0RQP-H5T12

Isolated DC-DC Converter

These units are designed to be highly efficient and low cost. Features include remote on/off, short circuit protection, over current protection, under-voltage lockout, over temperature protection, power management bus and so on.

The output of the converters has the droop function which allow the modules operating in parallel with high output current sharing precision. These converters are provided in an industry standard quarter brick package.

Key Features & Benefits

- 36 - 75 VDC Input
- 12 VDC @ 54.2 A Output
- 1/4th Brick Converter
- Fixed Frequency
- High Efficiency
- Input Under-Voltage Lockout
- Input Over-Voltage Lockout
- OCP/SCP
- Over Temperature Protection
- Over Voltage Protection
- Power Management Bus
- TRIM
- Remote Sense
- Approved to UL/CSA 62368-1
- Approved to IEC/EN 62368-1
- Approved to IEC/EN 60950-1
- Class II, Category 2, Isolated DC-DC Converter (refer to IPC-9592B)

RoHS Compliant

Applications

- Industrial
- Telecommunications

1. MODEL SELECTION

MODEL NUMBER	OUTPUT VOLTAGE	INPUT VOLTAGE	MAX. OUTPUT CURRENT	MAX. OUTPUT POWER	TYPICAL EFFICIENCY
0RQP-H5T12AG 0RQP-H5T12BG 0RQP-H5T12PG	9 - 12.6 VDC (Power Management Bus and Trim, Sense)	36 – 75 VDC	54.2 A	650 W	95.8% @ 48 Vin / 54.2 A

PART NUMBER EXPLANATION

0	R	QP	-	H5	T	12	x	G
Mounting Type	RoHS Status	Series Name		Output Power	Input Range	Output Voltage	Logic and Optional Features	Package Type
Through Hole Mount	RoHS	with Power Management Bus and Trim, Sense		650 W	36 – 75 V	12 V	A - Active High, without Droop B - Active Low, without Droop P - Active Low, with Droop	Tray Package

2. ABSOLUTE MAXIMUM RATINGS

PARAMETER	DESCRIPTION	MIN	TYP	MAX	UNITS
Input Voltage	Continuous	-0.3	-	75	V
	Operating transient ⩽ 100 ms	-	-	100	
	Non- operating continuous	85	-	100	
Remote On/Off		-0.3	-	18	V
Current Sink		0	-	10	mA
Isolation Voltage	Input to output	-	-	2250	V
Operating Temperature	Ambient temperature	-40	-	85	°C
Storage Temperature		-55	-	125	°C
Altitude		-	-	5000	m

NOTE: Ratings used beyond the maximum ratings may cause a reliability degradation of the converter or may permanently damage the device.

3. INPUT SPECIFICATIONS

All specifications are typical at 25°C unless otherwise stated.

PARAMETER	DESCRIPTION	MIN	TYP	MAX	UNIT
Operating Input Voltage	Vin	36	48	75	V
Input Current (full load)	Iin	-	-	20	A
Input Current (no load)		-	150	180	mA
Remote Off Input Current		-	15	20	mA
Input Reflected Ripple Current is (rms)	Vin = 48 V, Io= Io max	-	20	-	mA
Input Reflected Ripple Current is (pk-pk)		-	60	-	mA
Under-voltage Turn on Threshold	Lockout turn on	33	35	36	V
Under-voltage Turn off Threshold	Lockout turn off, non-latching	31	33	35	V

CAUTION: This converter is not internally fused. An input line fuse must be used in application. Recommended input fast-acting fuse on system board.

4. OUTPUT SPECIFICATIONS

All specifications are typical at nominal input, full load at 25°C unless otherwise stated.

PARAMETER	DESCRIPTION	MIN	TYP	MAX	UNIT
Output Voltage Set Point	Test condition of the output set point: Vin = 48 V, Io = 50% load at 25°C ambient	11.97	12.00	12.03	V
Output Voltage Regulation	(Over entire operating input voltage range, resistive load, and temperature conditions until end of life) without droop	11.76	12.00	12.24	V
	(Over entire operating input voltage range, resistive load, and temperature conditions until end of life) with droop	11.63	12.00	12.37	
Output Voltage Regulation					
Load Regulation	Io = 0~100% load (without droop)	-	20	40	mV
	Io = 0~100% load (with droop)	-	500	-	
Line Regulation	Vin = 36~75 V	-	20	60	mV
Regulation Over Temperature		-	150	200	mV
Output Ripple and Noise (pk-pk)	Vin = 48 V, Io = 100% load at 25°C ambient, 5 Hz - 20 MHz BW, 180 µF/16 V (OS-CON) + 120 µF/16 V (OS-CON) +1 µF/16 V (Ceramic)	-	250	350	mV
Output Ripple and Noise (rms)		-	80	120	mV
Output Current Range		0	-	54.2	A
Output DC Current Limit	Hiccup mode	63	65	67	A
Rise Time	Trise = Time for Vo to rise from 10% to 90% of Vo,set	-	25	-	ms
Turn-On Delay	Tdelay = Time until Vo = 10% of Vo,set Enable with Vin	-	20	35	ms
	Tdelay = Time until Vo = 10% of Vo,set Enable with on/off	-	20	35	
Overshoot at Turn on		-	0	3	%
Undershoot at Turn off		-	0	3	%
Output Capacitance		300	-	10000	µF
Transient Response					
△V 50%~75% of Max Load	di/dt = 0.1 A/µs, Vin = 48 VDC, Ta = 25°C, Tested with a 180 µF/16 V (OS-CON) + 120 µF/16 V (OS-CON) +1 µF/16 V (Ceramic)	-	350	-	mV
Settling Time		-	700	-	µs
△V 75%~50% of Max Load		-	350	-	mV
Settling Time		-	700	-	µs

5. GENERAL SPECIFICATIONS

PARAMETER		DESCRIPTION	MIN	TYP	MAX	UNIT
Efficiency	Io = 100% Irate	Vin = 48 V, Ta = 25 °C	-	95.8	-	%
	Io = 60% Irate		-	96	-	%
Switching Frequency			-	260	-	kHz
Over Temperature Protection			-	135	-	°C
Output Voltage Trim Range		For all operating input voltage	9	-	12.6	V
Over Voltage Protection (Static)		Latching mode	-	13.5	-	V
Weight			-	74	-	g
Dimensions (L × W × H)			2.30 x 1.45 x 0.53			inch
			58.42 x 36.83 x 13.50			mm
Isolation Characteristics						
Input to Output			-	-	2250	VDC
Input to Heatsink			-	-	2250	VDC
Output to Heatsink			-	-	500	VDC
Isolation Resistance			10M	-	-	Ohm
Isolation Capacitance			-	-	3300	pF

6. EFFICIENCY DATA

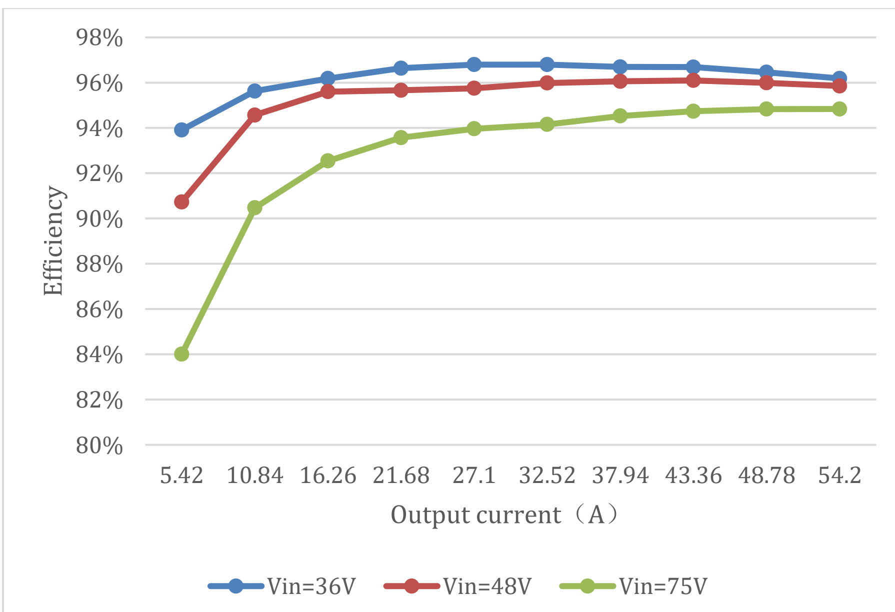


Figure 1. Efficiency data

7. REMOTE ON/OFF

PARAMETER	DESCRIPTION		MIN	TYP	MAX	UNIT
Signal Low (Unit On)	Active Low	Remote On/Off pin is open, the module is off	-0.3	-	0.8	V
Signal High (Unit Off)			2.4	-	18	V
Signal Low (Unit Off)	Active High	Remote On/Off pin is open, the module is on	-0.3	-	0.8	V
Signal High (Unit On)			2.4	-	18	V
Current Sink			0	-	1	mA

