APPLICATION NOTES

ATQ300 SERIES
18-75VDC INPUT / 300W OUTPUT
4:1 ISOLATED DC-DC CONVERTER

Advanced Technology Applications Qualified

"**A**chieve **T**otal **A**ssurance and **Q**uality in Power."

ATQ300 SERIES APPLICATION NOTES

The ATQ300 Series provides a high-performance solution for demanding power conversion applications. With its 300-Watt output power, 18 - 75VDC input voltage and 4:1 input voltage range, this isolated DC-DC converter ensures reliable operation and high efficiency. It is engineered for robustness supports a wide operating temperature range and complies with industrial standards.

I. *Compliant with MIL-STD-1275(*)(**) with external components*
II. *Compliant with MIL-STD-704(*)(**) with external components*

NOTE: * Suitable for COTS use. If the product is intended to be used with a military system, it must be tested in the internal structure of a system subject to military tests. ATAQ does not guarantee the use of this product in military and medical products.
** Modules with 18-75VDC input have limited compliance with MIL-STD-1275 and MIL-STD-704 standards when used with external components.

FEATURES TABLE

Feature	Specification	Details
Ultra-Wide Input Voltage:	18 – 75 VDC	- Over-Temperature, Over-Current, Short-Circuit, Over-Voltage, Under-Voltage Lockout protection. - Turned off by the ON/OFF input. - Output voltage trim range of ±10%. - Remote sense for the output voltage. - 2.40" L x 2.28" W x 0.50" H (61.0mm L x 57.9mm W x 12.7mm H) - Complies with safety standards for reliable operation.
Efficiency:	Up to 90%	
Switching Frequency:	Fixed, 220kHz	
Output Regulation:	Regulated Outputs	
Remote On/Off:	Yes	
Protection:	Fully (OTP/OCP/OVP/UVLO)	
Isolation Voltage:	1500Vdc I/O Isolation	
Operating Case Temperature:	-40°C to +100°C	
Package Size:	Half Brick Size	
Safety Approval:	UL60950-1 2nd Edition	

ELECTRICAL BLOCK DIAGRAM:

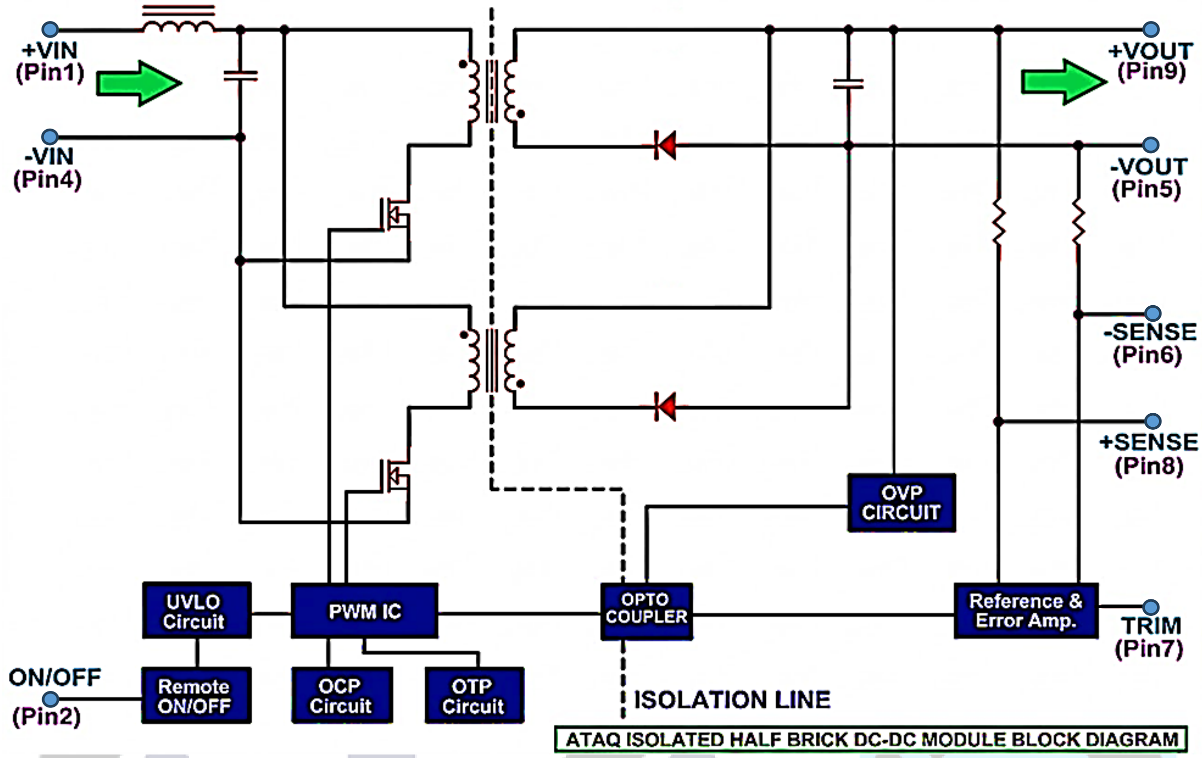


Figure-1

INPUT FILTERING AND EXTERNAL CAPACITANCE:

Figure 5 provides a diagram showing the internal input filter components. This filter dramatically reduces input terminal ripple current, which otherwise could exceed the rating of an external electrolytic input capacitor.

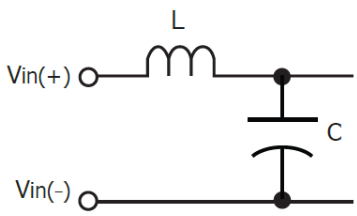
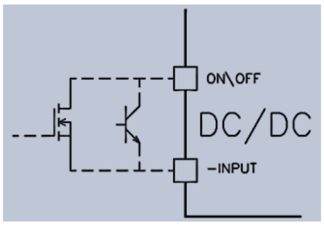


Figure-2: *Internal Input Filter Diagram*

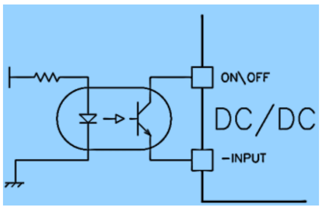
REMOTE ON/OFF:

The ON/OFF input pin permits the user to turn the power module ON or OFF via a system signal. The remote ON/OFF is available. Positive logic turns the module on during a logic high voltage on the ON/OFF pin, and OFF during a logic low.

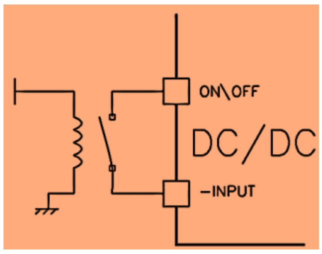
A properly de-bounced mechanical switch, open collector transistor, or FET can be used to drive the input of the ON/OFF pin. If not using the remote ON/OFF feature: For positive logic, leave the ON/OFF pin open.



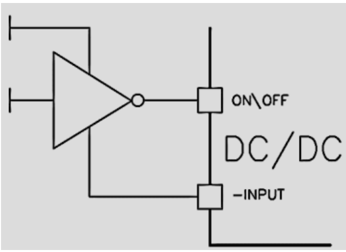
Some of the more common methods of interfacing to the ON/OFF pin. Shows a discrete NMOS or NPN transistor.



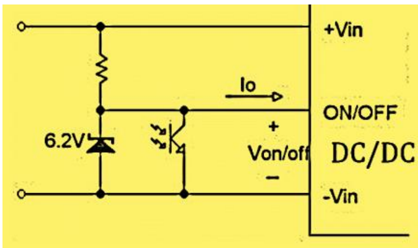
Shows an isolated ON/OFF driver using an optocoupler.



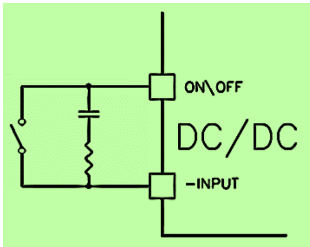
Shows a low power relay which also offers isolation.



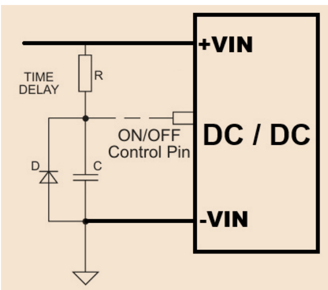
A standard TTL or CMOS driver can sometimes be used although .open



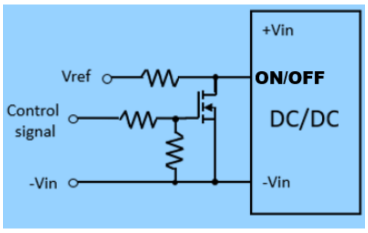
Level Control Using Line Voltage.



