

## FEATURES

### Electrical

- Peak Efficiency up to 98%
- Input range: 9~60Vdc
- Output range: 0~60Vdc
- Over current protection
- Input UVP
- Over Temperature Protection
- Remote ON/OFF, negative logic
- Pre-bias startup
- No minimum load required
- Parallel Operation with Active Current Sharing



## H60SB0A050

1/2 Brick DC/DC Regulated Power Module  
9~60Vin, 0~60Vout, 50A

The Delphi Series H60SB0A050, 9~60V input, Non-isolated single output, Half Brick, is regulated DC/DC converter, and is being offered from a world leader in power system and technology and manufacturing — Delta Electronics, Inc. The H60SB0A050 offers up to 50A output and 98% peak efficiency in an industry standard footprint. With creative design technology and optimization of component placement, these converters possess outstanding electrical and thermal performances, as well as extremely high reliability under highly stressful operating conditions. The H60SB0A050 can be connected in parallel for higher power without external oring-fet.

### Mechanical

Size(open frame):

60.5 x 57.9 x 11.2mm (2.38"x2.28"x0.44")

Size(with base plate):

60.5 x 57.9 x 13.0mm (2.38"x2.28"x0.51")

Size(with Baseplate and Encased):

63.2 x 60.6 x 13.0mm (2.49"x2.39"x0.51")

Size(with Flange Baseplate and Encased):

80.0 x 60.6 x 13.0mm (3.15"x2.39"x0.51")

### Safety & Reliability

- UL 62368-1 Pending
- ISO 9001, TL 9000, ISO 14001, QS 9000, OHSAS18001 certified manufacturing facility

## OPTIONS

- Base plate / Base plate & Encased / Flanged base plate & Encased
- PMBus communication

## SOLDERING METHOD

- Wave soldering
- Hand soldering

## APPLICATIONS

- Battery Charge
- Optical Transport
- Data Networking
- Communications
- Servers

(T<sub>A</sub>=25°C, airflow rate=300 LFM unless otherwise noted.)

PARAMETER	NOTES and CONDITIONS	H60SB0A050			
		Min.	Typ.	Max.	Units
<b>ABSOLUTE MAXIMUM RATINGS</b>					
Input Voltage					
Continuous		0		60	Vdc
Transient	100mS			80	Vdc
Operating Ambient Temperature (Ta)		-40		85	°C
Storage Temperature		-55		125	°C
Input/Output Isolation Voltage	Non-Isolation			NA	Vdc
<b>INPUT CHARACTERISTICS</b>					
Operating Input Voltage		9		60	Vdc
Input Under-Voltage Lockout					
Turn-On Voltage Threshold		7	8	9	Vdc
Turn-Off Voltage Threshold		5	6	7	Vdc
Lockout Hysteresis Voltage			2		Vdc
Input Over-Voltage Protection	Response with 150mS delay			65	Vdc
Input Current Limit	With Input Current limit Function			55	A
No-Load Input Current	V <sub>in</sub> =28V, V <sub>out</sub> = 12V I <sub>o</sub> =0A			100	mA
	V <sub>in</sub> =28V, V <sub>out</sub> = 24V I <sub>o</sub> =0A			90	mA
	V <sub>in</sub> =28V, V <sub>out</sub> = 48V I <sub>o</sub> =0A			180	mA
Off Converter Input Current	V <sub>in</sub> =48V			2	mA
Internal Input filter components value (C/L/C)			10/0.3/40		µF/µH/µF
Input Terminal AC Current	With External Filter 1µH inductor + Cinmin				mArms
<b>OUTPUT CHARACTERISTICS</b>					
Output Voltage Range		0		60	Vdc
Output Current Range		0		50	A
Output Regulation					
Load Regulation	I <sub>o</sub> =I <sub>o</sub> min to I <sub>o</sub> max			-4%*V <sub>out</sub> *I <sub>out</sub> /I <sub>omax</sub>	
Total Output Voltage Range	Between sense pins, over line, load, temp			+/-100mV +/- 0.5%V <sub>out</sub> +Load Regulation	
Output Voltage Ripple and Noise	5Hz to 20MHz bandwidth, Co=100uF				
Peak-to-Peak	V <sub>in</sub> =28V, V <sub>o</sub> =12V, 50A		110		mV
Peak-to-Peak	V <sub>in</sub> =28V, V <sub>o</sub> =24V, 50A		100		mV
Peak-to-Peak	V <sub>in</sub> =28V, V <sub>o</sub> =48V, 25A		100		mV
Output Over Current Limitation			55		A
Output Capacitance Range		100		15000	µF
Output Over Voltage Protection(hiccup mode)			65		V
<b>DYNAMIC CHARACTERISTICS</b>					
Output Voltage Current Transient	V <sub>in</sub> =28V, V <sub>out</sub> = 12V, Co=100uF, 0.1A/µs				
Positive Step Change in Output Current	75% I <sub>o,max</sub> to 50% I <sub>o,max</sub>		600		mV
Negative Step Change in Output Current	50% I <sub>o,max</sub> to 75% I <sub>o,max</sub>		400		mV
Settling Time (within 1% nominal V <sub>out</sub> )					µs
Turn-On Delay and Rise Time					
Start-Up Delay Time From Input Voltage	On/Off=On, from V <sub>in</sub> =Turn-on Threshold to V <sub>o</sub> =10% V <sub>o,nom</sub>		30		mS
Start-Up Delay Time From On/Off Control	V <sub>in</sub> =V <sub>in,nom</sub> , from On/Off=On to V <sub>o</sub> =10% V <sub>o,nom</sub>		30		mS
Output Voltage Rise Time Slew Rate	V <sub>o</sub> =10% to 90% V <sub>o,nom</sub>		0.3		V/mS
Output Voltage Overshoot at Start-Up			0		V
<b>EFFICIENCY</b>					
100% Load	V <sub>in</sub> =12V, V <sub>out</sub> = 48V		93.0		%
	V <sub>in</sub> =24V, V <sub>out</sub> = 48V		96.0		%
	V <sub>in</sub> =48V, V <sub>out</sub> = 12V		93.0		%
<b>FEATURE CHARACTERISTICS</b>					
Switching Frequency			280		KHz
On/Off Control, Negative Remote On/Off logic					
Logic Low (Module On)	V <sub>on/off</sub>	0		0.8	V
Logic High (Module Off)	V <sub>on/off</sub>	3.5		10	V
ON/OFF Current	I <sub>on/off</sub> at V <sub>on/off</sub> =0.0V			1	mA
Leakage Current	Logic High, V <sub>on/off</sub> =5V			1	mA
Ishare/I <sub>mon</sub>					
Pin voltage at no load			0.2		V
Pin voltage at full load(50A)			2.7		V
<b>GENERAL SPECIFICATIONS</b>					
MTBF	I <sub>o</sub> =80% of I <sub>o, max</sub> , T <sub>a</sub> =25°C	1.2			Mhours
Weight(with base plate)			105		grams
Weight(with base plate and encased)			155		grams
Weight(with flange base plate and encased)			159		grams

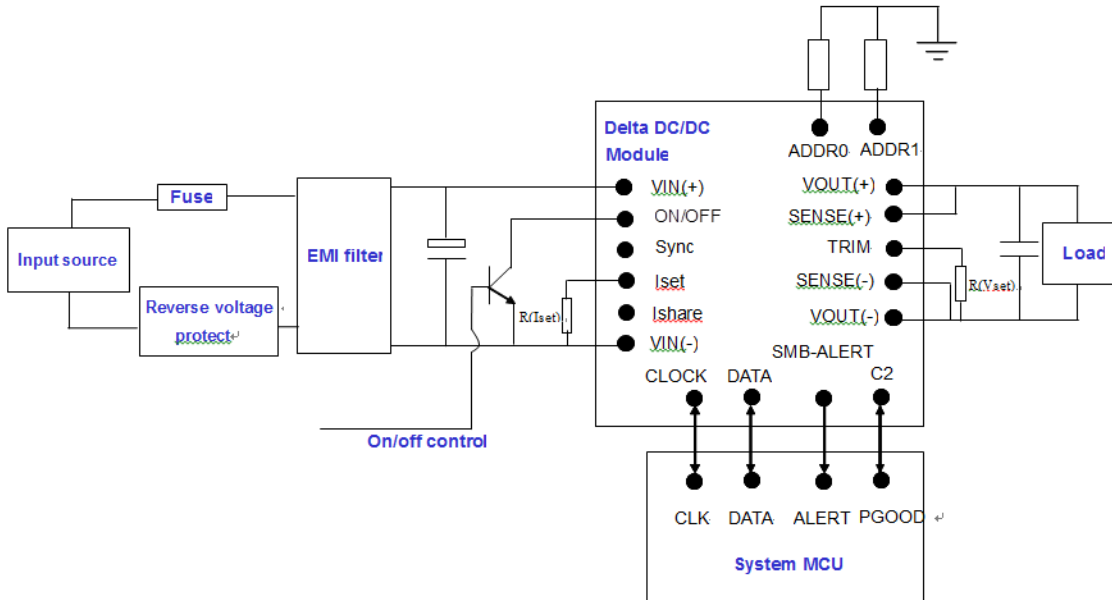


PARAMETER	NOTES and CONDITIONS	H60SB0A050			
		Min.	Typ.	Max.	Units
Over-Temperature Shutdown (With heat spreader)	Refer to Figure 18 for Hot spot location (48V <sub>in</sub> , 12V <sub>out</sub> , 80% Output Power)		110		°C
Over-Temperature Shutdown ( NTC resistor )			130		°C
Note: Please attach thermocouple on NTC resistor to test OTP function, the hot spots' temperature is just for reference.					
<b>PMBUS SIGNAL INTERFACE CHARACTERISTICS</b>					
Logic Input Low (V <sub>IL</sub> )	Data, SMBAlert, Clock pin	0		0.8	V
Logic Input High (V <sub>IH</sub> )	Data, SMBAlert, Clock pin	2.1		3.3	V
Logic Output Low (V <sub>OL</sub> )	Data, SMBAlert, Clock pin; IOL=6mA			0.4	V
Logic Output High (V <sub>OH</sub> )	Data, SMBAlert, Clock pin; IOH=-6mA	2.6			V
PMBus Operating Frequency Range			100 or 400		KHz
<b>PMBUS MONITORING CHARACTERISTICS</b>					
Output Current Reading Accuracy	Io=50% ~ 100% of Io, max; Io=5% ~ 50% of Io, max;	-5		+5	%
Output Voltage Reading Accuracy		-3		+3	A
Input Voltage Reading Accuracy		-2		+2	%
Temperature Reading Accuracy		-4		+4	%
		-5		+5	°C