Recommended remote on/off circuit for active low

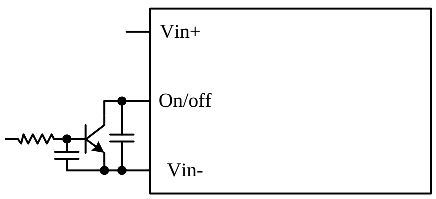


Figure 2. Control with open collector/drain circuit

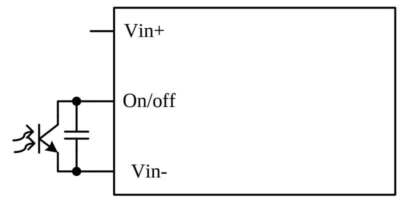


Figure 3. Control with photocoupler circuit

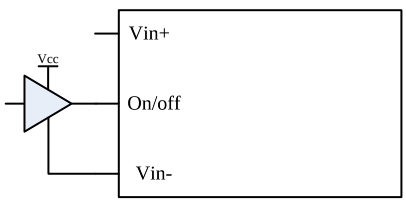


Figure 4. Control with logic circuit

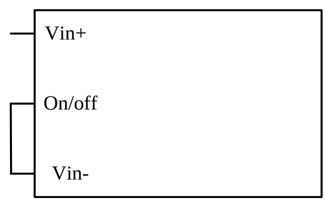


Figure 5. Permanently on

Recommended remote on/off circuit for active high

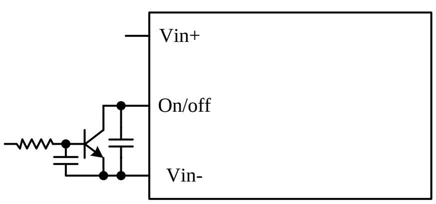


Figure 6. Control with open collector/drain circuit

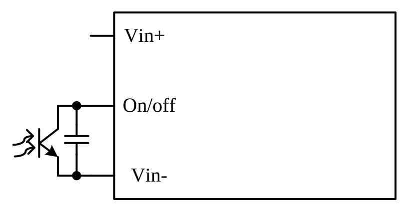


Figure 7. Control with photocoupler circuit

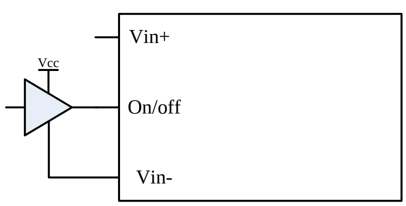


Figure 8. Control with logic circuit

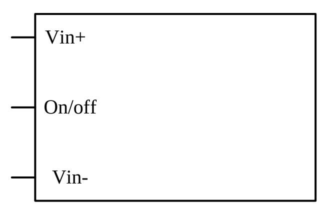


Figure 9. Permanently on

8. REMOTE SENSE

This module has remote sense compensation feature. It can minimize the effects of resistance between output and load in system layout and facilitate accurate voltage regulation at load terminals or other selected point.

1. Recommend the connection of remote sense compensation as below figure. There are a resistor RS+ (100 ohm) from Vo+ to Sense+ and a resistor RS- (100 ohm) from Vo- to Sense- inside of this module.

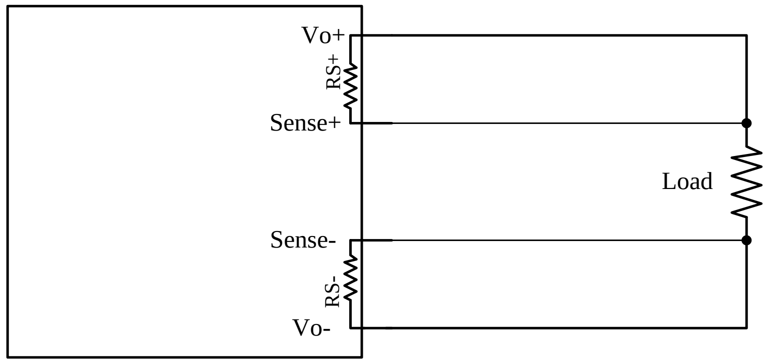


Figure 10.

2. If not using remote sense compensation, please connect sense directly to output at module's pin, that is, connect sense+ to Vo+ and sense- to Vo- at module's pin, the shorter the better. See below figure.

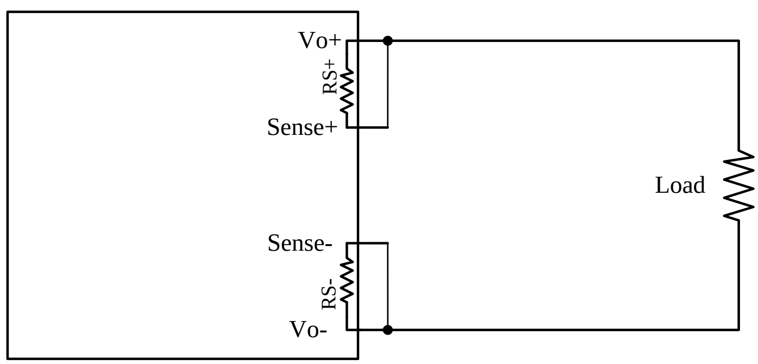


Figure 11.

9. INPUT NOISE

Input reflected ripple current

Test setup

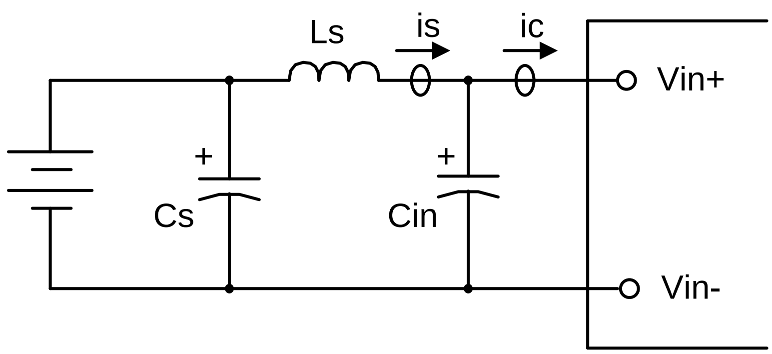


Figure 12.

Notes and values in testing:

is: Input Reflected Ripple Current

ic: Input Terminal Ripple Current

Ls: Simulated Source Impedance (10 µH)

Cs: NIL

Cin: Electrolytic capacitor, should be as close as possible to the power module to damp ic ripple current and enhance stability.

Recommendation: 220 µF, ESR < 0.1 Ω @ 100 kHz, 20°C.

Below measured waveforms are based on above simulated and recommended inductance and capacitance.

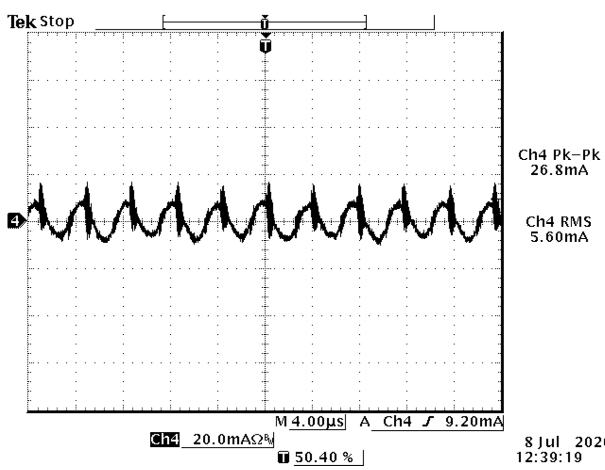


Figure 13. is (input reflected ripple current), AC component

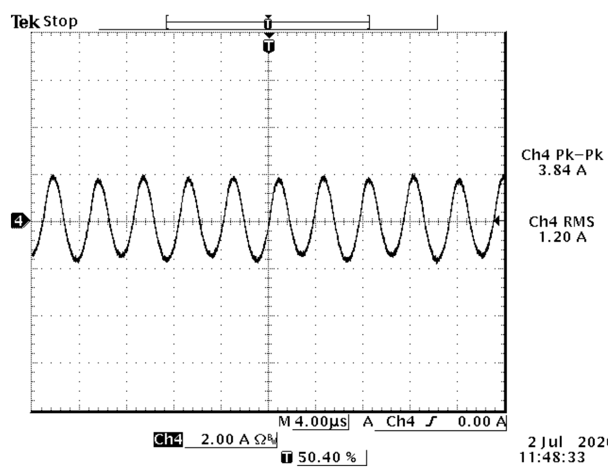


Figure 14. ic (input terminal ripple current), AC component

Test condition: 48 VDC input, 12 VDC / 54.2 A output and Ta = 25 °C.