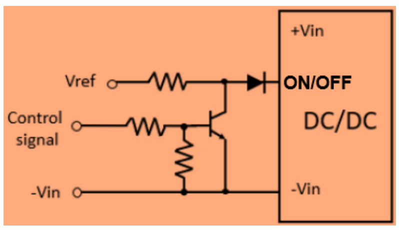
Any ON/OFF switch can be used.



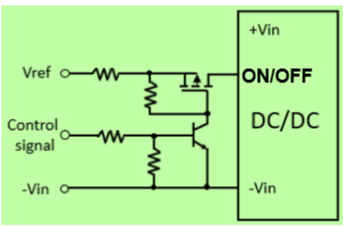
Soft-Start enabled RC delay circuit for controlled and stable power-on.



Signal interface and driver circuit for high-power switching controlled by low-current signals (MCU compatible). Designed for **Positive Logic:** Module activates when ON/OFF pin is pulled High. (Use N-Ch Mosfet).



Signal interface and driver circuit for high power switching controlled by low-current signals (MCU compatible). Designed for **Positive Logic**: Module activates when CTRL pin is pulled High. (Use NPN Transistor).



Positive logic level shifter circuit used to adapt different signal levels and actively drive the ON/OFF pin with Vref.

Figure-3a: Remote ON/OFF Medhods

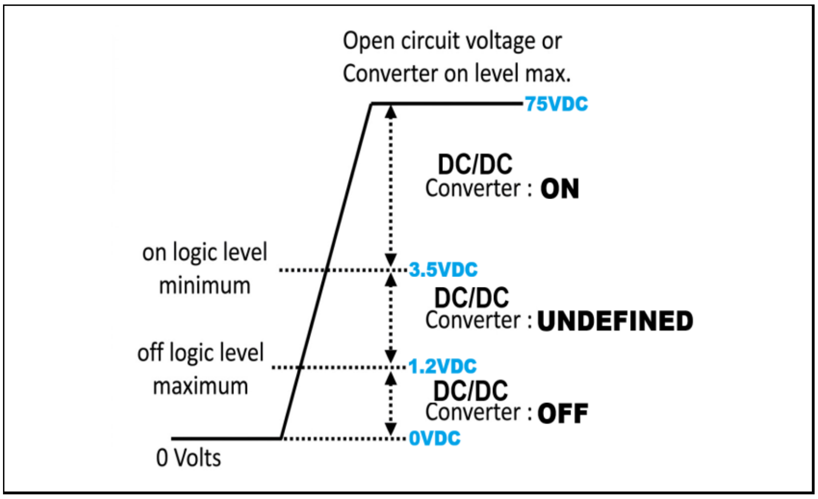


Figure-3b: Remote ON/OFF - Voltage Level Control for ON/OFF Pin

Remote ON/OFF Application Notes - Positive Logic

The DC-DC converters in this series are configured to operate with Positive Logic.

- When the ON/OFF pin is left floating or is in a high impedance/voltage state, the module is in the ON state.
- When the ON/OFF pin is pulled to the -Vin (Ground) pin (short-circuited), the module transitions to the OFF state.

When designing microcontroller (MCU) compatible external driver circuits (e.g., Transistors, MOSFETs, Level Shifters), the following critical aspects must be carefully considered:

1. Maximum Voltage Limit (Critical Warning): The external reference voltage (Vref) used to actively drive the ON/OFF pin must strictly not exceed the maximum ON/OFF pin voltage limit specified in the "Absolute Maximum Ratings" table of this document. Applying voltage levels exceeding this limit will cause permanent damage to the device.
2. Logic Inversion: In standard open-collector driver circuits utilizing an NPN transistor or N-Channel MOSFET, when the control signal from the microcontroller is "High" (Logic 1), the driver switch conducts and pulls the ON/OFF pin down to the -Vin level. Consequently, the module turns OFF. This hardware-level logic inversion must be taken into account during microcontroller software development.

OUTPUT OVER VOLTAGE PROTECTION:

The converter is protected against output over voltage conditions. When the output voltage is higher than the specified range, the module enters a hiccup mode of operation. The operation is identical with over current protection.

OVER TEMPERATURE PROTECTION:

These modules have an over-temperature protection circuit to safeguard against thermal damage. When the case temperature rises above over temperature shutdown threshold, the converter will shut down to protect it from overheating. The module will automatically restart after it cools down.

OPERATING TEMPERATURE RANGE:

The ATQ150 series converters can be operated within a wide case temperature range of -40°C to 100°C. Consideration must be given to the de-rating curves when ascertaining the maximum power that can be drawn from the converter.

The maximum power drawn from half-brick models is influenced by usual factors, such as:

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

REMOTE SENSE FUNCTIONALITY :

The ATQ150-WH series converters feature remote sensing capabilities on both output lines. This functionality shifts the effective output voltage regulation point from the module's output terminals directly to the load connection point.

By utilizing remote sense, the converter automatically adjusts its output voltage to compensate for voltage drops across distribution lines (such as PCB traces or cables), ensuring precise voltage regulation exactly at the point of load.

Remote Sense Voltage Range Limit:

The total allowable voltage drops compensated by the remote sense feature is strictly limited. The difference between the voltage at the output terminals and the voltage at the sense pins must not exceed 10% of the nominal output voltage:

The remote-sense voltage range is:

[(+Vout) - (-Vout)] – [(+Sense) – (-Sense)] ≦ 10% of Vo_nominal

If the remote sense feature is not required in your application, the sense pins must be connected locally to ensure stable and proper voltage regulation.

In this case, 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. This is shown in the schematic below. (Figure-8b).

DESIGN EXAMPLE:

24V Nominal Output Module (Vo_nominal = 24V)
For this specific module, the maximum distribution voltage drop (cable or PCB trace loss) that the Remote Sense feature can compensate for is strictly limited to 10% of the nominal output voltage, which equates to 2.4V.

Utilizing Remote Sense (Compensating for Line Drop)
Assume there is a long cable or a thin PCB trace between the DC-DC module and the load. The load requires exactly 24.0V for stable operation.

However, due to the resistance in the wiring (copper loss), a total distribution voltage drop of 1.5V occurs across the lines.

Sense Pins:
Connected directly across the load terminals, they sense the actual voltage at the load:

(+Sense) - (-Sense) = 24.0V

Vout Pins:
To overcome the 1.5V distribution loss and successfully deliver 24.0V to the load, the module automatically increases the voltage at its main output terminals:

(+Vout) - (-Vout) = 25.5V

Formula Verification:
25.5V - 24.0V = 1.5V

Since the calculated 1.5V difference is well below the maximum compensation limit of 2.4V (10% of 24V), the module will seamlessly and safely regulate the system.

[(+Vout) - (-Vout)] – [(+Sense) – (-Sense)] ≦ 10% of Vo_nominal
1.5V ≦ 2.4V

If the distribution drop were 3.0V instead, it would exceed the 10% limit, meaning the module would not be able to fully compensate for the voltage drop and could potentially trigger its over-voltage or over-power protection mechanisms.

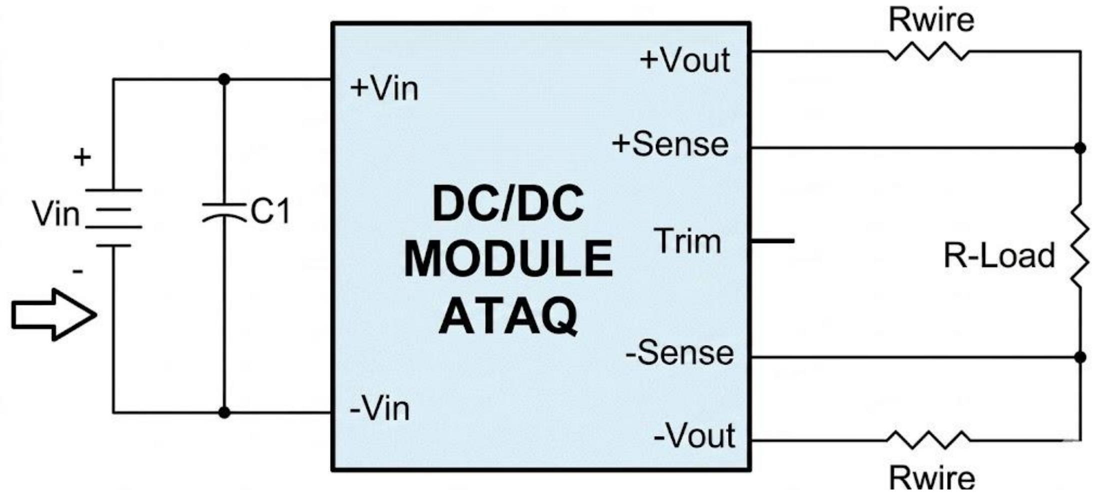


Figure-4

OUTPUT VOLTAGE ADJUSTMENT (TRIM / REMOTE SENSE) AND POWER LIMITS

When utilizing the Trim and Remote Sense features to adjust the output voltage of the ATQ300-EH series modules, the following critical operational limits must be strictly observed:

Maximum Voltage Variation:
Although the output voltage can be varied (increased or decreased) using both the Remote Sense and Trim pins, the maximum permissible variation for the output voltage is the larger of the two individual values, not the sum of both values.

