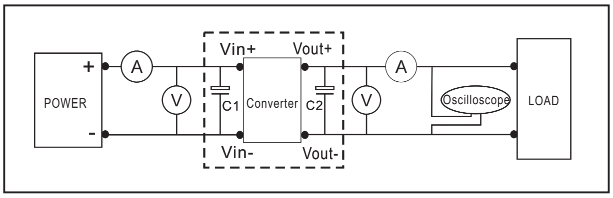
1. DC/DC Converter testing suggestions

After selecting the right converter based on input and output requirements, the correct testing method must be used to insure and verify specified performance parameters. The following are suggested test methods and test equipment requirements. Test conditions: room temperature TA=25℃ humidity<75%, rated input and rated load.



The model contains:

a) DC adjustable regulated power supply : output voltage range is suitable for DC/DC converter under test.

b) current meter A : accuracy 0.001A

c) voltage meter V: accuracy 0.001V

d) load resistance: rated load Rfull-load = Vout/Iout
unload Rmin-load =10x Rfull-load

e) wire: The larger cross section of copper the better. Using ohm's law, V=IR, make sure the wire used represents less than 0.1% of the overall voltages you are measuring.

Test

A: Wire

The proper wire shall be selected as described above. Smaller guage wire will result in potential errors in measuring the true efficiency and regulation parameters. Ensure all mechanical and solder connections are sound as this will also introduce errors.

B: Grounding

Improper grounding can cause unintended noise in the circuit. When testing ripple and noise, it is suggested that the single pole test method be used to lessen test error. (See graph “ripple and noise”)

C: Load

To insure useful test data, the testing load of regulated products should be within 10~100% of the rated output current/power, For unregulated product it is OK to test at no load, but be aware that the voltage accuracy is not specified at this load level.

D: Converter performance

After the input and output have been properly connected, performance testing can begin.

1) Input voltage accuracy:

Set input voltage at nominal value, output at rated load, the output voltage reading will be Vout, nominal output voltage will be Vnom. The formula:

$$\frac{V_{OUT} - V_{NOM}}{V_{NOM}} \text{ X100\%}$$

E.g. Regulated products IB1212LS-1W, the nominal input voltage is 12V, rated load is 144 ohm, the output voltage reading will be 12.039V.

$$\frac{12.039\text{VDC} - 12.000\text{VDC}}{12.000\text{VDC}} \text{ X100\%} = 0.325\%$$

2) Line regulation:

At nominal input voltage and full load, adjust input voltage over its full specified range.

a) Fixed input, isolated unregulated series:

$$\text{Line regulation} = \left| \frac{\Delta V_{OUT}}{\Delta V_{IN}} \right|$$

$$\Delta V_{OUT} = \frac{V_{OUT+10\%} - V_{OUT-10\%}}{V_{OUTNOM}} \%$$

$$\Delta V_{IN} = \frac{V_{IN+10\%} - V_{IN-10\%}}{V_{INNOM}} \%$$

In the formula:

$V_{in+10\%}$ nominal input voltage and add 10% as for its upper limit

$V_{in-10\%}$ nominal input voltage and minus 10% as for its lower limit

$V_{out+10\%}$ output voltage reading under full load when input voltage at its upper limit

$V_{out-10\%}$ output voltage reading under full load when input voltage at its lower limit

V_{innom} nominal input voltage

V_{outnom} output voltage reading under full load and nominal input voltage

If take for example, B0505LS-1W, connect a 25 ohm resistive load, input voltage range: ±10% (or 4.5V~5.5V),

$V_{in+10\%}$ =5.5 V; $V_{in-10\%}$ =4.5 V ; V_{innom}=5V

$V_{out+10\%}$ reads: 5.32V; $V_{out-10\%}$ reads:4.2V; V_{outnom} reads:4.77V

$$\Delta V_{OUT} = \frac{5.32\text{VDC} - 4.2\text{VDC}}{4.77\text{VDC}} \text{ X100\%} = 23.5\%$$

$$\Delta V_{IN} = \frac{5.5\text{VDC} - 4.5\text{VDC}}{5\text{VDC}} \text{ X100\%} = 20\%$$

$$\text{So the line regulation} = \left| \frac{\Delta V_{OUT}}{\Delta V_{IN}} \right| = 1.174$$