10. RIPPLE AND NOISE WAVEFORM

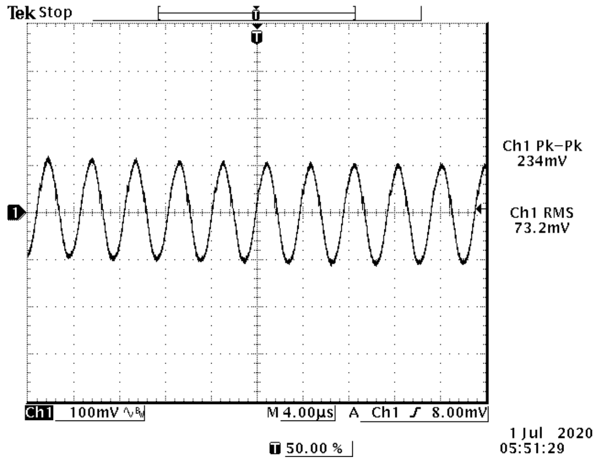


Figure 15. Ripple and noise waveform

Note: 48 VDC input, 12 VDC / 54.2 A output and Ta = 25 °C, 180 µF/16 V (OS-CON) + 120 µF/16 V (OS-CON) +1 µF/16 V (Ceramic).

11. TRANSIENT RESPONSE WAVEFORMS

Transient Response test condition: di/dt = 0.1 A/µs, 180 µF/16 V (OS-CON) + 120 µF/16 V (OS-CON) +1 µF/16 V (Ceramic).

CHI: Vout, CH2: Vout

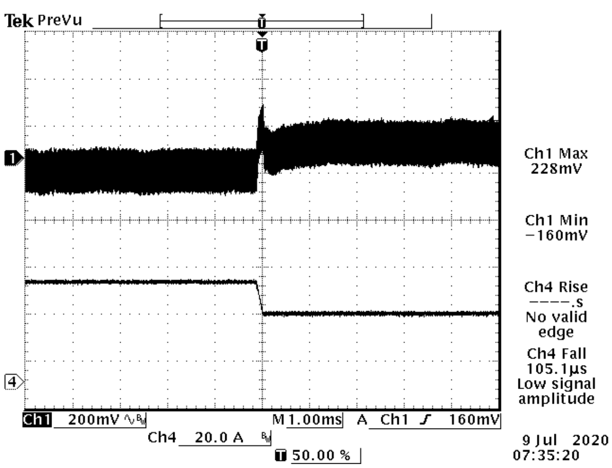


Figure 16. Vout = 12V, 75%-50% Load Transients at Vin = 48 V, Ta = 25°C

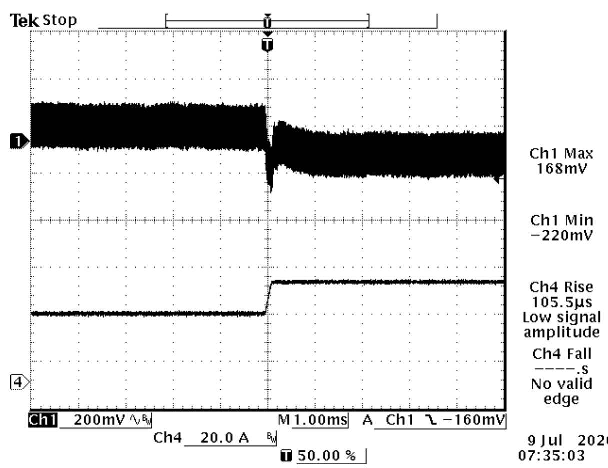


Figure 17. Vout = 12V, 50%-75% Load Transients at Vin = 48 V, Ta = 25°C

12. STARTUP & SHUTDOWN

Startup

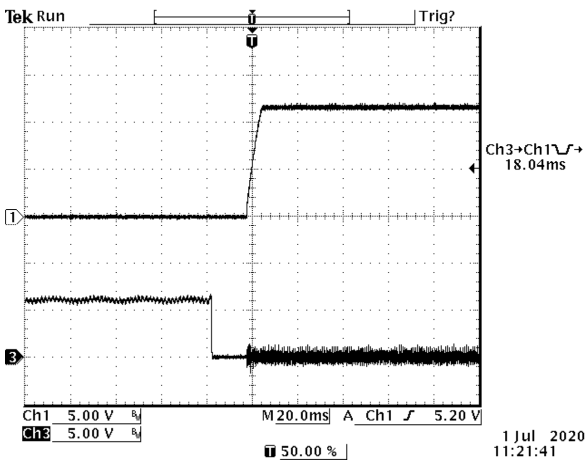


Figure 18. 48 VDC input, 12 VDC / 54.2 A output and Ta = 25 °C, 300 µF (OS-CON) +1 µF (Ceramic) CH1: Vout, CH3: Remote on/off (Active low)

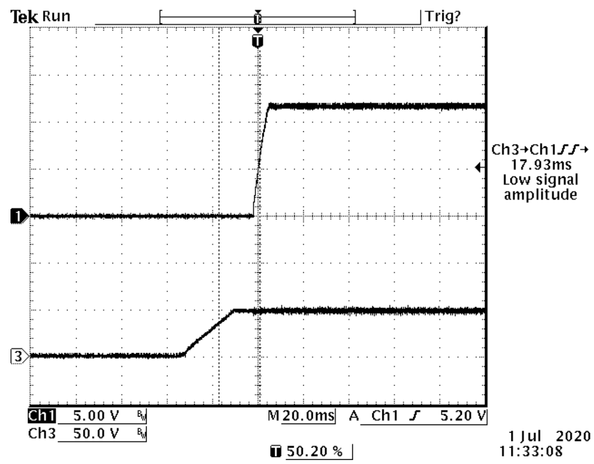


Figure 19. 48 VDC input, 12 VDC / 54.2 A output and Ta = 25 °C, 300 µF (OS-CON) +1 µF (Ceramic) CH1: Vout, CH3: Vin

Shutdown

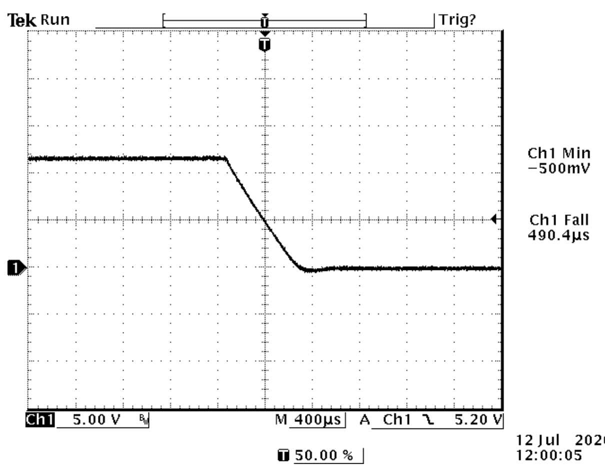


Figure 20. 48 VDC input, 12 VDC / 54.2 A output and Ta = 25 °C, 300 µF (OS-CON) +1 µF (Ceramic) CH1: Vout

13. UNDER VOLTAGE LOCKOUT

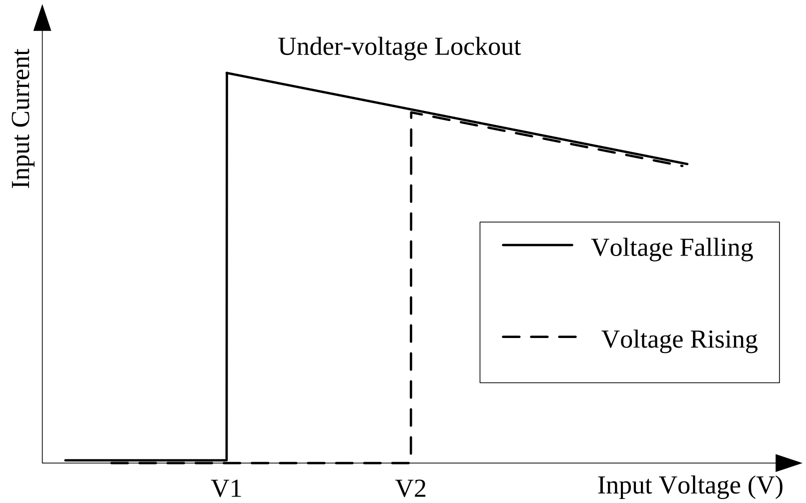


Figure 21. Under voltage lockout

V1 = 33 V
V2 = 35 V

14. OUTPUT CURRENT SHARE

Two or more 0RQP-H5T12P modules can be connected to implement the current share function as shown in below figure. In this application, it is necessary to connect the remote sense pin to load point from each module to ensure a balanced output current.