Power Limits when Trimming Up:
The total output power delivered by the module is the product of the voltage at the output terminals and the output current (Pout = Vout \ Iout).

Increasing the output voltage via Remote Sense or Trim will consequently increase the total output power if the load current remains unchanged.

Users must ensure that the module's output power remains at or below the maximum rated power (300W) under all conditions.

Current Limits when Trimming Down:
If the set output voltage (Vo.set) is adjusted below the nominal value (24V), the maximum available output power (Pout.max) will decrease accordingly. This occurs because the maximum rated output current (Io.max) is an absolute limit that cannot be exceeded.

Absolute Power Equation:
Consequently, the maximum output power is strictly dictated by the following absolute limit equation: Pout.max = Vo.set \ Io.max

DESIGN EXAMPLE FOR ATQ300-EH48S24:
The nominal output current limit for this module is Io.max = 12.50A (300W / 24V nominal).

Trimming Down:
If the output voltage is trimmed down to 20V, the maximum allowable output power is no longer 300W, but rather 250W (20V \times 12.5A). Exceeding 6.25A will trigger over-current protection.

Trimming Up:
If the output voltage is trimmed up to 26.4V (+10%), the maximum allowable output current must be derated to 11.36A (300W / 26.4V) to ensure the 300W maximum power rating is not exceeded.

OUTPUT CAPACITANCE:

For good transient response, low ESR output capacitors should be located close to the point of load. 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. The minimum output capacitance is 100uF which needs three or four-times capacitance when operating below -20℃ and the absolute maximum value of ATQ150 series' output capacitance, please refer to maximum output capacitance.

INPUT FUSING AND SAFETY CONSIDERATIONS:

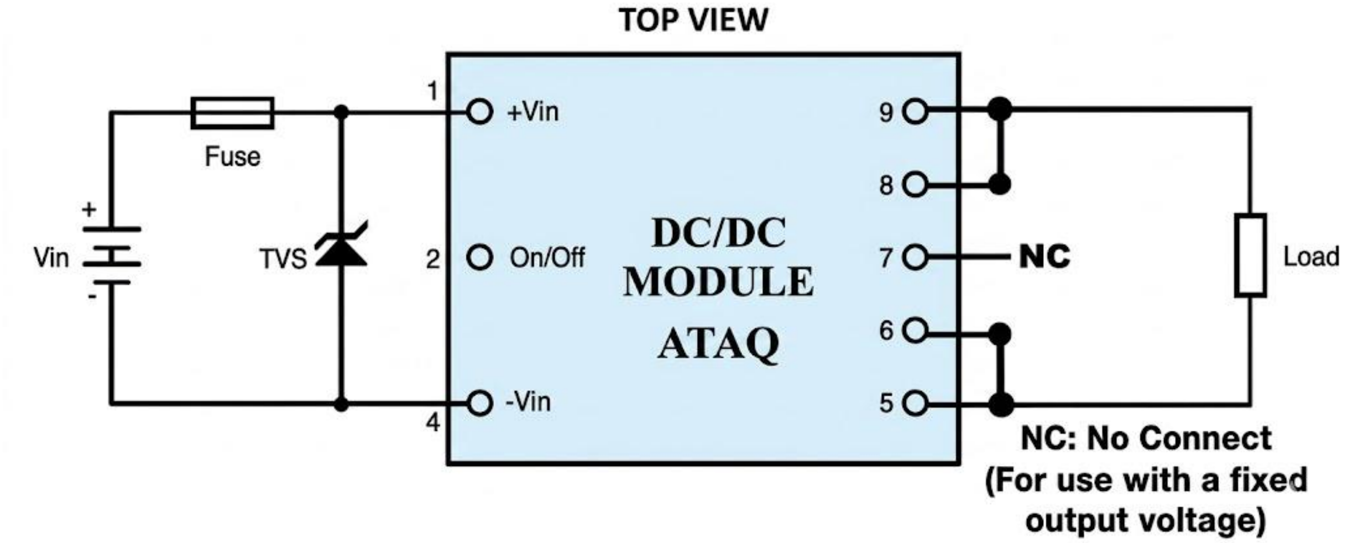


Figure-5

CAUTION: The ATQ150 series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommend a 30 A fast-acting fuse.

This power module can be used in a wide range of applications, from simple standalone operation to being an integral part of complex power architectures. To preserve maximum flexibility, internal fusing is not included.

To avoid security identification issues, we recommend choosing products certified in both America and Europe. Most fuses are approved for use on the AC side. Choosing a fuse that is also approved for use on the DC side will be an advantage.

Fuses can be simply classified into two types: fast-acting and time-delayed. Generally, the fast-acting type can activate instantly when the current flowing into the system exceeds the fuse's current rating.

The time-delayed type can hold for a short period before failing. Normally, the selection standard depends on the inrush current of the DC-DC modular system.

The time-delayed type will be suitable for high inrush current systems, and the fast-acting type is used for low inrush current systems.

In a DC-DC modular system, the operating voltage must always be below the fuse's maximum voltage rating. This is important because the fuse is not sensitive to voltage variations.

In addition to peak current protection for a DC-DC modular system, transient high voltage, such as sudden surges or fluctuations, also damages components in the modular power system. TVS (Transient Voltage Suppressor) diodes are commonly used at the front end to protect the entire power system.

It is recommended that the circuit has a transient voltage suppressor diode (TVS) across the input terminals to protect the unit against surge or spike voltages and input reverse voltage (as shown). A suitable part would be SMCJ78A.

COMMERCIAL CONDUCTED EMISSIONS:

EMI Test standard : EN55032 Class A and Class B Conducted Emission
Test Condition : Input Voltage: Nominal, Output Load: Full Load
Component Ranges : CX1, CX2 = 220uF / CY1, CY2 = 1-4.7nF / CM CHOKE=100-470uH / DM INDUCTOR= 1-47uF (or Short)

EMI and conducted noise meet EN55032 Class A:

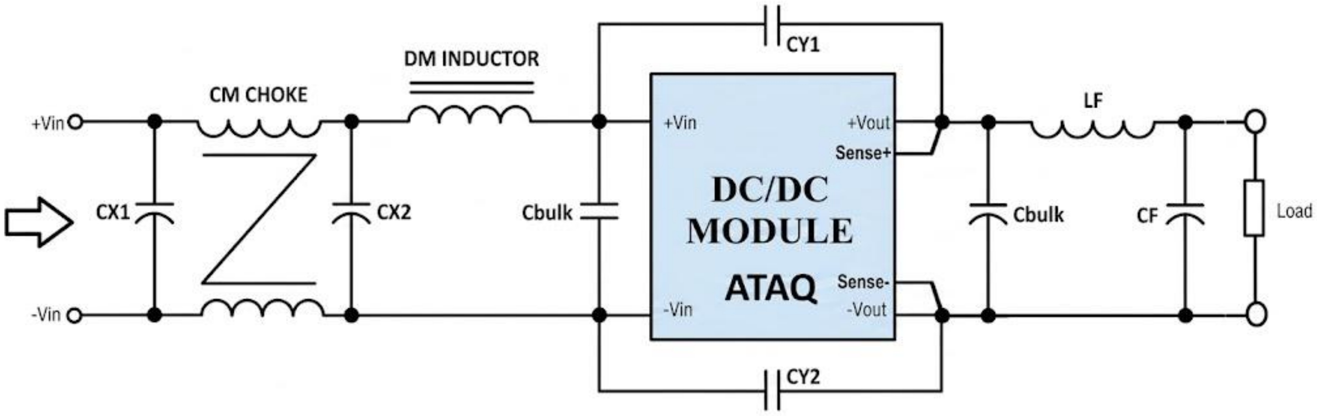


Figure-6

TEST SETUP:

For a typical electrical connection, please refer to the connection above. The basic test setup 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.