Vout=(5.32V-4.2V) / 4.77V *%=0.2348

Vin =(5.5V-4.5V) / 5V *%=0.2

B) Fixed input, isolated and regulated series, and wide input, regulated series:

$$\text{Line regulation} = \frac{V_{OUTN} - V_{MDEV}}{V_{OUTN}} \text{ X100\%}$$

At nominal input voltage, rated load, read output voltage as V_{OUTN}

At input voltage upper limit, rated load, read output voltage as V_{OUTH}

At input voltage lower limit, rated load, read output voltage as V_{OUTL}

V_{MDEV} chose in V_{OUTH} or V_{OUTL} the one deviated from V_{OUTN} more

3) Load regulation

As the input voltage is rated value, you can connect 10% and 100% constant resistance load and test the difference between 10% load and rated value & the difference between 100% load and rated value respectively.

$$\frac{V_{OUTNL} - V_{OUTFL}}{V_{OUTFL}} \%$$

$V_{out\ NL}$ output voltage at 10% load

$V_{out\ FL}$ output voltage at 100% voltage

e.g.: Fixed input product B0505XD-1W, rated load is U^2/P=144ohm, load range is 10%~100%, read

V_{outNL} = 5.29 V; V_{outFL} = 4.77 V; V_{outnom} = 5V

$$\text{load regulation} = \frac{5.29VDC - 4.77VDC}{4.77VDC} X100\% = 10.9\%$$

4) Efficiency

The proportion of input power and output power at rated input and rated load.

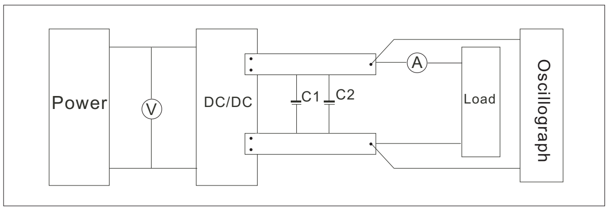
The formula:
$$\frac{I_{OUT} \times V_{OUT}}{I_{IN} \times V_{IN}} X100\%$$

e.g.: IB1212LS-1W, rated input 12V, full-load output 12.039V; current is 83.3mA, input current is 115.0mA.

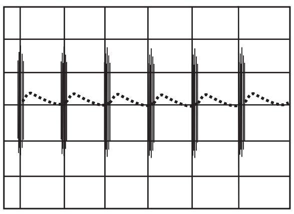
$$\frac{0.0833A \times 12.039V}{0.1150A \times 12.000V} X100\% = 73\%$$

5) Ripple and noise:

Ripple and noise is the AC component at the DC output, which affects output accuracy, we usually calculated ripple and noise with a peak to peak value(mVp-p) and test with parallel cable. As the figure shows:



As the DC/DC converter output end/side can contains high-frequency harmonics, and the common mode rejection ratio of most scopes is not so good, it is best to not use the ground wire provided on most probes. Attach the ground sleeve as shown in the figure above.



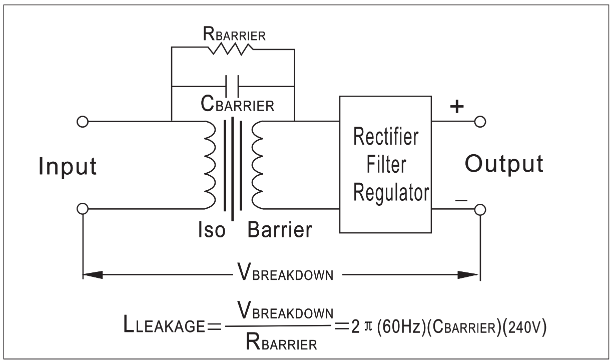
Tall, high frequency spikes are normally noise, and smaller lower frequency plots are generally ripple.

6) Start-up time

Start-up time is the time once the input voltage is present and within the specified range, the time it takes for the output of the converter to rise between 10% and 90% of its nominal value. This is usually tested and specified with a resistive load only. Other factors like additional output capacitance added by the customer can effect this time.

7) Isolation and insulation characters:

Isolation is one of the most important parameters of a DC/DC converter. Depending on the application, isolation values are typically between 1KV and 6KV depending on the DC/DC converter series. The isolation circuit drawing is shown in the figure below Isolation equivalent circuit:



$C_{BARRIER}$: Isolation capacitance; coupled between primary and secondary windings

$R_{BARRIER}$: Isolation resistance: DC resistance between input and output.

$I_{LEAKAGE}$: Leakage current; the current as a result of the input/output capacitance.