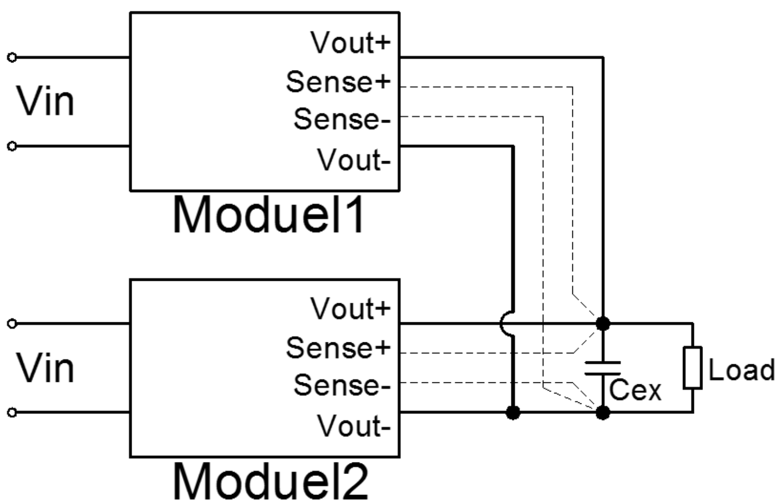
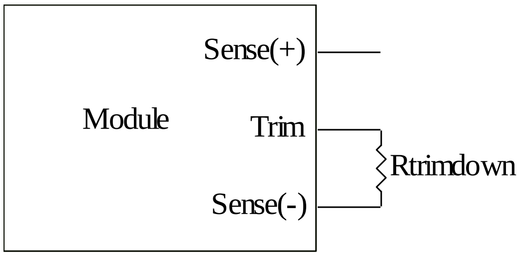


Figure 22. Output current share

15. OUTPUT TRIM EQUATIONS

Equations for calculating the trim resistor are shown below. The Trim Down resistor should be connected between the Trim pin and Sense (-) pin. The Trim Up resistor should be connected between the Trim pin and the Sense (+). Only one of the resistors should be used for any given application.

Trim down test circuit



$$Rtrimdown = \frac{511}{|delta|} - 10.22[k\Omega]$$

Figure 23. Trim down test circuit

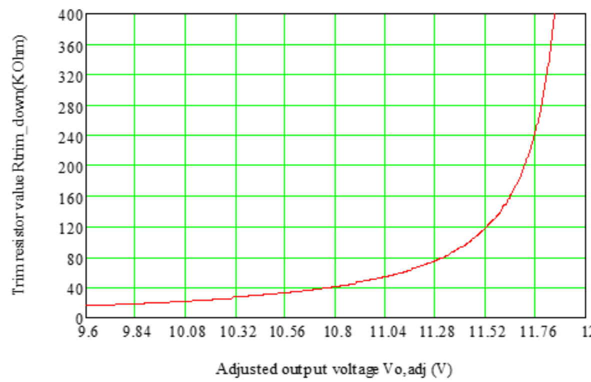
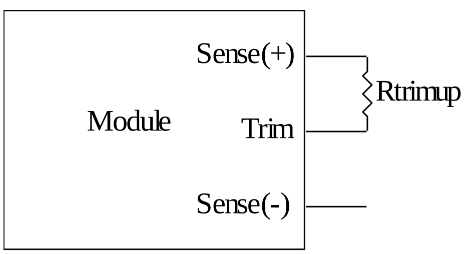


Figure 24. Trim down curve

Trim up test circuit



$$Rtrimup = \frac{(100 + delta) \cdot Vo \cdot 5.11 - 626}{1.225 \cdot delta} - 10.22[k\Omega]$$

Figure 25. Trim up test circuit

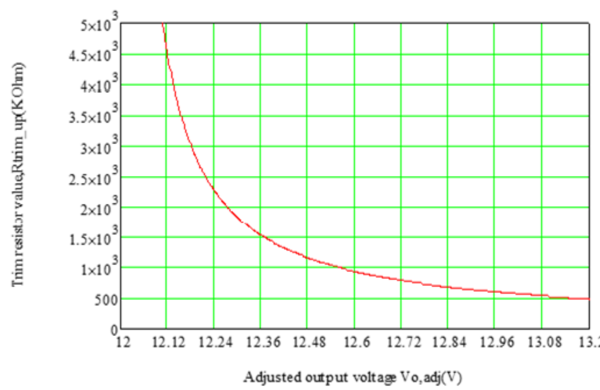


Figure 26. Trim up curve

Note:

Vo_req = Desired (trimmed) output voltage [V].

Output voltage Vo = 12 V.

$$delta = \frac{(Vo\_req - Vo)}{Vo} \times 100[\%]$$

Note:

1. The trim used the VOUT_COMMAND of Power Management Bus and the trim used the function of trim pin (6 pin) cannot be used at the same time.

2. If use VOUT_COMMAND of Power Management Bus to trim Vout set point, then the function of trim pin (6 pin) will be disabled immediately. And if need enable the function of trim pin(6pin) to trim Vout set point again, should turn off and turn on the input voltage of module to restart module.

16. THERMAL DERATING CURVES

Thermal Considerations:

New high power architectures require an accurate thermal design. Design engineers have to optimize the module working conditions and ensure reliable operation. Convection cooling is the common mode to cool down the module. Heat transfer is dependent on a test setup and it is important to characterize the module in an environment similar to existent electronic applications. Reported thermal data reflects real operating conditions because the values are physically measured in a wind tunnel.

Thermal Test Setup:

A module in electronic cards is typically located in a busy area without relevant space around it.
To simulate a real condition and avoid turbulence we add a cover with defined dimensions.
The distance has to be 6.35 mm (0.25 inch) from the top of the module and 6.35 mm (0.25 inch) on the left and right side of the module.
The values reflect most of the real applications and it is a common procedure in the power module market.
Ambient temperature and airflow are measured in front of the module at the distance of 76.2 mm (3 inch).

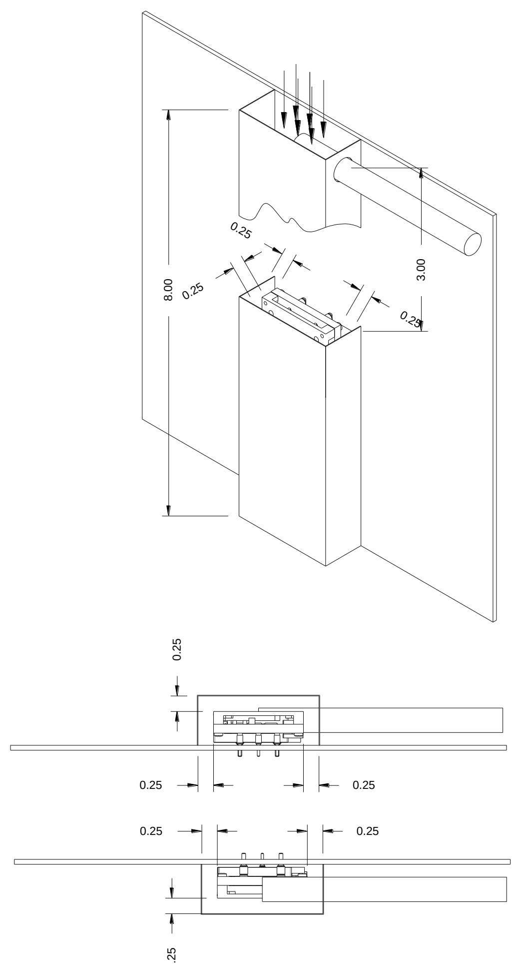


Figure 27. Thermal test setup

Test setup drawing all measures in inch.

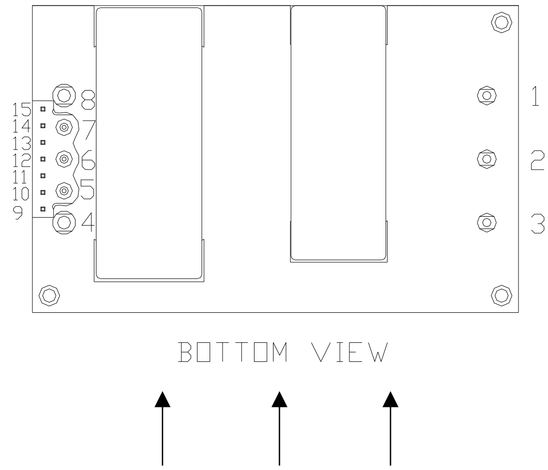


Figure 28. Forced Airflow Direction-1

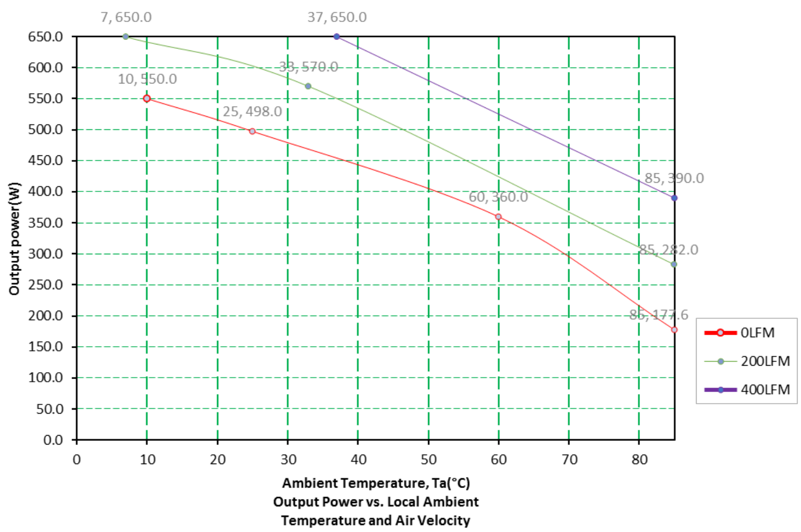


Figure 29. Derating curve @Vin = 48 V

Note: Output power vs. ambient temperature and air velocity @ Vin = 48 V (Longitudinal Orientation, airflow from Vin(-) to Vin(+)).