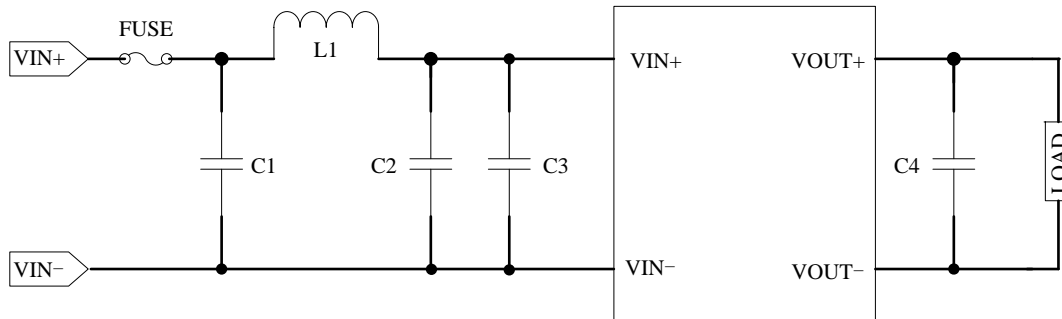
## PIN DEFINATION

Pin#	Name	Function	Pin#	Name	Function	Pin#	Name	Function
1	Vin(+)	Positive supply input	7	Vout(-)	Negative power output	13	Sig-Gnd	Signal ground
2	ON/OFF	Input to enable/disable the converter, TTL	8	Sense(-)	Negative power Voltage Sense	14	Data	PMBUS data line
3	Syncln	Input to synchronize the converter to an external clock, TTL	9	Trim	Input to set the maximum output voltage	15	SMBALERT	PMBUS SMBALERT line
4	Iset	Input to set the maximum output current	10	Sense(+)	Positive output voltage Sense	16	Clock	PMBUS clock line
5	Ishare	Current monitor or Current share	11	Vout(+)	Positive power output	17	Addr1	The high order digit of the address
6	Vin(-)	Negative supply input	12	C2	PGOOD Pin	18	Addr0	The low order digit of the address

## SIMPLIFIED APPLICATION CIRCUIT



## SUGGESTED FILTER CIRCUIT



	Value	Manufacturer	PN	Quantity(Pcs)
Fuse	80A	Littlefuse	0456040.DR 40A	2
L1	1.5uH	WE	Order code: 74436410150 1.5uH	1
C1	100uF ceramic cap	TDK	CKG57NX7R2A106MT 10uF/100V	10
C2	470uF electrolytic cap	NCC	EKZN101EC3471MLN31 470uF/100V	1
C3	100uF ceramic cap	TDK	CKG57NX7R2A106MT 10uF/100V	10
C4	100uF electrolytic cap	NCC	EKZN101ETD101MJ201 100uF/100V	1

## ELECTRICAL CHARACTERISTICS CURVES

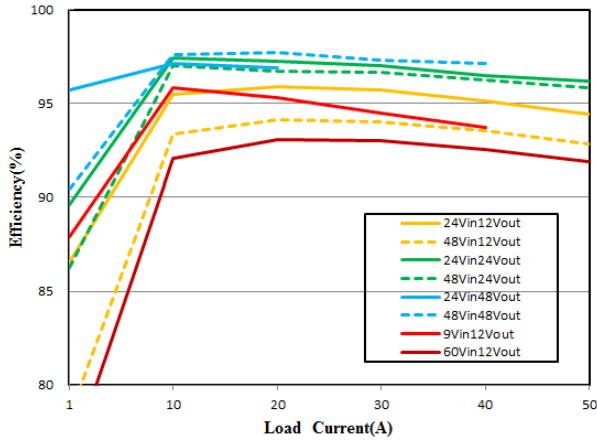


Figure 1: Efficiency vs. Load Current at Ta=25°C

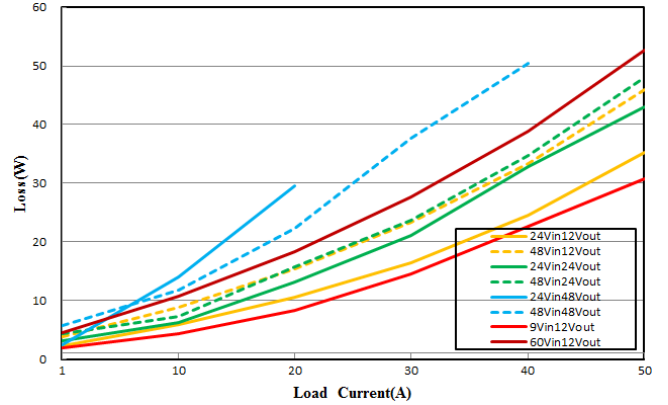


Figure 2: Loss vs. Output Power at Ta=25°C

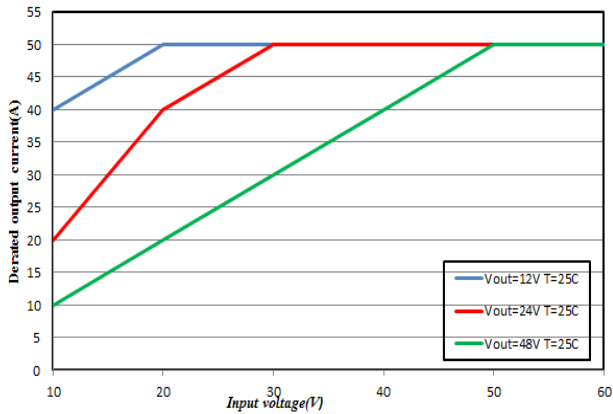
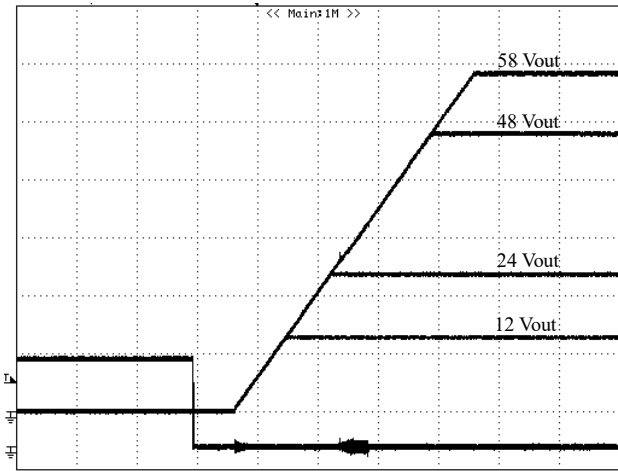
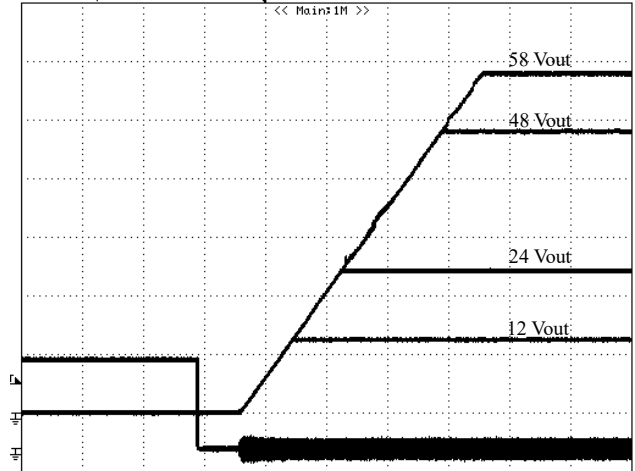


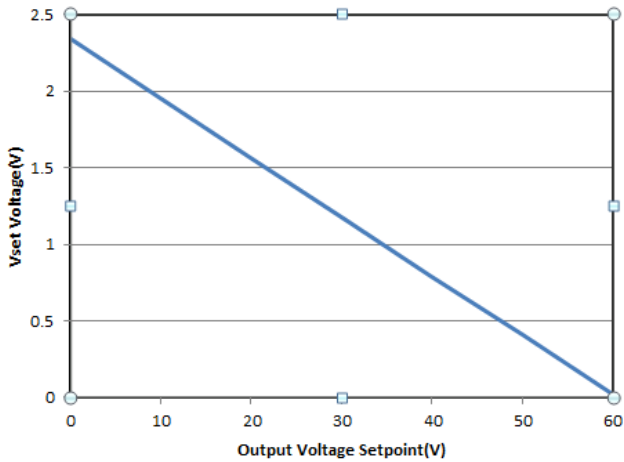
Figure 3: Input Voltage vs. Output Current showing typical current limit curves.



