re-start when the applied voltage is brought back above the Start-up Threshold. The hysteretic built into this function avoids an indeterminate on/off condition at a single input voltage. See **Electrical Specifications** table for actual limits.

Start-Up Time

There are two Start-Up Times. The first, Input to Output Start-Up Time is the interval between the point at which a ramping input voltage crosses the Start-Up Threshold voltage and the point at which the fully loaded output voltage enters and remains within it specified ±1% accuracy band. Actual measured times will vary with input source impedance, external input capacitance, and the slew rate and final value of the input voltage as it appears to the converter. The second, Enable to Output Start-Up Time assumes the converter is turned off via the Enable control with the nominal input voltage already applied. The specification defines the interval between the point at which the converter is turned on and the point at which the fully loaded output voltage enters and remains within its specified ±1% accuracy band.

Enable Control
The primary-side, Enable Control function can be specified to operate with either positive or negative polarity. Positive-polarity devices are enabled when the enable pin is left open or is pulled high. See **Electrical Specifications** table for Enable Function Input
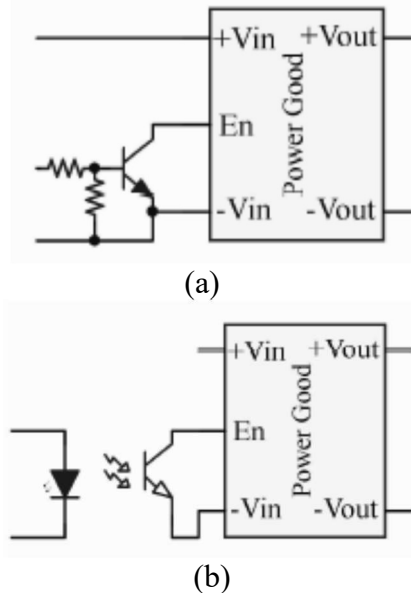
Positive-polarity
Devices are disabled when the enable pin is pulled low (under +1.0V with respect to –input).

Negative-polarity
Devices are off when the enable pin is high/open and on when the enable pin is pulled low.
See Figure 3 for the connection example.

(a)

(b)

Figure 3. Driving the Enable Control pin

Dynamic control of the remote enable function is best accomplished with a mechanical relay or an open collector/ open drain drive circuit. The drive circuit should be able to sink appropriate current when activated and withstand appropriate voltage when deactivated.

Current Limiting
When power deliver of the converters higher than the rated power, the DC/DC converter will go into a current limiting mode. In this condition, output voltages will decrease proportionately with increases in output current, thereby maintaining somewhat constant power dissipation. This is commonly referred to as power limiting. Current limit inception is defined as the point where the full power output voltage falls below the specified tolerance. If the load current being drawn from the converter is significant enough, the unit will go into a shot circuit condition. See "Short Circuit Condition.

Short Circuit Condition
When a converter is in current limit mode the output voltages will drop as the output current demand continuously increases to excess the pre-setting point then controller will shut down the converter. Following a timeout period of 10 to 20 milliseconds. The converter will restart and build up the output voltages to their appropriate values. If the short circuit condition persists, another shutdown cycle will be initialed. This on/off cycling is referred to as "hiccup" mode. The hiccup cycling reduces the average output current, thereby preventing internal temperatures from rising to excessive levels. The converter is capable of enduring an indefinite short circuit output condition. About the detailed protection function, see "Output Power Protection.

Thermal Shutdown
The DC/DC converters are equipped with thermal shutdown circuitry. If the internal temperature of the converter rises above the designed operating temperature, the OTP function will shut down the unit. When the internal temperature decreases below the threshold of the temperature setting, then the units will self-restart. See **Electrical Specifications** table for Over Temperature Protection.

Output Over Voltage Protection
The output voltage is monitored by an OVP circuitry. If the output voltage or the voltage apply from external of the converter rises to a fault condition (pre-setting value), which could be damaging to the load circuitry, then OVP circuitry will shut down the unit until the Input Voltage or Enable Input was recycled.
Apply an external voltage to the Synchronous-Rectifier models may cause permanent damages on the module.
OVP set-point is 10% higher than maximum output voltage.

Dual output：
converter will shutdown if Vout > Vout nominal + 10%.

Single output：
converter will shutdown if Vout > Vout nominal
+ 20%.Because the single output converters have a trim function that allows users to adjust the output voltage from +10% to –10%; hence, the Output Over Voltage Protection is setting > 20%,to avoid trim voltage influences OVP.

