AV60C Half-brick Series

Technical Reference Notes

48V Input, 5V Output

50-150W DC-DC Converter

(Rev01)

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Introduction

The AV60C half-brick series of switching DC-DC converters is one of the most cost effective options available in component power. The series uses an industry standard package size of **2.4”x2.28”x0.5**” and pinout configuration, provides standard control, trim, and sense functions, also features high power density up to **54.8W/in^3** which gives more selectivity to meet small size requirement.

AV60C half-brick series comes in 48V input version with a 2:1 (36-75V) input range. This series has input LVP, output OVP, OCP, short circuit protection and over temperature protection. There are isolated single output 3.3V, 5V, 12V, 15V and the isolation voltage is 1500Vdc. This series is designed to meet CISPR22, FCC class A, UL and CSA certifications.

The design features of the AV60C half-brick series set a new standard for high density power converters. The unit employs an aluminum baseplate to carry all of the power components, and conduct the dissipated heat to the ambient. A conventional, multi-layer printed circuit board, over the top of the power substrate, contains all of the small signal control circuitry, all constructed with automated SMD technology.

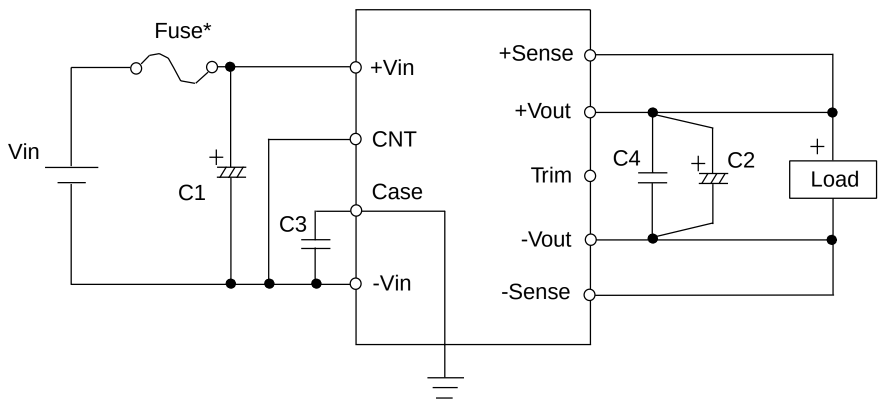
Feature

- High Efficiency
- High power density
- Low output noise
- Metal baseplate
- CNT function
- Remote sense
- Trim function
- Input under-voltage lockout
- Output short circuit protection
- Output current limiting
- Output over-voltage protection
- Overtemperature protection
- High input-output isolation voltage

Options

- Heat sink available for extended operation.
- Choice of CNT logic configuration.

Typical Application



Fuse*: Use external fuse (fast blow type) for each unit.

50W output : 5A fuse

75W output : 7.5A fuse

100W output : 10A fuse

150W output : 20A fuse

C1*: Recommended input capacitor C1

-20 °C ~ +100 °C: ≥ 47µF/100V electrolytic or ceramic type capacitor.

-40 °C ~ +100 °C: ≥ 47µF/100V ceramic type capacitor only.

C2*: Recommended output capacitor C2

-20 °C~ +100 °C: 1000µF/10V (electrolytic capacitor) for 50W-75W

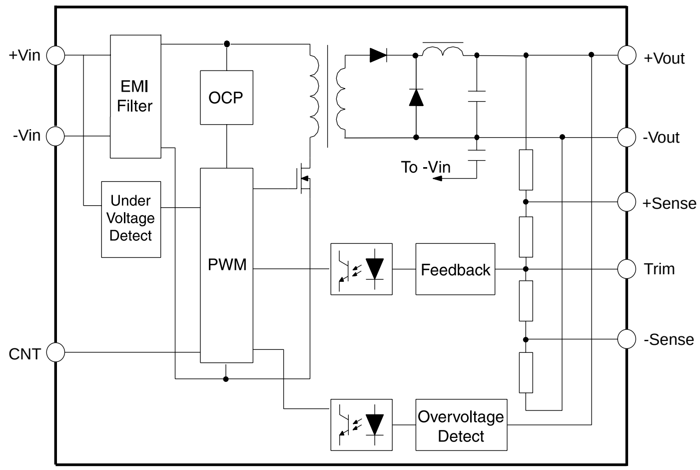
2200µF/10V (electrolytic capacitor) for 100W-150W

-40 °C~ +100 °C: For this temperature range, use two pieces of the recommended capacitor above.

C3: Recommended 4700pF/2000V

C4: Recommended 0.1µF/10V

Block Diagram



Ordering Information

Model Number	Input Voltage	Output Voltage	Output Current	Ripple (mV rms)	Noise (mV pp)	Efficiency min.	Efficiency typ.
AV60C-048L-050F10	36-75V	5V	10A	40	150	83%	84%
AV60C-048L-050F10N	36-75V	5V	10A	40	150	83%	84%
AV60C-048L-050F15	36-75V	5V	15A	40	150	83%	85%
AV60C-048L-050F15N	36-75V	5V	15A	40	150	83%	85%
AV60C-048L-050F20	36-75V	5V	20A	40	150	83%	85%
AV60C-048L-050F20N	36-75V	5V	20A	40	150	83%	85%
AV60C-048L-050F30	36-75V	5V	30A	40	150	83%	85%
AV60C-048L-050F30N	36-75V	5V	30A	40	150	83%	85%

Absolute Maximum Rating

Characteristic	Min	Typ	Max	Units	Notes
Input Voltage(continuous)	-0.3		80	Vdc	
Input Voltage(peak/surge)	-0.3		100	Vdc	100ms non-repetitive
Case temperature	-40		100	°C	
storage temperature	-55		125	°C	

Input Characteristics

Characteristic	Min	Typ	Max	Units	Notes
Input Voltage Range	36	48	75	Vdc	
Input Reflected Current		30	50	mAp-p	
Turn-off Input Voltage	30	33	35	V	
Turn-on Input Voltage	31	34	36	V	
Turn On Time		20	35	ms	

CNT Function

Characteristic	Min	Typ	Max	Units	Notes
Logic High	3		15	Vdc	
Logic Low			1.2	Vdc	
Control Current			2	mA	

General Specifications

Characteristic	Min	Typ	Max	Units	Notes
MTBF		2000		k Hrs	Bellcore TR332, Tc=40°C
Isolation			1500	Vdc	
Pin solder temperature			260	°C	wave solder < 10 s
Hand Soldering Time			5	s	iron temperature 425°C
Weight		75		grams	

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AV60C-048L-050F10(N) Output Characteristics

Characteristic	Min	Typ	Max	Units	Notes
Power		50		W	
Output Current	1		10	A	
Output Setpoint Voltage	4.95	5	5.05	Vdc	Vin=48V, Io=10A
Line Regulation		0.02	0.2	%Vo	Vin=36~75V, Io=10A
Load Regulation		0.1	0.5	%Vo	Io=0~10A, Vin=48V
Dynamic Response					
50-75% load		2.5	5	%Vo	Ta=25°C, DI/Dt=1A/10µs
		100	250	µs	Ta=25°C, DI/Dt=1A/10µs
50-25% load		2.5	5	%Vo	Ta=25°C, DI/Dt=1A/10µs
		100	250	µs	Ta=25°C, DI/Dt=1A/10µs
Current Limit Threshold	11	13	14	A	
Short Circuit Current		17		A	
Efficiency	83	84		%	Vin=48V, Io=10A
Trim Range	90		110	%Vo	
Over Voltage Protection Setpoint	5.75		7	V	
Sense Compensation			0.5	V	0.25V each leg
Temperature Regulation			0.02	%Vo/°C	
Ripple (rms)		20	40	mV	(0 to 20MHz Bandwidth)
Noise (p-p)		100	150	mV	(0 to 20MHz Bandwidth)
Over Temperature Protection		105		°C	
Switching Frequency		300		kHz	
Maximum Capacitor Load			10000	µF	