$V_{BREAKDOWN}$: Test voltage. It is usually 240VAC/60HZ.

$$Z_f = \frac{1}{J\ 2\pi f C_{IS}} \qquad I_L = \frac{V_{test}}{Z_f}$$

Zc = 1/(2*Pi*f*Cis) ***(there should not be a J in the denominator)****

When it refers to other value, this is the formula for Vbreakdown. Where:

C_{IS}: Isolation capacitance f: frequency V_{test}: test signal voltage

In general, DC/DC converters are constructed to minimize Isolation Capacitance, and therefore minimize Leakage Current.

For isolation testing,

Isolation, dielectric strength test: test 1 min., input/output (at AC/DC specified peak value)

Insulation resistance test: the value should be above 1GOhm when applying 500VDC from input/output

Note: Mornsun's G and H series products are of very low isolation capacitance (TYP: 10PF). This is to be able to meet the tough demands in the medical field.

AC-DC Converter Application Guidelines

1. Foreword

The following guidelines should be carefully read prior to converter use. Improper use may result in the risk of electric shock, damaging the converter, or fire.

1) Risk of Injury

A. To avoid the risk of burns, do not touch the heat sink or the converter's case.

B. Do not touch the input terminals or open the case and touch internal components, which cold result in electric shock or burns.

C: When the converter is in operation, keep hands and face at a distance to avoid potential injury during improper operation.

2) Installation Advice

A. Please make sure the input terminals and signal terminals are properly connected in accordance with the stated datasheet requirements.

B. To ensure safe operation and meet safety standard requirements, install a ***slow blow*** fuse at input of the converter.

C: Installation and use of AC/DC converters should be handled by a qualified professional.

D: AC/DC converters are used in the primary transmission stage of a design and thus, should be installed in compliance with certain safety standards.

E: Please ensure that the input and output of the converter are incorporated into the design out of the reach of the end user. The end product manufacturer should also ensure that the converter is protected from being shorted by any service engineer or any metal filings.

F: The application circuits and parameters shown are for reference only. All parameters and circuits are to be verified before completing the circuit design.

G: These guidelines are subject to change without notice; please check our website for updates.

2 General AC-DC Converter Applications

1) Basic Application Circuit

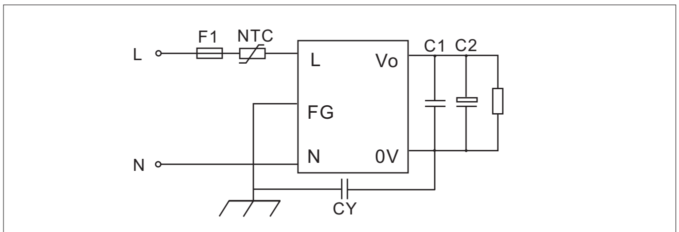


Figure 1. General AC-DC converter applications circuit

In Figure 1, F1 refers to the input fuse. Proper fuse selection should be a safety agency approved, slow blow fuse. Selection of the proper fuse rating is necessary to ensure power converter and system protection (potential failure if the rating is too high) and prevent false fuse blowing (which could happen if the rating is too low). Below is the formula to calculate the proper rating:

$I = 3 \times V_o1 \times I_o1$ / / Vin(min.)

V_o1 = output voltage

I_o1 = output current;

= the converter's efficiency;

Vin(min) = the minimum input voltage

Futher circuit notations:

¨**NTC** is a thermistor.

¨**CY** and CX are safety capacitors.

¨**C1** is a high frequency ceramic capacitor or polyester capacitor, 0.1ìF/50V.

¨**C2** is output filtering high frequency aluminum electrolytic capacitor. Select a 220ìF rating if the output current is greater than 5A, or a 100ìF rating if the output current is less than 5A. The insulation voltage should be derated to less than 80% of rated value.

For dual or triple output converters, the circuit of input side remains the same and the outputs should be considered independently in component selection (see Figure 3).

The application circuit shown in Figure 1 is typical application circuit, whereby all MORNSUN products will meet EMI Class B, and Class 3 lightening strike and surge testing (see component datasheets for more details). To comply with more stringent EMC testing, additional filtering should be incorporated. See Figure 2 for a suggested filtering circuit.

