FG5SR54022NRFA

1200W DC/DC Power Modules

Delphi Series FG5SR54022NRFA, full Brick Family DC/DC Power Modules: 480~800V in, 54V/22A out, 1200W

The Delphi Module FG5SR54022NRFA, full brick, 480~800V input, single output, isolated DC/DC converter is the latest offering from a world leader in power system and technology and manufacturing — Delta Electronics, Inc. This product provides up to 1200 watts power in an industry standard footprint and pin out. 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.

FEATURES

- High efficiency : 96.4% @ 600Vin full load
- Size:116.8mm*61.0mm*12.7mm(4.6'' *2.4'' *0.5'')
- Industry standard pin out and footprint
- Fixed frequency operation
- Input UVLO
- Input OVP
- Hiccup output over current protection (OCP)
- Latch output over voltage protection (OVP)
- Output current limited protection(OCL)
- Auto recovery OTP
- Negative enable (Positive enable optional)
- Trim: up +5%, down -15%
- Active current sharing
- Remote sense
- Sync start
- Monotonic startup into normal
- 4242V isolation and reinforce insulation
- No minimum load required
- ISO 9001, TL 9000, ISO 14001, QS9000, OHSAS18001 certified manufacturing facility
- EN61373 pending，EN50155 pending.
- EN60950-1 pending

APPLICATIONS

- HVDC Datacenter
- Testing Equipment
- Electrical Vehicle
- Railway /Transportation System

TECHNICAL SPECIFICATIONS

PARAMETER	NOTES and CONDITIONS	FG5SR54022NRFA			
		Min.	Typ.	Max.	Units
1. ABSOLUTE MAXIMUM RATINGS					
1.1 Input Voltage		0	600	800	Vdc
1.2 Input surge withstand	<100ms			850	Vdc
1.3 Operating Baseplate Temperature		-40		100	°C
1.4 Storage Temperature		-55		125	°C
1.5 Input/Output Isolation Voltage	reinforce			4242	Vdc
2. INPUT CHARACTERISTICS					
2.1 Operating Input Voltage		480	600	800	Vdc
2.2 Input Under-Voltage Lockout					
2.2.1 Turn-On Voltage Threshold		460	470	480	Vdc
2.2.2 Turn-Off Voltage Threshold		450	460	470	Vdc
2.3 Input Over-Voltage Lockout					
2.3.1 Turn-On Voltage Threshold		780	790	800	Vdc
2.3.2 Turn-Off Voltage Threshold		810	820	830	Vdc
2.4 Maximum Input Current	Vin=480V ,Io=100% Load	2.56	2.58	2.60	A
2.5 No-Load Input Current	Vin=600V, Io=0A	20.0	24.8	29.6	mA
2.6 Off Converter Input Current	Vin=600V	2.50	2.75	3.00	mA
2.7 Input Reflected-Ripple Current（pk-pk）	Vin=600V, Io=100% Load ,Cin=200uF/900V Refer to Figure 9			1000	mA
2.8 Inrush Current (I2t)					A2S
2.9 Input Voltage Ripple Rejection	120Hz				dB
3. OUTPUT CHARACTERISTICS					
3.1 Output Voltage Set Point	Vin=600V, Io=0A, Tc=25°C	53.2	54	54.8	Vdc
3.1.1 Load regulation	Vin=600V, Io=0 to100% Load	--100		+100	mV
3.1.2 Line regulation	Vin=480V to 800V, Io=0A	-100		+100	mV
3.1.3 Temperature regulation	Vin=600V, Tc= min to max case temperature	−140		+140	mV
3.2 Output Voltage Ripple and Noise	5Hz to 20MHz bandwidth, Refer to Figure 11				
3.2.1 Peak-to-Peak	Vin=600V , Io=100% Load		300	360	mV
3.2.2 rms	Vin=600V , Io=100% Load		78	96	mV
3.3 Operating Output Current Range	Vin=480V to 800V		22		A
3.4 Output Current Limitation	Vin=480V to 800V	24	27	30	A
3.5 Output Over Current Protection	Vo=54V,Vo<10%Vo.set,Io step=0.1A/mS	29	32	35	
4.DYNAMIC CHARACTERISTICS					
4.1 Output Voltage Current Transient	Vin=600V, Io slew rate 0.1A/uS.				
4.1.1 Positive Step Change in Output Current	50% to 75% Load	-2000	-1500		mV
4.1.2 Negative Step Change in Output Current	75% to 50% Load		1500	2000	mV
4.2 Turn-On Transient					
4.2.1 Start-Up Time, From On/Off Control	Vin=480V to 800V	80	100	120	ms
4.2.2 Start-Up Time, From Input	Vin=480V to 800V	80	100	120	ms
4.2.3 Rise time(Vout from 10% to 90%)	Vin=480V to 800V	65	75	85	ms
4.3 Maximum output capacitor	Vout nominal at full load (resistive load)		5000		
5. EFFICIENCY					
5.1 100% Load	Vin=600V	96.0	96.5	97.5	%
5.2 60% Load	Vin=600V	95.7	96.2	96.7	%
6.ISOLATION CHARACTERISTICS					
6.1 Input to Output			4242		Vdc
6.2 Input to Case			2121		Vdc
6.3 Output to Case			500		Vdc
6.4 Isolation Resistance			10		MΩ
7. FEATURE CHARACTERISTICS					
7.1 Switching Frequency			100		kHz
7.2 ON/OFF Control, Negative Remote On/Off logic					
7.2.1 Logic High (Module Off)		3.5		5	V
7.2.2 Logic Low (Module On)		0		1.5	V
7.3 Output Voltage Trim Range		-15		+5	%
7.4 Output Over-Voltage Protection	Over full temp range; % of nominal Vout	108	112	116	%
8. PMBUS SIGNAL INTERFACE CHARACTERISTICS					
8.1 Input High Voltage (CLK,DATA)		2.1		3.3	Vdc
8.2 Input Low Voltage (CLK,DATA)		0		0.8	Vdc
8.3 Input High Level Current (CLK,DATA)		-10		10	uA
8.4 Input Low Level Current (CLK,DATA)		-10		10	uA
8.5 PMBUS Operating Frequency Range			100or 400		Khz
9. GENERAL SPECIFICATIONS					
9.1 Weight		240	250	260	grams
Over-Temperature Shutdown	Refer to Figure 22 for Hot spot location (600Vin,80% Io, natural convection)				°C
Over-Temperature Shutdown （NTC resistor）	Refer to Figure 22 for Hot spot location (600Vin,80% Io, natural convection)		125		°C
Note: Please attach thermocouple on NTC resistor to test OTP function, the hot spots' temperature is just for reference.					