AV60C-048L-050F15(N) Output Characteristics

Characteristic	Min	Typ	Max	Units	Notes
Power		75		W	
Output Current	1.5		15	A	
Output Setpoint Voltage	4.95	5	5.05	Vdc	Vin=48V, Io=15A
Line Regulation		0.02	0.2	%Vo	Vin=36~75V, Io=15A
Load Regulation		0.1	0.5	%Vo	Io=0~15A, Vin=48V
Dynamic Response					
50-75% load		2.5	5	%Vo	Ta=25°C, DI/Dt=1A/10µs
		100	250	µs	Ta=25°C, DI/Dt=1A/10µs
50-25% load		2.5	5	%Vo	Ta=25°C, DI/Dt=1A/10µs
		100	250	µs	Ta=25°C, DI/Dt=1A/10µs
Current Limit Threshold	16.5	19	21	A	
Short Circuit Current		25		A	
Efficiency	83	85		%	Vin=48V, Io=15A
Trim Range	90		110	%Vo	
Over Voltage Protection Setpoint	5.75		7	V	
Sense Compensation			0.5	V	0.25V each leg
Temperature Regulation			0.02	%Vo/°C	
Ripple (rms)		20	40	mV	(0 to 20MHz Bandwidth)
Noise (p-p)		100	150	mV	(0 to 20MHz Bandwidth)
Over Temperature Protection		105		°C	
Switching Frequency		300		kHz	
Maximum Capacitor Load			10000	µF	

AV60C-048L-050F20(N) Output Characteristics

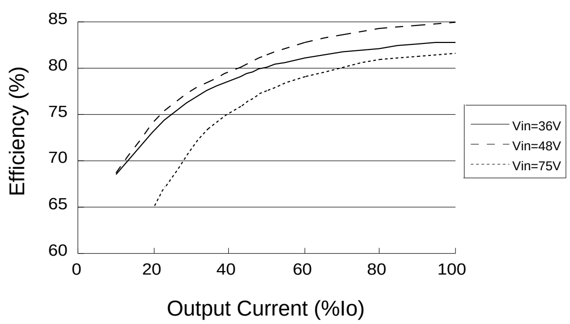
Characteristic	Min	Typ	Max	Units	Notes
Power		100		W	
Output Current	2		20	A	
Output Setpoint Voltage	4.95	5	5.05	Vdc	Vin=48V, Io=20A
Line Regulation		0.02	0.2	%Vo	Vin=36~75V, Io=20A
Load Regulation		0.1	0.5	%Vo	Io=0~20A, Vin=48V
Dynamic Response					
50-75% load		2.5	5	%Vo	Ta=25°C, DI/Dt=1A/10µs
		100	250	µs	Ta=25°C, DI/Dt=1A/10µs
50-25% load		2.5	5	%Vo	Ta=25°C, DI/Dt=1A/10µs
		100	250	µs	Ta=25°C, DI/Dt=1A/10µs
Current Limit Threshold	22	25	28	A	
Short Circuit Current		34		A	
Efficiency	83	85		%	Vin=48V, Io=20A
Trim Range	90		110	%Vo	
Over Voltage Protection Setpoint	5.75		7	V	
Sense Compensation			0.5	V	0.25V each leg
Temperature Regulation			0.02	%Vo/°C	
Ripple (rms)		20	40	mV	(0 to 20MHz Bandwidth)
Noise (pp)		100	150	mV	(0 to 20MHz Bandwidth)
Over Temperature Protection		105		°C	
Switching Frequency		300		kHz	
Maximum Capacitor Load			10000	µF	

AV60C-048L-050F30(N) Output Characteristics

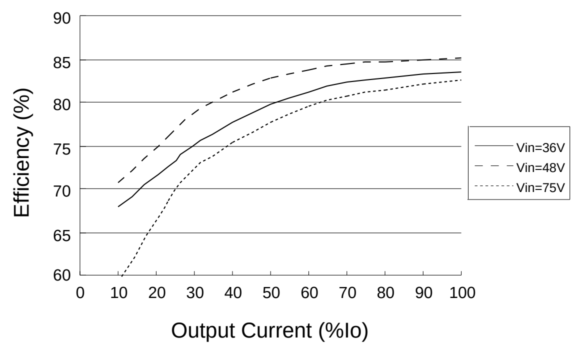
Characteristic	Min	Typ	Max	Units	Notes
Power		150		W	
Output Current	3		30	A	
Output Setpoint Voltage	4.95	5	5.05	Vdc	Vin=48V, Io=30A
Line Regulation		0.02	0.2	%Vo	Vin=36~75V, Io=30A
Load Regulation		0.1	0.5	%Vo	Io=0~30A, Vin=48V
Dynamic Response					
50-75% load		2.5	5	%Vo	Ta=25°C, DI/Dt=1A/10µs
		100	250	µs	Ta=25°C, DI/Dt=1A/10µs
50-25% load		2.5	5	%Vo	Ta=25°C, DI/Dt=1A/10µs
		100	250	µs	Ta=25°C, DI/Dt=1A/10µs
Current Limit Threshold	32	36	40	A	
Short Circuit Current		50		A	
Efficiency	83	85		%	Vin=48V, Io=30A
Trim Range	90		110	%Vo	
Over Voltage Protection Setpoint	5.75		7	V	
Sense Compensation			0.5	V	0.25V each leg
Temperature Regulation			0.02	%Vo/°C	
Ripple (rms)		20	40	mV	(0 to 20MHz Bandwidth)
Noise (pp)		100	150	mV	(0 to 20MHz Bandwidth)
Over Temperature Protection		105		°C	
Switching Frequency		300		kHz	
Maximum Capacitor Load			10000	µF	

Efficiency Characteristic Curves *(at 25 °C)*

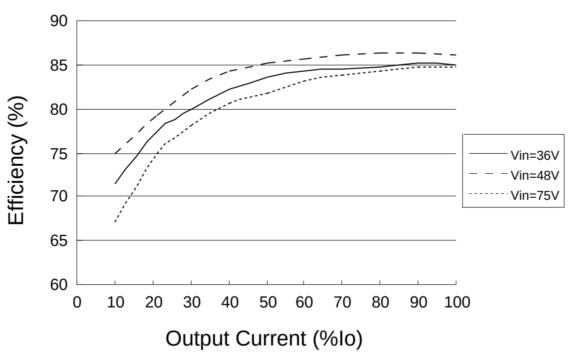
Typical Efficiency AV60C-048L-050F10N



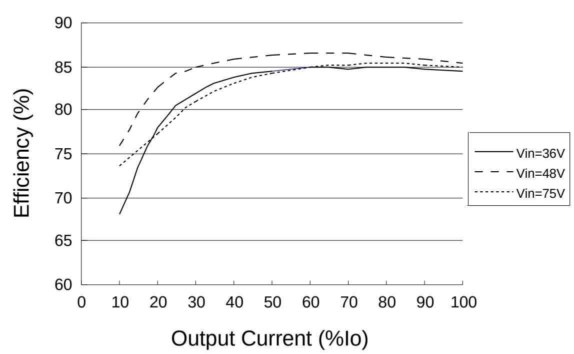
Typical Efficiency AV60C-048L-050F15N



Typical Efficiency AV60C-048L-050F20N



Typical Efficiency AV60C-048L-050F30N



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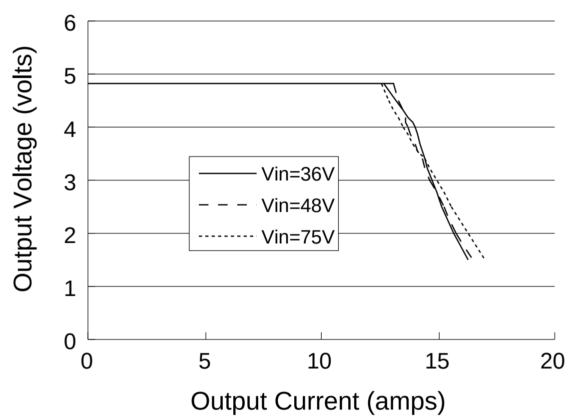
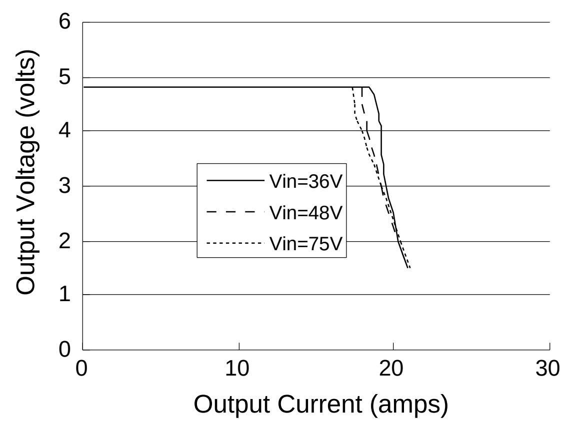
Overcurrent Protection (OCP) *(at 25 °C)*

