



Q54SC07033

Quarter Brick DC/DC Power Module

42~60V in, 0.6~7V/33A out, Max 231W

Q54SC07033, quarter brick, 42~60V input, single output 7V, are full digital control DC/DC converter, and are the latest offering from a world leader in power system and technology and manufacturing — Delta Electronics, Inc. This product provides up to 230 watts of power at 42~60V input in an industry standard, DOSA compliant footprint and pin out. The Q54SC07033 offers more than 93.5% high efficiency at 54V input, 7V output and 33A load. There is a built-in digital PWM controller in the Q54SC07033 series, which is used to complete the V_o feedback, PWM signal generation, droop current sharing, fault protection, output voltage trim, on/off control and PMBUS communications, and so on. With the digital control, many design and application flexibility, advanced performance, and reliability are obtained. The Q54SC07033 can be connected in parallel directly for higher power without adding external oring-fet.

FEATURES

- ◆ Input voltage range: 42V~60V
- ◆ Output voltage range (trim and PMBUS) 0.6V~7V
- ◆ High efficiency : 93.5% @ 54Vin/33A
- ◆ Size: 58.4mm x 36.8mm x 12.0mm (2.3" x 1.45" x 0.47")
- ◆ Industry standard DOSA compliant pin out
- ◆ Fully protected: Input UVLO, Output OCP and OVP, OTP
- ◆ Droop current sharing
- ◆ 1500V isolation
- ◆ No minimum load required
- ◆ Fixed frequency operation
- ◆ ISO 9001, TL 9000, ISO 14001, QS9000, OHSAS18001 certified manufacturing facility

OPTIONS

- ◆ Positive or Negative On/Off logic
- ◆ Droop current sharing
- ◆ Digital pins
- ◆ Heat spreader

APPLICATIONS

- ◆ Datacom / Networking
- ◆ Wireless networks
- ◆ Optical network equipment
- ◆ Server and data storage
- ◆ Industrial / Test equipment

SOLDERING METHOD

- ◆ Hand soldering
- ◆ Wave soldering

TECHNICAL SPECIFICATIONS

($T_A=25^{\circ}\text{C}$, airflow rate=400 LFM, $V_{in}=54\text{Vdc}$, nominal V_{out} unless otherwise noted.)

PARAMETER	NOTES and CONDITIONS	Q54SC07033			
		Min.	Typ.	Max.	Units
ABSOLUTE MAXIMUM RATINGS					
Input Voltage					
Continuous		0		60	Vdc
Transient (100ms)				75	Vdc
On/off Pin Voltage		0		10	V
Other Pin Voltage	Trim/Current Sharing, C2, Data, SMBAlert, Clock, Addr1, Addr0	-0.3		3.6	V
Output negative voltage				0.3	V
Operating ambient Temperature		-40		85	$^{\circ}\text{C}$
Storage Temperature		-55		125	$^{\circ}\text{C}$
Input/Output Isolation Voltage				1500	Vdc
INPUT CHARACTERISTICS					
Operating Input Voltage		42	54	60	Vdc
Input Under-Voltage Lockout					
Turn-On Voltage Threshold (Adjustable via PMBus, VIN_ON)		34		36	Vdc
Turn-Off Voltage Threshold (Adjustable via PMBus, VIN_OFF)		31		34	Vdc
Lockout Hysteresis Voltage			2		Vdc
Maximum Input Current	$V_{in}=42\text{V}$, 100% Load			7.5	A
No-Load Input Current	$V_{in}=54\text{V}$		70		mA
Off Converter Input Current	$V_{in}=54\text{V}$	10	18	26	mA
Input Capacitance		100			μF
Inrush Current (I^2t)				1	A ^2S
Input Reflected-Ripple Current	P-P thru 12 μH inductor, 5Hz to 20MHz		50		mA
Input Voltage Ripple Rejection	120Hz		50		dB
OUTPUT CHARACTERISTICS					
Output Voltage Set Point (Adjustable via PMBus)	$V_{in}=54\text{V}$, $I_o=0\text{A}$, $T_a=25^{\circ}\text{C}$	6.88	7	7.12	Vdc
Output Voltage Regulation					
Line Regulation	$V_{in}=42\text{V}$ to 60V, $I_o=100\%$ load			± 40	mV
Load Regulation	$V_{in}=42\text{V}$ to 60V, $I_o=I_{o,min}$ to $I_{o,max}$			± 40	mV
Temperature Regulation	$V_{in}=42\text{V}$ to 60V, $I_o=100\%$ load, $T_a=-40\text{C}$ to 85C			± 120	mV
Output voltage sense					
Resistance between VOUT(+) and SENSE +			1		Kohm
Capacitor between SENSE + and VOUT(-)			0		nF
Output Voltage Trim and PMBUS Range	$V_{in}=42\text{V}$ to 60V, $P_{out} \leq \text{max rated power}$, $I_o \leq I_{o,max}$	0.6		7	Vdc
Output Voltage Remote Sense Range (note 2)	$V_{in}=42\text{V}$ to 60V, $P_{out} \leq \text{max rated power}$, $I_o \leq I_{o,max}$				Vdc
Output Over-Voltage Lockout (Adjustable via PMBus, VOUT_OV_FAULT_LIMIT)			9		Vdc
Operating Output Current Range	Full input voltage range	0		33	A
Output DC Current-Limit Inception		110		145	%
Output Capacitance		300		15000	μF
Output Voltage Ripple and Noise	$V_{in}=54\text{V}$, Full load, 20MHz bandwidth				
Peak-to-Peak	$C_o=300\mu\text{F}/16\text{V}$ (polymer) + 10 $\mu\text{F}/16\text{V}$ (Tantalum Capacitor) + 1 $\mu\text{F}/16\text{V}$ (Ceramic)		50	80	mV
RMS	$C_o=300\mu\text{F}/16\text{V}$ (polymer) + 10 $\mu\text{F}/16\text{V}$ (Tantalum Capacitor) + 1 $\mu\text{F}/16\text{V}$ (Ceramic)		13	25	mV
DYNAMIC CHARACTERISTICS					
Output Voltage Current Transient	$V_{in}=54\text{V}$, Load Slew rate 0.1A/ μs with a 1 μF ceramic, a 10 μF tantalum, and a 300 μF polymer capacitor				
Positive Step Change in Output Current	50% $I_{o,max}$ to 75% $I_{o,max}$		350	500	mV
Negative Step Change in Output Current	75% $I_{o,max}$ to 50% $I_{o,max}$	-500	-350		mV
Settling Time (within 1% V_{out} nominal)			500		μs
Turn-On Transient (Adjustable via PMBus)					
Start-Up Time, From On/Off Control	From On/off to 90% V_o final value		55		ms
Start-Up Time, From Input	From Input to 90% V_o final value		75		ms
Output voltage Rise Time	From 10% V_o final value to 90% V_o final value		30		ms
EFFICIENCY					
100% Load	$V_{in}=54\text{V}$		93.5		%
60% Load	$V_{in}=54\text{V}$		93.8		%
ISOLATION CHARACTERISTICS					
Input to Output				1500	Vdc
Isolation Resistance		10			M Ω
Isolation Capacitance			6800		pF

TECHNICAL SPECIFICATIONS

($T_A=25^{\circ}\text{C}$, airflow rate=400 LFM, $V_{in}=54\text{Vdc}$, nominal V_{out} unless otherwise noted.)