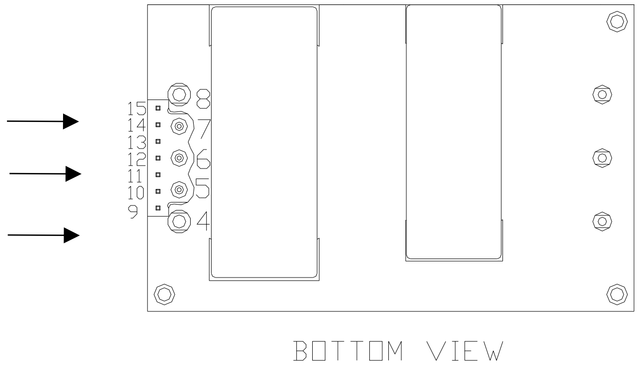


Figure 30. Forced Airflow Direction-2

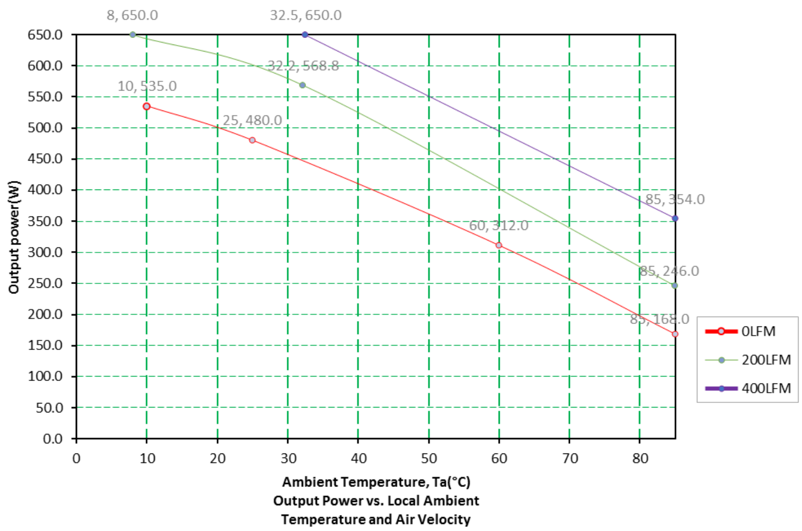


Figure 31. Derating curve @Vin = 56 V

Note: Output power vs. ambient temperature and air velocity @ Vin = 56 V (Longitudinal Orientation, airflow from Vout to Vin).

17. SAFETY & EMC

Safety:

1. Approved to IEC/EN 60950-1
2. Approved to IEC/EN 62368-1
3. Approved to UL/CSA 62368-1

EMC:

Conductive EMI: EN 55032 class A

Compliance to EN 55032 class A (both peak and average) with the following inductive and capacitive filter

Test condition: Vin = 48 V Full Load

Test Setup:

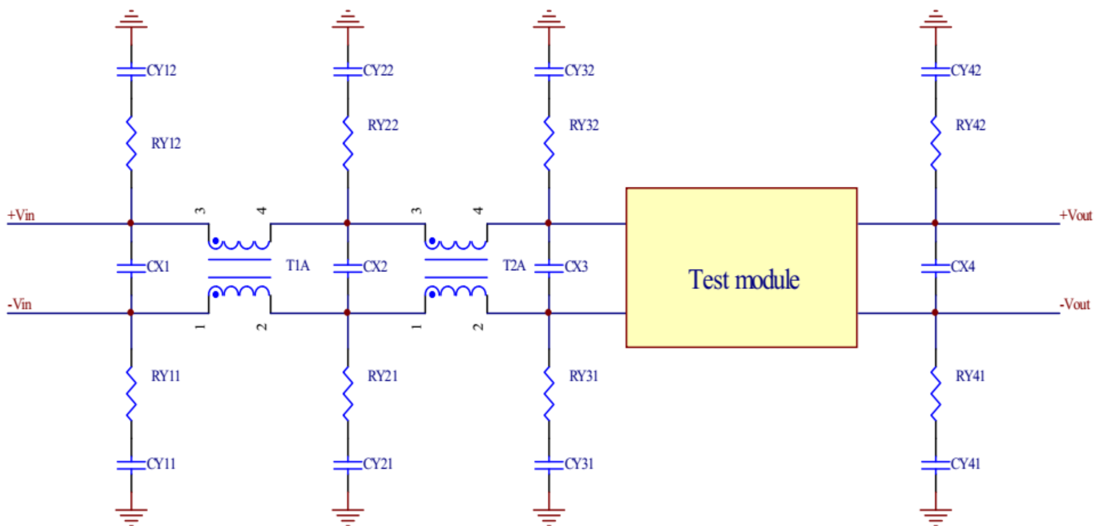


Figure 32.

Item	Designator	Parameter	Vendor	Vendor P/N
1	CX2	AL-EL CAP 220UF 20% 100V UHE2A221MHD6 Lead Type	Nichicon	UHE2A221MHD6
2	CX3	AL-EL CAP 220UF 20% 100V UHE2A221MHD6 Lead Type	Nichicon	UHE2A221MHD6
3	T2A	C20200-15 1.2mH 0.006Ωmax Irate=16Amax		
4	T1A	SHORT		
5	CX4	POLYMER AL SOLID CAP 1200μF+/-20% 16V -55 to +105C 8X20mm	chemi-com	APSG160ELL122MH20S
6	CY31,CY32,CY41,CY42	CAP Y2 4700PF +/-20% 250VAC 7.5mm	vishay	VY2472M41Y5VS6UV7
7	All resister	SHORT		
8	CX1	NIL		

Positive:

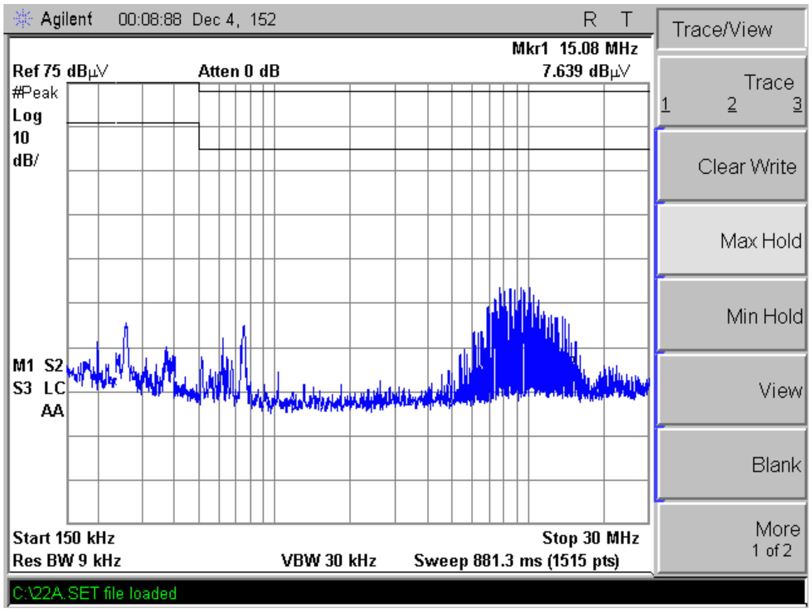


Figure 33.

Negative:

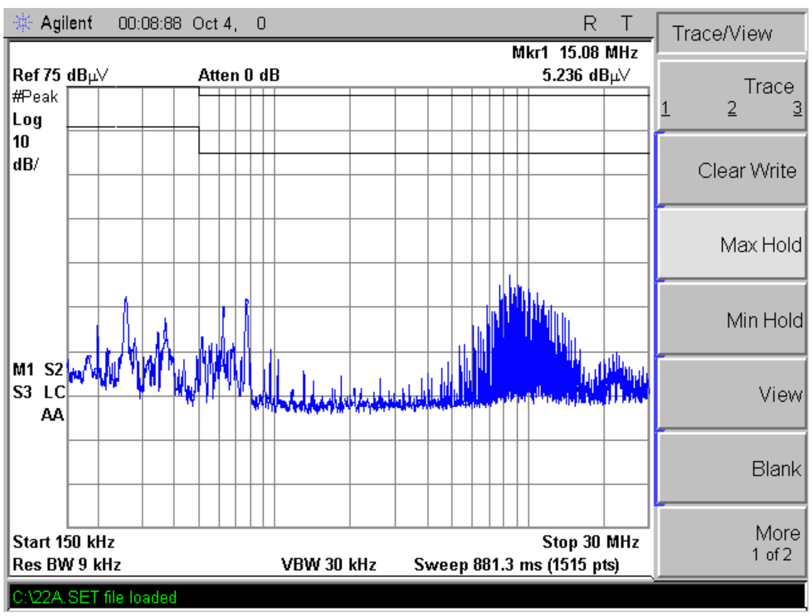


Figure 34.

18. POWER MANAGEMENT BUS

POWER MANAGEMENT BUS DIGITAL FEATURE DESCRIPTION

The module supports Power Management Bus to allow to be monitored, controlled and configured by the system. More detailed Power Management Bus information can be found in the Power Management Bus Power Management Protocol Specification, Part I and part II, revision 1.3, which is shown in the System Management Interface Forum Web site: www.powerSIG.org. The supported Power Management Bus commands of the module are listed below in the supported POWER MANAGEMENT BUS COMMANDS section.