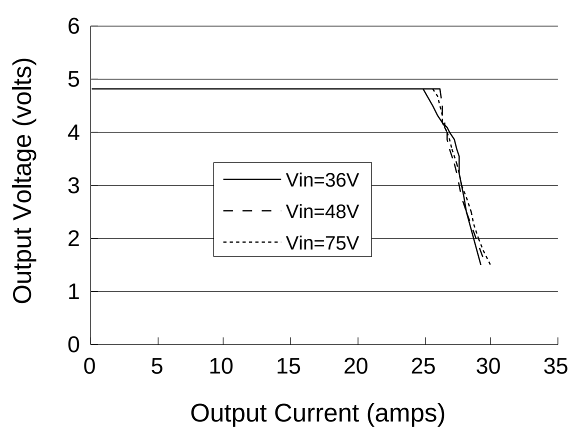
Typical Output Overcurrent Performance
AV60C-048L-050F10N



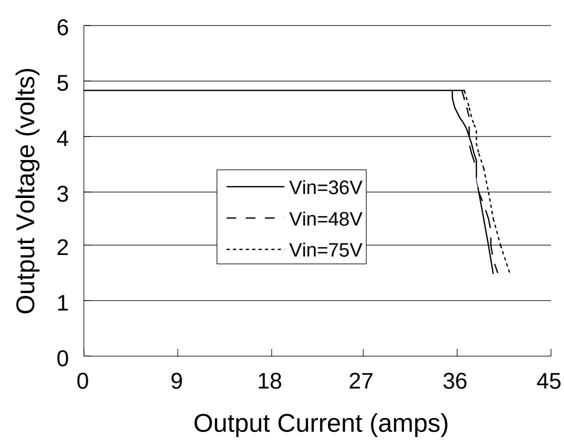
Typical Output Overcurrent Performance
AV60C-048L-050F15N



Typical Output Overcurrent Performance
AV60C-048L-050F20N

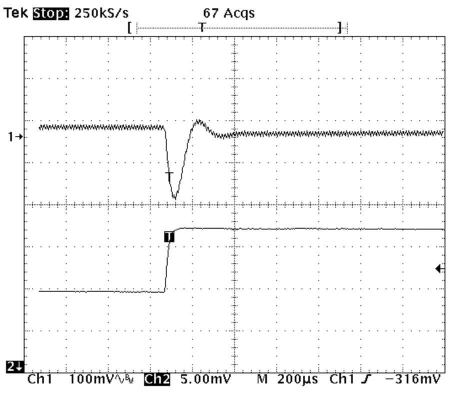


Typical Output Overcurrent Performance
AV60C-048L-050F30N

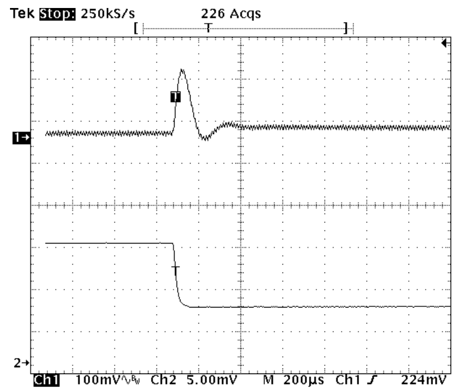


Transient response *(at 25 °C)*

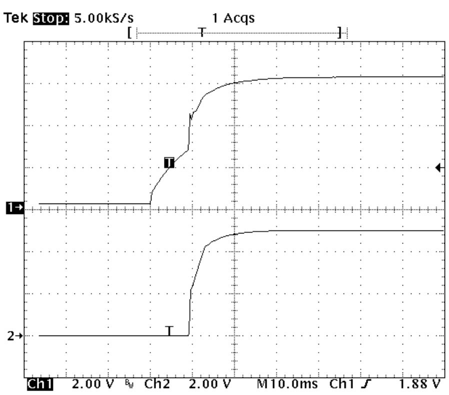
Typical Transient Response Load Increased from 50%Iomax to 75%Iomax AV60C-048L-050F30N



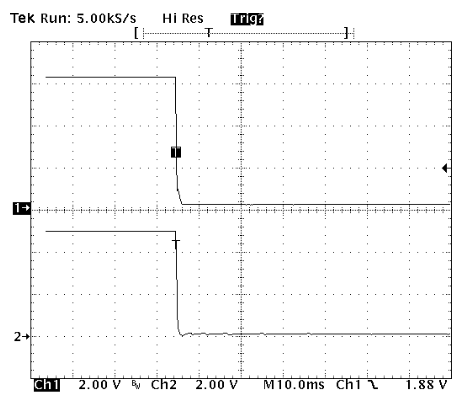
Typical Transient Response Load Decreased from 50%Iomax to 25%Iomax AV60C-048L-050F30N



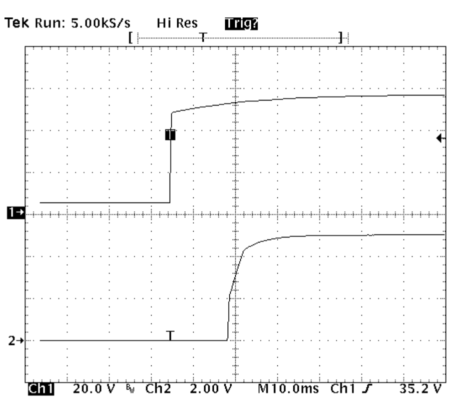
Typical Start-Up from CNT Control AV60C-048L-050F30N



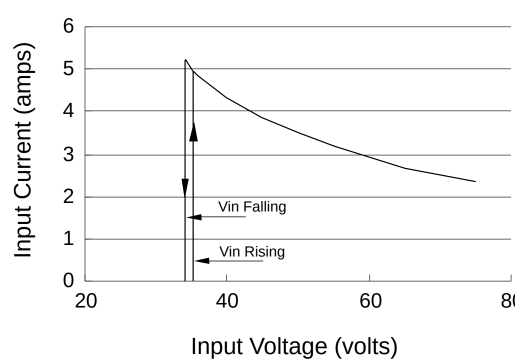
Typical Shut-down from CNT Control AV60C-048L-050F30N



Typical Output Voltage Start-up From Power On



Typical Input Current AV60C-048L-050F30N



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Pins

The +Vin and -Vin input connection pins are located as shown in figure 1. AV60C half-brick converters have a 2:1 input voltage range and 48 Vin converters can accept 36-75Vdc. Care should be taken to avoid applying reverse polarity to the input which can damage the converter.

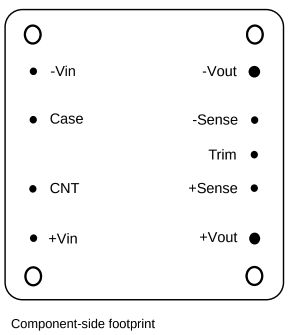

Fig.1 Pin Location

Input Characteristic

Fusing

The AV60C half-brick power module has no internal fuse. An external fuse must always be employed! To meet international safety requirements, a 250 Volt rated fuse should be used. If one of the input lines is connected to chassis ground, then the fuse must be placed in the other input line.

Standard safety agency regulations require input fusing. Recommended fuse ratings for the AV60C half-brick series are shown in Table 1.

Input Reverse Voltage Protection

Under installation and cabling conditions where reverse polarity across the input may occur, reverse polarity protection is recommended. Protection can easily be provided as shown in figure 2. In both cases the diode rating is determined by the power of the converter. Diodes should be rated as shown in Table1.

Table 1

Series	Fuse Rating(48Vin)
50W	5A
75W	7.5A
100W	10A
150W	20A

Placing the diode across the inputs rather than in-line with the input offers an advantage in that the diode only conducts in a reverse polarity condition, which increases circuit efficiency and thermal performance.

Input Undervoltage Protection

The AV60C half-brick is protected against undervoltage on the input. If the input voltage drops below the acceptable range, the converter will shut down. It will automatically restart when the undervoltage condition is removed.

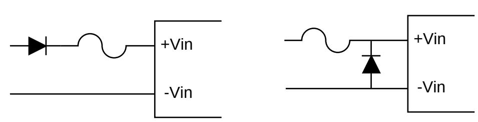

Fig.2 Reverse Polarity Protection Circuits

Input Filter

Input filters are included in the converters to help achieve standard system emissions certifications. Some users however, may find that additional input filtering is necessary. The series has an internal switching frequency of 300 kHz so a high frequency capacitor mounted close to the input terminals produces the best results. To reduce reflected noise, a capacitor can be added across the input as shown in figure 3, forming a π filter. A 47µF/100V electrolytic capacitor is recommended for C1.