PARAMETER	NOTES and CONDITIONS	Q54SC07033			
		Min.	Typ.	Max.	Units
FEATURE CHARACTERISTICS					
Switching Frequency			130		KHz
ON/OFF Control, Remote On/Off logic	Default Negative logic				
Logic Low (Module On)	$V_{on/off}$ at $I_{on/off}=1.2\text{mA}$	-0.7		0.8	V
Logic High (Module Off)	$V_{on/off}$ at $I_{on/off}=0.0\ \mu\text{A}$	3.5		50	V
ON/OFF Current (for both remote on/off logic)	$I_{on/off}$ at $V_{on/off}=0.0\text{V}$			1.2	mA
GENERAL SPECIFICATIONS					
MTBF	$I_o=80\%$ of I_o max; $T_a=25^{\circ}\text{C}$; Airflow=600LFM		1		M
Weight(without heat spreader)			50		grams
Weight(with heat spreader)			65		grams
Over-Temperature Shutdown (Without heat spreader)	Refer to Figure 13 for Hot spot 1 location (54Vin,80% I_o , 200LFM,Airflow from Vin+ to Vin-)		125		$^{\circ}\text{C}$
Over-Temperature Shutdown (With heat spreader)	Refer to Figure 15 for Hot spot 2 location (54Vin,80% I_o , 200LFM,Airflow from Vin+ to Vin-)		118		$^{\circ}\text{C}$
Over-Temperature Shutdown (NTC resistor)	Refer to Figure 13 for NTC resistor location		125		$^{\circ}\text{C}$

Note1: Please attach thermocouple on NTC resistor to test OTP function, the hot spots' temperature is just for reference. And the OTP is Adjustable via PMBus.
Note2: Output voltage range 5.8% for remote sense-; Output voltage range 10% for remote sense+.

DIGITAL INTERFACE SPECIFICATIONS

($T_A=25^{\circ}\text{C}$, airflow rate=400 LFM, $V_{in}=54\text{Vdc}$, nominal V_{out} unless otherwise noted.)

PARAMETER	NOTES and CONDITIONS	Q54SC07033			
		Min.	Typ.	Max.	Units
PMBUS SIGNAL INTERFACE CHARACTERISTICS					
Input High Voltage (CLK, DATA)		2.1		3.3	Vdc
Input Low Voltage (CLK, DATA)		0		0.8	Vdc
Input high level current (CLK, DATA)		-10		10	μA
Input low level current (CLK, DATA)		-10		10	μA
Output Low Voltage (SMBALERT#)	SMBALERT, sink current 2mA			0.4	Vdc
Output high level open drain leakage current (SMBALERT#)	SMBALERT, 3.6V	0		10	μA
PMBus Operating frequency range			100 or 400		kHz
VOUT setting precision by PMBUS (Note3)	$7\text{V} > V_{out} > 3\text{V}$	-10		10	mV
	$3\text{V} > V_{out} > 0.6\text{V}$	-30		30	mV
VOUT setting resolution by PMBUS (Note3)	The minimum step to increase or decrease V_{out}	-5		5	mV
Measurement System Characteristics					
Output current reading accuracy	$16.5\text{A} < I_{OUT} < 33\text{A}$	-5	1.4	3	%
	$1\text{A} < I_{OUT} < 16.5\text{A}$	-1.7		2.5	A
VOUT reading accuracy			1		%
VIN reading accuracy		-2		+2	Vdc
Temperature sense range		0			$^{\circ}\text{C}$
Temperature reading accuracy		-5		+5	$^{\circ}\text{C}$

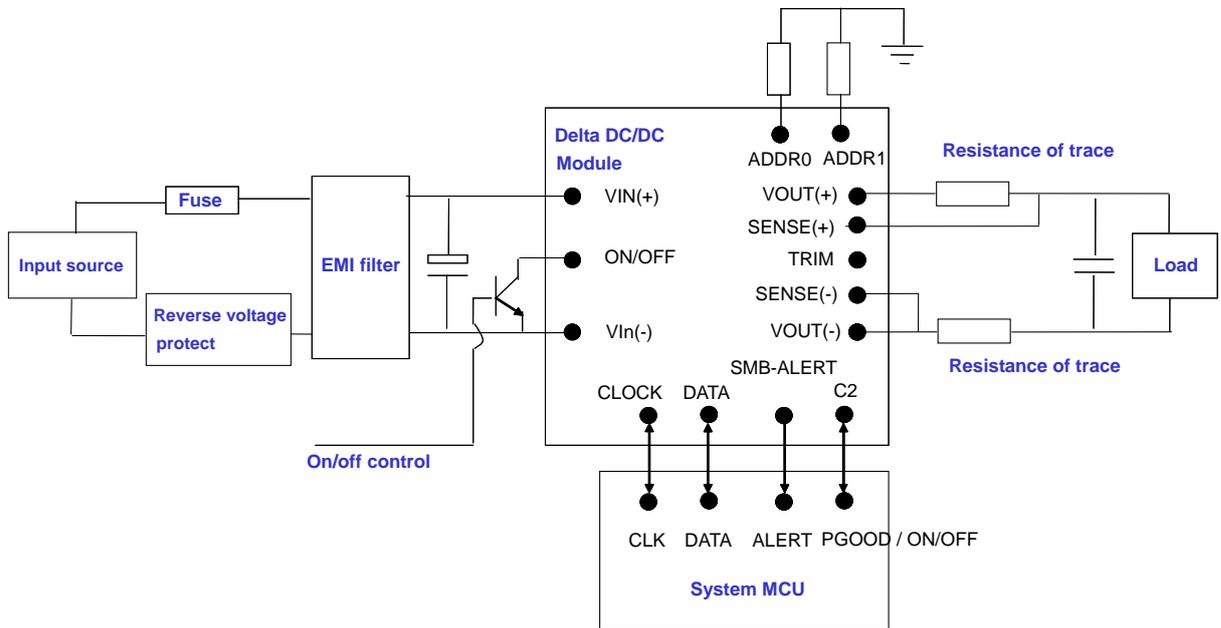
Note3: PMBUS adjust the voltage between SENSE+ and SENSE-, Not VOUT+ and VOUT-

PIN DEFINITION

Pin#	Name	Function	Pin#	Name	Function
1	VIN(+)	Source input voltage	9	C2	PGOOD pin, and this pin also could be configured as secondary on/off control pin
2	ON/OFF	Primary on/off control pin	10	DGND	Signal ground
3	VIN(-)	Input return	11	PMBus DATA	PMBus data line
4	VOOUT(-)		12	SMBALERT	PMBus SMBAlert line
5	SENSE(-)	Remote sense	13	PMBus CLOCK	PMBus clock line
6	TRIM	Trim (note 4)	14	ADDR1	ADDR1 pin sets the high order digit of the address.
7	SENSE(+)	Remote sense	15	ADDR0	ADDR0 pin sets the low order digit of the address.
8	VOOUT(+)				

Note4: see the last page.

SIMPLIFIED APPLICATION CIRCUIT



ELECTRICAL CHARACTERISTICS CURVES

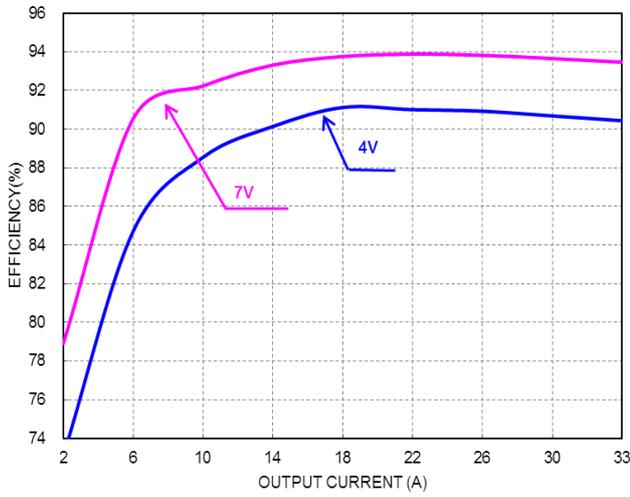


Figure 1: Efficiency vs. load current for 7V_Vout, 4V_Vout at 54V input voltage at 25°C.