- Put input capacitor, CF1 more than 330uF for ATQ300 48Vin models If the ambient temperature is less than -20℃, use twice the recommended capacitor above. If the impedance of the input line is high, the input capacitor must be more than above.
- Put output capacitors; CF2 and Cb2, according to minimum and maximum capacitor recommendations. If the ambient temperature is less than -20℃, use at least 3 pieces of the recommended minimum capacitors.
- Use an external fuse for each unit.
- Cb capacitors can be taken as 100nF bypass capacitors.

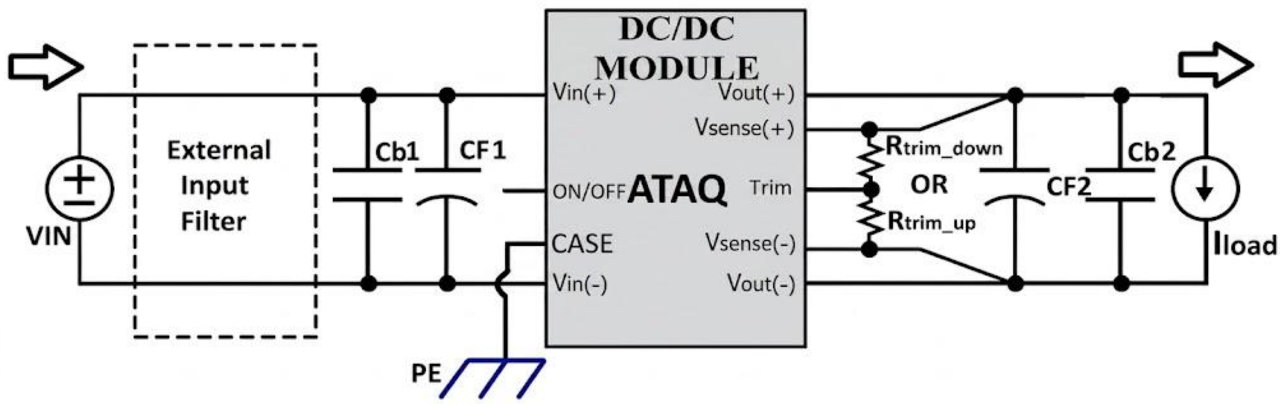


Figure-7: Typical electrical connection (Positive logic)

EFFICIENCY TEST SETUP:

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

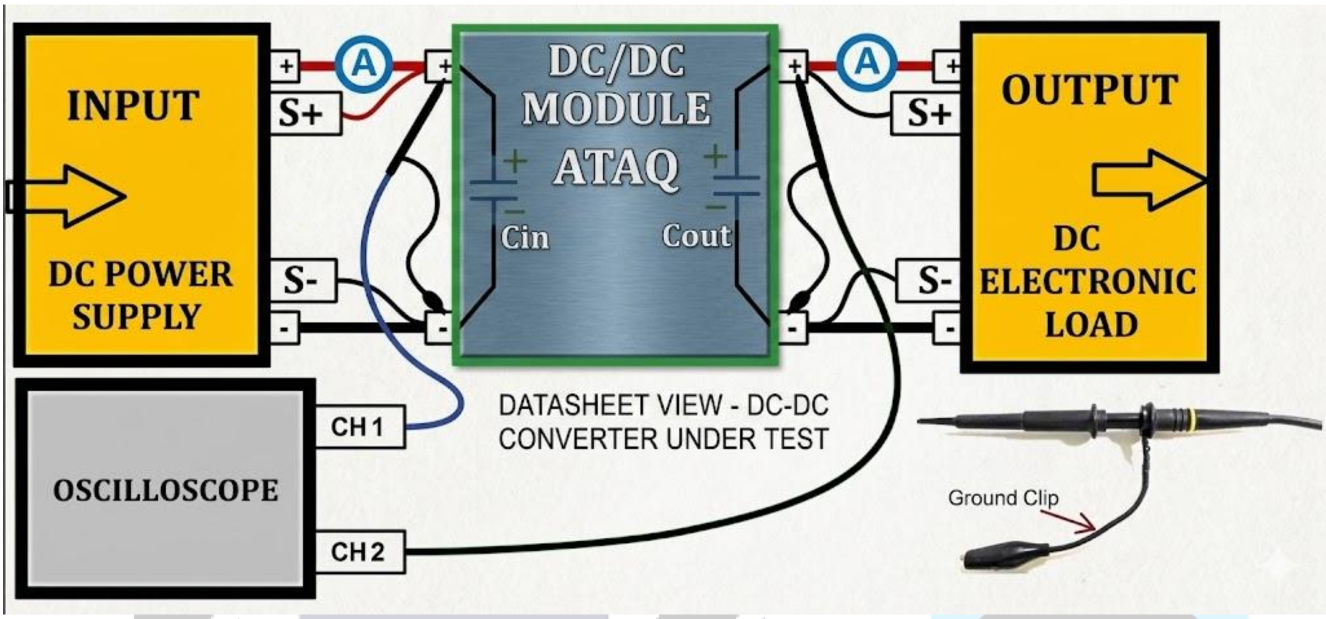


Figure-8a

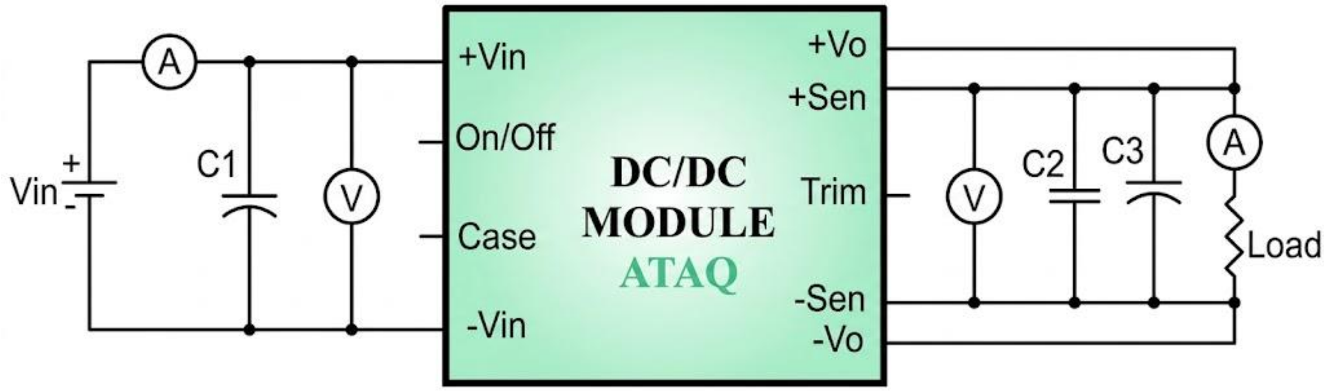


Figure-8b

All measurements are taken at the module terminals.

The value of efficiency is defined as:

$$\eta = \frac{Vo \times Io}{Vin \times Iin} \times 100\%$$

Where:

- Vo is output voltage
- Io is output current
- Vin is input voltage
- Iin is input current.

OUTPUT RIPPLE AND NOISE:

Output ripple and noise are measured with 10uF solid tantalum capacitors and 1.0uF ceramic across the output.

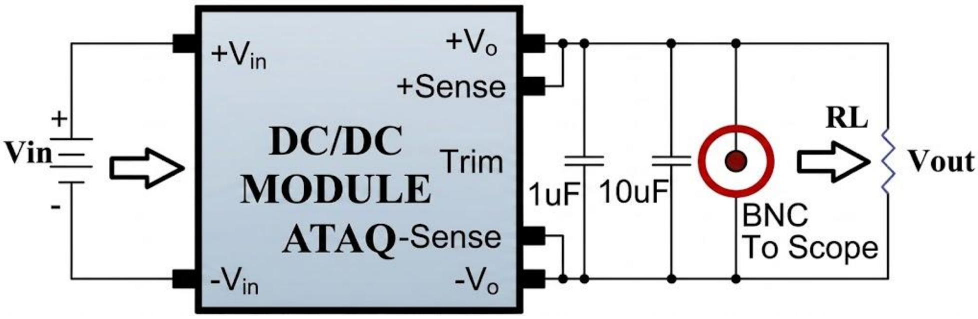


Figure-9

POWER MODULE PARALLEL CONNECTION:

Since each power module has a tolerance, if they are directly connected in parallel without taking measures that evenly distribute the current for the power modules, It will cause the output load unbalanced, as shown in Figure-14a.