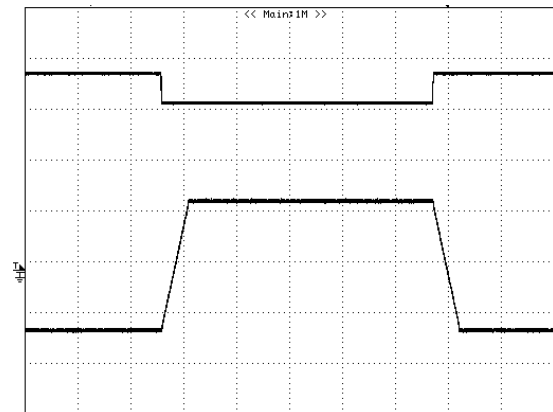
**Figure 4: Remote On/Off (negative logic) at no load**  
 $V_{in} = 28V$   
 Time: 50ms/div.  
 $V_{out}$  (top trace): 12Vout, 24Vout, 48Vout, 58Vout, 10V/div;  
 $V_{remote\ On/Off}$  signal (bottom trace): 5V/div.



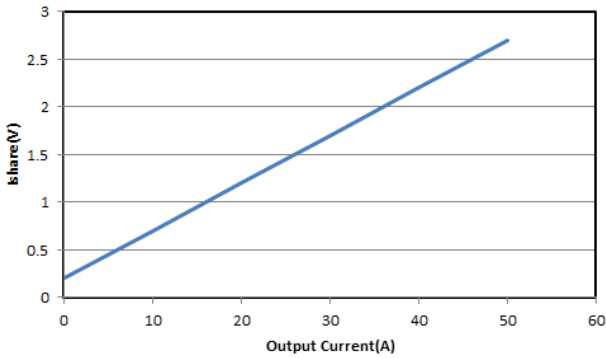
**Figure 5: Remote On/Off (negative logic) at full load**  
 $V_{in} = 28V$   
 Time: 50ms/div.  
 $V_{out}$  (top trace): 12Vout, 24Vout, 48Vout, 58Vout, 10V/div;  
 $V_{remote\ On/Off}$  signal (bottom trace): 5V/div.



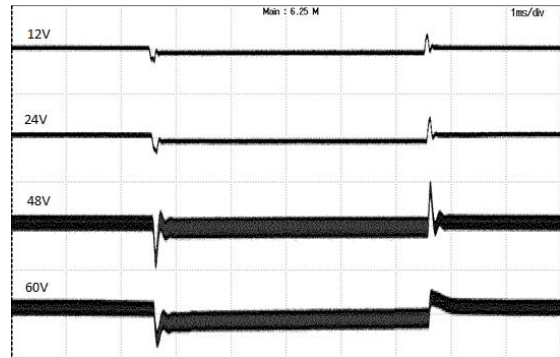
**Figure 6: Vset pin voltage vs. Output voltage set point.**



**Figure 7: Output Voltage vs. Vset pin voltage dynamic;**  
 $V_{in} = 28V, I_o = 10A$   
 Time: 50ms/div.  
 Top trace: Vset pin voltage(500mV/div)  
 Bottom trace: Output Voltage(3V/div)

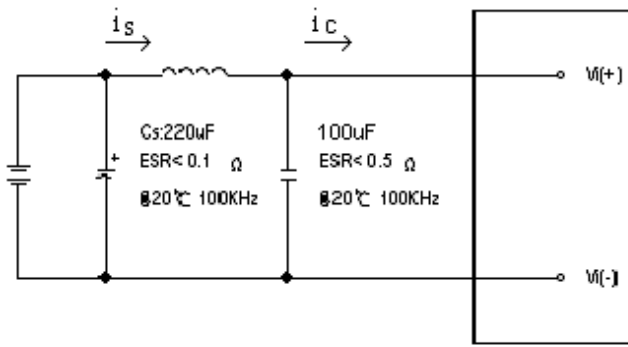


**Figure 8:** Ishare/Imon pin voltage vs. output load current.

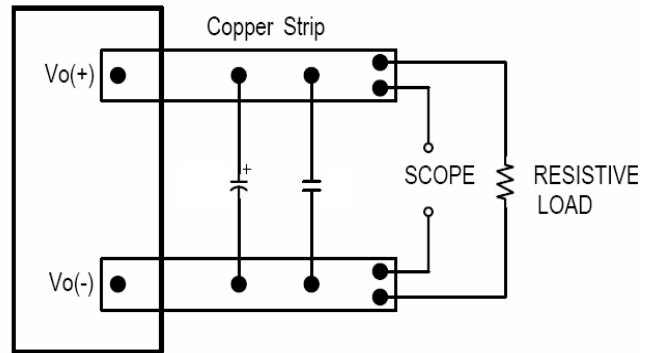


**Figure 9:** Transient Response

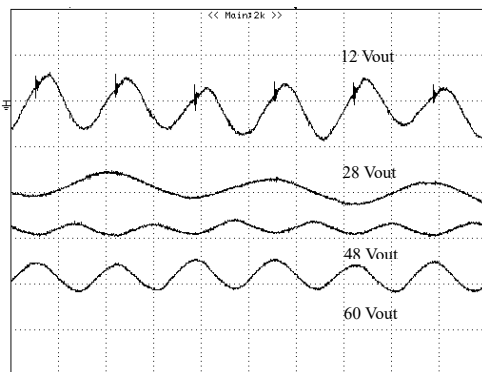
(28Vin, di/dt=0.1A/Us, from top trace to bottom trace  
 12Vout, 25A-37.5A-25A; 24Vout, 25A-37.5A-25A;  
 48Vout, 12A-18A-12A ; 60Vout, 5A-7.5A-5A.  
 2V/div, 1ms/div; Cout is 100uF.



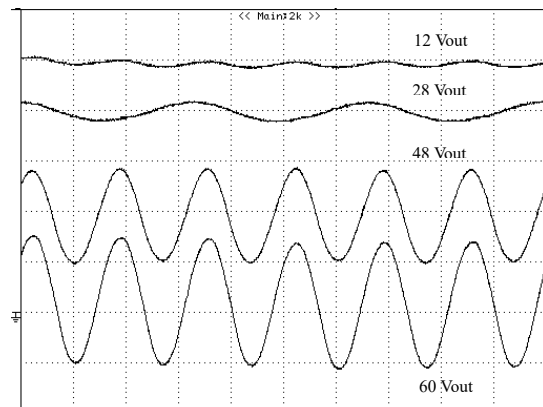
**Figure 10:** Test Setup Diagram for Input Ripple Current  
 Note: Measured input reflected-ripple current with a simulated source Inductance ( $L_{TEST}$ ) of 12 $\mu$ H. Capacitor Cs offset possible battery impedance. Measure current as shown above.



**Figure 11:** Test Setup for Output Voltage Noise and Ripple



**Figure 12:** Input Terminal Ripple Current,  $i_c$ , at max output current and nominal input voltage(28V) with 12 $\mu$ H source impedance and 33 $\mu$ F electrolytic capacitor (50 mA/div, 2us/div).



**Figure 13:** Output Voltage Ripple and Noise at input voltage(28V) and rated load current (500 mV/div) Load capacitance: 100uF. Bandwidth: 20MHz, (2us/div)

## Input Source Impedance

The impedance of the input source connecting to the DC/DC power modules will interact with the modules and affect the stability. A low ac-impedance input source is recommended. A low ESR electrolytic capacitor higher than 100µF (ESR < 0.7Ω at 100kHz) is suggested.

## Safety Considerations

The power module must be installed in compliance with the spacing and separation requirements of the end-user's safety agency standard, i.e. IEC 62368-1: 2014 (2nd edition), EN 62368-1: 2014 (2nd edition), UL 62368-1, 2nd Edition, 2014-12-01 and CSA C22.2 No. 62368-1-14, 2nd Edition, 2014-12, if the system in which the power module is to be used must meet safety agency requirements.

Both the input and output of this product meet SELV requirement.

This power module is not internally fused. To achieve optimum safety and system protection, an input line fuse is highly recommended. The safety agencies require a normal-blow fuse with 70A maximum rating to be installed in the ungrounded lead. A lower rated fuse can be used based on the maximum inrush transient energy and maximum input current.

## Soldering and Cleaning Considerations

Post solder cleaning is usually the final board assembly process before the board or system undergoes electrical testing. Inadequate cleaning and/or drying may lower the reliability of a power module and severely affect the finished circuit board assembly test. Adequate cleaning and/or drying is especially important for un-encapsulated and/or open frame type power modules. For assistance on appropriate soldering and cleaning procedures, please contact Delta's technical support team.

## Remote On/Off

The remote on/off feature on the module is negative logic. Negative logic turns the module on during logic low and off during logic high. Remote on/off can be controlled by an external switch between the on/off terminal and the VIN (-) terminal. The switch can be an open collector or open drain.