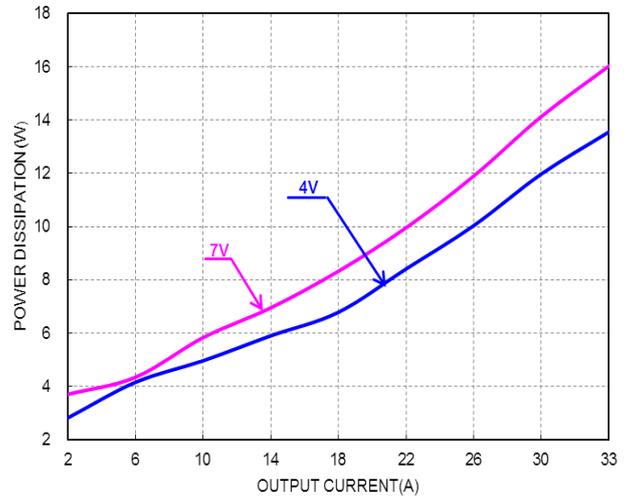


Figure 2: Power loss vs. load current for 7V_Vout, 4V_Vout at 54V input voltage at 25°C.

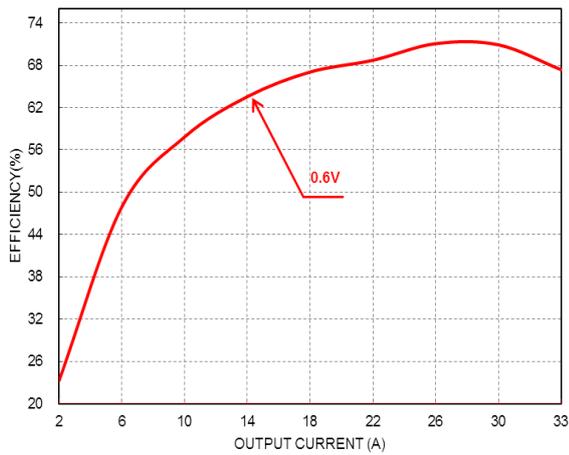


Figure 3: Efficiency vs. load current for 0.6V_Vout at 54V input voltage at 25°C.

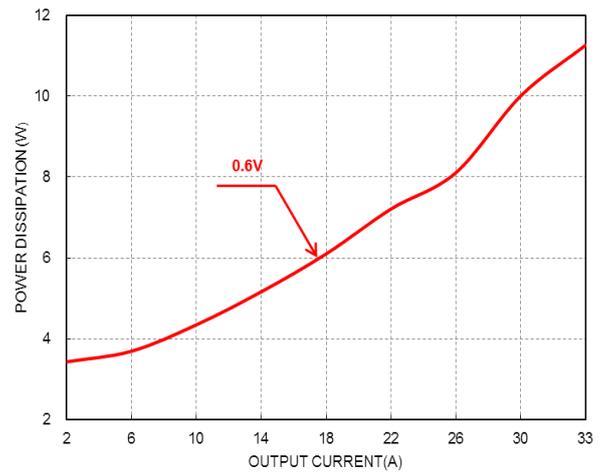


Figure 4: Power loss vs. load current for 0.6V_Vout at 54V input voltage at 25°C.

ELECTRICAL CHARACTERISTICS CURVE

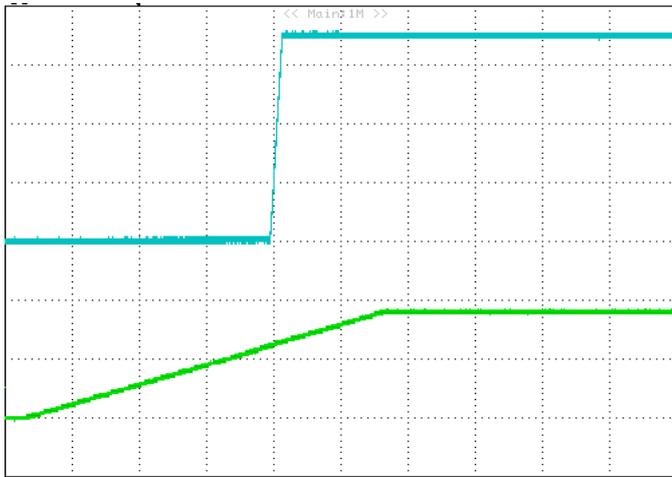


Figure 5: Turn-on transient at zero load current (100 ms/div).
Top Trace: Vout; 2V/div; Bottom Trace: input voltage: 20V/div.

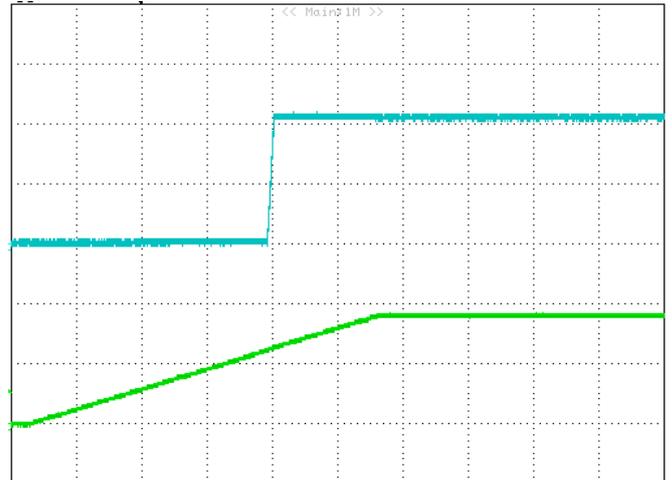


Figure 6: Turn-on transient at zero load current (100 ms/div).
Top Trace: Vout; 2V/div; Bottom Trace: input voltage: 20V/div.

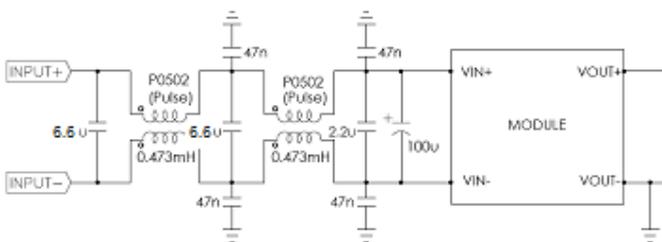
Input Source Impedance

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. If the source inductance is more than a few μH , we advise adding a $100\mu\text{F}$ electrolytic capacitor (ESR $< 0.2 \Omega$ at 100 kHz) mounted close to the input of the module to improve the stability.

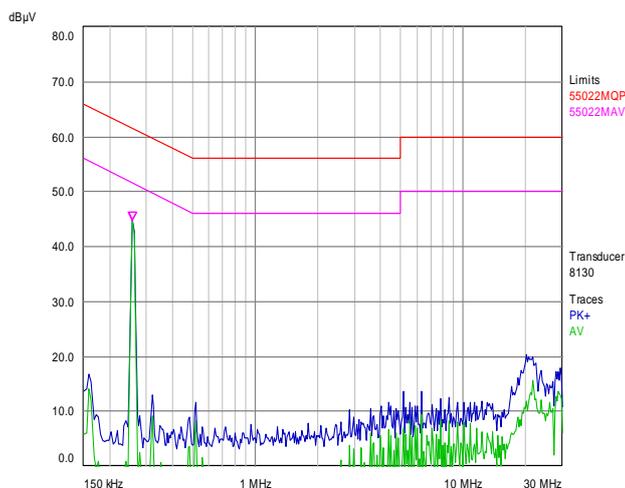
Layout and EMC Considerations

Delta's DC/DC power modules are designed to operate in a wide variety of systems and applications. For design assistance with EMC compliance and related PWB layout issues, please contact Delta's technical support team. An external input filter module is available for easier EMC compliance design. Below is the reference design for an input filter and tested result which can meet class B in CISPR 22.

Schematic:



Test result:



25C, 54Vin, full load, Green line is average peak mode and blue line is quasi mode.

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.

Over-Power Protection

The modules include an internal output over-power protection circuit, which will endure power limiting for an unlimited duration during output overload. If the output current exceeds the OCP set points, the modules will automatically shut down (hiccup mode).