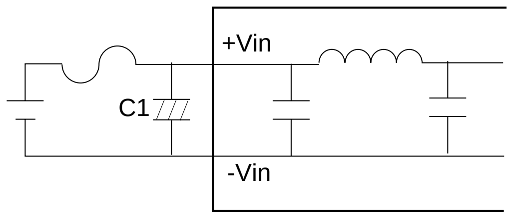

Fig.3 Ripple Rejection Input Filter

For conditions where EMI is a concern, a different input filter can be used. Figure 4 shows an input filter designed to reduce EMI effects. C_1 is a 47µF/100V electrolytic capacitor, and C_2 is a 1µF/100V metal film or ceramic high frequency capacitor, C_{y1} and C_{y2} are each 1000pF/1500Vdc high frequency ceramic capacitors, and L1 is a 1mH common mode choke.

When a filter inductor is connected in series with the power converter input, an input capacitor C_1 should be added. An input capacitor C_1 should also be used when the input wiring is long, since the wiring can act as an inductor. Failure to use an input capacitor under these conditions can produce large input voltage spikes and an unstable output.

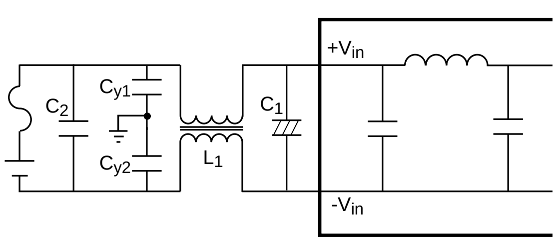

Fig.4 EMI Reduction Input Filter

CNT Function

Two CNT logic options are available.

Negative logic applying a voltage less than 1.2V to the CNT pin will enable the output, and applying a voltage greater than 3V will disable it.

Positive logic applying a voltage larger than 3V to the CNT pin will enable the output, and applying a voltage less than 1.2V will disable it.

Negative logic, device code suffix " N " . Positive logic, device code suffix nothing is the factory-preferred.

If the CNT pin is left open, the converter will default to " control off " operation in negative logic, but default to " control on " in positive logic.

The maximum voltage that can be applied to the control pin is 15V.

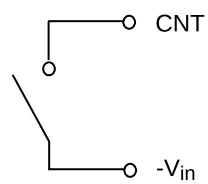

Fig.5 Simple Control

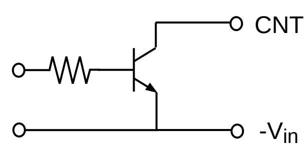

Fig.6 Transistor Control

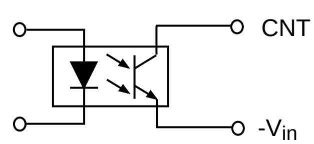

Fig.7 Isolated Control

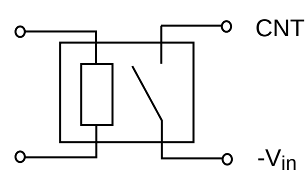

Fig.8 Relay Control

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Input-Output Characteristic

Safety Consideration

For safety-agency approval of the system in which the power module is used, the power module must be installed in compliance with the spacing and separation requirements of the end-use safety agency standard, i.e., UL1950, CSA C22.2 No. 950-95, and EN60950.

The input-to-output 1500VDC isolation is an operational insulation. The DC/DC power module should be installed in end-use equipment, in compliance with the requirements of the ultimate application, and is intended to be supplied by an isolated secondary circuit.

When the supply to the DC/DC power module meets all the requirements for SELV(<60Vdc), the output is considered to remain within SELV limits (level 3). If connected to a 60Vdc power system, double or reinforced insulation must be provided in the power supply that isolates the input from any hazardous voltages, including the ac mains. One Vin pin and one Vout pin are to be grounded or both the input and output pins are to be kept floating. Single fault testing in the power supply must be performed in combination with the DC/DC power module to demonstrate that the output meets the requirement for SELV. The input pins of the module are not operator accessible.

Note: Do not ground either of the input pins of the module, without grounding one of the output pins. This may allow a non-SELV voltage to appear between the output pin and ground.

Case Grounding

For proper operation of the module, the case or baseplate of the AV60C half-brick module does not require a connection to a chassis ground. Whether to ground the case must be decided by safety considerations, and entirely determined by the final application. If the AV60C half-brick module is not in a metallic enclosure in a system, it may be advisable to directly ground the case to reduce electric field emissions. Leaving the case floating can help to reduce magnetic field radiation from common mode noise currents. If the case has to be grounded for safety or other reasons, an inductor can be connected to chassis at DC and AC line frequencies, but be left floating at switching frequencies. Under this condition, the safety requirements are met and the emissions are minimized. In general, the inductor maintains a DC resistance from the case to chassis ground of no more than 0.1 S during the safely conducting of all the available input current. All the available input current refer to the value of the input fuse to the module. IEC 950 requires testing the DC resistance at 1.5 times that value. Specific safety requirements may dictate something different.

Output Characteristics

Minimum Load Requirements

There is a 10% (of full load) minimum load required in the main output.

The series modules will maintain regulation and operate properly with a NO LOAD condition. However, the transient response is altered below a minimum output load condition. When the module is operating below the minimum load, the transient amplitude and recovery time are both increased when the load is stepped higher, the output ripple continues to meet the peak to peak requirements. For the AV60C half-brick modules, the 10% minimum load requirement is strictly in order to meet all performance specifications.

Remote Sensing

The AV60C half-brick converter can remotely sense both lines of its output which 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 series in order to compensate for voltage drops in distribution and maintain a regulated voltage at the point of load.

When the converter is supporting loads far away, or is used with undersized cabling, significant voltage drop can occur at the load. The best defense against such drops is to locate the load close to the converter and to ensure adequately sized cabling is used. When this is not possible, the converter can compensate for a drop of up to 0.25V per lead, or a total of 0.5V, through use of the sense leads.

When used, the + and - Sense leads should be connected from the converter to the point of load as shown in figure 9 using twisted pair wire. The converter will then regulate its output voltage at the point where the leads are connected. Care should be taken not to reverse the sense leads. If reversed, the converter will trigger OVP protection and turn off. When not used, the +Sense lead must be connected with +Vo, and -Sense with -Vo. Also note that the output voltage and the remote sense voltage offset must be less than the minimum overvoltage trip point.

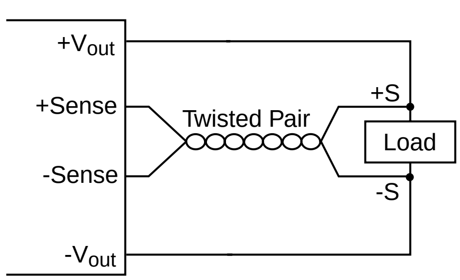


Fig.9 Sense Connections

Note that at elevated output voltages the maximum power rating of the module remains the same, and the output current capability will decrease correspondingly.

Output Trimming

Users can increase or decrease the output voltage set point of a module by connecting an external resistor between the TRIM pin and either the SENSE (+) or SENSE (-) pins. The trim resistor should be positioned close to the module.

If not using the trim feature, leave the TRIM pin open.

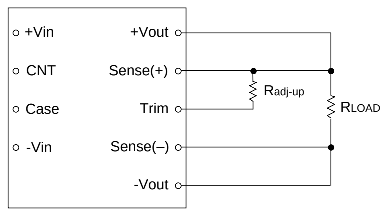
Trimming up by more than 10% of the nominal output may damage the converter. Trimming down more than 10% can cause the converter to regulate improperly. Trim down and trim up circuits and the corresponding configuration are shown in figure 10 and figure 11.

Note that at elevated output voltages the maximum power rating of the module remains the same, and the output current capability will decrease correspondingly.

The circuits and test results for the trim up and trim down configurations are displayed as following:

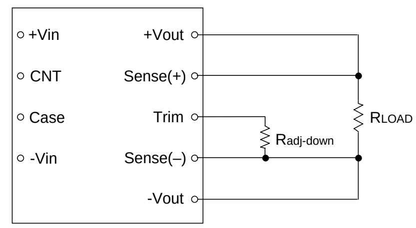
Output Over-Current Protection

AV60C half-brick series DC/DC converters feature foldback current limiting as part of their Overcurrent Protection (OCP) circuits. When output current exceeds 110 to 140% of rated current, such as during a short circuit condition, the output will shutdown immediately, and can tolerate short circuit conditions indefinitely. When the overcurrent condition is removed, the converter will automatically restart.



$$R_{adj\text{-}up} = \frac{Vo(100+y)}{1.26y} - \frac{(100+2y)}{y}$$

Where y is the adjusting percentage of the voltage.
0 < y < 10
Radj-up is in kΩ.



$$R_{adj\text{-}down} = \frac{100}{y} - 2$$

where y is the adjusting percentage of the voltage.
0 < y < 10
Radj-down is in kΩ.