For negative logic if the remote on/off feature is not used, please short the on/off pin to VIN (-).

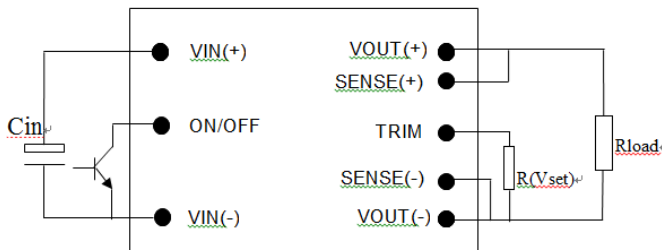


Figure 14: Remote On/Off Implementation

## Synchronization

The module will synchronize its switching to a clock signal at the Sync pin (relative to Sense-) of between 250KHz and 350KHz. For noise immunity, the input has 0.1V hysteresis. It can be driven by any standard logic gate. The input has an internal 5KΩ pull-up to 3.3V; if unused, leave this input floating or tie it directly to Sense-.

## Output Voltage Set Point

The output voltage can be programmed to any voltage between 0 V dc and Vmax by connecting one resistor between the Vset(Trim) pin (9) and Sense- (8); See Figure 15. For a desired output voltage, the value of the resistor should be:

$$R_{vset}(vset) = \left[ \left( \frac{11830 \times V_{max}}{V_{set} + 0.058 \times V_{max}} \right) - 10912 \right] (\Omega)$$

Alternatively, the Vset(Trim) pin can be driven from an external voltage source:

$$V_{vset}(Vset) = 2.366 - 2.316 \left( \frac{V_{set}}{V_{max}} \right)$$

Vset = desired output voltage set point

Vmax = maximum rated output voltage (60V)

Undriven, this pin floats at 2.5V which sets the output to 0V.

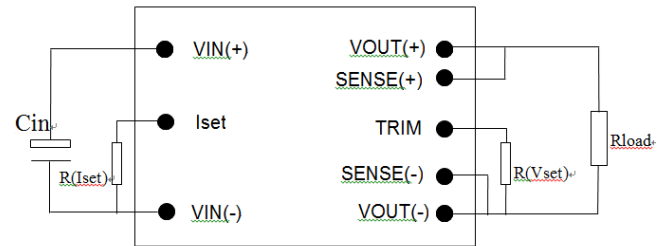


Figure 15

## Output Current Setting

The maximum output current (effectively the current limit) can be reduced to any value between 0 and Imax by connecting one resistor between the Iset pin (4) and Sense- (8); see Figure 15. The value of the resistor should be:

$$R_{Iset}(Iset) = \frac{25 I_{set}}{3.3 I_{max} - 2.5 I_{set}} (\Omega)$$

Alternatively, the Iset pin can be driven from an external voltage source:

$$V_{iset}(Iset) = 2.5 \times \left( \frac{I_{set}}{I_{max}} \right)$$

Iset = desired output current set point

Imax = maximum rated output current (50A)

Undriven, Iset pin floats to 3.3V which sets the current limit at its nominal value of 110% \* Imax.



## Over-Current Protection

The modules include an internal output over-current protection circuit, which will endure current limiting for an unlimited duration during output overload. If the output current exceeds the OCP set point, the modules will shut down and enter latch mode. Need to repower input voltage to turn on the module.

## Over-Voltage Protection

The modules include an internal input over-voltage protection circuit and output voltage protection circuit, which monitors the voltage on the input terminals and the output terminals. If this voltage exceeds the over-voltage set point, the protection circuit will shut down, and then restart with a time delay after the fault no longer exist.

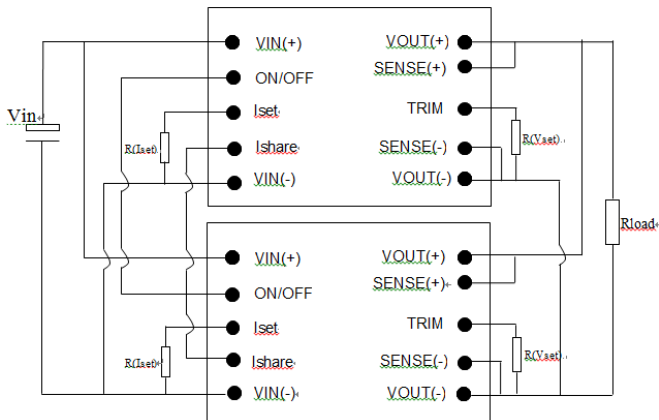
## Over-Temperature Protection

The over-temperature protection consists of circuitry that provides protection from thermal damage. If the temperature exceeds the over-temperature threshold the module will shut down. The module will restart after the temperature is within specification.

## Parallel

The modules provide active current sharing mode.

For the active current sharing: it permits maximum 8% output voltage deviation between two modules. By connecting the Vout pin and Ishare pin of the parallel module together, the current sharing can be realized automatically.



**Figure 16: Parallel and current sharing configuration**

The module can be parallel directly for higher power without adding external oring-fet. And the failure of a power supply should not affect the load sharing or output voltages of the other supplies still operation

For a normal parallel operation the following precautions must be observed:

1. The current sharing accuracy equation is:
 
$$X\% = |I_{o1} - I_{o2}| / I_{rate}$$
 Where,
  - Io1 is the output current of module1;
  - Io2 is the output current of module2
  - Irate is the rated full load current of per module.
2. To ensure a better steady current sharing accuracy, below design guideline should be followed:
  - a) The inputs of the converters must be connected to the same voltage source; and the PCB trace resistance from Input voltage source to Vin+ and Vin- of each converter should be equalized as much as possible.
  - b) The PCB trace resistance from each converter's output to the load should be equalized as much as possible.
  - c) For accurate current sharing accuracy test, the module should be soldered in order to avoid the unbalance of the touch resistance between the modules to the test board.
3. To ensure the parallel module can start up monotonically without triggering the OCP circuit, below design guideline should be followed:
  - a) Before all the parallel modules finished start up, the total load current should be lower than the rated current of 1 module.
  - b) The ON/OFF pin of the converters should be connected together to keep the parallel modules start up at the same time.
  - c) The under voltage lockout point will slightly vary from unit to unit. The dv/dt of the rising edge of the input source voltage must be greater than 1V/ms to ensure that the parallel module start up at the same time.

## PMBus Communication

The module has a digital PMBus interface to allow the module to be monitored, controlled and configured by the system. The module supports 3 PMBus signal lines, Data, Clock, SMBALERT (optional), and 2 Address line Addr0 and Addr1. More detail PMBus information can be found in the PMB Power Management Protocol Specification, Part I and part II, revision 1.2; which is shown in <http://pmbus.org>. Both 100kHz and 400kHz bus speeds are supported by the module. Connection for the PMBus interface should be following the High Power DC specifications given in section 3.1.3 in the SMBus specification V2.0 or the Low Power DC specifications in section 3.1.2. The complete SMBus specification is shown in <http://smbus.org>.

The module supports the Packet Error Checking (PEC) protocol. It can check the PEC byte provided by the PMBus master, and include a PEC byte in all message responses to the master.

SMBALERT protocol is also supported by the module. SMBALERT line is also a wired-AND signal; by which the module can alert the PMBUS master via pulling the SMBALERT pin to an active low. There are two ways that the master and the module response to the alert of SMBALERT line.

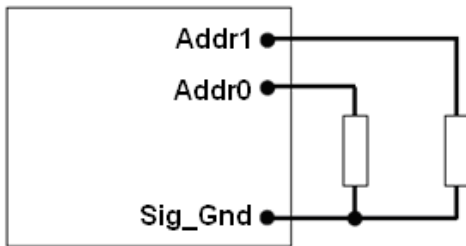
One way is for the module used in a system that does not support Alert Response Address (ARA). The module is to retain its resistor programmed address, when it is in an ALERT active condition. The master will communicate with the slave module using the programmed address, and using the various READ\_STATUS commands to find who cause for the SMBALERT. The CLEAR\_FAULTS command will clear the SMBALERT.

The module contains a data flash used to store configuration settings, which will not be programmed into the device data flash automatically. The STORE\_DEFAULT\_ALL command must be used to commit the current settings are transfer from RAM to data flash as device defaults

## PMBUS Addressing

The Module has flexible PMBUS addressing capability. When connect different resistor from Addr0 and Addr1 pin to GND pin, 64 possible addresses can be acquired. The address is in the form of octal digits; Each pin offer one octal digit, and then combine together to form the decimal address as shown in below.

$$\text{Address} = 8 * \text{ADDR1} + \text{ADDR0}$$



Corresponded to each octal digit, the requested resistor values are shown in below, and +/-1% resistors accuracy can be accepted. If there is any resistances exceeding the requested range, address 127 will be return. 0-12 and 40, 44, 45, and 55 in decimal address can't be used, since they are reserved according to the SMBus specifications, and which will also return address 127.

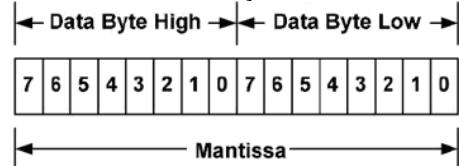
Octal digit	Resistor(Kohm)
0	10
1	15.4
2	23.7
3	36.5
4	54.9
5	84.5
6	130
7	200

## PMBus Data Format

The module receives and report date in LINEAR format. altering the exponent is supported. DIRECT format is not supported by the module.