The modules will try to restart after shutdown. If the overload condition still exists, the modules will shut down again. This restart trial will continue until the overload condition is corrected.

The OCP function could be changed via PMBUS. The command related to OCP function are IOUT_OC_WARN_LIMIT, IOUT_OC_FAULT_LIMIT and IOUT_OC_FAULT_RESPONSE.

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 modules will shut down, and enter the auto-restart mode.

For auto-restart mode, the module will monitor the module temperature after shutdown. Once the temperature of module is decreased by an OTP hysteresis, the module will restart.

The OTP function could be changed via PMBUS. The command related to OTP function are OT_WARN_LIMIT, OT_FAULT_LIMIT and OT_FAULT_RESPONSE.

Input Under Voltage Lockout

When Vin exceeds Vin turn on threshold, the module output is enabled, when Vin falls below Vin turn off threshold, the module output is disabled. Vin turn on threshold and Vin turn off threshold can be reconfigured via the PMBus interface.

The Vin UVP function could be changed via PMBUS. The command related to Vin UVP function are VIN_ON and VIN_OFF.

Output Overvoltage Protection

The module can detect and respond to output overvoltage conditions. If the overvoltage condition causes the output voltage to rise above the limit in the Specifications Table, the module will shut down.

The modules will try to restart after shutdown. If fault condition still exists, the modules will shut down again. This restart trial will continue until the fault condition is corrected.

The Vo OVP function could be changed via PMBUS. The command related to Vo OVP function are VOUT_OV_WARN_LIMIT, VOUT_OV_FAULT_LIMIT and VOUT_OV_FAULT_RESPONSE.

Input Over Voltage Lockout

The module can detect and respond to input overvoltage conditions. If the input voltage rises above the limit in the Specifications Table, the module will shut down.

The module is factory default configured for auto-restart operation. The auto-restart feature continually monitors the input voltage and will restart the module when the level falls 6V below the Input OVP level.

The Vin OVP function could be changed via PMBUS. The command related to Vin OVP function are VIN_OV_FAULT_LIMIT and VIN_OV_FAULT_RESPONSE.

Remote ON/OFF (ENABLE)

The remote ON/OFF (ENABLE) feature on the module is negative logic. The low logic turns the modules on. And the high logic, or floating, turns the modules off.

Remote ON/OFF (ENABLE) 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 the negative logic, if the remote ON/OFF (ENABLE) feature is not used, please maintain the ENABLE pin to Vin(-).

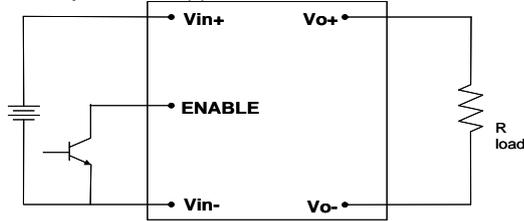


Figure 7: Remote ON/OFF (ENABLE) implementation

Secondary Remote On/Off

Reference to the Vo(-) terminal, there is a C2 pin. The default configuration is set to PGOOD function. And such pin can be reconfigured as secondary remote on/off pin by the PMBus interface including either negative or positive logic. Negative logic turns the module on during a logic low and off during a logic high. Positive logic turns the modules on during a logic high and off during a logic low. The secondary remote on/off can be controlled by an external switch between the on/off terminal and the Vo(-) terminal. The switch can be an open collector or open drain.

MFR_C1_C2_ARA_CONFIG, MFR_C2_LOGIC, MFR_PGOOD_POLARITY are used to config C2 pin function.

Remote Sense

Remote sense minimizes the effects of distribution losses by regulating the voltage at the remote-sense connections (See Figure 8). The SENSE(-) pin should be always connected to VO(-) pin. The voltage between the remote-sense pins and the output terminals must not exceed the output voltage sense range given in the Feature Specifications

$$[VO(+)-VO(-)]-SENSE(+)\leq 0.5V$$

The output voltage can also be increased by the trim, the maximum increase for the output voltage is the sum of both. The amount of power delivered by the module is defined as the voltage at the output terminals multiplied by the output current. When using remote sense and trim, the output voltage of the module can be increased, which at the same output current, would increase the power output of the module. Care should be taken to ensure that the maximum output power of the module remains at or below the maximum rated power (Maximum rated power = Vo,set x Io,max)

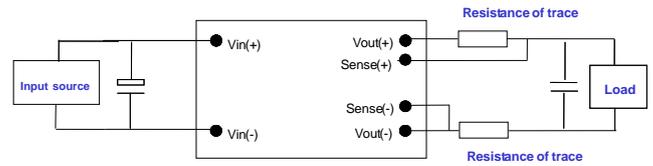


Figure 8: Circuit Configuration for remote sense.

Configurable Control Pins

The module contains one configurable control pins C2, referenced to the module secondary SIG_GND. See Mechanical Views for pin locations. The following table list the default factory configurations for the functions assigned to the pin.

C2 Pin Designation/Function	Configuration
Power Good	Factory Default
On/Off	Optional Vias PMBUS

Output Voltage Adjustment (TRIM) ^{note4}

To increase or decrease the output voltage set point, connect an external resistor between the TRIM pin and either the Vo(+) or Vo(-). The TRIM pin should be left open if this feature is not used.

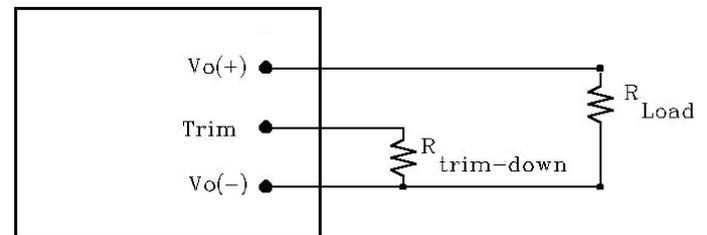


Figure 9: Circuit configuration for trim-down (decrease output voltage)

If the external resistor is connected between the TRIM and Vo (-) pins, the output voltage set point decreases (Fig. 9). The external resistor value required to obtain a percentage of output voltage change Δ% is defined as:

$$R_{trim_down} = \left[\frac{511}{\Delta} - 5.512 \right] (K\Omega)$$

Ex. When Trim_down – 10%(7V × 0.9 = 6.3V)

$$R_{trim_down} = \left[\frac{511}{\Delta} - 5.512 \right] (K\Omega) = 45.6(K\Omega)$$

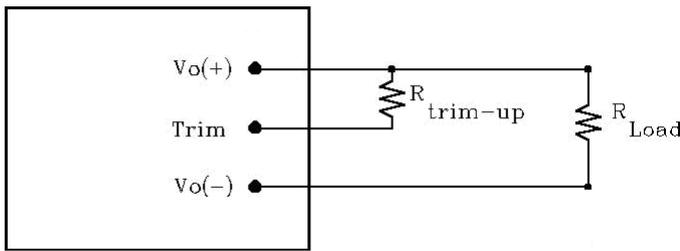


Figure 10: Circuit configuration for trim-up (increase output voltage)

If the external resistor is connected between the TRIM and Vo (+) the output voltage set point increases (Fig.10) The external resistor value required to obtain a percentage output voltage change $\Delta\%$ is defined as:

$$R_{trim_up} = \frac{5.11V_o(100 + \Delta)}{1.225\Delta} - \frac{511}{\Delta} - 5.51(K\Omega)$$

Ex. When Trim_up + 10% ($7V \times 1.1 = 7.7V$)

$$R_{trim_up} = \frac{5.11 \times 7 \times (100 + 10)}{1.225 \times 10} - \frac{511}{10} - 5.51 = 264(K\Omega)$$

Care should be taken to ensure that the maximum output power of the module remains at or below the maximum rated power.

Note4: see the last page.