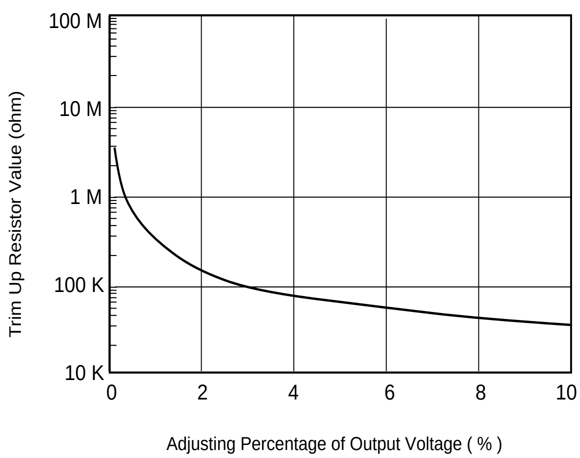


Fig.10. Trim Up Circuit and Curves

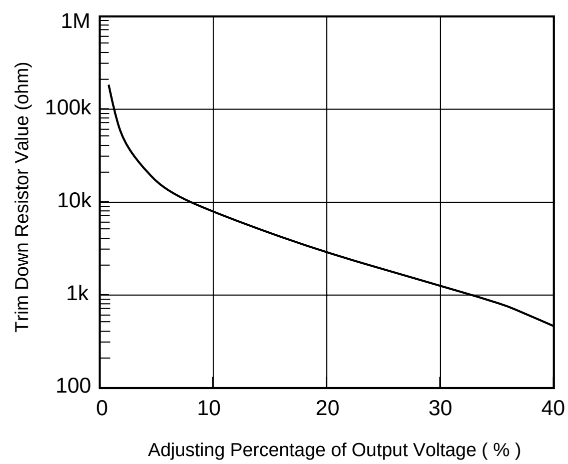


Fig.11. Trimming Down Circuit and Curves

Output Over-Voltage Protection

The over-voltage protection has a separate feedback loop which activates when the output voltage is between 5.75V-7V. When an over-voltage condition occurs, a " turn off " signal was sent to the input of the module, and shut off the output. The module will restart after power on again.

Output Filters

When the load is sensitive to ripple and noise, an output filter can be added to minimize the effects. A simple output filter to reduce output ripple and noise can be made by connecting a capacitor across the output as shown in figure 12. The recommended value for the output capacitor is 2200µF/10V.

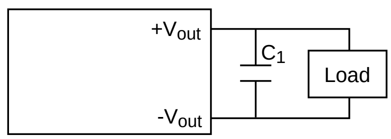


Fig.12 Output Ripple Filter

Extra care should be taken when long leads or traces are used to provide power to the load. Long lead lengths increase the chance for noise to appear on the lines. Under these conditions C2 can be added across the load as shown in figure 13. The recommended component for C2 is 2200µF/10V capacitor and connecting a 0.1µF ceramic capacitor in parallel generally.

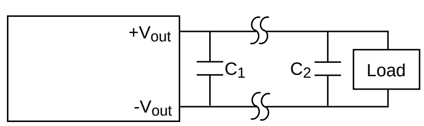


Fig.13 Output Ripple Filter For a Distant Load

Decoupling

Noise on the power distribution system is not always created by the converter. High speed analog or digital loads with dynamic power demands can cause noise to cross the power inductor back onto the input lines. Noise can be reduced by decoupling the load. In most cases, connecting a 10 µF tantalum capacitor in parallel with a 0.1µF ceramic capacitor across the load will decouple it. The capacitors should be connected as close to the load as possible.

Ground Loops

Ground loops occur when different circuits are given multiple paths to common or earth ground, as shown in figure 14. Multiple ground points can slightly different potential and cause current flow through the circuit from one point to another. This can result in additional noise in all the circuits. To eliminate the problem, circuits should be designed with a single ground connection as shown in figure 15.

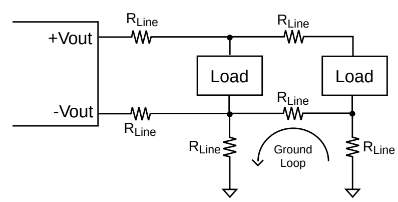


Fig.14 Ground Loops

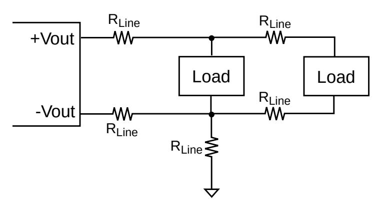


Fig.15 Single Point Ground

Parallel Power Distribution

figure 16 shows a typical parallel power distribution design. Such designs, sometimes called daisy chains, can be used for very low output currents, but are not normally recommended. The voltage across loads far from the source can vary greatly depending on the IR drops along the leads and changes in the loads closer to the source. Dynamic load conditions increase the potential problems.

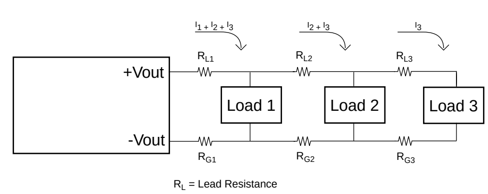


Fig.16 Parallel Power Distribution

Radial Power Distribution

Radial power distribution is the preferred method of providing power to the load. Figure 17 shows how individual loads are connected directly to the power source. This arrangement requires additional power leads, but it avoids the voltage variation problems associated with the parallel power distribution technique.

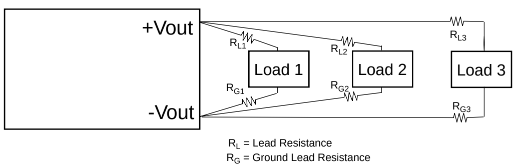


Fig.17 Radial Power Distribution

Mixed Distribution

In the real world a combination of parallel and radial power distribution is often used. Dynamic and high current loads are connected using a radial design, while static and low current loads can be connected in parallel. This combined approach minimizes the drawbacks of a parallel design when a purely radial design is not feasible.

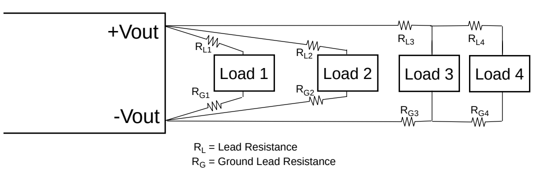


Fig.18 Mixed Power Distribution

Redundant Operation

A common requirement in high reliability systems is to provide redundant power supplies. The easiest way to do this is to place two converters in parallel, providing fault tolerance but not load sharing. Oring diodes should be used to ensure that failure of one converter will not cause failure of the second. figure 19 shows such an arrangement. Upon application of power, one of the converters will provide a slightly higher output voltage and will support the full load demand. The second converter will see a zero load condition and will "idle". If the first converter should fail, the second converter will support the full load. When designing redundant converter circuits, Shottky diodes should be used to minimize the forward voltage drop. The voltage drop across the Shottky diodes must also be considered when determining load voltage requirements.

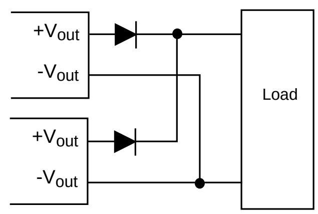


Fig.19 Redundant Operation

	USA	Europe	Asia	
TEL:	1-760-930-4600	44-(0)1384-842-211	852-2437-9662	
FAX:	1-760-930-0698	44-(0)1384-843-355	852-2402-4426	www.astec.com

ASTEC

Thermal Management

Technologies

AV60C Half-brick series 50 W to 150 W modules feature high efficiency and the 5V output units have typical efficiency of 85% at full load. With less heat dissipation and temperature-resistant components such as ceramic capacitors, these modules exhibit good behavior during prolonged exposure to high temperatures. Maintaining the operating case temperature (Tc) within the specified range help keep internal-component temperatures within their specifications which in turn help keep MTBF from falling below the specified rating. Proper cooling of the power modules is also necessary for reliable and consistent operation.

Basic Thermal Management

Measuring the case temperature of the module (Tc) as the method shown in figure 20 can verify the proper cooling. Figure 20 shows the metal surface of the module and the pin locations. The module should work under 90°C for the reliability of operation and T_C must not exceed 100 °C while operating in the final system configuration. The measurement can be made with a surface probe after the module has reached thermal equilibrium. If a heat sink is mounted to the case, make the measurement as close as possible to the indicated position. It makes the assumption that the final system configuration exists and can be used for a test environment.