For commands that set or report any voltage thresholds related to the output voltage, the module supports the linear data format consisting of a two byte value with a 16-bit, unsigned mantissa, and a fixed exponent of -9.

The format of the two data bytes is shown below:



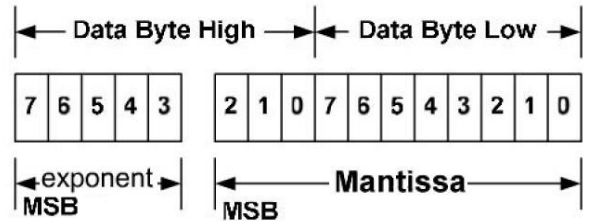
The equation can be written as:

$$V_{out} = \text{Mantissa} \times 2^{-9}$$

For example, considering set  $V_{out}$  to 12V by VOUT\_COMMAND, the read/write data can be calculated refer to below process:

1. Mantissa =  $V_{out} / 2^{-9} = 12 / 2^{-9} = 6144$ ;
2. Converter the calculated Mantissa to hexadecimal 0x1800.

For commands that set including input voltages, output current, temperature, time and frequency, the format of the two data bytes is shown as in below:



For example, considering set the turn on threshold of input under voltage lockout to 34V by VIN\_ON command; the read/write data can be calculated refer to below process:

1. The read  $V_{in}$  value is hexadecimal E910
2. The high 5 bit in binary is 11101, so the Mantissa is  $2^{-3}$ .
3. Low 11 bits 00100010000, in decimal is 272
4. So the real  $V_{in}$  value is  $272 / 2^{-3}$  is 34v.

## Supported PMBus Commands

The main PMBus commands described in the PMBus 1.2 specification are supported by the module. Partial PMBus commands are fully supported; Partial PMBus commands have difference with the definition in PMBus 1.2 specification. All the supported PMBus commands are detail summarized in below table.

Command	Code	Description	Type	Compatible with standard PMBUS or not?	Data Format	Default value	Range limit	Data units	Exponent	Note
OPERATION	0x01	Turn the module on or off by PMBUS command	R/W byte	Refer to below description	Bit field	0x80	/	/	/	/
ON_OFF_CONFIG	0x02	Configures the combination of primary on/off pin and PMBUS command	R/W byte	Not support turn off delay and fall time setup	Bit field	0x1D	/	/	/	0x1D (Neg Logic); 0x1F (Pos Logic);
CLEAR_FAULTS	0x03	Clear any fault bits that have been set	Send byte	Yes	/	/	/	/	/	/
WRITE_PROTECTION	0x10	Set or Clear the bit of Write protection	R/W byte	Yes	/	0x80	/	/	/	
STORE_DEFAULT_ALL	0x11	Stores operating parameters from RAM to data flash	Send byte	Yes	/	/	/	/	/	This command is effective to the parameter of all command in the table.
VOUT_MODE	0x20	To read Vo data format	Read byte	Yes	mode+exp	0x17	/	/	/	/
VOUT_OV_FAULT_LIMIT	0x40	Set the output overvoltage fault threshold.	R/W word	Yes	Vout Linear	65	1~70	V	-9	Must be higher than the value of VOUT_COMMAND and VOUT_OV_WARN_LIMIT
VOUT_OV_WARN_LIMIT	0x42	Set a threshold causing an output voltage high warning.	R/W word	Yes	Vout Linear	64	1~70	V	-9	Must be less than VOUT_OV_FAULT_LIMIT value
OT_FAULT_LIMIT	0x4F	Set the over temperature fault threshold.	R/W word	Yes	TEMP Linear	130	125~140	Deg. C		Must be greater than OT_WARN_LIMIT value
OT_WARN_LIMIT	0x51	Set a threshold causing a temperature high warning.	R/W word	Yes	TEMP Linear	100	80~120	Deg. C		Must be less than OT_FAULT_LIMIT value
VIN_OV_FAULT_LIMIT	0x55	Set the input overvoltage fault threshold.	R/W word	Yes	Vin Linear	63	1~64	V		
STATUS_WORD	0x79	Returns the information with a summary of the module's fault/warning	Read word	Refer to below description	Bit field	/	/	/	/	/
STATUS_VOUT	0x7A	Returns the information of the module's output voltage related fault/warning	R/W byte	Refer to below description;	Bit field	/	/	/	/	/
STATUS_IOUT	0x7B	Returns the information of the module's output current related fault/warning	R/W byte	Refer to below description	Bit field	/	/	/	/	/
STATUS_INPUT	0x7C	Returns the information of the module's input over voltage and under voltage fault	R/W byte	Refer to below description	Bit field	/	/	/	/	/
STATUS_TEMPERATURE	0x7D	Returns the information of the module's temperature related fault/warning	R/W byte	Refer to below description;	Bit field	/	/	/	/	/
STATUS_CML	0x7E	Returns the information of the module's communication related faults.	R/W byte	Refer to below description	Bit field	/	/	/	/	/
READ_VIN	0x88	Returns the input voltage of the module	Read word	Yes	Vin Linear	/	/	Volts	/	/
READ_VOUT	0x8B	Returns the output voltage of the module	Read word	Yes	Vout Linear	/	/	Volts	/	/
READ_IOUT	0x8C	Returns the output current of the module	Read word	Yes	Iout Linear	/	/	Amps	/	/
READ_TEMPERATURE_1	0x8D	Returns the module's hot spot temperature of the module	Read word	Yes	TEMP Linear	/	/	Deg. C	/	/
READ_TEMPERATURE_2	0x8E	Returns the module's hot spot temperature of the module	Read word	Yes	TEMP Linear	/	/	Deg. C	/	/
PMBUS_REVISION	0x98	Reads the revision of the PMBus	Read byte	Yes	Bit field	22	/	/	/	/

## OPERATION [0x01]

Bit number	Purpose	Bit Value	Meaning	Default Settings , 0x80
7:	Enable/Disable the module	1	Output is enabled	1
		0	Output is disabled	
6:0	Reserved			0000000

## ON\_OFF\_CONFIG [0x02]

Bit number	Purpose	Bit Value	Meaning	Default Settings , 0x1D (negative) /0x1F (positive)
7:5	Reserved			000
4	Controls how the unit responds to the primary on/off pin and the OPERATION command;	1	Module does not power up until commanded by the primary ON/OFF pin and the OPERATION	1
		0	Module power up at any time regardless of the state of the primary ON/OFF pin and the OPERATION	
3	Controls how the unit responds to the OPERATION command	1	Module responds to the 7 bit in the OPERATION	1
		0	Module ignores the 7 bit in the OPERATION	
2	Controls how the unit responds to the primary on/off pin	1	Module requires the primary ON/OFF pin to be asserted to start the unit	1
		0	Module ignores the state of the primary ON/OFF pin	
1	Control logic of primay on/off pin	1	Positive Logic	0, negative; 1, positive.
		0	Negative Logic	
0	Unit turn off delay time control	1	Shut down the module with 0 delay cycle	1

## STATUS\_WORD [0x79]

### High byte

Bit number	Purpose	Bit Value	Meaning
7	An output over voltage fault or warning	1	Occurred
		0	No Occurred
6	An output over current fault or warning	1	Occurred
		0	No Occurred
5	An input voltage fault, including over voltage and undervoltage	1	Occurred
		0	No Occurred
4	Reserved		
3	Power_Good	1	is negated
		0	ok
2:0	Reserved		

### Low byte

Bit number	Purpose	Bit Value	Meaning
7	Reserved		
6	OFF (The unit is not providing power to the output, regardless of the reason)	1	Occurred
		0	No Occurred
5	An output over voltage fault	1	Occurred
		0	No Occurred
4	An output over current fault	1	Occurred
		0	No Occurred
3	An input under voltage fault	1	Occurred
		0	No Occurred
2	A temperature fault or warning	1	Occurred
		0	No Occurred
1	CML (A communications, memory or logic fault )	1	Occurred ;
		0	No Occurred
0	Reserved		

**STATUS\_VOUT [0x7A]**

Bit number	Purpose	Bit Value	Meaning
7	Output over voltage fault	1	Occurred ;
		0	No Occurred
6	Output over voltage warning	1	Occurred ;
		0	No Occurred
5:0	Reserved		

**STATUS\_IOUT [0x7B]**

Bit number	Purpose	Bit Value	Meaning
7	Output over current fault	1	Occurred ;
		0	No Occurred
6	Reserved		
5	Output over current warning	1	Occurred ;
		0	No Occurred
4:0	Reserved		

**STATUS\_INPUT [0x7C]**

Bit number	Purpose	Bit Value	Meaning
7	Input over voltage fault	1	Occurred ;
		0	No Occurred
6: 5	Reserved		
4	Input under voltage fault	1	Occurred ;
		0	No Occurred
3:0	Reserved		

**STATUS\_TEMPERATURE [0x7D]**

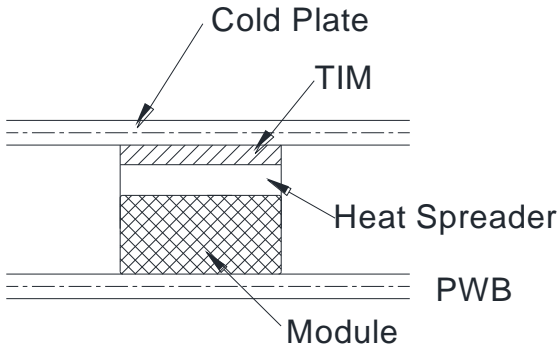
Bit number	Purpose	Bit Value	Meaning
7	Over temperature fault	1	Occurred ;
		0	No Occurred
6	Over temperature warning	1	Occurred ;
		0	No Occurred
5:0	Reserved		

**STATUS\_CML [0x7E]**

<b>Bit number</b>	<b>Purpose</b>	<b>Bit Value</b>	<b>Meaning</b>
7	Invalid/Unsupported Command Received	1	Occurred ;
		0	No Occurred
6	Invalid/Unsupported Data Received	1	Occurred ;
		0	No Occurred
5	Packet Error Check Failed	1	Occurred ;
		0	No Occurred
4:0	Reserved		

## Thermal Testing Setup

The following figure shows thermal test setup. The power module is mounted on a 185mmX185mm, 105µm (3Oz), 6 layers test PWB and attach to a cold plate with thermal interface material (TIM).