Power Good, PG

The module provides a Power Good (PG) signal which is provided by the IC inside module, voltage level 3.3V, to indicate that the output voltage is within the normal output voltage range of the power module. The PG signal will be de-asserted to a low state if any condition such as overtemperature, overcurrent or loss of regulation occurs that would result in the output voltage going below the normal voltage range value.

The Vout PG function could be changed via PMBUS. The command related to Vout PG function are POWER_GOOD_ON and POWER_GOOD_OFF.

Parallel and Droop Current Sharing

The modules are capable of operating in parallel, and realizing current sharing by droop current sharing method. There is about 400mV output voltage droop from 0A to full output Load, and there is no current sharing pin. By connecting the Vin pin and the Vo pin of the parallel module together, the current sharing can be realized automatically.

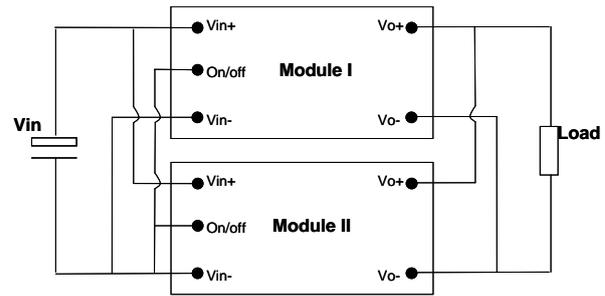


Figure 11: Parallel and droop current sharing configuration for no redundancy requirement system

If system has no redundancy requirement, the module can be parallel directly for higher power without adding external oring-fet; whereas, If the redundancy function is required, the external oring-fet should be added.

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

1. The current sharing accuracy equation is:

$$X\% = |I_o - (I_{total} / N)| / I_{rated}$$

Where, I_o is the output current of per module;

I_{total} is the total load current;

N is parallel module numbers;

I_{rated} 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 module 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.

THERMAL CONSIDERATIONS

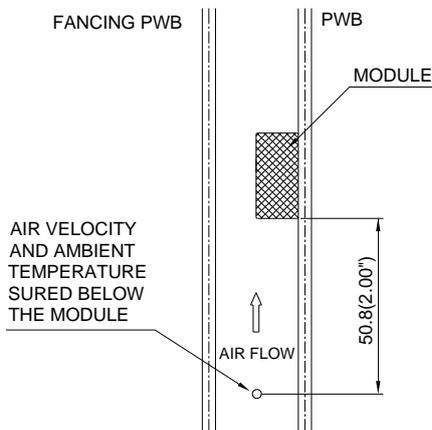
Thermal management is an important part of the system design. To ensure proper, reliable operation, sufficient cooling of the power module is needed over the entire temperature range of the module. Convection cooling is usually the dominant mode of heat transfer.

Hence, the choice of equipment to characterize the thermal performance of the power module is a wind tunnel.

Thermal Testing Setup

Delta's DC/DC power modules are characterized in heated vertical wind tunnels that simulate the thermal environments encountered in most electronics equipment. This type of equipment commonly uses vertically mounted circuit cards in cabinet racks in which the power modules are mounted.

The following figure shows the wind tunnel characterization setup. The power module is mounted on a 185mmX185mm,70µm (2Oz),6 layers test PWB and is vertically positioned within the wind tunnel. The space between the neighboring PWB and the top of the power module is constantly kept at 6.35mm (0.25").



Note: Wind Tunnel Test Setup Figure Dimensions are in millimeters and (Inches)

Figure 12: Wind tunnel 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 (WITHOUT HEAT SPREADER)

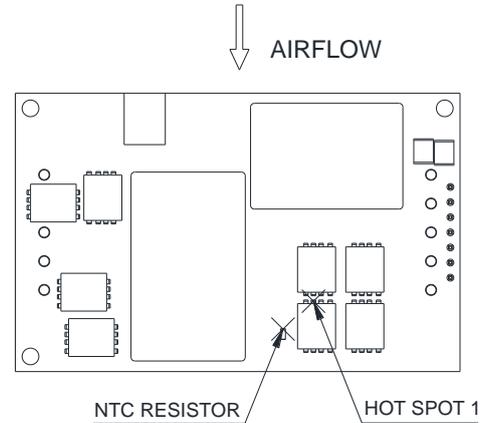


Figure 13: * Hot spot 1 & NTC resistor temperature measured point, the allowed maximum hot spot 1 temperature is defined at 118°C

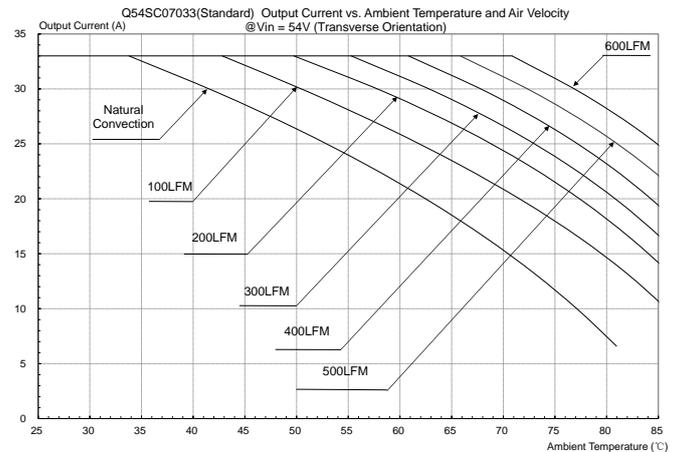


Figure 14: Output current vs. ambient temperature and air velocity @Vin=54V(Transverse Orientation, airflow from Vin+ to Vin-, without heat spreader)

THERMAL CURVES (WITH HEAT SPREADER)

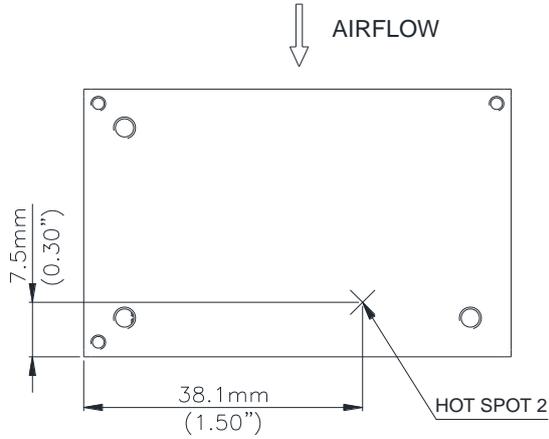


Figure 15: * Hot spot 2 temperature measured point, the allowed maximum hot spot 2 temperature is defined at 108°C

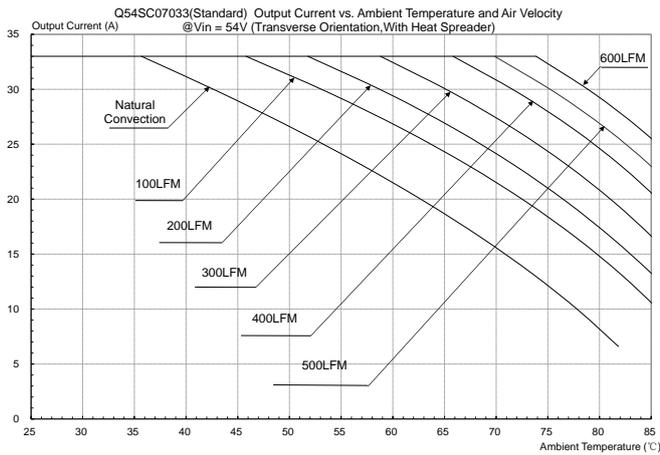


Figure 16: Output current vs. ambient temperature and air velocity @Vin=54V(Transverse Orientation, airflow from Vin+ to Vin-, with heat spreader)

DIGITAL FEATURE DESCRIPTIONS

The module has a digital PMBus interface to allow the module to be monitored, controlled and configured by the system. The module supports 4 PMBus signal lines, Data, Clock, SMBALERT (optional), Control (C2 pin, 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. And the module also can communicate with the master that does not implement the PEC mechanism.