The module supports four Power Management Bus signal lines: PMBDATA, PMBCLK, SMBALERT (optional), Control (C2 pin, optional), and two Address lines: Addr0 and Addr1.

Connection for the Power Management Bus interface should follow 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.

SMBALERT protocol is supported. SMBALERT line is also a wired-AND signal, by which the module can alert the Power Management Bus master via pulling the SMBALERT pin to an active low to indicate a fault condition. The master will communicate with the slave module using the programmed address and use the various READ_STATUS commands to find the cause for the SMBALERT. The CLEAR_FAULTS command will clear the SMBALERT.

The module also supports the Packet Error Checking (PEC) protocol. It can check the PEC byte provided by the Power Management Bus master and include a PEC byte in all messages transmitted back to the master.

POWER MANAGEMENT BUS ADDRESSING

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

Address = 8 * ADDR1 + ADDR0

Corresponded to each octal digit, the requested resistor values are shown below, and +/-1% resistors accuracy can be accepted. If there are any resistances exceeding the requested range, address 64 will be return. 0-12 and 40, 44, 45, and 55 in decimal address cannot be used, since they are reserved according to the SMBus specifications, and which will also return address 16.

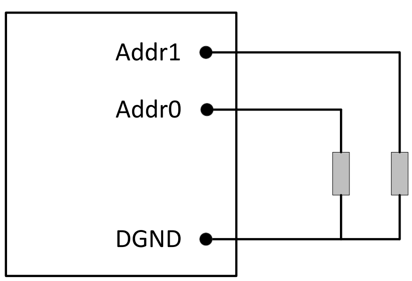


Figure 35.

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

NOTE:
1. Power Management Bus communication is only supported when vin normal and remote on
2. If boot load function is needed, there can not be an I2C slave address of 0x58 on I2C bus

POWER MANAGEMENT BUS APPLICATION CIRCUIT

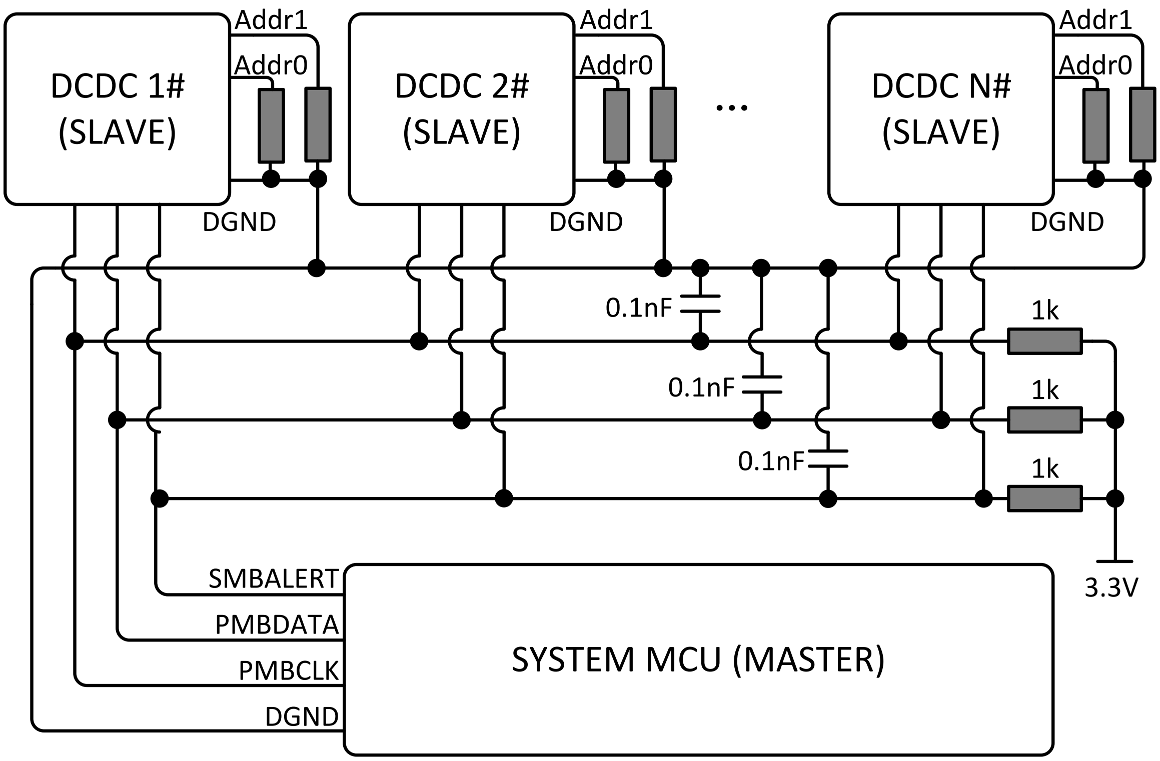


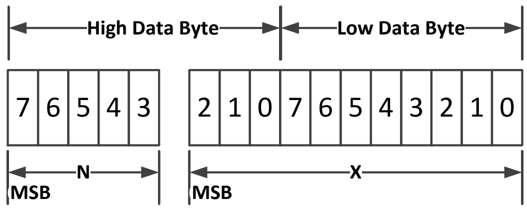
Figure 36. Power Management Bus Application Circuit

PARAMETER	NOTES	MIN	NOM	MAX	UNITS
Logic Input Low (VIL)	1	0		0.8	V
Logic Input High (VIH)	1	2.1		3.3	V
Logic Output Low (VOL)	2			0.65	V
Logic Output High (VOH)	3	2.3			V
Power Management Bus Operating Frequency Range			100/400		kHz
Output Current Reading Accuracy	4	-5		+5	%
	5	-3		+3	A
Output Voltage Reading Accuracy		-2		+2	%
Input Voltage Reading Accuracy		-4		+4	%
Temperature Reading Accuracy		-5		+5	℃

Notes	
1	PMBDATA, PMBCLK pin
2	PMBDATA, SMBAlert, PMBCLK pin; IOL = 4 mA
3	PMBDATA, SMBAlert, PMBCLK pin; IOH = -4 mA
4	Vin = 54 V, Io = 50% ~ 100% of Iomax;
5	Vin = 54 V, Io = 5% ~ 50% of Iomax;

POWER MANAGEMENT BUS DATA FORMAT

For commands which is except to the output voltage, including input voltage, output current, temperature, PWM frequency, duty cycle, the controller will use the 2-byte linear format as defined by the Power Management Bus system management protocol. The linear data format contains 2 bytes which include a 5-bit two's complement exponent and an 11-bit two's complement mantissa as below. The transmitted value Y is reported as the form $Y = X*2^N$.

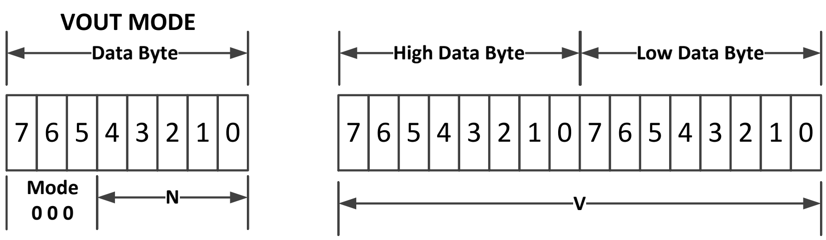


For example, to set the over temperature fault threshold 135 deg C by OT_FAULT_LIMIT command, the read/write data can be calculated refer to below: the binary number of N is 0, whose decimal number is 0.

X = TOTP/2(0) = 135, whose binary is 0b00010000111.

Combine X and N, the binary is 0b0000000010000111. The hexadecimal of OT_FAULT_LIMIT is 0x0087.

The output voltage parameters use the Power Management Bus Vout linear format. The data format is shown below.



The voltage will be in the form $Voltage = V*2^N$. The Mantissa and exponent in this equation will be read and reported using 3 bytes. The first byte is the VOUT_MODE byte which will always contain 000 in the 3 MSB's. The 5 LSB's are the exponent. The exponent N is fixed and equals -10. The other 2 bytes N will contain the Mantissa. In the above format N is a 5-bit two's complement binary integer and V is a 16-bit unsigned binary integer. All 16 bits are reported to be compatible with the Power Management Bus protocol.

For example, to set Vout to 12V by VOUT_COMMAND, the read/write data can be calculated refer to below process:
$V = Vout/2^{(-10)} = 12/2^{(-10)} \approx 12288$
Convert the decimal to hexadecimal format is 0x3000. So the VOUT_COMMAND is 0x3000.

SUPPORTED POWER MANAGEMENT BUS COMMANDS

The main Power Management Bus commands described in the Power Management Bus 1.3 specification are supported by the module. Partial Power Management Bus commands are fully supported; Partial Power Management Bus commands have difference with the definition in Power Management Bus 1.3 specification. All the supported Power Management Bus commands are detailed summarized in the below table.