Output Voltage (typ.)		3.3V	5.0V	12V	15V	24V
OVP Trip Value	Single Output	3.96V	6V	14.4V	18V	28.8V
	Dual Output	n/a	n/a	13.2V	16.5V	26.4V

Input Reverse Polarity protection
If the input voltage polarity is accidentally reversed, an internal diode will become forward biased and likely draw excessive current from the power source. If the source is not current limited nor the circuit appropriately fused, it could cause permanent damage to the converter.

Input Fusing
Certain applications and/or safely agencies may require the installation of fuses at the inputs of power conversion components. Fuses should also be used if the possibility of a sustained, non-current limited, input voltage polarity reversal exists. Generally, using a slow blow fuse with 200% approx. of the max. input current, for example, for ESB/C series DC/DC converters, slow blow fuses are recommended with values no greater than the following. See every datasheets for Over Temperature Protection.

Output Power Rank	ESB/C24/36Models Fuse Value	ESB/C48 Models Fuse Value
10 W	1.0 Amps	0.5 Amps
15 W	2.0 Amps	1.0 Amps
20 W	2.5 Amps	1.5 Amps
25 W	3.0 Amps	1.5 Amps
35 W	4.0 Amps	2.0 Amps

Trimming Output Voltage – for Single output models

Only the single output converters have a trim function that allows users to adjust the output voltage from +10% to –10%, please refer to the trim table in every datasheet for details.

Adjustments to the output voltage can be used with a simple fixed resistor as shown in Figures 4 and 5. A single fixed resistor can increase or decrease the output voltage depending on its connection. Resistors should be located close to the converter.

※ If the trim function is not used, leave the trim pin open.

※ Trim adjustments higher than the specified range can have
an adverse effect on the converter's performance and
are not recommended.

Excessive voltage differences between output voltage and sense voltage, in conjunction with trim adjustment of the output voltage; can cause the OVP circuitry to activate.

Thermal de-rating is based on maximum output current and voltage at the converter's output pins. Use of the trim and sense functions can cause output voltages to increase, thereby increasing output power beyond the converter's specified rating. Therefore: (V_{OUT} at pins) X (I_{OUT}) $\leqq$ rated output power
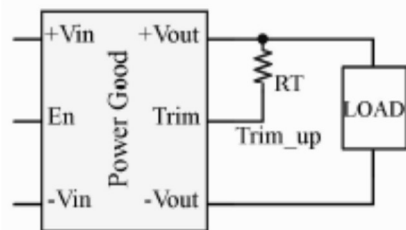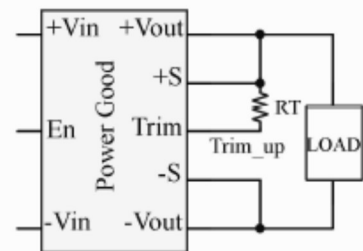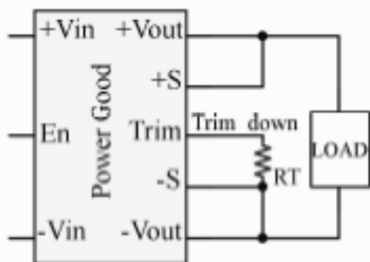

(a)
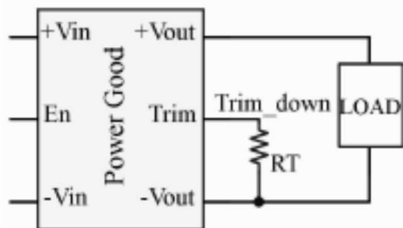
(b)

**Figure 4. Trim Connections To Output Voltages adjustment
For Non Brick Series**

(a)

(b)

**Figure 5. Trim Connections To Output Voltages adjustment
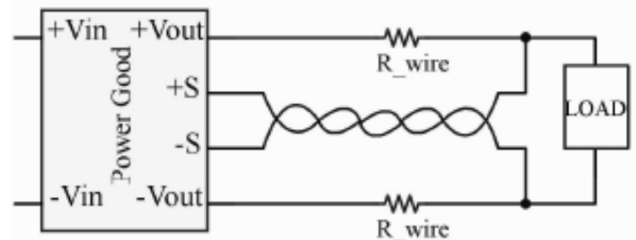For Brick Series**

Remote Sense

Expect for non-brick series converters, all brick series converters employ the remote sense feature to provide point of use regulation, thereby overcoming moderate IR drops in pcb conductors or cabling. The Sense and VOUT lines are internally connected through low value resistors. Nevertheless, if the sense function is not used for remote regulation, the user should connect the +Sense to +VOUT and –Sense to –VOUT at the DC-DC converter pins as shown in Figure 6(a) below.