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 only one way that the master and the module response to the alert of SMBALERT line.

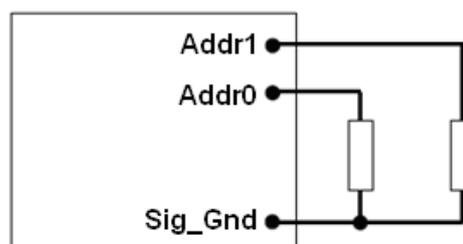
This way is for the module used in a system that does not support Alert Response Address (ARA). The module is to retain its resistor programmed address, when it is in an ALERT active condition. The master will communicate with the slave module using the programmed address, and using the various READ_STATUS 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.

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



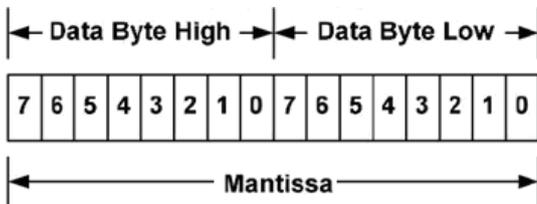
Corresponded to each octal digit, the requested resistor values are shown in below, and +/-1% resistors accuracy can be accepted. If there is any resistances exceeding the requested range, address 127 will be return. 0-12 and 40, 44, 45, and 55 in decimal address can't be used, since they are reserved 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. The Exponent of the data words is fixed at a reasonable value for the command; altering the exponent is not 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 -12. The format of the two data bytes is shown below:



The equation can be written as:

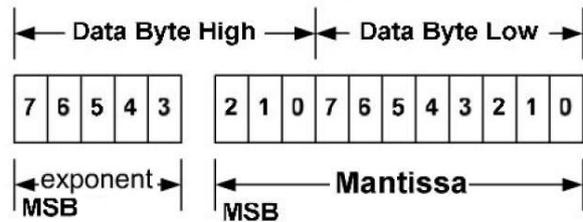
$$V_{out} = \text{Mantissa} \times 2^{(-12)}$$

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

$$\text{Mantissa} = V_{out}/2^{(-12)} = 12/2^{(-12)} = 49152;$$

Converter the calculated Mantissa to hexadecimal 0xC000.

For commands that set or report all other thresholds, including input voltages, output current, temperature, time and frequency, the supported linear data format is a two byte value with: an 11 bit, two's complement mantissa, and a 5 bit, two's complement exponent (scaling factor). The format of the two data bytes is shown as in below.



The equation can be written as:

$$\text{Value} = \text{Mantissa} \times 2^{(\text{exponent})}$$

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:

Get the exponent of V_{in} , -3; whose binary is 11101

$$\text{Mantissa} = V_{in}/2^{(-3)} = 34/2^{(-3)} = 272;$$

Converter the calculated Mantissa to hexadecimal 110, then converter to binary 00100010000; Combine the exponent and the mantissa, 11101 and 00100010000; Converter binary 1110100100010000 to hexadecimal E910.

SUPPORTED PMBUS COMMANDS

The main PMBus commands described in the PMBus 2.0 specification are supported by the module. Partial PMBus commands are fully supported; Partial PMBus commands have difference with the definition in PMBus 2.0 specification. All the supported PMBus commands are detail summarized in below table

Command	Command Code	Command description	Transfer 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 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 this table.
RESTORE_DEFAULT_ALL	0x12	Restores operating parameters from data flash to RAM	Send byte	Yes	/	/	/	/	/	This command can't be issued when the power unit is running.
VOUT_MODE	0x20	Read Vo data format	Read byte	Yes	mode+exp	0x14	/	/	/	/
VOUT_COMMAND	0x21	Set the output voltage normal value	R/W word	Yes	Vout Linear	7	0.6 ~8	Volts	-12	/
VOUT_MARGIN_HIGH	0x25	Set the output voltage margin high value	R/W word	Yes	Vout Linear	7.6	<8.0	Volts	-12	/
VOUT_MARGIN_LOW	0x26	Set the output voltage margin low value	R/W word	Yes	Vout Linear	1	>0.6	Volts	-12	/

Command	Command Code	Command description	Transfer type	Compatible with standard PMBUS or not?	Data Format	Default value	Range limit	Data units	Exponent	Note
FREQUENCY_SWITCH	0x33	Set the switching frequency	R/W word	Yes	Frequency Linear	130	120 ~ 150	KHz	-2	Write command need module off condition
VIN_ON	0x35	Set the turn on voltage threshold of Vin under voltage lockout	R/W word	Yes	Vin Linear	35	33~36	V	-3	VIN_ON should be higher than VIN_OFF
VIN_OFF	0x36	Set the turn off voltage threshold of Vin under voltage lockout	R/W word	Yes	Vin Linear	33	31~34	V	-3	VIN_ON should be higher than VIN_OFF
VOUT_OV_FAULT_LIMIT	0x40	Set the output overvoltage fault threshold.	R/W word	Yes	Vout Linear	10	8~12	V	-12	Must be higher than the value of VOUT_COMMAND and VOUT_OV_WARN_LIMIT;
VOUT_OV_FAULT_RESPONSE	0x41	Instructs what action to take in response to an output overvoltage fault.	Read byte	Refer to below description;	Bit field	0xB8	/	N/A	/	Default Hiccup mode
VOUT_OV_WARN_LIMIT	0x42	Set a threshold causing an output voltage high warning.	R/W word	Yes	Vout Linear	9	8~12	V	-12	Must be the same or less than VOUT_OV_FAULT_LIMIT value
IOUT_OC_FAULT_LIMIT	0x46	Set the output overcurrent fault threshold.	R/W word	Yes	Iout Linear	43	33~55	A	-4	Must be greater than IOUT_OC_WARN_LIMIT value
IOUT_OC_FAULT_RESPONSE	0x47	Instructs what action to take in response to an output overcurrent fault.	Read byte	Refer to below description;	Bit field	0xF8	/	N/A	/	Default Hiccup mode
IOUT_OC_WARN_LIMIT	0x4A	Set a threshold causing an output current high warning.	R/W word	Yes	Iout Linear	36	33~55	A	-4	Must be less than IOUT_OC_FAULT_LIMIT value
OT_FAULT_LIMIT	0x4F	Set the over temperature fault threshold.	R/W word	Yes	TEMP Linear	125	25~140	Deg. C	-2	Must be greater than OT_WARN_LIMIT value
OT_FAULT_RESPONSE	0x50	Instructs what action to take in response to an over temperature fault.	Read byte	Refer to below description;	Bit field	0xB8	/	N/A	/	Default Hiccup mode

Command	Command Code	Command description	Transfer type	Compatible with standard PMBUS or not?	Data Format	Default value	Range limit	Data units	Exponent	Note
OT_WARN_LIMIT	0x51	Set a threshold causing a temperature high warning.	R/W word	Yes	TEMP Linear	100	25~140	Deg.C	-2	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	100	48~100	V	-3	/
VIN_OV_FAULT_RESPONSE	0x56	Instructs what action to take in response to an input overvoltage fault.	Read byte	Refer to below description;	Bit field	0XB8	/	N/A	/	Default Hiccup mode
POWER_GOOD_ON	0x5E	Sets the output voltage at which the bit 3 of STATUS_WORD high byte should be asserted.	R/W word	Yes	Vout Linear	6	0.6~8	V	-12	Must be greater than POWER_GOOD_OFF value
POWER_GOOD_OFF	0x5F	Sets the output voltage at which the bit 3 of STATUS_WORD high byte should be negated.	R/W word	Yes	Vout Linear	4	0.6~8	V	-12	Must be less than POWER_GOOD_ON value
TON_DELAY	0x60	Sets the time from a start condition is received until the output voltage starts to rise	R/W word	Yes	Time Linear	20	20~500	ms	-1	/
TON_RISE	0x61	Sets the time from the output starts to rise until the voltage has entered the regulation band.	R/W word	Yes	Time Linear	30	15~500	ms	-1	/
STATUS_WORD	0x79	Returns the information with a summary of the module's fault/warning	Read word	Refer to below description;	Bit field	/	/	/	/	/
STATUS_VOLT	0x7A	Returns the information of the module's output voltage related fault/warning	R/W byte	Refer to below description;	Bit field	/	/	/	/	/
STATUS_CURRENT	0x7B	Returns the information of the module's output current related fault/warning	R/W byte	Refer to below description;	Bit field	/	/	/	/	/