The power converter with higher output current will bear greater stress, and long-term used will reduce the life of the power module. Or the current limit is trigged by one power module, and then the protection makes the output function invalid.

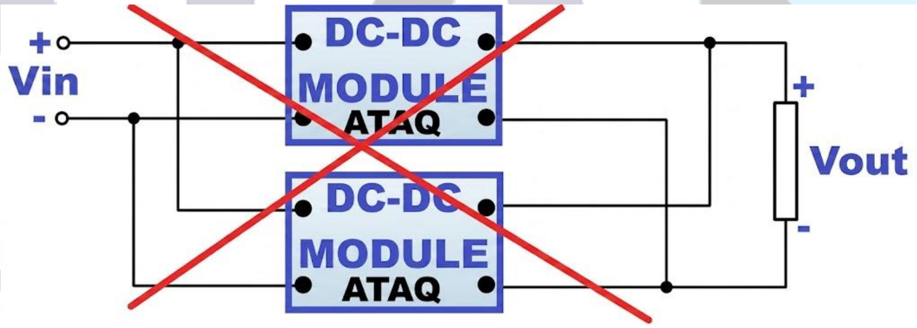


Figure-10a

The voltage droop method is connecting an external resistor at the output of the power converter to let the output voltage reduce, as the load current increases. This method has no signal connection between the power converters and is not affected by each other. It is an open loop current sharing method.

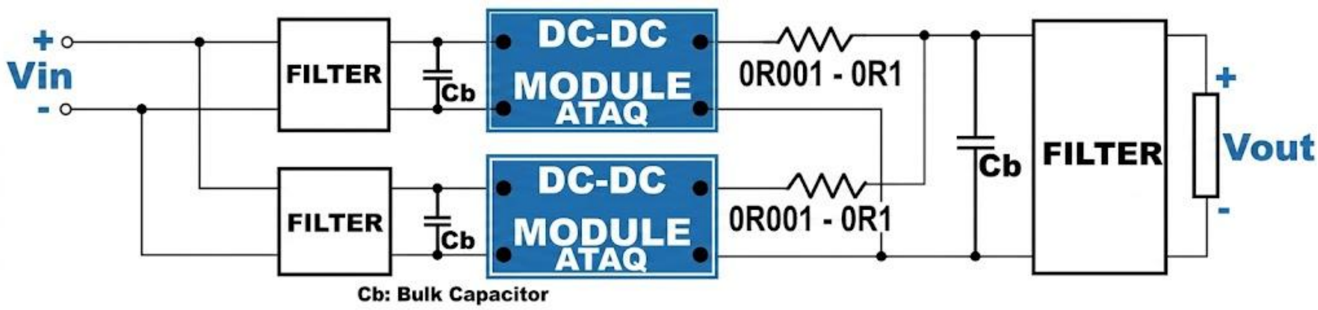


Figure-10b

POWER MODULE N+1 PARALLEL CONNECTION:

If the converters are used in parallel, it is recommended to connect ORing diode in series.

The current limit of ORing diode should be higher than the converter’s output current. This kind of application is only suitable for spare function. It is not suitable to operate both converters at full load.

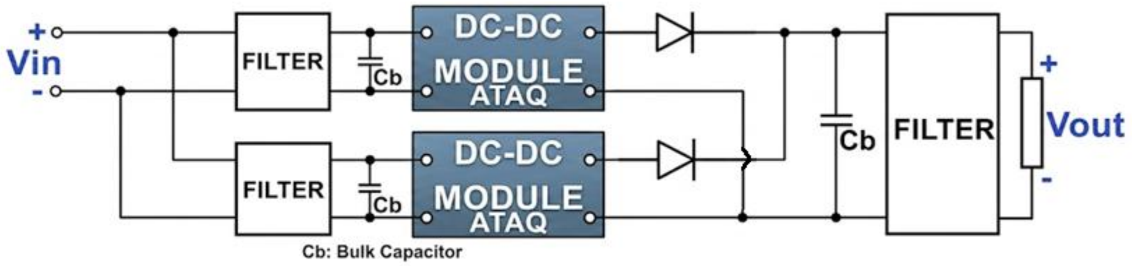


Figure-10c

POWER MODULE SERIAL CONNECTION:

When two isolated DC-DC converters are connected in series to generate a higher Vout, reverse-connected high-current fast clamp diodes (preferably Schottky or ultrafast types) are used at the series junction to prevent one module from being driven into reverse polarity / reverse voltage stress if the other module is off, faulted, or momentarily unbalanced; the diodes clamp the junction within approximately one diode drop, protecting the converters and improving series-DC-DC modules robustness.

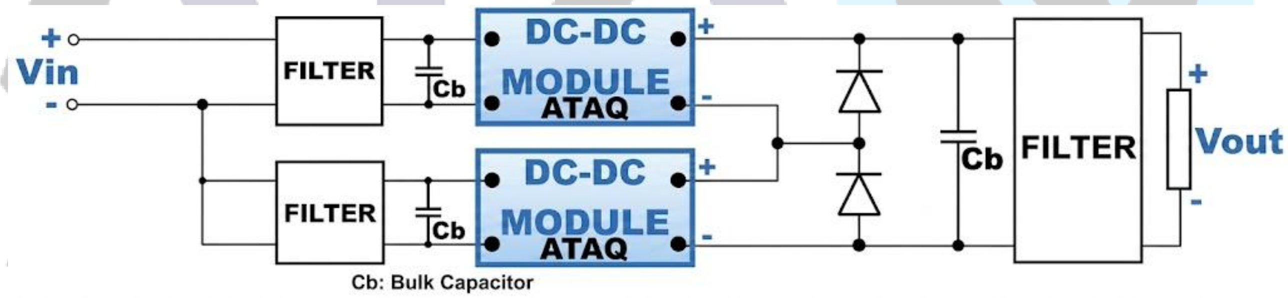


Figure-11

RECOMMENDED APPLICATIONS FOR BETTER EMI/EMC COMPLIANCE:

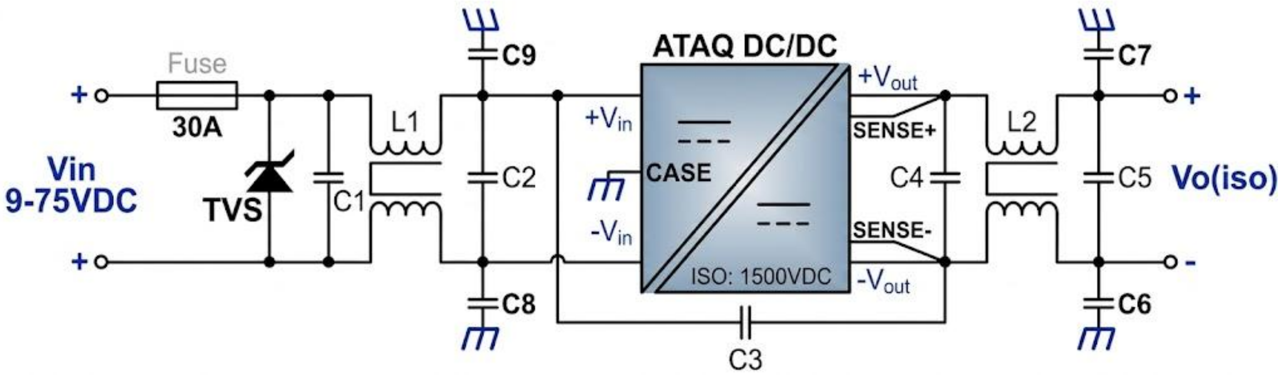


Figure-12a

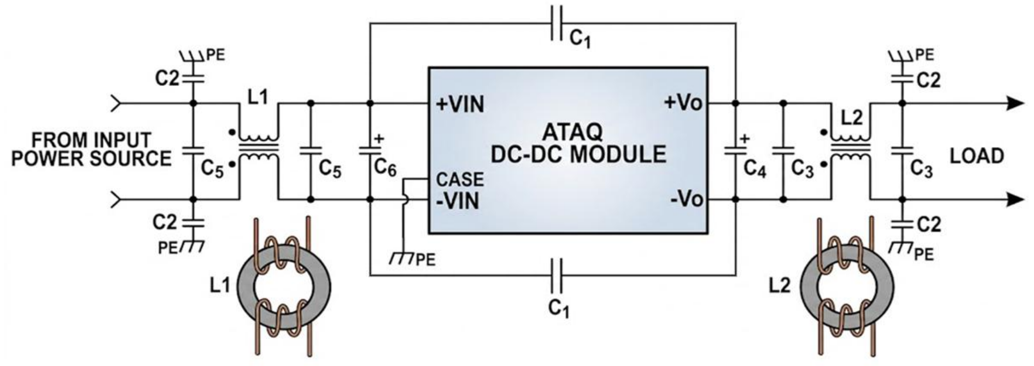


Figure-12b

THERMAL CONSIDERATIONS:

The power module is designed to operate in a variety of thermal environments. However, to ensure reliable operation, adequate cooling must be provided. Heat dissipation occurs through conduction, convection, and radiation to the surrounding environment.