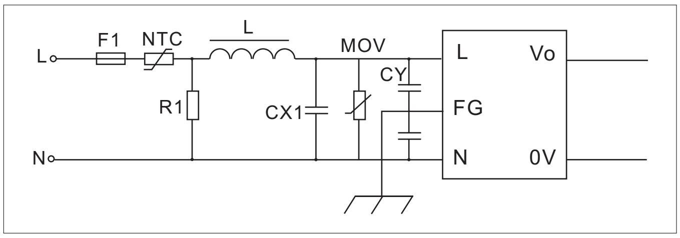


Figure 2. Input filter circuit

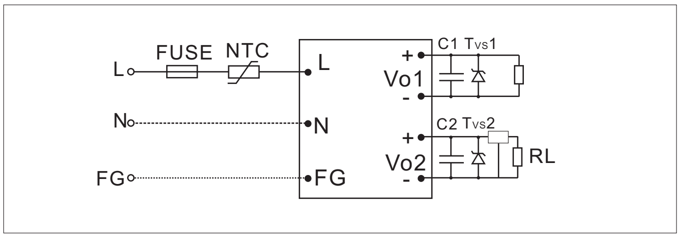


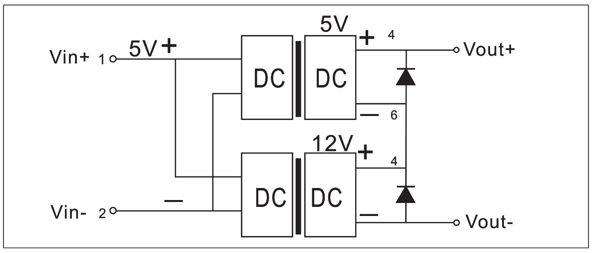
Figure 3. Typical application circuit

For multi-output converters, the main output is typically a fully regulated output. If the end application requires critical regulation on the auxiliary output(s), a linear regulator or other regular should be added after the converter. (Note: Some MORNSUN converters have built in linear regulators; please contact our Technical Department for details).

Additional converter applications

1) DC/DC converters used in series

Isolated DC/DC converters allow the connections of their outputs in series to create higher voltages if necessary. Please see figure below for proper series connection.



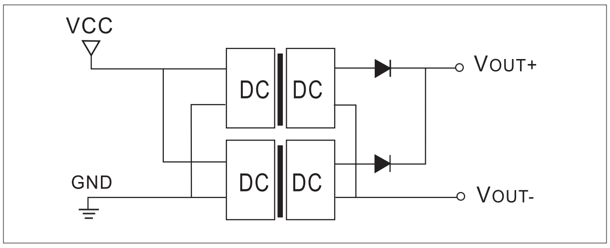
Converter 1 is 5Vout, and Converter 2 is 12Vout. As you can see a nominal 17VDC output converter can be created by applying the 5V and 12V converters in series. Be careful not to exceed the rated current either of the converters, as now the rated current is equal to which ever one is the lesser.

2) DC/DC converters connected in parallel.

While it is possible with some converters in some applications to be connected for parallel operation, it is generally not recom mended as one cannot guarantee that an equal current is shared by each converter. Isolation diodes help this, but it is not guaranteed.

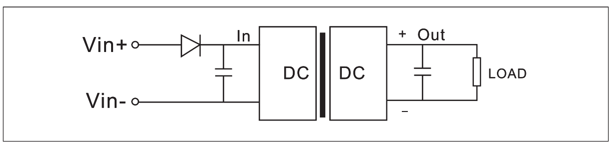
The following figure shows a parallel connection, but the actual application is redundancy. As long as the total power taken from the pair is equal to just a single converter, then if a converter fails, then the other will take over without loss of service.

Only identical converters should be connected in this manner.



3) Input reverse polarity protection

The "+" input is connected with positive pole of power supply and "-"input is connected with negative pole of power supply (In telecommunication field is -48VDC), So the high-voltage terminal should be connected with "+" input and the low-voltage terminal should be connected with "-" output, otherwise, it will cause the permanent damage. It is recommended to connect a diode to protect the input stage, if inadvertent connection of the input is possible. Note that the diode will dissipate power and create heat.

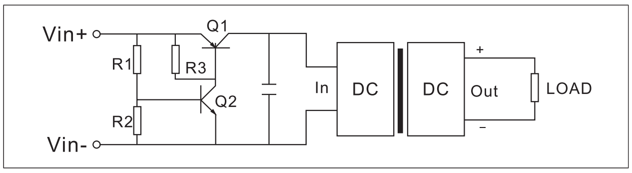


It is recommended to connect a low voltage drop Schottky diode at "+" input as shown.