Command	Command Code	Command description	Transfer type	Compatible with standard PMBUS or not?	Data Format	Default value	Range limit	Data units	Exponent	Note
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	/	/	V	-3	/
READ_VOUT	0x8B	Returns SENSE(+) to SENSE(-) voltage of the module	Read word	Yes	Vout Linear	/	/	V	-12	/
READ_IOUT	0x8C	Returns the output current of the module	Read word	Yes	Iout Linear	/	/	A	-4	/
READ_TEMPERATURE_1	0x8D	Returns the module's hot spot temperature of the module	Read word	Yes	TEMP Linear	/	/	Deg.C	-2	/
PMBUS_REVISION	0x98	Reads the revision of the PMBus	Read byte	Yes	Bit field	0x42	/	/	/	/
MFR_C1_C2_ARA_CONFIG	0xE0	Config C2 pin function	R/W byte	Refer to below description;	Bit field	0x00	/	/	/	/
MFR_C2_Configure	0xE1	Config C2 pin logic	R/W byte	Refer to below description;	Bit field	0x00	/	/	/	/
MFR_PGOOD_POLARITY	0xE2	Config Power Good logic	R/W byte	Refer to below description;	Bit field	0x01	/	/	/	Default Positive PGOOD logic
MFR_SERIAL	0x9E	Reads the SN of module	R/W block	/	Total 8 ASCII	'xxxxxxx'	Note 5			SN use 8 ASCLL

Note 5: the SN information as show follow: "xxxxxxx"
 "xx"(year) "xx"(week) "xxx"(Number);

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:	Reserved			0
5:4	Margins	00	No margin	00
		01	Margin low(Act on Fault)	
		10	Margin high(Act on Fault)	
3:0	Reserved			0000

VOUT_OV_FAULT_RESPONSE [0x41]

Bit number	Purpose	Bit Value	Meaning	Default Settings, 0xB8
7:6	Response settings	10	Unit shuts down and responds according to the retry settings	10
5:3	Retry setting	111	Unit continuously restarts while fault is present until commanded off	111
		000	Unit does not attempt to restart on fault	
2:0	Delay time setting	000	No delay supported	000

IOUT_OC_FAULT_RESPONSE [0x47]

Bit number	Purpose	Bit Value	Meaning	Default Settings, 0xF8
7:6	Response settings	11	Unit shuts down and responds according to the retry settings	11,
5:3	Retry settings	111	Unit continuously restarts while fault is present until commanded off	111
		000	Unit does not attempt to restart on fault	
2:0	Delay time setting	000	No delay supported	000

OT_FAULT_RESPONSE [0x50]

Bit number	Purpose	Bit Value	Meaning	Default Settings, 0xB8
7:6	Response settings	10	Unit shuts down and responds according to the retry settings	10,
5:3	Retry settings	111	Unit continuously restarts while fault is present until commanded off	111
		000	Unit does not attempt to restart on fault	
2:0	Delay time setting	000	No delay supported	000

VIN_OV_FAULT_RESPONSE [0x56]

Bit number	Purpose	Bit Value	Meaning	Default Settings, 0xF8
7:6	Response settings	11	Unit shuts down and responds according to the retry settings	11
5:3	Retry setting	111	Unit continuously restarts while fault is present until commanded off	111
		000	Unit does not attempt to restart on fault	
2:0	Delay time setting	000	No delay supported	000

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]

Bit number	Purpose	Bit Value	Meaning
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		

MFR_C1_C2_ARA_CONFIG [0xE0]

Bit number	Purpose	Bit Value	Meaning
7:5	Reserved	000	Reserved
4	ARA	0	ARA not functional, module remains at resistor programmed address when SMBLAERT is asserted
3:0	PIN Configuration	0000	C2 pin: POWER_GOOD
		0010	C2 pin: ON/OFF (Secondary)

MFR_C2_Configure [0xE1]

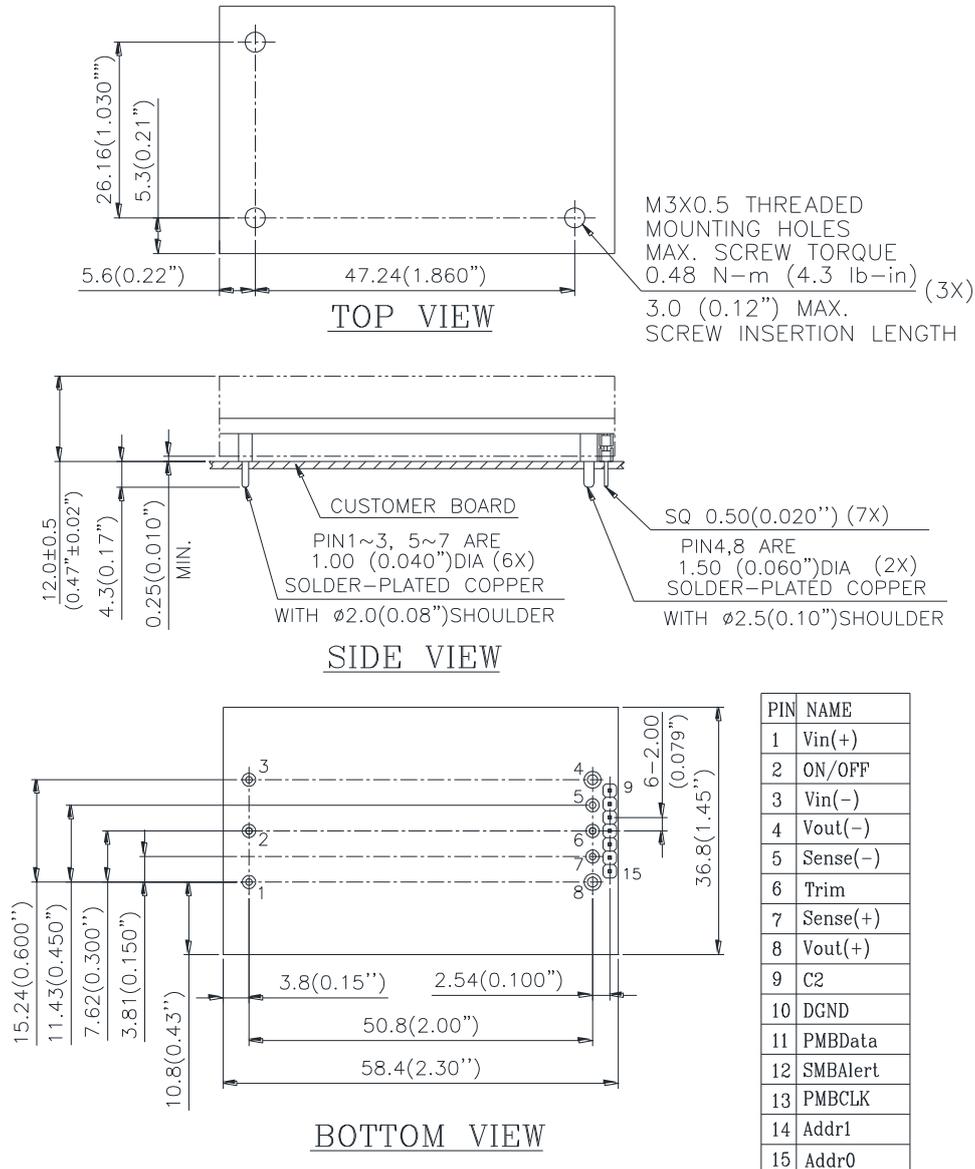
Bit number	Purpose	Bit Value	Meaning
7:2	Reserved	000000	Reserved
1	ON/OFF Configuration	0	Secondary side on/off pin state when mapped to C2 is ignored
		1	AND – Primary and Secondary side on/off
0	Secondary Side ON/OFF Logic	0	Negative Logic (Low Enable: Input < 0.8V wrt Vout(-))
		1	Positive Logic (High Enable: Input > 2.0V wrt Vout(-))