COMMAND	CODE	COMMAND DESCRIPTION	TYPE	DATA FORMAT	DEFAULT VALUE	DATA UNITS	NOTE
OPERATION	0x01	Configures the operational state of the module	R/W byte	Bit field	0x80	/	1
ON_OFF_CONFIG	0x02	Configures the combination of CONTROL pin input and serial bus commands needed to turn the module on and off	Read byte	Bit field	0x1C	/	1,2
CLEAR_FAULTS	0x03	Clear any fault bits that have been set	Send byte	/	/	/	/
RESTORE_DEFAULT_ALL	0x12	Restore the factory settings to the non-volatile memory	Write	/	/	/	5
STORE_USER_ALL	0x15	Store the current settings to the non-volatile memory	Write	/	/	/	5
VOUT_MODE	0x20	Vo data format	Read byte	mode + exponent	0x16	/	/
VOUT_COMMAND	0x21	Set the output voltage normal value	R/W word	Vout linear	12/12.25	Volts	8
VOUT_MAX	0x24	Set an upper limit on the output voltage the module can command	Read word	Vout linear	12.6	Volts	/
VOUT_MARGIN_HIGH	0x25	Set the output voltage margin high value	Read word	Vout linear	12.5	Volts	/
VOUT_MARGIN_LOW	0x26	Set the output voltage margin low value	Read word	Vout linear	10	Volts	/
VOUT_MIN	0x2B	Set a lower limit on the output voltage the module can command	Read word	Vout linear	8	Volts	/
MAX_DUTY	0x32	Set the maximum duty cycle	Read word	Linear	50	%	/
FREQUNCY_SWITCH	0x33	Set the switching frequency	Read word	Linear	130	kHz	/
VOUT_OV_FAULT_LIMIT	0x40	Set the output over voltage fault threshold	R/W word	Vout linear	13.5	Volts	4
VOUT_OV_FAULT_RESPONSE	0x41	Instructs what action to take in response to an output overvoltage fault	R/W byte	Bit field	0x80	/	1
IOUT_OC_FAULT_LIMIT	0x46	Set the output overcurrent fault threshold	R/W word	Linear	65	A	3,4
IOUT_OC_FAULT_RESPONSE	0x47	Instructs what action to take in response to an output overcurrent fault	R/W byte	Bit field	0xF8	/	1
OT_FAULT_LIMIT	0x4F	Set the over temperature fault threshold	R/W word	Linear	135	Deg C	3,4
OT_FAULT_RESPONSE	0x50	Instructs what action to take in response to an over temperature fault	R/W byte	Bit field	0xB8	/	1
MFR_C1_C2_CONFIG	0x6C	Configure C2 pin function	R/W byte	Bit field	0x00	/	1
MFR_C2_CONFIG	0x6D	Configure C2 pin logic	R/W byte	Bit field	0x00	/	1
MFR_PGOOD_POLARITY	0x6E	Configure power good logic	R/W byte	Bit field	0x00	/	1
STATUS_WORD	0x79	Returns the information with a summary of the unit's fault condition	Read word	Bit field	0	/	1,6
STATUS_VOUT	0x7A	Returns the information with a summary of the unit's output voltage condition	Read byte	Bit field	0	/	1,6
STATUS_IOUT	0x7B	Returns the information with a summary of the unit's output current condition	Read byte	Bit field	0	/	1,6
STATUS_TEMPERATURE	0x7D	Returns the information with a summary of the unit's temperature condition	Read byte	Bit field	0	/	1,6
STATUS_CML	0x7E	Returns the information with a summary of the unit's communication condition	Read byte	Bit field	0	/	1,6
READ_VIN	0x88	Returns the input voltage of the module	Read word	Linear	/	Volts	/
READ_VOUT	0x8B	Returns the output voltage of the module	Read word	Vout Linear	/	Volts	/
READ_IOUT	0x8C	Returns the output current of the module	Read word	Linear	/	A	/

COMMAND	CODE	COMMAND DESCRIPTION	TYPE	DATA FORMAT	DEFAULT VALUE	DATA UNITS	NOTE
READ_TEMPERATURE_1	0x8D	Returns the temperature of the module	Read word	Linear	/	Deg C	/
POWER MANAGEMENT BUS_REVISION	0x98	Reads the revision of the Power Management Bus	Read byte	Bit field	0x33	/	1
MFR_ID	0x99	Reads the ID of the manufacture	Read block	ASCII	BELF	/	/
FIRMWARE_REV	0x9B	Reads the revision of the firmware	Read block	ASCII	/	/	7

NOTES:

1. Refer to below detailed description
2. OPERATION command controls module on/off
3. Before write operation, it is necessary to read the register data and parse out the corresponding linear format N value, then convert write value based on N
4. In order to ensure that the product works properly, the adjustment range of the protection limit value is limited, when the set value exceeds the upper or lower limits, the lower limit value is automatically set. The following table shows the upper and lower limits

COMMAND	CODE	THE LOW LIMIT	THE UPPER LIMIT
VOUT_OV_FAULT_LIMIT	0x40	13.2	14
IOUT_OC_FAULT_LIMIT	0x46	43	70
OT_FAULT_LIMIT	0x4F	120	140

5. Read or write this command, PSU will shut down until next vin power cycle
6. ALL the fault bits set in all the status registers remain set, even if the fault condition is removed or corrected, until one of the following occur:
   1) A remote off then remote on cycle;
   2) The device receives a CLEAR_FAULTS command;
   3) Vin power is removed from the module.
7. Two byte count command, value varies according to software version
8. No-load condition, default value is 12(without droop),12.25(with droop)

OPERATION (0x01)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7	Turn the module on/off	1 0	On Off	1
6	Reserved	/	/	0
5:4	Control the source of the output voltage command	00 01 10 11	VOUT_COMMAND VOUT_MARGIN_LOW VOUT_MARGIN_HIGH /	00
3:0	Reserved	/	/	0000

ON_OFF_CONFIG (0x02)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7:5	Reserved	/	/	000
4	Module powers up regardless of the state of the CONTROL pin and OPERATION command or not	0 1	/ Wait CONTROL and OPERATION	1
3	Module powers up regardless of the state of the OPERATION command or not	0 1	/ Wait OPERATION command	1
2	Module powers up regardless of the state of the CONTROL pin or not (Not supported)	0 1	/ Wait CONTROL pin	1
1:0	Reserved	/	/	00

VOUT_OV_FAULT_RESPONSE (0x41)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7:6	Response when fault happens	00-01 10 11	/ The module shuts down and response according to the retry setting in bits [5:3] /	10
5:3	Retry setting	000 001-110 111	Module does not attempt to restart until a RESET signal or OPERATION command, or Bias power is removed / Attempts to restart continuously until it is commanded off	000
2:0	Reserved	/	/	000

IOUT_OC_FAULT_RESPONSE (0x47)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7:6	Response when fault happens	00-10 11	/ The module shuts down and response according to the retry setting in bits [5:3]	11
5:3	Retry setting	000 001-110 111	Module does not attempt to restart until a RESET signal or OPERATION command, or Bias power is removed / Attempts to restart continuously until it is commanded off	111
2:0	Reserved	/	/	000

OT_FAULT_RESPONSE (0x50)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7:6	Response when fault happens	00-01 10 11	/ The module shuts down and response according to the retry setting in bits [5:3] /	10
5:3	Retry setting	000 001-110 111	Module does not attempt to restart until a RESET signal or OPERATION command, or Bias power is removed / Attempts to restart continuously until it is commanded off	111
2:0	Reserved	/	/	000

MFR_C1_C2_CONFIG (0x6C)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7:2	Reserved	/	/	000000
1	Pin configuration	0 1	C2 pin: POWER_GOOD C2 pin: ON/OFF (Secondary)	0
0	Reserved	/	/	0

MFR_C2_CONFIG (0x6D)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7:2	Reserved	/	/	000000
1	ON/OFF Configuration	1 0	And- Primary and secondary side on/off C2 pin signal is ignored	0
0	Secondary Side ON/OFF logic	1 0	Positive Logic (High level enable: input > 2.64V) Negative Logic (Low level enable: input < 0.66V)	0

MFR_PGOOG_POLARITY (0x6E)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7:1	Reserved	/	/	0000000
0	Power Good Logic	1	Positive PGOOD logic	0
		0	Negative PGOOD logic	

STATUS_WORD (0x79)				
HIGH BYTE				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7	VOUT	1	An output voltage fault has occurred	0
		0	Not occurred	
6	IOUT/POUT	1	An output current or output power fault has occurred	0
		0	Not occurred	
5	INPUT (Not supported)	1	An input overvoltage fault has occurred	0
		0	Not occurred	
4	Reserved	/	/	0
3	Power_Good	1	Power_Good signal is negated	0
		0	Power_Good signal is ok	
2:1	Reserved	/	/	00
0	UNKNOWN	1	A fault type not given in bits [15:1] of the SATUS_WORD has been detected	0
		0	Not occurred	
LOW BYTE				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7	Busy	1	A fault was declared because the device was busy and unable to respond	0
		0	Not occurred	
6	Off	1	This bit is asserted if the unit is not providing power to the output, regardless of the reason, including simply not being enabled	0
		0	Not occurred	
5	VOUT_OV_FAULT	1	An output overvoltage fault has occurred	0
		0	Not occurred	
4	IOUT_OC_FAULT	1	An output overcurrent fault has occurred	0
		0	Not occurred	
3	VIN_UV_FAULT (Not supported)	1	An input under voltage fault has occurred	0
		0	Not occurred	
2	TEMPERATURE	1	A temperature fault has occurred	0
		0	Not occurred	
1	CML	1	A communication, memory or logic fault has occurred	0
		0	Not occurred	
0	NONE_OF_THE_ABOVE	1	A fault or warning not listed in bits [7:1] of this byte has occurred	0
		0	Not occurred	