4) Input under voltage protection

When the DC/DC converter is sharing a power source with other circuits, a large input voltage drop caused by external circuits or over load can lead to an input voltage that is below the minimum input voltage specified by the converter. So it is recommended to adopt an under voltage protection circuit to cut off the DC input when the input voltage drops below the minimum specified for the converter.

Low voltage turn-off circuit

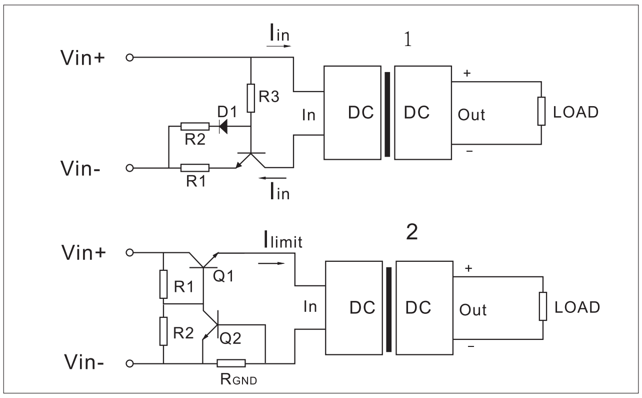


Where R1,R2 set as low voltage switching limit, PNP transistor can be used, or a p-channel MOSFET. Please consult factory for proper calculations.

Note: For low voltage input products, the above circuit will produce a 0.7V voltage drop.

5) Input short-circuit protection

Most unregulated DC/DC converters with RCC open loop circuit have no short-circuit protection. We especially recommend the following circuit to implement short circuit protection. As the figure shows:



Please consult factory for complete calculations.

Solution 1: Iin=1.4 * I (rated input current I) ;
R1=200/ Iin (acurracy: 1%) ;
R2=R1 * â(accuracy: 1%)
Vb=0.7+ [Iin * R1 * (â+1) / â * 1000]
R3=[(Vin-Vb) *R1 * R2 * (â+1)]/ {(Vb-0.7) * [R2+R1(â+1)]}

Solution 2: R_{GND}=0.7V / I limit (recommended)
Q1,Q2 can be common switching transistor

6) Over current and over voltage protection

The permitted input voltage and input current is restricted to be within the range specified on the dataheets to prevent damage to the DC/DC converter. Below are some techniques to add some additional over voltage protection and over current protection on a standard DC/DC converter. As the figure below: Please consult factory for specific recommendations.

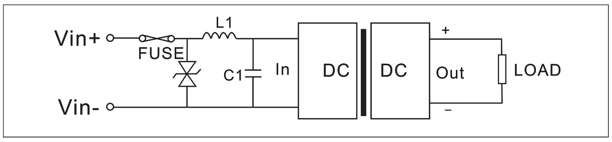


Figure 1：instant over voltage and over current protection circuit.

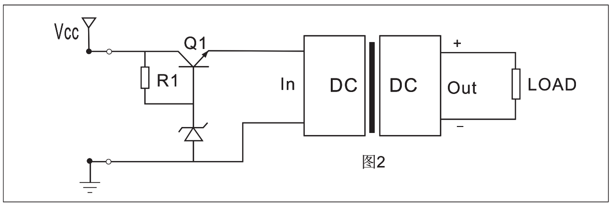


Figure 2: Continuous over voltage protection circuit.

As the figure shows:

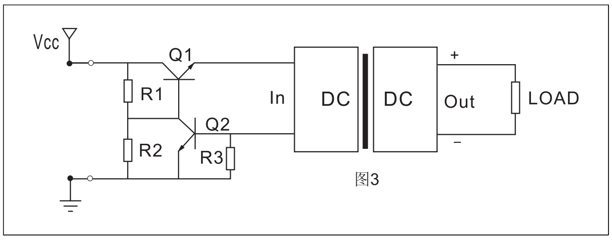


Figure 3: Continuous over current protection circuit

As the figure shows:

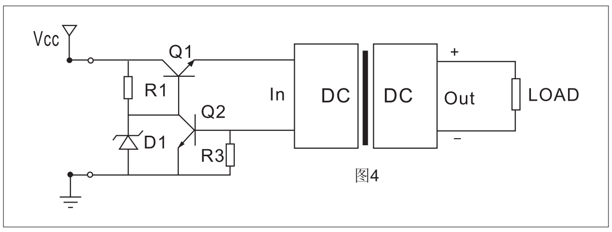


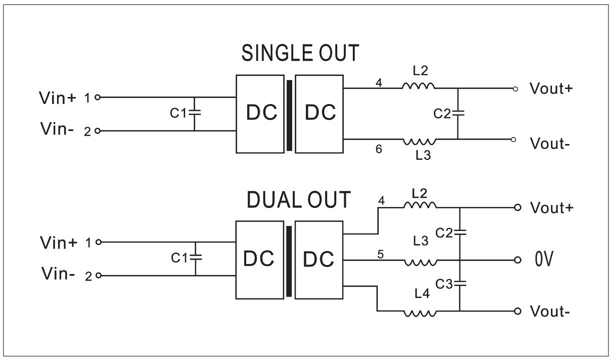
Figure 4. Continuous over voltage and over current protection circuit

7. Input and output filtering circuit

Most Mornsun DC/DC converters do not require additional components for filtering, etc. However, if further noise and ripple voltage reduction are required, here are some techniques.

1) Reduce ripple

Considerations here are that the additional output capacitance added, if excessive, may cause the DC/DC converter some difficulty during power up. In most cases this value is shown on the datasheet. Any questions, please consult the factory.



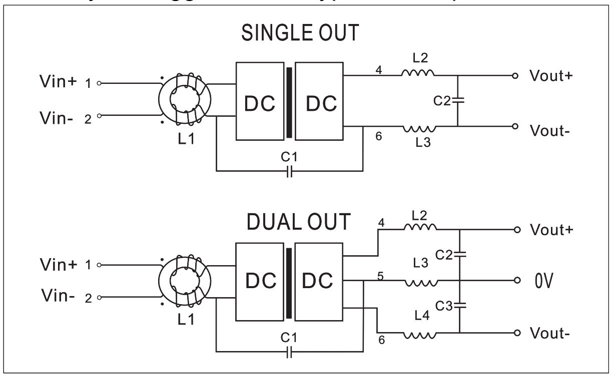
C1: EMI Filter and to reduce input ripple: connect aluminum electrolytic capacitor, please refer to datasheet to verify maximum capacitance value.

L2/L3/L4: Form an LC filter network to reduce output noise and ripple. It is recommended to use powered iron magnetic cores and copper magnet wire suitably rated.

C2/C3: Form an LC filter network to reduce output noise and ripple. It is recommended to use aluminum electrolytic capacitors. Please see datasheet for maximum values.

2) Noise reduction

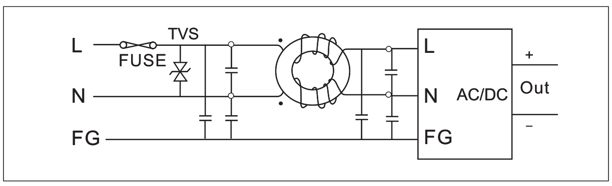
For proper calculations of these filter networks, please consult the factory for suggestions. A typical example is shown below:



8.Electromagnetic compatibility

As DC-DC converter is typically down stream from the incoming system AC power, where EMC requirements and regulations are required. However, Mornsun AC/DC products may fall into the requirements of these EMC regulations. Below is a recommended EMC filter circuit that can be employed on the same PCB that the Mornsun AC/DC converter is installed. Please contact factory for detailed calculations and suggestions. With the proper filter, Mornsun AC/DC power supplies will meet the standard Class B levels of EN55022 and others.

The following diagram is one of that for your reference.



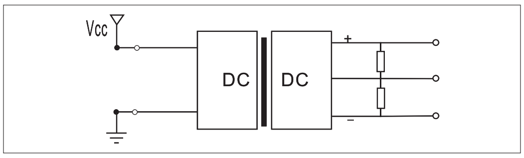
9.Capacitive load

To meet the requirements of capacitive loads, it is recommended for wide input series, the recommended capacitor is 100uF.