The remote sense lines carry very little current and therefore require minimal cross-sectional-area conductors. The sense lines are used by the feedback control-loop to regulate the output. As such, they are not low impedance points and must be treated with care in layouts and cabling. Sense lines on a pcb should be run adjacent to dc signals, preferably ground. In cables and discrete wiring applications, twisted pair or other techniques should be implemented as shown in Figure 6(b) below.
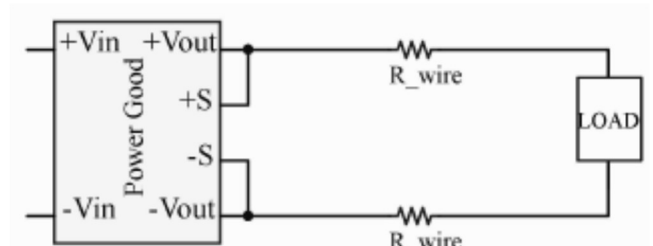
(a)

(b)

Figure 6. Remote Sense Circuit Configuration

All brick series converters will compensate for drops between the output voltage and the sense voltage at the DC-DC provided that:

[Vout(+) –Vout(–)] –[Sense(+) –Sense (–)] $\leqq$ 5% Vout

Floating Outputs

Since these are isolated DC/DC converters, their outputs are "floating" with respect to their input. Designers will normally use the -Vout as the ground/return of the load circuit. You can, however, use the +Vout as ground return to effectively reverse the output polarity.

Minimax Output Load Requirement

All DC/DC converters regulate within spec and are stable under no-load to full load conditions. Operation under no-load conditions however might slightly increase the output ripple and noise.

EMI Consideration

ESB/C series converters can meet Class B in EN 55032, CISP 22 and FCC part 15J without external Filter. Except for ESB/C series, the conducted EMI measurement is recommended to use a simple extra circuit at input of DC/DC converters to meet the standard. The extra π filter usually consists of two parallel capacitors and a series inductor below. For further details, please contact us.
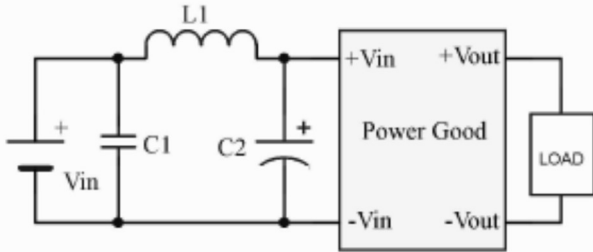

Figure 7. Recommended extra conducted EMI filter

Connection in Series

There are two types of the applications, one is to create positive and negative voltages, one is to build higher output voltage.
Connection methods are shown as below：
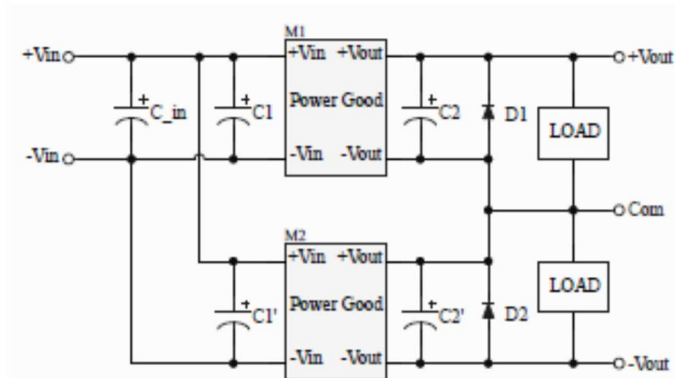
(1) Positive and negative output voltage