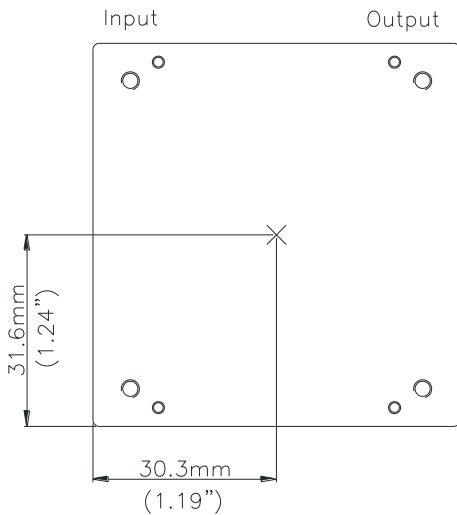


**Figure 17:** Thermal test setup

## Thermal Derating

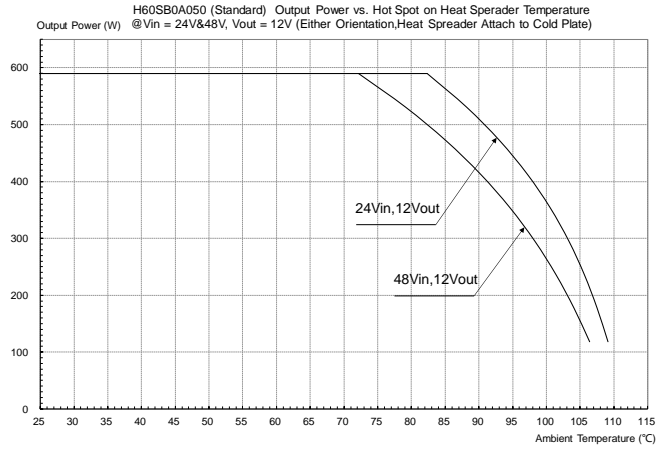
Heat can be removed by increasing airflow over the module. To enhance system reliability, the power module should always be operated below the maximum operating temperature. If the temperature exceeds the maximum module temperature, reliability of the unit may be affected.

## Thermal Curves (With Heat Spreader)

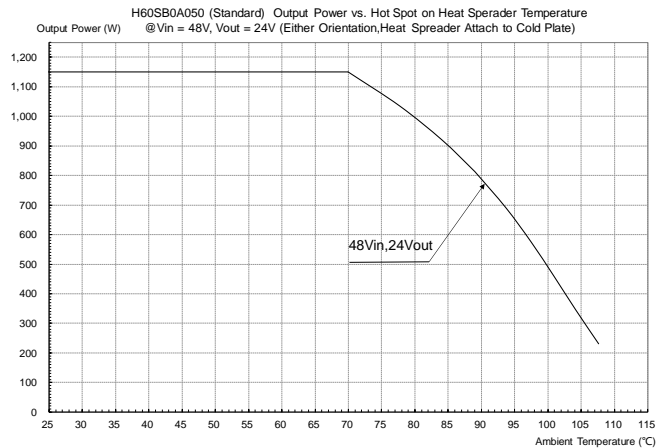


**Figure 18:** \* Hot spot's location on the heat spreader.

## Thermal Curves (With Heat Spreader)



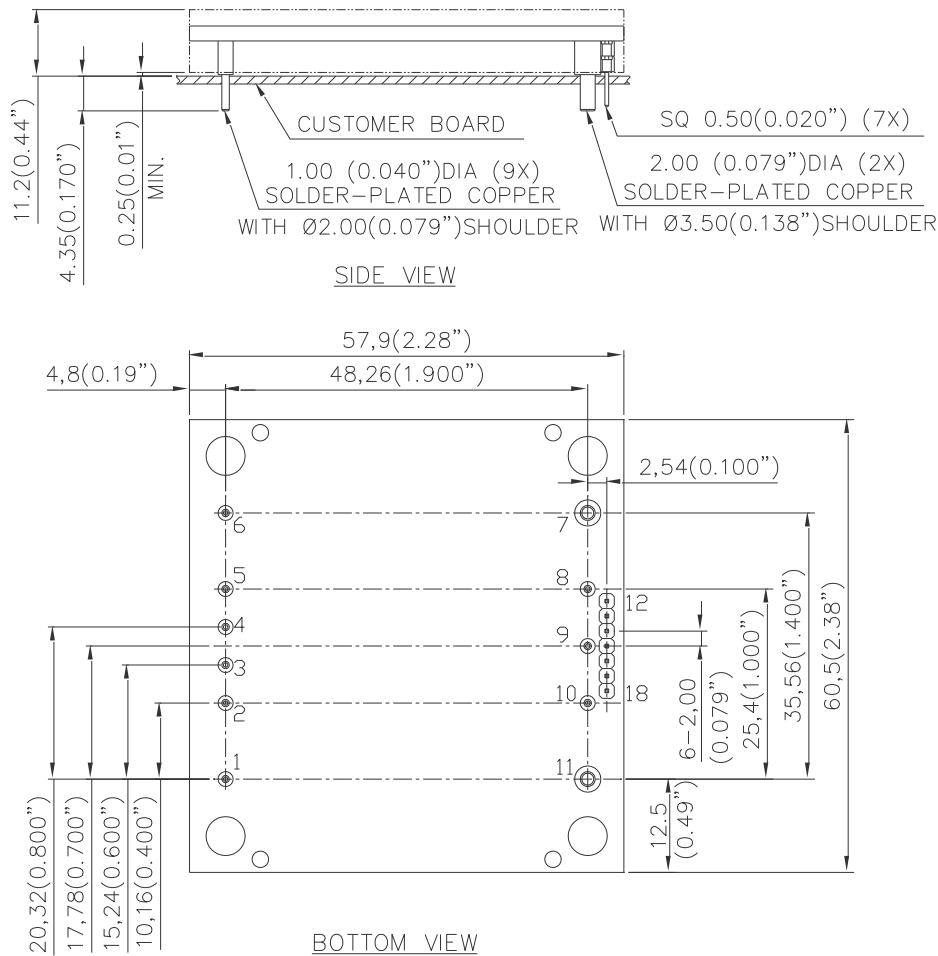
**Figure 19:** Output power vs. Heat spreader temperature @  $V_{in}=24V\&48V$ ,  $V_{out}=12V$  (Either Orientation)



**Figure 20:** Output power vs. Heat spreader temperature @  $V_{in}=48V$ ,  $V_{out}=24V$  (Either Orientation)



## Mechanical Drawing (Open Frame)



### NOTES:

DIMENSIONS ARE IN MILLIMETERS AND (INCHES)

TOLERANCES: X.Xmm±0.5mm(X.XX in.±0.02 in.)

X.XXmm±0.25mm(X.XXX in.±0.010 in.)