The following text and graphs show guidelines to predict the thermal performance of the module for typical configurations that include heat sinks in natural or forced airflow environments. Note that Tc of module must always be checked in the final system configuration to verify proper

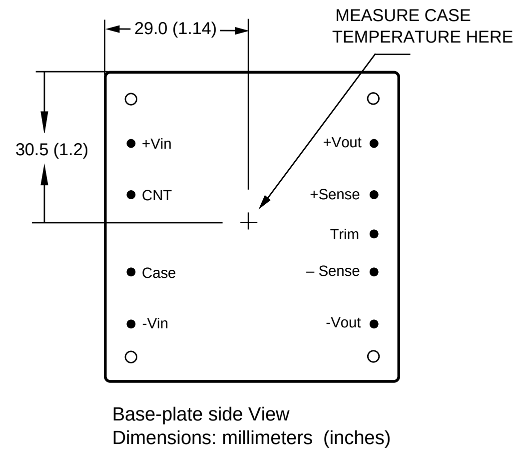


Fig.20 Case Temperature Measurement

operational due to the variation in test conditions.

Thermal management acts to transfer the heat dissipated by the module to the surrounding environment. The amount of power dissipated by the module as heat (P_D) is got by the equation below:

$$P_D = P_I - P_O$$

where : P_I is input power;
P_O is output power;
P_D is dissipated power.

Also, module efficiency (η) is defined as the following equation:

$$\eta = P_O / P_I$$

If eliminating the input power term, from two above equations can yield the equation below:

$$P_D = P_O (1-\eta) / \eta$$

The module power dissipation then can be calculated through the equation.

Because each power module output voltage has a different power dissipation curve, a plot of power dissipation versus output current over three different line voltages is given in each module-specific data sheet. The typical power dissipation curve of AV60C half-brick series 5V output are shown as figure 21 to figure 24.

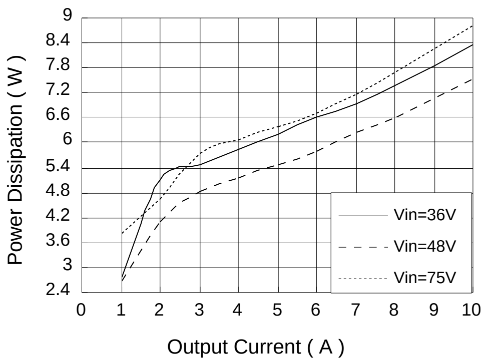


Fig.21 AV60C-048L-050F10N Power Dissipation

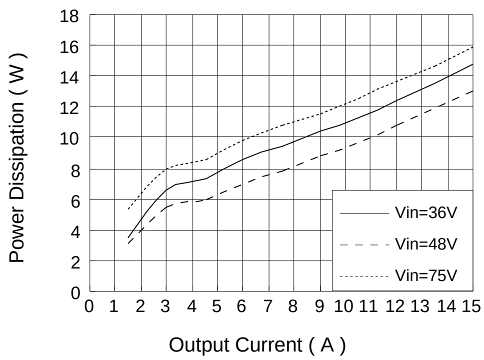


Fig.22 AV60C-048L-050F15N Power Dissipation

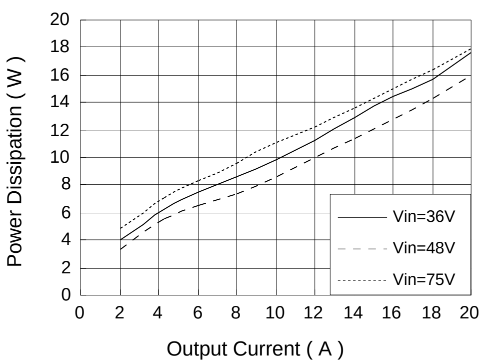


Fig.23 AV60C-048L-050F20N Power Dissipation

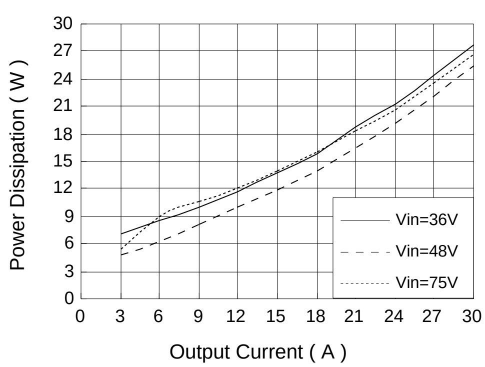


Fig.24 AV60C-048L-050F30N Power Dissipation

Module Derating

Experiment Setup

From the experimental set up shown in figure 25, the derating curves as figure 26 can be drawn. Note that the PWB (printed-wiring board) and the module must be mounted vertically. The passage has a rectangular cross-section. The clearance between the facing PWB and the top of the module is kept 13 mm (0.5 in.) constantly.

Convection Without Heat Sinks

Heat transfer can be enhanced by increasing the airflow over the module. Figure 26 shows the maximum power that can be dissipated by the module.

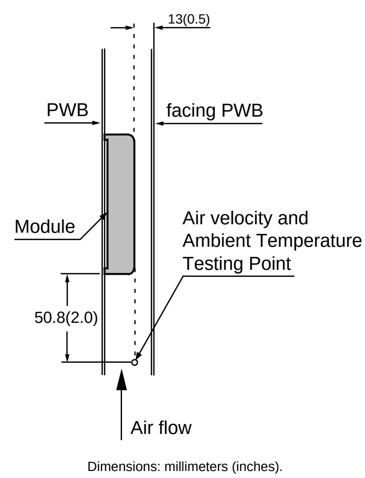


Fig.25 Experiment Set Up

In the test, natural convection airflow was measured at 0.05 m/s to 0.1 m/s (10 ft./min. to 20 ft./min.). The 0.5 m/s to 4.0 m/s (100 ft./min. to 800 ft./min.) curves are tested with externally adjustable fans. The appropriate airflow for a given operating condition can be determined through figure 26.

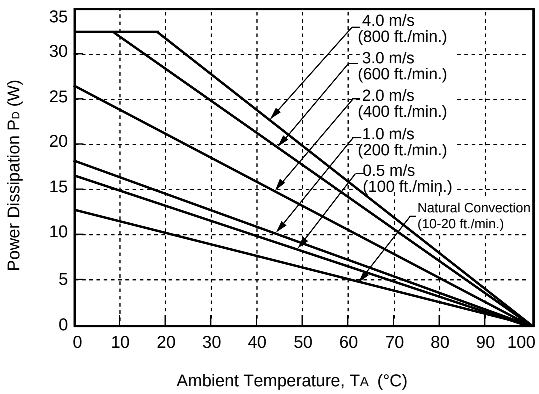


Fig.26 Forced Convection Power Derating without Heat Sink

Example 1. How to calculate the minimum airflow required to maintain a desired Tc?

If a AV60C-048L-050F30N module operates with a 48V line voltage, a 25 A output current, and a 40 °C maximum ambient temperature, what is the minimum airflow necessary for the operating?

Determine P_D (referenced **Fig.24)** with condition:

V_{in} = 48 V

I_O = 25 A

Get: P_D = 20 W

And with T_A = 40 °C

Determine airflow (Fig.26):

v = 3 m/s (600 ft./min.)

Example 2. How to calculate the maximum output power of a module in a certain convection and a max. T_A?

What is the maximum power output for a AV60C-048L-050F30N operating at following conditions:

V_{in} = 48 V

v = 3.0 m/s (600 ft./min.)

T_A = 40 °C

Determine P_D (Fig.26)

P_D = 21 W

Determine I_O (Fig.24):

I_O = 26 A

Calculate P_O:

$P_O = (V_O) \times (I_O) = 5 \times 26 = 130$ W

Although the two examples above use 100 °C as the maximum case temperature, for extremely high reliability applications, one may design to a lower case temperature as shown in Example 4 on page 24.

Heat Sink Configuration

Several standard heat sinks are available for the AV60C half-brick 50 W to 150 W modules as shown in figure 27 to figure 29.