MFR_PGOOD_POLARITY [0xE2]

Bit number	Purpose	Bit Value	Meaning
7:1	Reserved	0000000	Reserved
0	Power Good Logic	0	Negative PGOOD logic
		1	Positive PGOOD logic

MECHANICAL DRAWING(WITH HEAT-SPREADER)

***For modules with through-hole pins and the optional heat spreader, they are intended for wave soldering assembly onto system boards, please do not subject such modules through reflow temperature profile.**



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

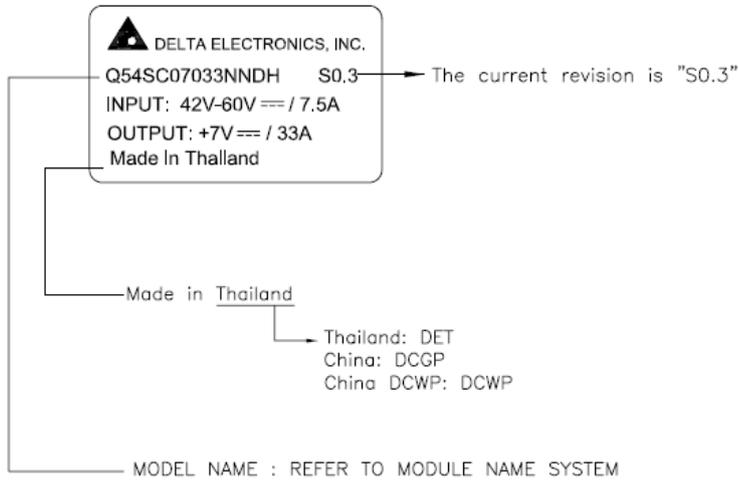
Pin Specification:

Pins 1-3, 5-7
Pins 4,8
Pins 9-15

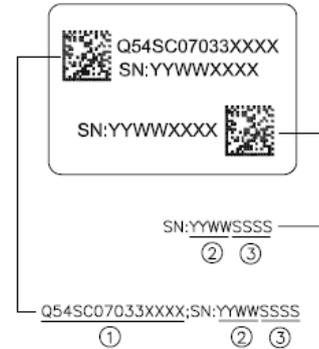
1.00mm (0.040") diameter (All pins are copper with matte Tin plating over Nickel under plating)
1.50mm (0.059") diameter (All pins are copper with matte Tin plating over Nickel under plating)
SQ 0.50mm(0.020") (All pins are copper with gold flash plating)

LABEL SPEC

SPEC. LABEL



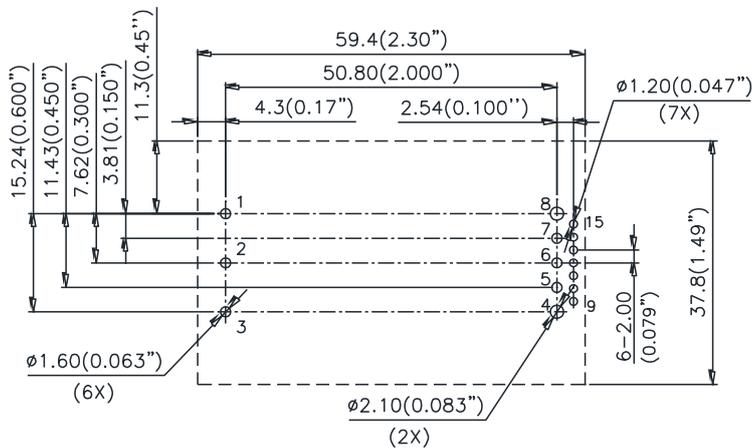
SN. LABEL



- ① DELTA MODEL NAME
 FOR EXAMPLE: Q54SC07033NNDH
- ② YYWW: DATE CODE
 YY: 2 CODE YEAR (2000 USE "00" ,...2014 USE "14",2015 USE "15")
 WW: 2 CODE WEEK
- ③ SSSS: SERIES NO.
 0001,...0009,000A,...000Z,0010,...(I,O,Q ARE NOT USED)

NOTE:
 1. BARCODE TYPE "DATAMATRIX", ECC: 200

SUGGESTED LAYOUT



PIN	NAME
1	Vin(+)
2	ON/OFF
3	Vin(-)
4	Vout(-)
5	Sense(-)
6	Trim
7	Sense(+)
8	Vout(+)
9	C2
10	DGND
11	PMBData
12	SMBAlert
13	PMBCLK
14	Addr1
15	Addr0

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

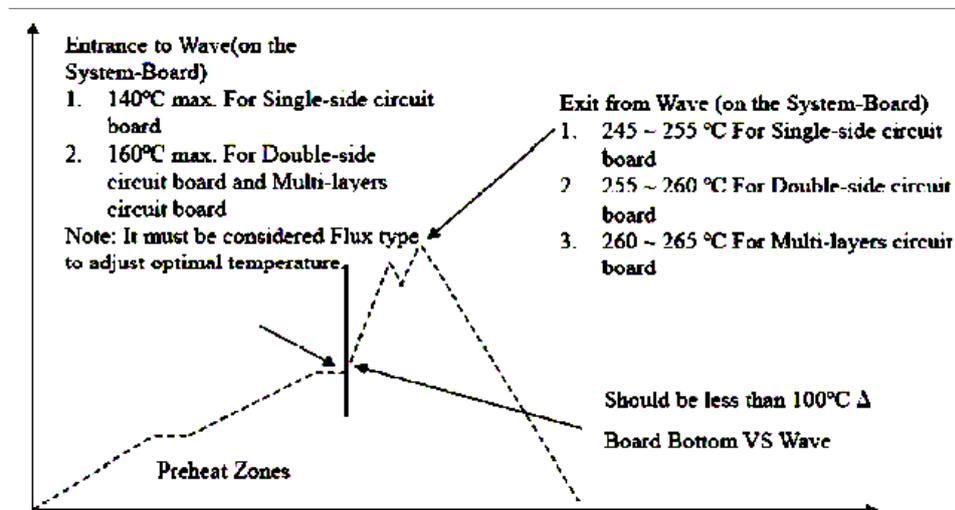
SOLDERING METHOD

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 following table. The suggested soldering process must keep the power module's internal temperature below the critical temperature of 217°C continuously.

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

Q	54	S	C	070	33	N	N	D	H
Type of Product	Input Voltage	Number of Outputs	Product Series	Output Voltage	Output Current	ON/OFF Logic	Pin Length / Type	Pin assignment	Option Code
Q - Quarter Brick	54 - 42~60V	S - Single	C - Series number	070 - 7V	33 - 33A	P - Positive N - Negative	R - 0.170" N - 0.145"	D - with Digital pins and sense pins	H: With Trim pin, With Heat Spreader

RECOMMENDED PART NUMBER

MODEL NAME	INPUT		OUTPUT		EFF @ 100%LOAD
Q54SC07033NNDH	42V~60V	7.5A	7V	33A	93.5%

*** For modules with through-hole pins and the optional heatsink, they are intended for wave soldering assembly onto system boards; please do not subject such modules through reflow temperature profile.**

Note4: If use VOUT_COMMAND of PMBUS to trim Vout set point, then the function of trim pin(7 pin) will be disabled immediately. And if need enable the function of trim pin(7pin) to trim Vout set point again, should turn off and turn on the input voltage of module to restart module.

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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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