Pin No.	Name	Function
1	+Vin	Positive input voltage
2	ON/OFF	Remote ON/OFF
3	SyncIn	Input to synchronize the converter to an external clock
4	Iset	Input to set the maximum output current.
5	Ishare	Input/Output: Current monitor or Current share.
6	-Vin	Negative input voltage
7	-Vout	Negative output voltage
8	-Sense	Negative Power Voltage Sense,
9	Trim	Output voltage trim
10	+Sense	Positive Power Voltage Sense
11	+Vout	Positive output voltage
12	C2	
13	Sig_Gnd	Signal ground
14	Data	PMBus data line
15	SMBAlert	PMBus SMBAlert line
16	Clock	PMBus clock line
17	Addr1	ADDR1 pin sets the high order digit of the address
18	Addr0	ADDR0 pin sets the high order digit of the address

### Pin Specification:

Pins 1~6,8~10

Pins 7,11

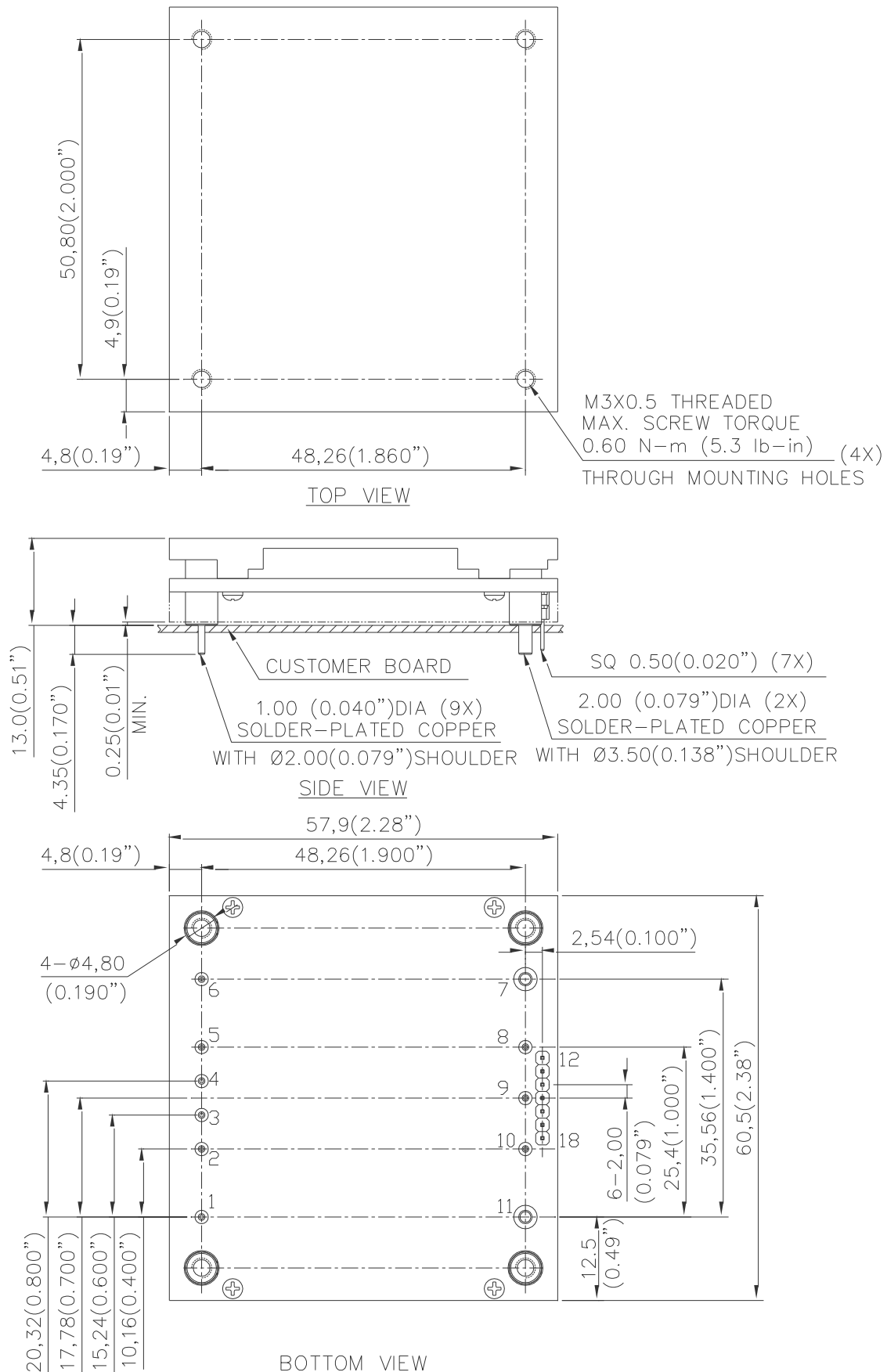
Pins 12~18

1.00mm (0.040") diameter; copper with matte Tin plating and Nickel under plating

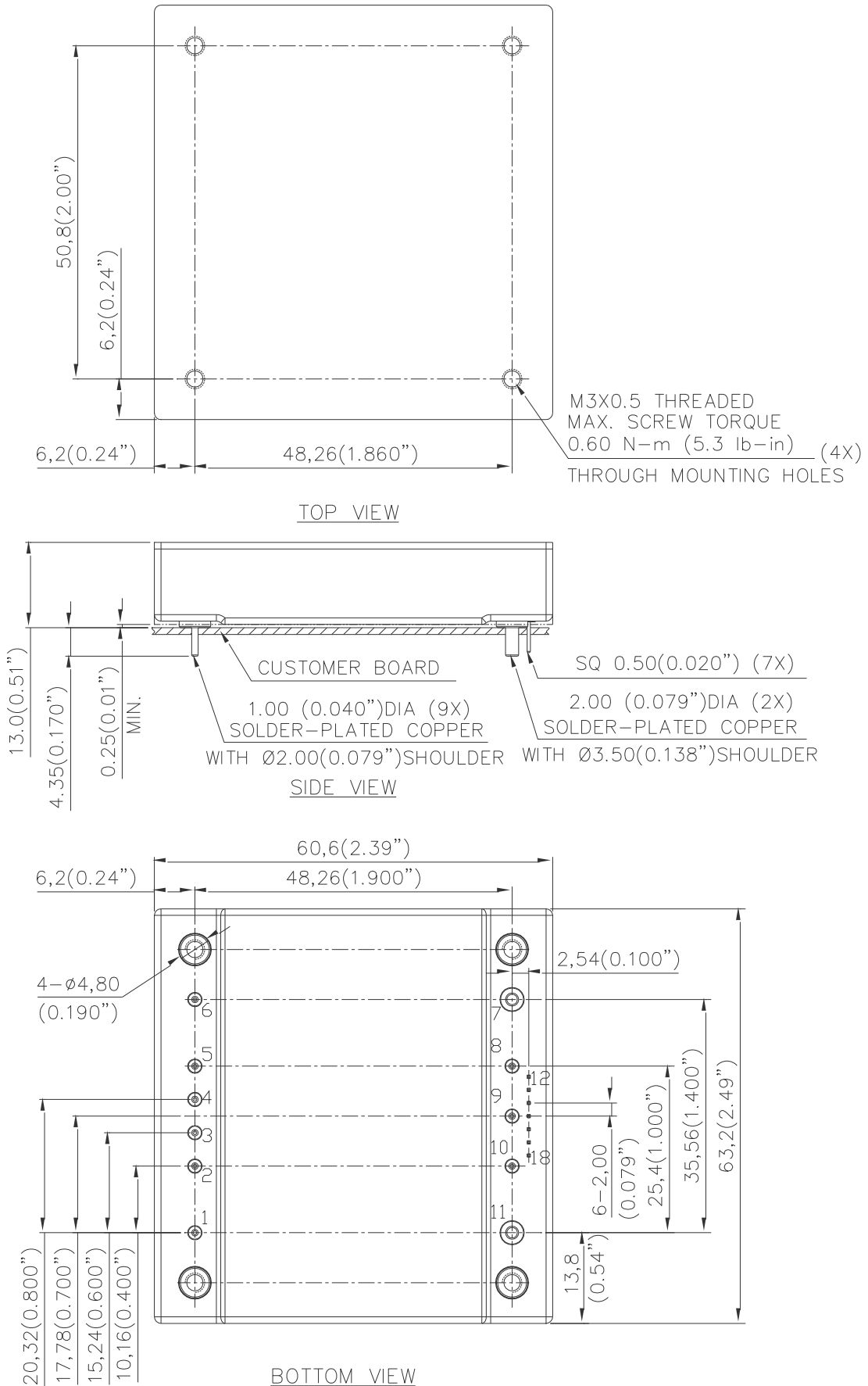
2.00mm (0.079") diameter; copper with matte Tin plating and Nickel under plating