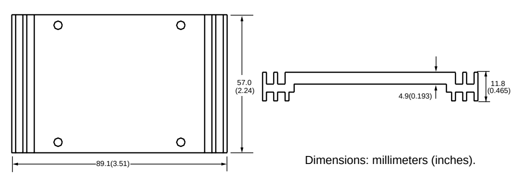


Fig.27 Non Standard Heatsink

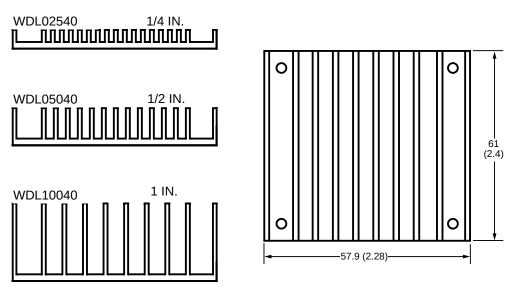


Fig.28 Longitudinal Fins Heat Sink

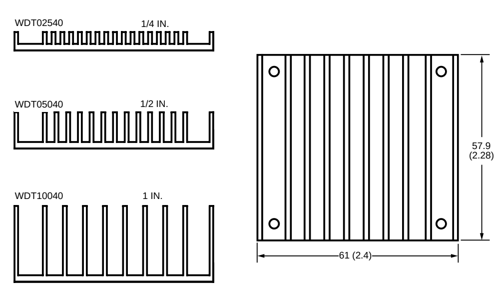


Fig.29 Transverse Fins Heat Sink

The heat sinks mount to the top surface of the module with screws torqued to 0.56 N-m (5 in.-lb). A thermally conductive dry pad or thermal grease is placed between the case and the heat sink to minimize contact resistance (typically 0.1° C/W to 0.3° C/W) and temperature differential.

Nomenclature for heat sink configurations is as follows:

WDxyyy40

where:

x = fin orientation: longitudinal (L) or transverse (T)

yyy = heat sink height (in 100ths of inch)

For example, WDT5040 is a heat sink that is transverse mounted (see figure 29) for a 61 mm x 57.9 mm (2.4 in.x 2.28 in.) module with a heat sink height of 0.5 in.

Heatsink Mounting Advice

A crucial part of the thermal design strategy is the thermal interface between the baseplate of the module and the heatsink. Inadequate measures taken here will quickly negate any other attempts to control the baseplate temperature. For example, using a conventional dry insulator can result in a case-heatsink thermal impedance of >0.5° C/W, while use one of the recommended interface methods (silicon grease or thermal pads available from Astec) can result in a case-heatsink thermal impedance around 0.1°C/W.

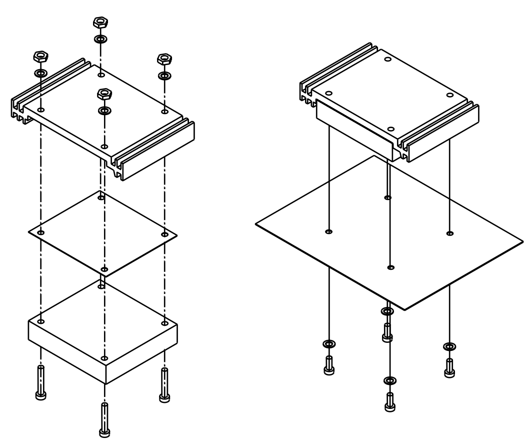


Fig.30 Heat Sink Mounting

Natural Convection with Heat Sink

The power derating for a module with the heat sinks (shown as figure 27 to figure 29) in natural convection is shown in figure 31. In this test, natural convection generates airflow about 0.05 m/s to 0.1 m/s (10ft./min to 20ft./min). Figure 31 can be used for heat-sink selection in natural convection environment.

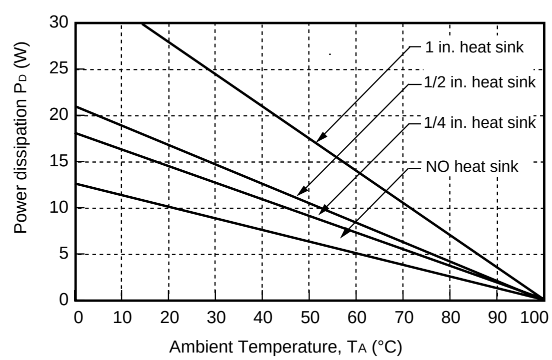


Fig.31 Heat Sink Power Derating Curves, Natural Convection

Example 3. How to select a heat sink?

What heat sink would be appropriate for a AV60C-048L-050F30N in a natural convection environment at nominal line, 3/4 load, and maximum ambient temperature of 40°C?

Determine P_D (referenced **Fig.24)** with condition:

V_{in} = 48 V

I_O = 3/4 (30) = 23 A

T_A = 40 °C

Get: P_D = 19 W

Determine Heat Sink (Fig.31):

1 in. allows up to T_A = 45 °C

Basic Thermal Model

There is another approach to analyze module thermal performance, to model the overall thermal resistance of the module. This presentation method is especially useful when considering heat sinks. The following equation can be used to calculate the total thermal resistance .

$R_{CA} = \Delta T_{C,\ max} / P_D$

Where R_{CA} is the module thermal resistance.

$\Delta T_{C,\ max}$ is the maximum case temperature rise.

P_D is the module power dissipation.

In this model, P_D, $\Delta T_{C,\ max}$, and R_{CA} are equals to current flow, voltage drop, and electrical resistance, respectively, in Ohm's law, as shown in figure 32. Also, $\Delta T_{C,\ max}$ is defined as the difference between the module case temperature (T_C) and the inlet ambient temperature (T_A).

$\Delta T_{C,\ max} = T_C - T_A$

Where T_C is the module case temperature;

T_A is the inlet ambient temperature.

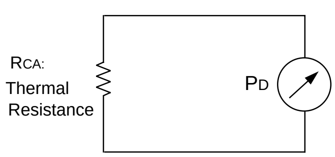


Fig.32 Basic Thermal Resistance Model

For AV60C half-brick series 50W to 150W 5V output converters, the module's thermal resistance values versus air velocity have been determined experimentally and shown in figure 33. The highest values on each curve represents the point of natural convection.

Figure 33 is used for determining thermal performance under various conditions of airflow and heat sink configurations.

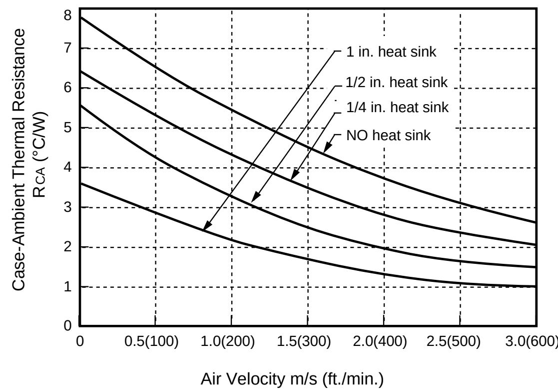


Fig.33 Case-to-Ambient Thermal Resistance Curves; Either Orientation

Example 4. How to determine the allowable minimum airflow to heat sink combinations necessary for a module under a desired Tc and a certain condition?

Although the maximum case temperature for the AV60C half-brick series converters is 100°C, you can improve module reliability by limiting Tc,max to a lower value. How to decide? For example, what is the allowable minimum airflow for AV60C-048L-050F30N heat sink combinations at desired Tc of 80 °C? The working condition is as following:

$V_{in} = 48$ V, $I_O = 25$A, $T_A = 40$ °C

Determine P_D (Fig.24)

$P_D = 20$ W

Then solve R_{CA}:

$R_{CA} = \Delta T_{C,\ max} / P_D$

$R_{CA} = (T_C - T_A) / P_D$

$R_{CA} = (80 - 40) / 20 = 2$°C/W

Determine air velocity from Fig.33:

If no heat sink:

v > 3.0 m/s (600 ft./min.)

If 1/4 in. heat sink:

v = 3.0 m/s (600 ft./min.)

If 1/2 in. heat sink:

v = 2.0 m/s (400 ft./min.)

If 1 in. heat sink:

v = 1.2 m/s (240 ft./min.)

Example 5. How to determine case temperature (Tc) for the various heat sink configurations at certain air velocity?

What is the allowable Tc for AV60C-048L-050F30N heat sink configurations at desired air velocity of 2.0 m/s, and it is operating at a 48 V line voltage, a 25 A output current, a 40 °C maximum ambient temperature?

Determine P_D (Fig.24) with condition:

V_{in} = 48 V

I_O = 25 A

T_A = 40 °C

v = 2.0 m/s (400 ft./min.)

Get: P_D = 20 W

Determine T_C: $T_C = (R_{CA} \times P_D) + T_A$

Determine the corresponding thermal resistances (R_{CA}) from Fig.33:

No heat sink: R_{CA} = 3.8 °C/W

T_C = (3.8 x 20) + 40 = 116 °C

1/4 in. heat sink: R_{CA} = 2.8 °C/W

T_C = (2.8 x 20) + 40 = 96 °C

1/2 in. heat sink: R_{CA} = 2.0 °C/W

T_C = (2.0 x 20) + 40 = 80 °C

1 in. heat sink: R_{CA} = 1.2 °C/W

T_C = (1.2 x 20) + 40 = 64 °C

In this configuration, the heat sink would have to be at least 1/4 in. high so that the power module does not exceed the maximum case temperature of 100°C.