Figure 8. Positive and negative output voltage

(2) the output voltage increasing

If there is no reverse blocking diode in the power supply, we should add an external blocking diode to prevent the damage of power supply while starting up. The voltage rating of the external diodes must be greater than 2 times of Vout. The current rating of external diodes shall be greater than rating output current of each converter. See Figure 9.
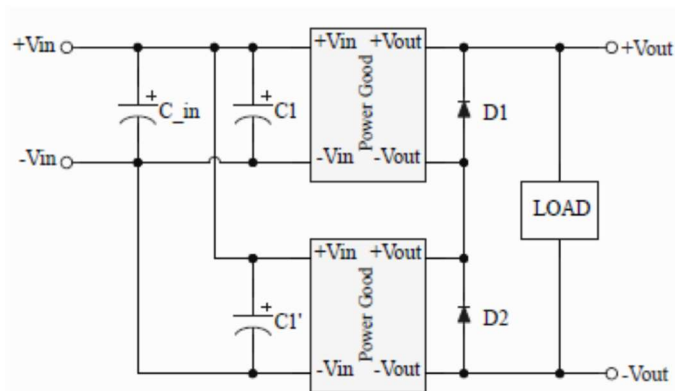

Figure 9. output voltage Increasing

Connection in Parallel

In general, there are two types of the parallel methods, one is active and the other is passive.

(1) Active current share

All DC/DC series converters don't provide an active parallel function.

(2) Passive current share

A simple method of parallel connection is the use of an oring diode on each unit. See figure 10. By adjusting the outputs with Potentiometers, it is possible to achieve the current sharing of the units. Figure 11.1 and figure 11.2 show the relation between output voltage and output load current.

The voltage rating of the external diodes must be greater than Vout. The current rating of external diodes should be greater than 2 times of each output.

The strength is that it's oring diode will become reversed biased and reduce the failure rate from affecting the bus voltage. This is the essential feature in a redundant power configuration. The weakness is the power loss in the diodes and dissipating the heat generated in the diodes. The loss is significant and should always be considered.
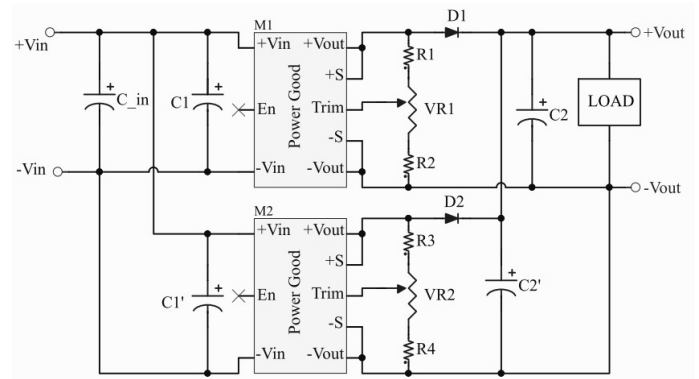
Figure 10. Connection in Parallel

SHB110120-V-P-B300-2PCS

Test Watt	Module 1		Module 2		ΔI
	Vout(V)	Iout(A)	Vout(V)	Iout(A)	
60W	12.020	3.1	12.019	2.8	9.52%
120W	12.018	5.8	12.018	5.4	7.14%
180W	12.017	8.3	12.016	7.8	6.21%
240W	12.013	10.7	12.012	10.3	3.81%
300W	12.009	13.1	12.009	12.9	1.54%
360W	12.008	15.4	12.008	15.3	0.65%
420W	12.006	18.2	12.005	17.8	2.22%
480W	12.005	20.4	12.005	20.4	0.00%
540W	12.002	23.0	12.002	23.2	0.87%
600W	12.000	25.2	12.001	25.6	1.57%
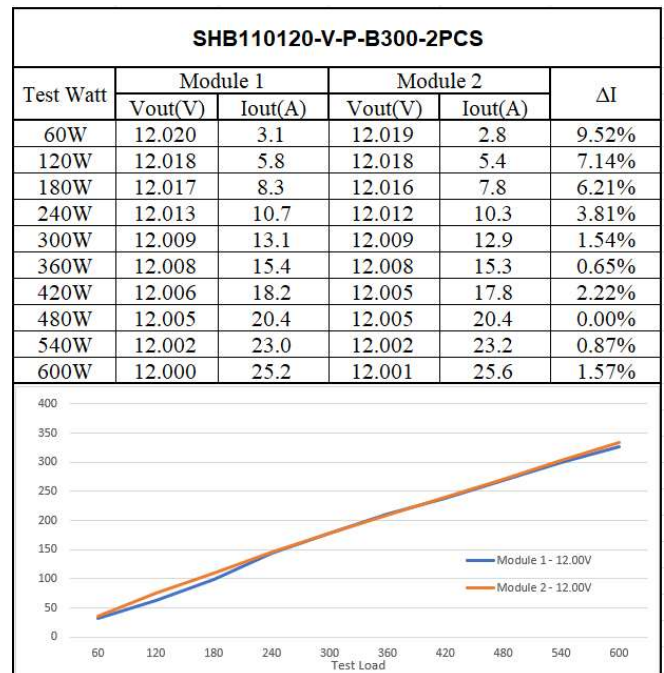
Figure 11.1 four module parallel