Digital pins; Square 0.50mm (0.020"); copper with golden flash plating

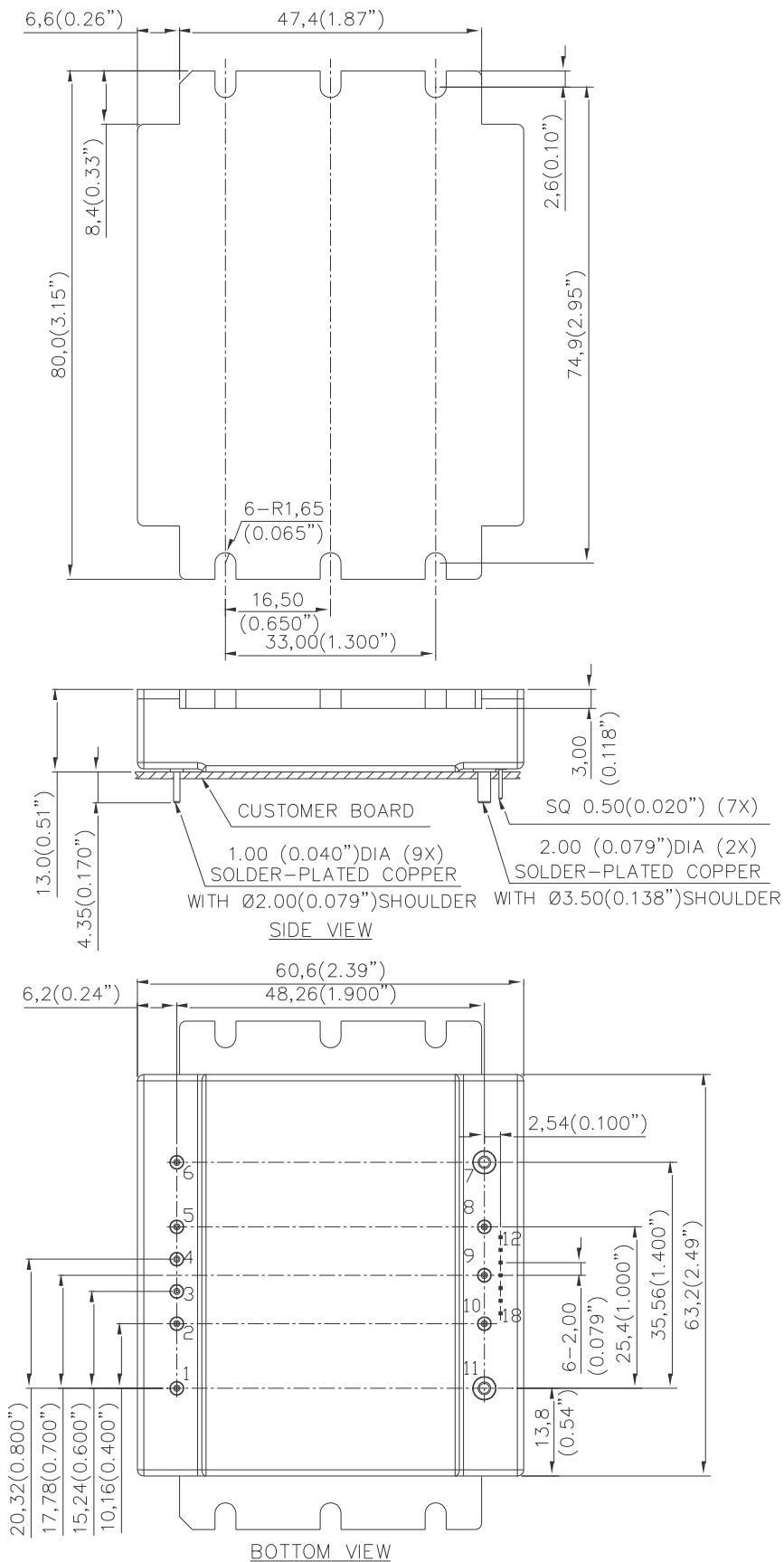
## Mechanical Drawing (With Baseplate)



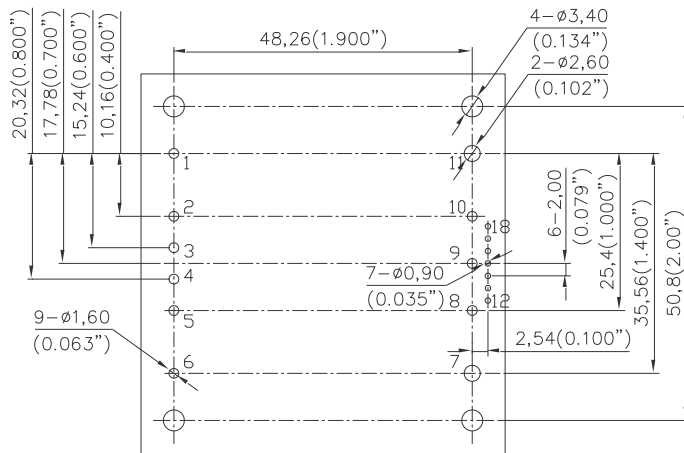
## Mechanical Drawing (With Baseplate and Encased)



## Mechanical Drawing (With Flange Baseplate and Encased)



## Recommended Pad Layout



PIN	NAME	PIN	NAME
1	Vin(+)	12	C2
2	ON/OFF	13	Sig-Gnd
3	SynCln	14	Data
4	Iset	15	SMBAlert
5	Ishare	16	Clock
6	Vin(-)	17	Addr1
7	Vout(-)	18	Addr0
8	Sense(-)	Optional: pin12~18	
9	Trim		
10	Sense(+)		
11	Vout(+)		

NOTES:  
 DIMENSIONS ARE IN MILLIMETERS AND (INCHES)  
 TOLERANCES: X.Xmm±0.5mm(X.XX in.±0.02 in.)  
 X.XXmm±0.25mm(X.XXX in.±0.010 in.)

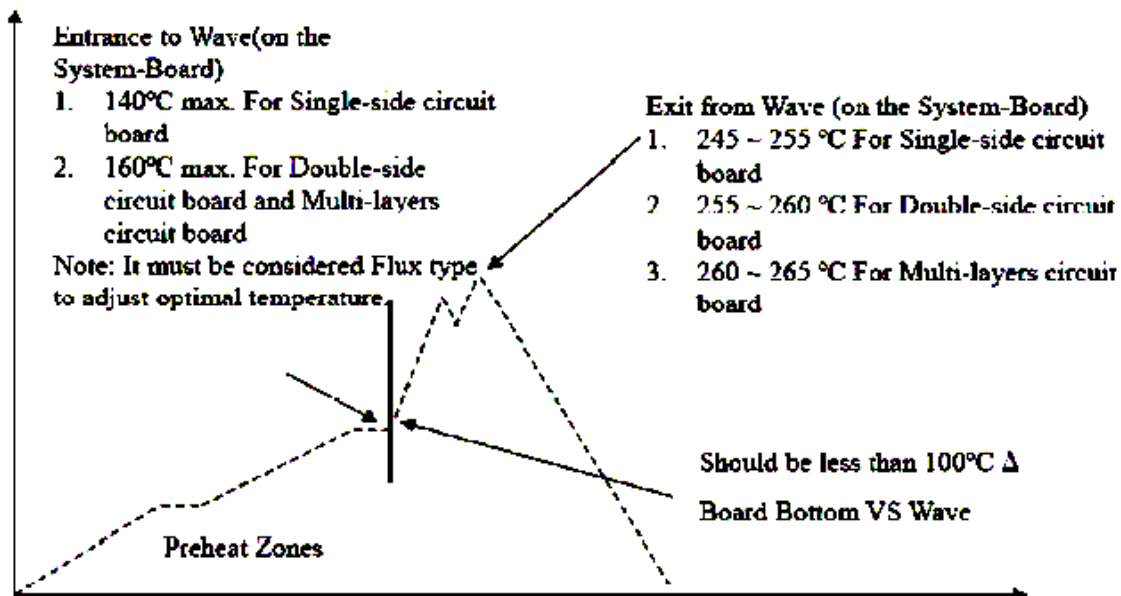
## Soldering Method

Generally, as the most common mass soldering method for the solder attachment, wave soldering is used for through-hole power modules and reflow soldering is used for surface-mount ones. Delta recommended soldering methods and process parameters are provided in this document for solder attachment of power modules onto system board. SAC305 is the suggested lead-free solder alloy for all soldering methods.

Reflow soldering is not a suggested method for through-hole power modules due to many process and reliability concerns. If you have this kind of application requirement, please contact Delta sales or FAE for further confirmation.

## Wave Soldering (Lead-free)

Delta's power modules are designed to be compatible with single-wave or dual wave soldering. The suggested soldering process must keep the power module's internal temperature below the critical temperature of 217 °C continuously. The recommended wave-soldering profile is shown in following figure.



Recommended Temperature Profile for Lead-free Wave Soldering

Note: The temperature is measured on solder joint of pins of power module.

The typical recommended (for double-side circuit board) preheat temperature is 115+/-10°C on the top side (component side) of the circuit board. The circuit-board bottom-side preheat temperature is typically recommended to be greater than 135°C and preferably within 100 °C of the solder-wave temperature. A maximum recommended preheat up rate is 3°C /s. A maximum recommended solder pot temperature is 255+/-5°C with solder-wave dwell time of 3~6 seconds. The cooling down rate is typically recommended to be 6°C/s maximum.



## Hand Soldering (Lead Free)

Hand soldering is the least preferred method because the amount of solder applied, the time the soldering iron is held on the joint, the temperature of the iron, and the temperature of the solder joint are variable. The recommended hand soldering guideline is listed in Table 1. The suggested soldering process must keep the power module's internal temperature below the critical temperature of 217°C continuously.

**Table 1 Hand-Soldering Guideline**

Parameter	Single-side Circuit Board	Double-side Circuit Board	Multi-layers Circuit Board
Soldering Iron Wattage	90	90	90
Tip Temperature	385+/-10°C	420+/-10°C	420+/-10°C
Soldering Time	2 ~ 6 seconds	4 ~ 10 seconds	4 ~ 10 seconds

## PART NUMBERING SYSTEM

H	60	S	B	0A0	50	N	R	D *note	C
Type of Product	Input Voltage	Number of Outputs	Product Series	Output Voltage	Output Current	ON/OFF Logic	Pin Length /Type	Electrical Option	Mechanical Option
H - Half Brick	60 - 9~60V	S - Single	B - Series number	0A0 - Adjustable	50 -50A	N - Negative	R - 0.170"	D - Digital pins A - Analog pins	B - baseplate C - base plate & encased F - flanged baseplate& encased

Note for mechanical pins option:

1. D- Digital pins\*: with PMbus pins(pin12~18)
2. A- Analog pins\*: without PMbus pins(pin12~18)

## RECOMMENDED PART NUMBER.

Model Name	Input	Output	Peak Eff.
H60SB0A050NRDC	9V~60V	50A	98.0%

Please contact with Delta sales/FAE for different optional functions.

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## WARRANTY

Delta offers a two (2) year limited warranty. Complete warranty information is listed on our web site or is available upon request from Delta.

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