AV60C Half-brick Series

Mechanical Considerations

Installation

Although AV60C half-brick series converters can be mounted in any orientation, free air-flowing must be taken. Normally power components are always put at the end of the airflow path or have the separate airflow paths. This can keep other system equipment cooler and increase component life spans.

Soldering

AV60C half-brick series converters are compatible with standard wave soldering techniques. When wave soldering, the converter pins should be preheated for 20-30 seconds at 110°C, and wave soldered at 260°C for less than 10 seconds.

When hand soldering, the iron temperature should be maintained at 425°C and applied to the converter pins for less than 5 seconds. Longer exposure can cause internal damage to the converter. Cleaning can be performed with cleaning solvent IPA or with water.

MTBF

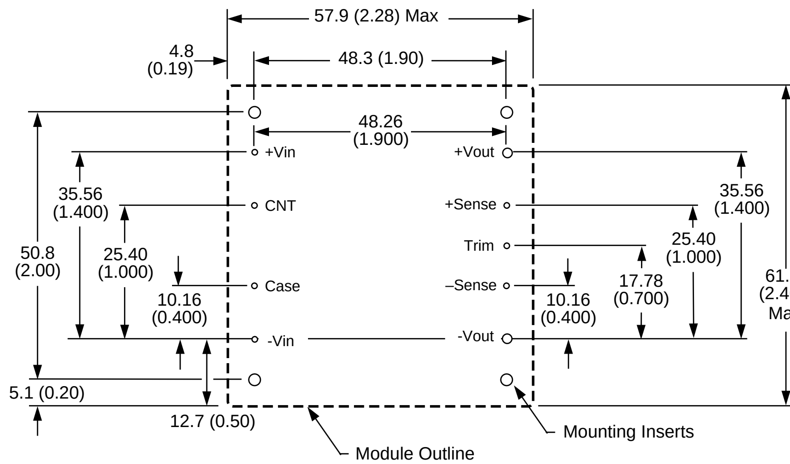
The MTBF, calculated in accordance with Bellcore TR-NWT-000332 is 2,000,000 hours. Obtaining this MTBF in practice is entirely possible. If the ambient air temperature is expected to exceed +25°C, then we also advise a heatsink on the AV60C half-brick series, oriented for the best possible cooling in the air stream.

ASTEC can supply replacements for converters from other manufacturers, or offer custom solutions. Please contact the factory for details.

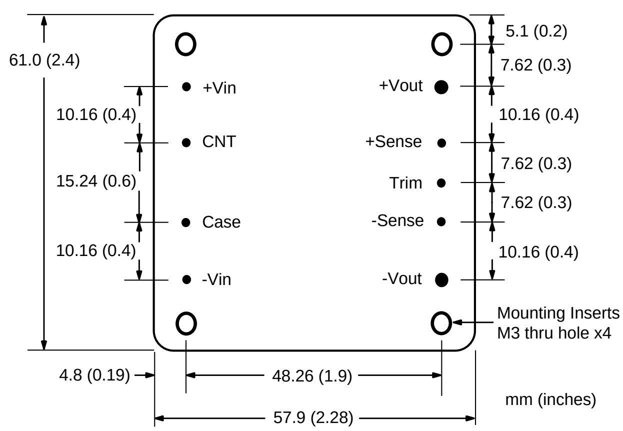
Recommend Hole Pattern

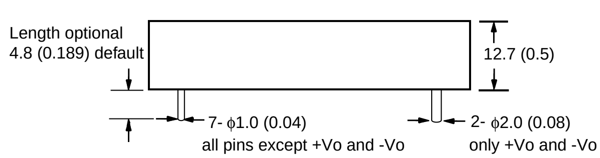
Base-plate side view

Dimensions are in millimeters and (inches).



Mechanical Chart





Pin Length Option	Device Code Suffix
4.80mm ± 0.5mm 0.189in. ± 0.020in.	none (default)
3.80mm ± 0.25mm 0.150in. ± 0.010in.	-6
5.80mm ± 0.5mm 0.228in. ± 0.02in.	-7
2.80mm ± 0.25mm 0.110in. ± 0.010in.	-8

Tolerances:

Inches	Millimeters
.xx ±0.020	.x ±0.5
.xxx ±0.010	.xx ±0.25

Pins

>4mm ±0.02inch (±0.5mm)

<4mm ±0.01inch (±0.25mm)

Base-plate side view

PART NUMBER DESCRIPTION

ss pp c - 0 iv L - xxx f yy h n - p - mx-Options

p = Pin Length
Omit this digit for Standard 5mm
6 = 3.8mm, 7= 5.8mm
8 = 2.8mm

iv = Input Voltage
05 = Range centered on 5V
12 = Range centered on 12V
24 = 18 to 36(2:1), 9 to 36V(4:1)
36 = 20 to 60V
46 = 18V to 75V (4:1)
48 = Typ 36 to 75V

Enable Logic Polarity
Omit for Positive Enable Logic
N = Negative Enable
Except: AK60C-20H, BK60C-30H
Omit for Negative Logice
P = Positive Logic

c = Pinout compatability
A= Astec Footprint or " non Lucent" footprint
C= Ind Std, Exact Lucent drop in

H = High Efficiency (Synch rect.)
Omit H if Conventional Diode (low Eff)

yy = Output Current
ie. 08 = 8 Amps

pp = Package Type
40 = 1" x 2" SMD
42 = 1.5" x 2" SMD
45 = 1.45" X 2.3" (1/4 Brk)
60 = 2.4" X 2.3" (1/2 Brk)
80 = Full size 4.6" x 2.4"
72= 2.35" X 3.3 (3/4 Brk)

f = # of Outputs
F = Single Output
D = Dual Output

xxx = Output Voltage
Format is XX.X (ie 1.8V = 018)

ss = Series
AA = 1/2brick Dual (Old designator)
AK = Ind Std sizes (1/4, 1/2, full) <150W
AM/BM = Full size, astec pin out
AL = Half size, astec pin-out
BK = Ind Std size =>150W or feature rich
AV = Avansys Product

mx = Options
M1,M2 = .25" Height Heatsink
M3,M4 = .5" height Heatsink
M5.M6 = 1.0" Height Heatsink

Note: For some products, they may not conform with the PART NUMBER DESCRIPTION above absolutely.

NEW PART NUMBER DESCRIPTION

A	c	s	ii	$V_1 V_2 V_3$	V_{in}	-	e	t	p	Mx

Output Voltage

A = 5.0V	E = 7.5V
F = 3.3V	B = 12V, C = 15V
G = 2.5V	L = 8V, H = 24V, R = 28V
D = 2.0V / 2.1V	Omit V2 and V3 if Single Output
Y = 1.8V	Omit V3 if Dual Output
M = 1.5V	**ie for Dual Output 5 and 3.3V**
K = 1.2V	**V1 =A, V2 = F, V3 =Omit**
J = 0.9V	**V1 =A, V2 = F, V3 =Omit**

ii = Output Current Max
ie 60 = 60 Amps

S = Size
F = Full Brick
H = Half Brick
Q = Quarter Brick
S = 1 X 2 18 Pin SMT
E = 1 X 2 Thru Hole
C = (.53X1.3X.33) SMT (Austin Lite drop in)
V = Conventional Package (2X2.56") or (
A = SIP
W = Convent pkg (Wide 2.5X3)
R = 1 X 1 Thru Hole
A = SIP
T = 1.6 X 2

c = Construction
E = Enhanced Thermals (Baseplate or adapter plate)
I = Integrated (Full Featured) Hong Kong models
L = Low Profile (Open Frame, No case - Isolated)
P = Open Frame (SIP or SMT) non-isolated

Vin = Input Voltage range
300 = 250V to 450V
48 = 36V to 75V
24 = 18V to 36V
03 = 1.8V to 5.0V
08 = 5.0V to 13.0V
PFC: Power Factor Corrected

E = Enable Logic for > 15W
Omit this digit for Positive enable
N = Negative Logic

E = Enable Logic for < 15W
Omit this digit for no enable option
1 = Negative Logic
4 = Positive Logic

Trim for 1W to 15W
9 = Trim Added

P = Pin Length
Omit this digit for Standard 5mm
6 = 3.8mm
8 = 2.8mm
7 = 5.8 mm

Mx - Factory Options
customer Specific

Note: For some products, they may not conform with the NEW PART NUMBER DESCRIPTION above absolutely.