SHB110120-V-P-B300-4PCS

Test Watt	Module 1		Module 2		Module 3		Module 4	
	Vout(V)	Iout(A)	Vout(V)	Iout(A)	Vout(V)	Iout(A)	Vout(V)	Iout(A)
120W	12.020	2.59	12.019	3.0	12.012	2.3	12.011	2.1
240W	12.018	5.28	12.018	6.3	12.011	4.5	12.011	3.8
360W	12.017	8.28	12.016	9.2	12.010	6.7	12.010	5.8
480W	12.013	12.03	12.012	12.1	12.008	8.3	12.009	7.5
600W	12.009	14.81	12.009	14.8	12.005	10.5	12.006	9.8
720W	12.008	17.57	12.008	17.4	12.003	12.8	12.004	12.2
840W	12.006	19.83	12.005	20.1	12.000	15.1	12.002	15.0
960W	12.005	22.47	12.005	22.6	11.998	17.4	12.000	17.5
1080W	12.002	25.00	12.002	25.2	11.996	19.7	11.997	20.1
1200W	12.000	27.29	12.001	27.8	11.992	22.3	11.993	22.6

Figure 11.2 four module parallel

Redundancy

As stated above, DC-DC Converters' connection in parallel is used to reduce the failure rate and further to improve the reliability of the system. An important thing is that it's not desirable to lift power. Because the output voltage of the DC-DC converters can't be completely equal, the converter with higher output voltage may provide full load current. It does not matter but make sure that the output current from each power supply does not exceed the rated current. See Figure 12.
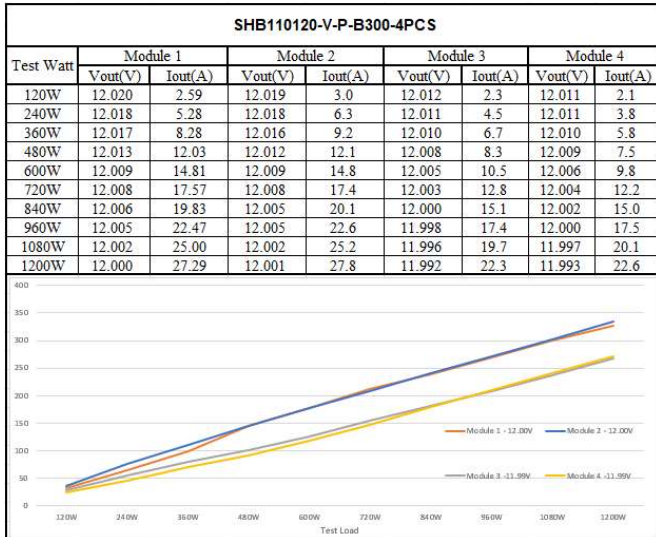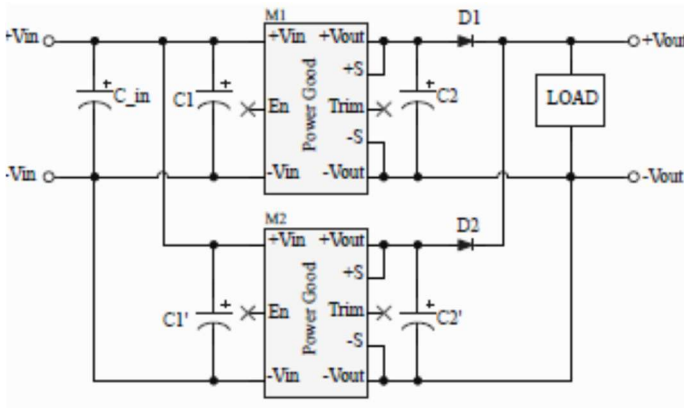

Figure 12. Redundant Connect

The method of testing OVP
1. Provide the module with typical input voltage and with 10% load.
2. Add an external voltage source (120% of the nominal) onto the secondary side.
3. After Step 2, OVP activates, which in turn the input current drops.
4. When the source is removed from the output side, the module recovers automatically and continues to function.