10.Output low load and overload protection

1) Low load prevention circuit

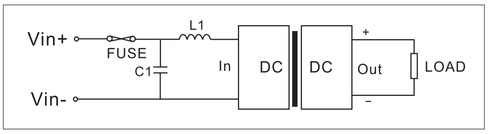
Most isolated DC/DC converters have some minimum load required to guarantee proper operation and regulation. Typically, this is 10% (non-isolated series can stand continuous unload). The output voltage will increase above stated spec for unregulated, For example, when converter is supplying power to a relay, MOSFET or IC of low power consumption(such as 485), it is recommended to guarantee a 10% load under worst case conditions.
As the figure shows:

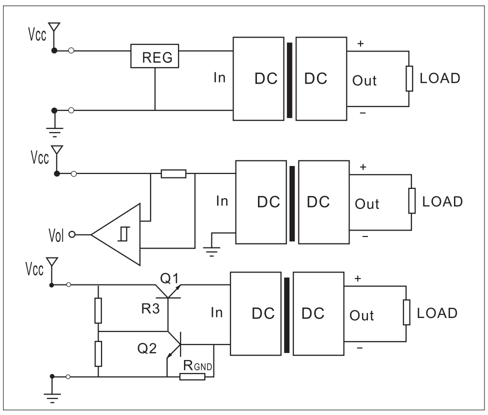


2) Overload prevention circuit

Though some current can be limited by a filter, when overload and/or short circuit conditions occur, a high current can cause damage to DC/DC converters. It is recommended that one installs a slow blow type fuse of rating 3 times max input current on the input as shown. Contact factory for details.

As the figure shows Simple overload protection





(1) Sometimes a circuit breaker can be used.

(2) Sometimes we also can avoid overload by limiting the input current as the above figure shows:

A: Utilize a pre-regulator to limit the input current, but the overall efficiency will be reduced.

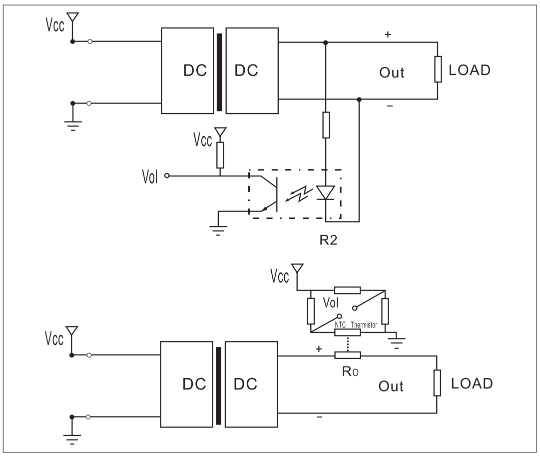
B: A series resistor network may be placed before the converter to limit current, but in all but a few cases, this is usually impractical.

C: To limit input current by setting R_{GND}, $0.7V=R_{GND}*I_{LIMIT}$ with an op amp circuit.

(3)

A: An opto-isolator can be used to limit PWM duty cycle.

B: A thermistor can be used to measure the current and provide feedback to the PWM.



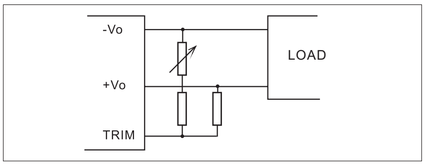
11. Special function pin explanation

1) Output voltage trimming range

Through adding a resistor at the TRIM terminal, the user can adjust the output voltage ±10% around its rated value. The total output power of the converter should be limited to its maximum specified output power.

Figure 1 shows how to connect the external trim resistors. If only to adjust to higher (or lower) voltage, the resistor could be connected only between TRIM terminal and negative output (or positive output). The general rules are, to increase output voltage, adding resistor between TRIM terminal and negative output is all that is needed; to decrease output voltage, then adding resistor between TRIM terminal and positive output is all that is needed. If TRIM is not needed, just leave it open circuit.

Figure 1: How to connect resistors for trimming



2） Remote on/off control

Remote ON/OFF control refers to the turning on or off the converter by external means. Remote on/off control pin is usually called CTL terminal, CNT terminal or REM terminal. There're two standard remote control models.

Positive Logic:

CTL terminal connected directly to -VIN, output OFF; CTL terminal open or connected to up level (TTL High) output ON.

Negative Logic:

CTL terminal connected directly to -VIN, output ON; CTL terminal open, output OFF.

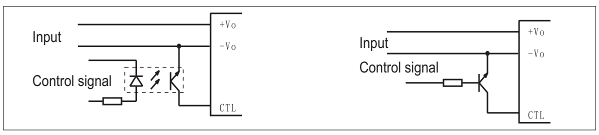


Figure 2: isolated control method Figure 3: general control method

In some special applications, isolated control method is required, see figure 2 for the reference circuit.