To verify proper cooling, measure the temperature at the test point shown in the figure below. The temperature at this location must not exceed the "Maximum Case Temperature." During operation, maintain the test point temperature at or below this limit. For applications requiring extremely high reliability, you may choose to limit the temperature to a lower value.

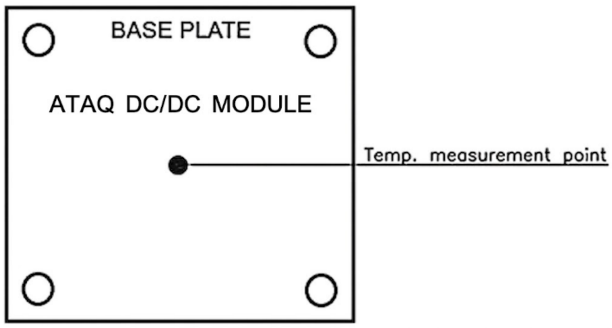


Figure-13a

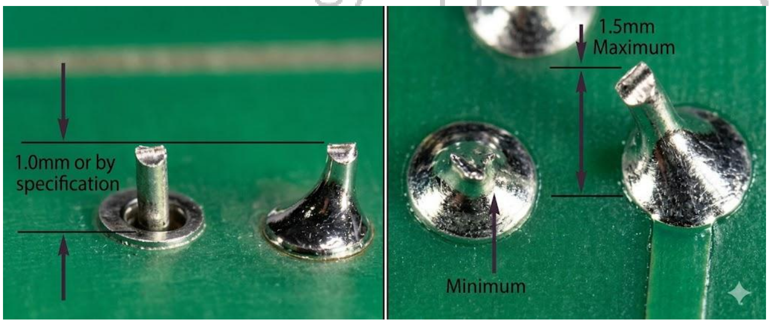


Figure-13b

Depending on the mother board thickness it might be necessary to adjust all the pins length equally around 1mm (0.04”) length according to IPC-A-610 class 3 (see Figure-13b hereafter). In case of wave soldering use, it is necessary to respect the maximum length of 1.5mm (0.06”) to avoid the ball joint accumulation effect. Therefore, this operation must be accomplished before the soldering process.

We strictly recommend in this case not to bend the pins during the length adjustment process as this will weaken them and may cause internal damage to the converter. Therefore, a special leveling tool may be required for this operation, this could be as simple as a piece of aluminum plate cut to the same level of the pins length and drilled slightly larger than the pins diameter (0.3~0.5mm or 0.012~0.02”).

HEAT SINK USAGE:

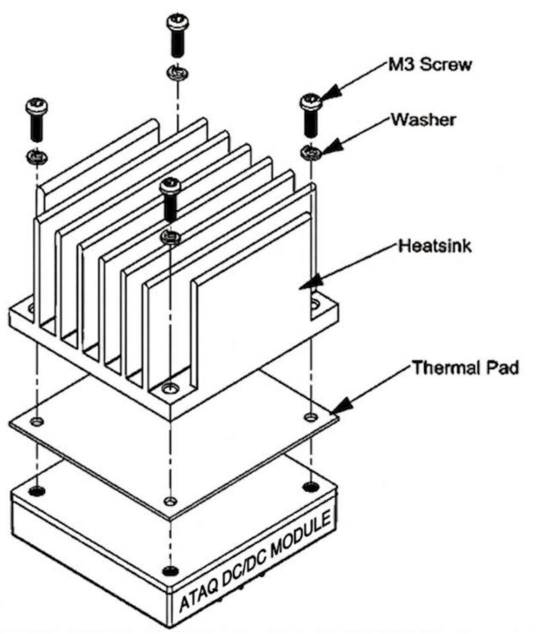


Figure-14

Heat sinks can be purchased separately and are designed to be easily mounted onto the converter using a set of four screws, four washers, and a thermal pad. These components work together to ensure optimal thermal contact and efficient heat dissipation, thereby enhancing the overall performance and reliability of the power module.

The heat sink kits include all the necessary hardware for installation, consisting of one high-quality heat sink, a precisely cut thermal pad, and a complete set of screws and washers. The thermal pad plays a critical role in improving heat transfer between the converter and the heat sink, ensuring that the module operates within safe temperature limits even under demanding conditions.

By incorporating a heat sink, users can significantly extend the lifespan of the converter, especially in environments with high ambient temperatures or continuous high-load operation.

You may want to use a cooler for half-brick DC-DC converters. In this case; the cooler selection is important so that the air inside the device flows in the specified flow direction.

Depending on the air flow direction, you can choose one of the following. The cooler types given below are cheaper due to the way they are produced. With these coolers; "**Lengthwise Air Flow"** or "**Crosswise Air Flow"** can be provided.