STATUS_VOUT (0x7A)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7	VOUT_OV_FAULT	1 0	Occurred Not occurred	0
6:5	Reserved	/	/	00
4	VOUT_UV_FAULT	1 0	Occurred Not occurred	0
3:0	Reserved	/	/	0000

STATUS_IOUT (0x7B)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7	IOUT_OC_FAULT	1 0	Occurred Not occurred	0
6:0	Reserved	/	/	0000000

STATUS_TEMPERATURE (0x7D)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7	OT_FAULT	1 0	Occurred Not occurred	0
6:0	Reserved	/	/	0000000

STATUS_CML (0x7E)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7	Invalid or unsupported command received	1 0	Occurred Not occurred	0
6	Invalid or unsupported data received	1 0	Occurred Not occurred	0
5:0	Reserved	/	/	000000

POWER MANAGEMENT BUS_REVISION (0x98)				
Bit number	**Purpose**	**Bit value**	**Meaning**	**Default settings**
7:4	Indicate the revision of Power Management Bus Specification Part I to which the device is compliant	0000 0001 0010 0011	1.0 1.1 1.2 1.3	1.3
3:0	Indicate the revision of Power Management Bus Specification Part II to which the device is compliant	0000 0001 0010 0011	1.0 1.1 1.2 1.3	1.3

19. MECHANICAL DIMENSIONS

OUTLINE

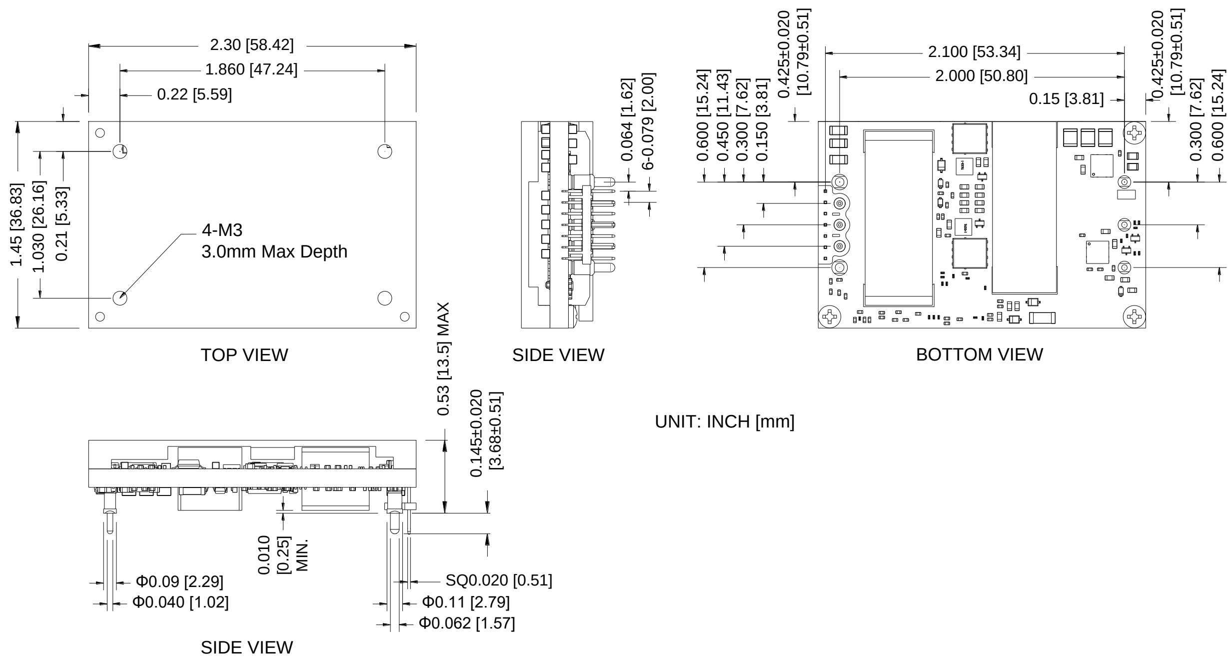


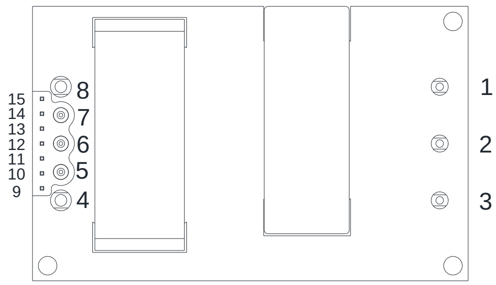
Figure 37. Outline

NOTE: This module is recommended and compatible with Pb-Free Wave Soldering and must be soldered using a peak solder temperature of no more than 260 °C for less than 5 seconds.

NOTES:

1) All Pins: Material - Copper Alloy;
   Finish – PIN 1/2/3/4/8 tin plated. Others gold plated.
2) Un-dimensioned components are shown for visual reference only.
3) All dimensions in inch [mm]; Tolerances: x.xx +/-0.02 inch [0.51 mm]. x.xxx +/-0.010 inch [0.25 mm]. Unless otherwise stated.

PIN DEFINITIONS

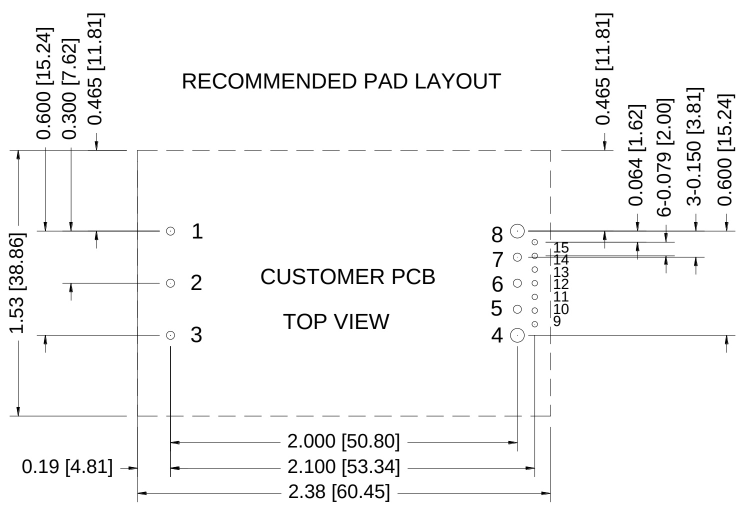


BOTTOM VIEW

Figure 38. Pins

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

RECOMMENDED PAD LAYOUT



1,2,3,5,6,7 Φ0.065 HOLE SIZE, Φ0.110 min PAD SIZE
4,8 Φ0.085 HOLE SIZE, Φ0.130 min PAD SIZE
9,10,11,12,13,14,15 Φ0.035 HOLE SIZE, Φ0.065 min PAD SIZE

Figure 39. Recommended pad layout

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+86 755 298 85888

Europe, Middle East
+353 61 225 977

North America
+1 408 785 5200

20. REVISION HISTORY

DATE	REVISION	CHANGES DETAIL	APPROVAL
2017-06-05	AA	First release	S. Wang
2017-08-31	AB	Add droop	S. Wang
2017-09-07	AC	Update THERMAL DERATING CURVE and EFFICIENCY DATA	S.Wang
2017-10-25	AD	Update THERMAL DERATING CURVE and Input reflected ripple current	S.Wang
2018-06-20	AE	Update Output Trim Equations	S.Wang
2018-07-09	AF	Update Non-Isolated to Isolated in the Key Features & Benefits	S. Wang
2019-09-05	AG	Update power management bus information	S. Wang
2020-06-15	AH	Update mechanical pins, efficiency, weight, altitude and thermal derating curves. Add safety&EMC.	H.Yu
2020-08-11	AI	Add module photo and safety certification. Update power management bus information, efficiency and waveforms.	H.Yu
2020-09-09	AJ	Add output current share.	H.Yu
2020-10-10	AK	Update module photo.	H.Yu
2021-05-24	AL	Add object ID. Update power management bus information. Update thermal test setup drawing by correcting the height.	XF.Jiang

For more information on these products consult: tech.support@psbel.com

NUCLEAR AND MEDICAL APPLICATIONS - Products are not designed or intended for use as critical components in life support systems, equipment used in hazardous environments, or nuclear control systems.
TECHNICAL REVISIONS - The appearance of products, including safety agency certifications pictured on labels, may change depending on the date manufactured. Specifications are subject to change without notice.