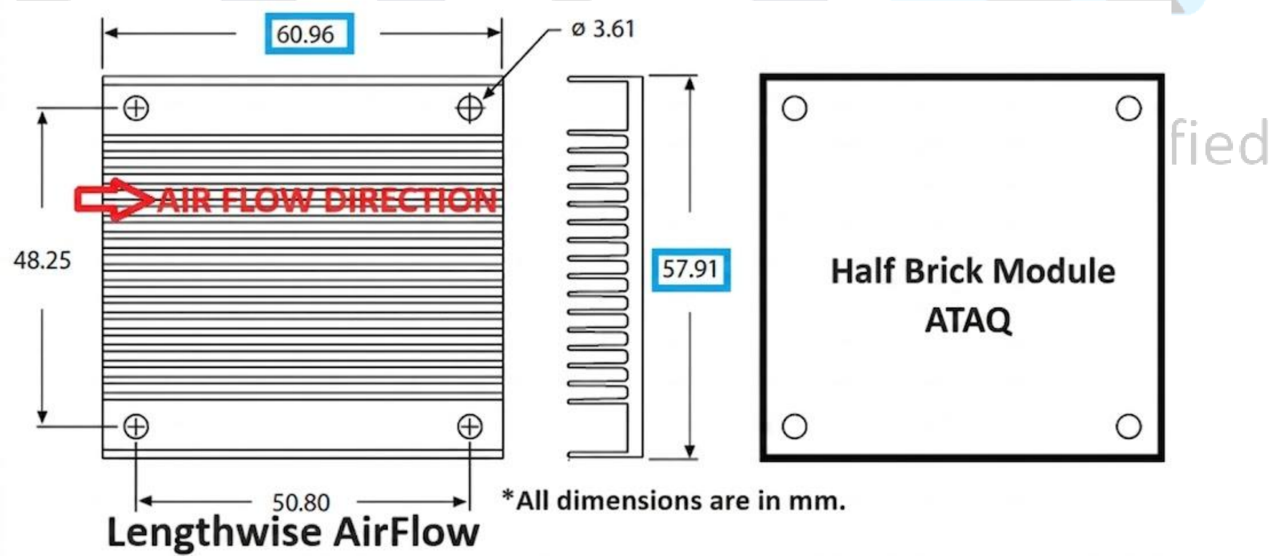


Figure-15a

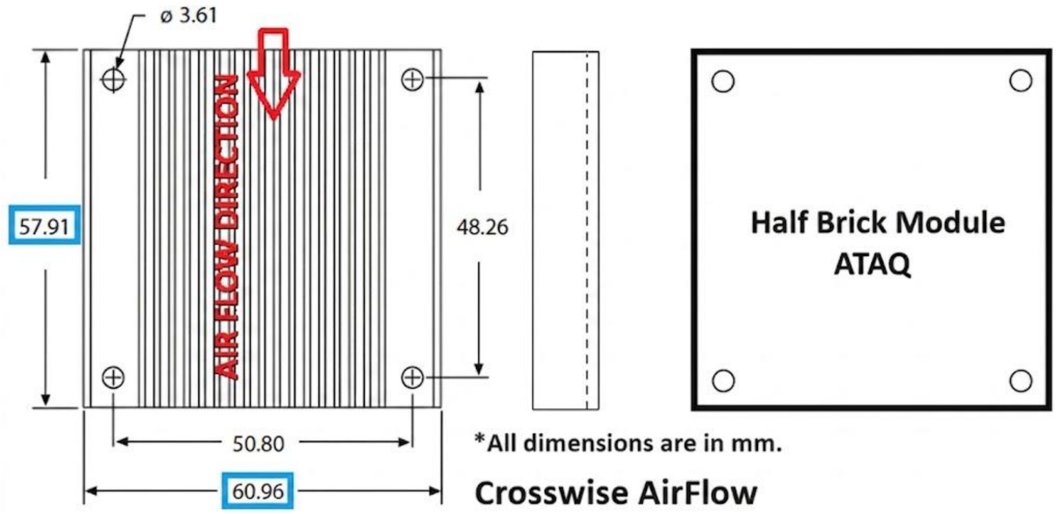
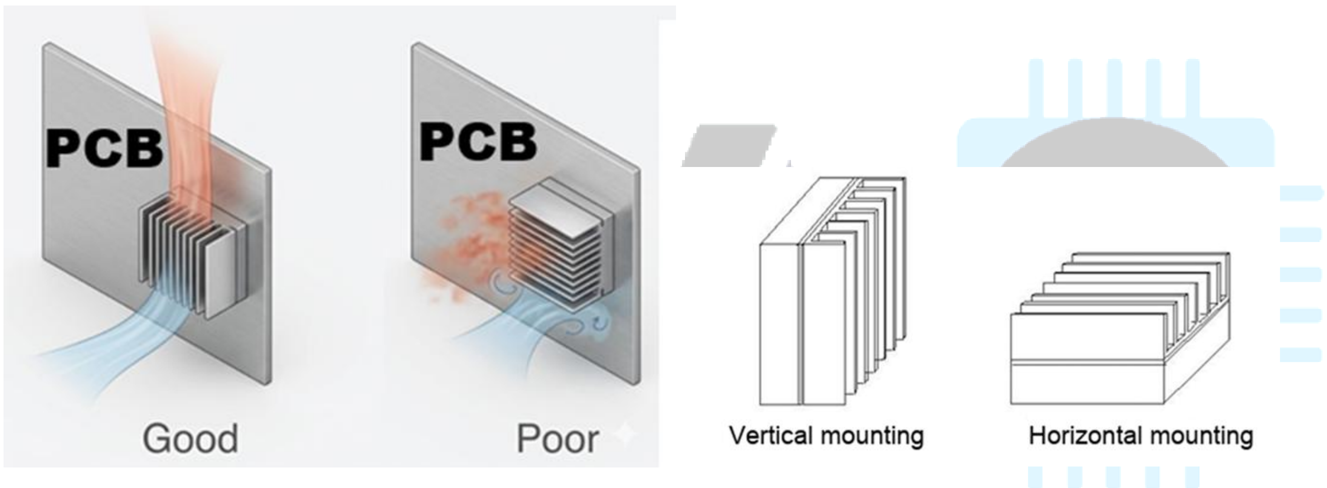


Figure-15b



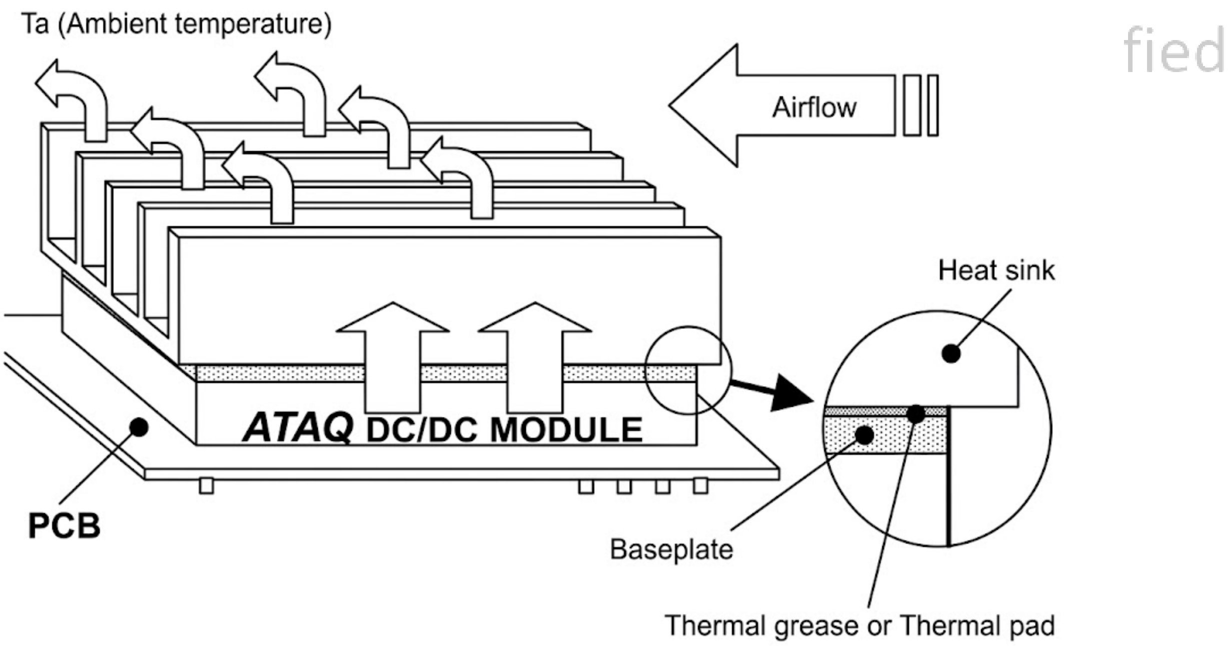


Figure-15c

In Figure 15c, the DC-DC module is mounted on a vertical PCB panel. Use a heat sink with fins running vertically for natural convection.

Vertical Fin Orientation (GOOD - Left Side): In this configuration, the heatsink fins are aligned vertically (up and down). Air heated by natural convection can easily rise through the channels between the fins without obstruction. This allows cooler air to enter more effectively from below the heatsink, creating a continuous, even airflow. Heated air quickly leaves the heatsink, and maximum heat transfer occurs. The airflow lines are smooth and strong.

Horizontal Fin Orientation (POOR - Right Side): Here, the heatsink fins are aligned horizontally (side-by-side). Although heated air tries to rise, it hits the horizontal fins above and gets trapped there (eddies form). This accumulation of hot air prevents cooler air from entering from below and disrupts the airflow. The airflow becomes fragmented, irregular, and weak. This significantly reduces cooling performance.

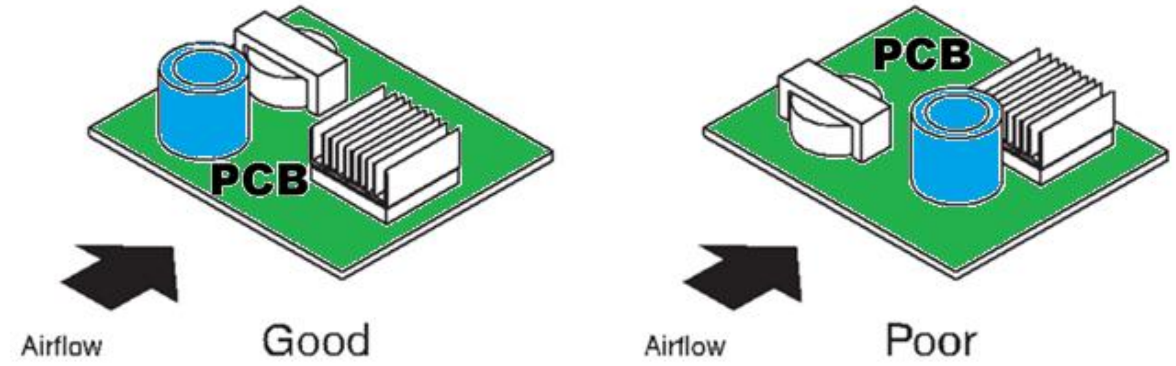


Figure-15d

In Figure-20d, the DC-DC module is mounted on a horizontal PCB panel. Avoid blocking the airflow to the modules with other components.

Good Placement (Left Side): The heatsink fins are parallel to the airflow direction, and there are no large components (transformers, coils, etc.) obstructing the airflow in the air intake path. This placement allows air to pass freely, providing maximum cooling efficiency.

Poor Placement (Right Side): Large components are located directly in front of the heatsink, blocking the airflow (or the fins are positioned perpendicular to the flow). This placement causes turbulence, prevents clean air from reaching the heatsink, and significantly reduces thermal performance.

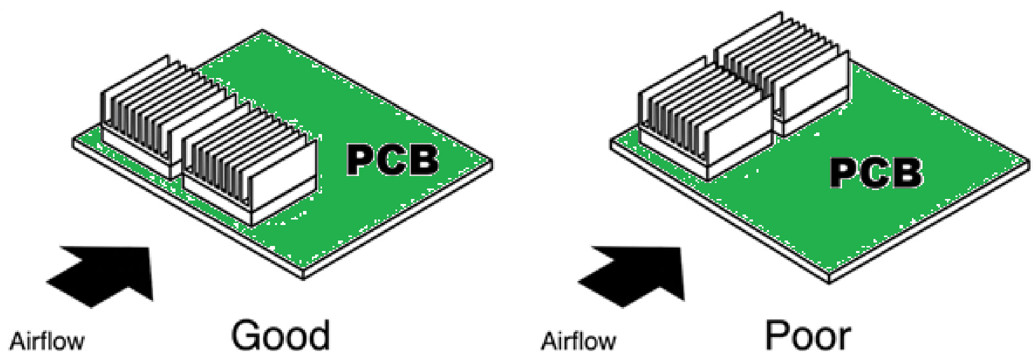


Figure-15e

In Figure 15e, two DC-DC modules are mounted on a horizontal PCB panel. Stagger modules to improve cooling and facilitate even heat distribution between modules.

Good Layout (Left Side): Heatsink fins are oriented parallel to the forced airflow direction. This allows air to pass smoothly and unobstructed between the fins, maximizing heat dissipation across all surfaces.

Poor Layout (Right Side): Heatsink fins are oriented perpendicular to the airflow. This acts as a barrier, blocking airflow, creating turbulence, and preventing fresh air from reaching the inner fins, which severely degrades cooling performance.

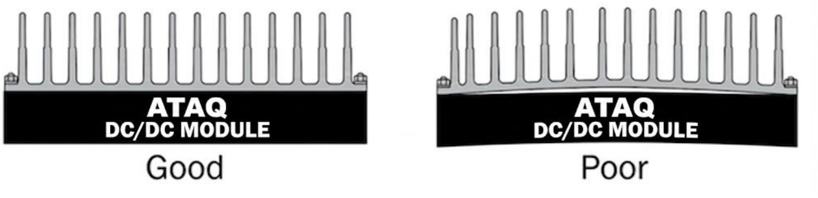


Figure-15f

HEATSINK MOUNTING AND SURFACE CONTACT

To achieve optimal thermal performance and long-term reliability, perfect mechanical contact must be maintained between the heatsink and the module's baseplate. As illustrated (Figure-15e) in the "Good" example, the heatsink surface must be perfectly flat and sit flush against the module without any gaps.

Over-tightening or unevenly torquing the mounting screws, or using a heatsink with an insufficiently rigid base, can cause the heatsink to bow or warp (as shown in the "Poor" example).

This creates air gaps with high thermal resistance at the center, severely impeding heat transfer and potentially leading to module overheating. To prevent this, strictly adhere to the specified maximum mounting torque limits during installation, and always apply a suitable Thermal Interface Material (TIM, such as thermal grease or a thermal pad) to fill any microscopic voids between the mating surfaces.

HEAT SINK MOUNTING

The interface between the baseplate and heat sink is smooth, flat, and free of debris.

Unless the baseplate and the heat sink are placed in close contact with each other, contact thermal resistance will increase until heat radiation becomes insufficient. Always use either thermal grease or thermal pads.

- To install the heat sink, fasten with screws through all four mounting holes.(Figure-20g)
- When mounting heat sinks to modules, use M3 screws torqued uniformly in the holes provided.

<u>The following tightening sequence should be used;</u>

- Lightly finger-tighten all screws.
- (2) Torque screws to 0.4N-m (5.0kg-cm) max as shown in Figure-15g.

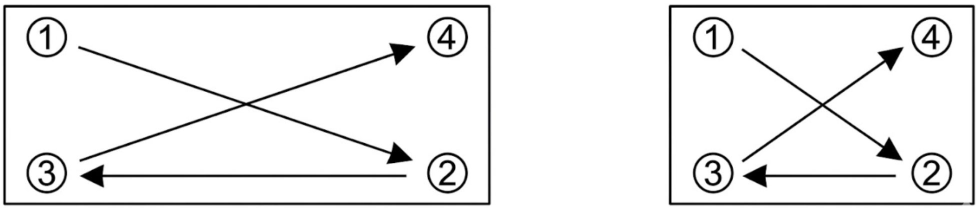


Figure-15g

INDUCTIVE LOAD AND BATTERY APPLICATIONS:

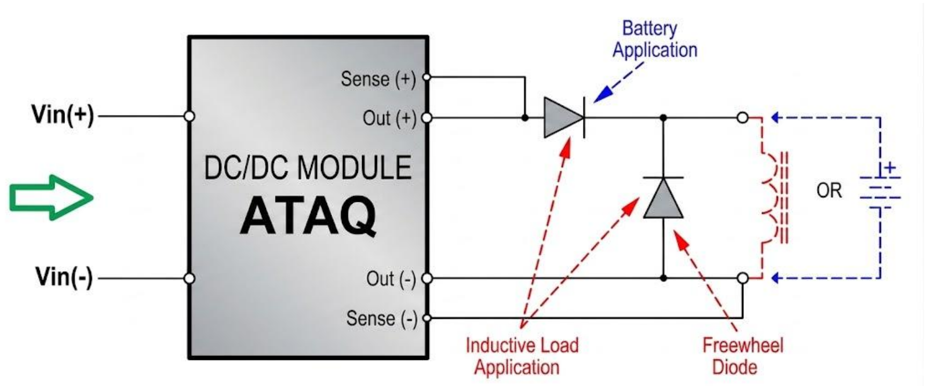


Figure-16

When connecting a battery or an inductive load (such as motors, relays, or coils) to the output of the ATQ150-WH36SXX series DC/DC converter modules, the recommended external protection circuit shown in the schematic must be implemented to prevent potential damage to the module.

- **Battery Application:** If a battery is connected to the output, a series blocking diode must be installed on the **Out(+)** line. This prevents reverse current from flowing from the battery back into the module when the converter is powered down or the input voltage is disconnected.
- **Inductive Load Application:** When driving inductive loads, severe high-voltage spikes or back electromotive force (back-EMF) generated during circuit switching can damage the module. To suppress these transients, two diodes are required:
  1. A series diode connected to the **Out(+)** line.
  2. A freewheel diode connected in parallel across the load. The anode of the freewheel diode must be connected to the negative line (**Out(-)**), and its cathode must be connected to the positive line after the series blocking diode.

Note (Sense Pins Connection): As shown in the schematic, the remote sense pins, **Sense(+)** and **Sense(-)**, must be locally shorted directly to the **Out(+)** and **Out(-)** pins on the module side, rather than the load side of the external protection diodes. The voltage and current ratings of the selected diodes must be chosen according to the maximum output parameters of the target application.

Disclaimer of Liability:
The design of external circuits (such as soft-start, input/output filtering, over-voltage protection, etc.) and the selection of components used in conjunction with the ATQ300-EH48SXX series DC-DC modules are the sole responsibility of the user. Recommended application circuits are provided for reference purposes only. ATAQ shall not be held liable for any damage or failure of the module or the integrated system resulting from improper external component selection, incorrect circuit design, electrical stress beyond specified limits, or any usage contrary to the provided data sheet specifications. Any damages arising from such improper use will void the product warranty.

For other technical issues besides this document, you can click the link below to access the technical Q&A section titled "QUESTIONS AND ANSWERS FROM OUR CUSTOMERS ABOUT OUR ATAQ DC-DC MODULES" at the bottom of our webpage.

Contact ATAQ for further information and to order.