ELECTRICAL CHARACTERISTICS CURVES

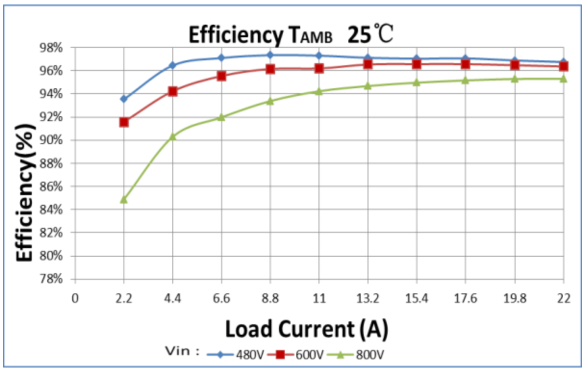


__Figure 1:__ Efficiency vs. load current for 480，600 and 800 input voltage at 25°C.

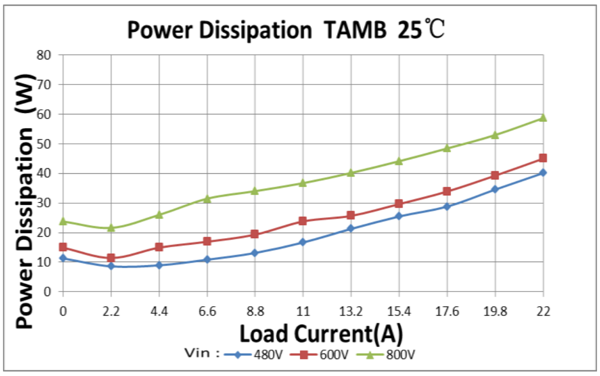


__Figure 2__: Power dissipation vs. load current for 480，600 and 800 input voltage at 25°C.

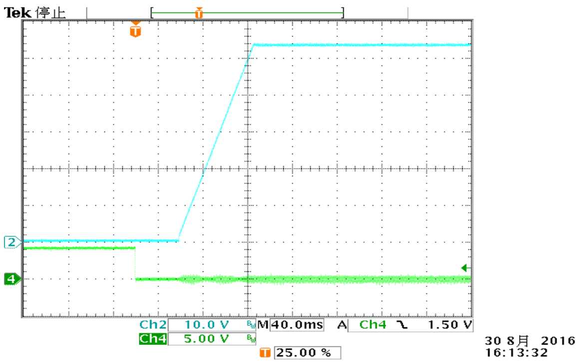


__Figure 3:__ Turn-on transient at zero load current) (40ms/div).
Top Trace: Vout: 10V/div; Bottom Trace: ON/OFF input: 5V/div.

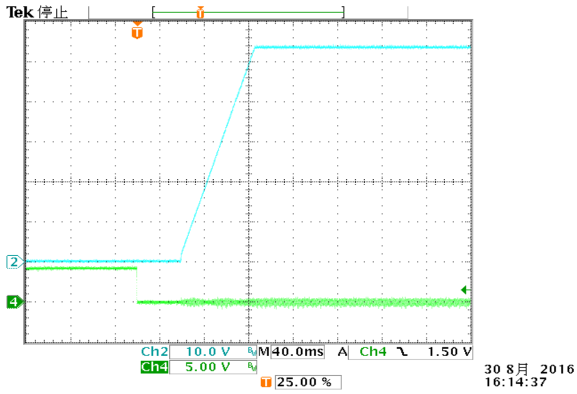


__Figure 4:__ Turn-on transient at full load current (40ms/div).
Top Trace: Vout: 10V/div; Bottom Trace: ON/OFF input: 5V/div.

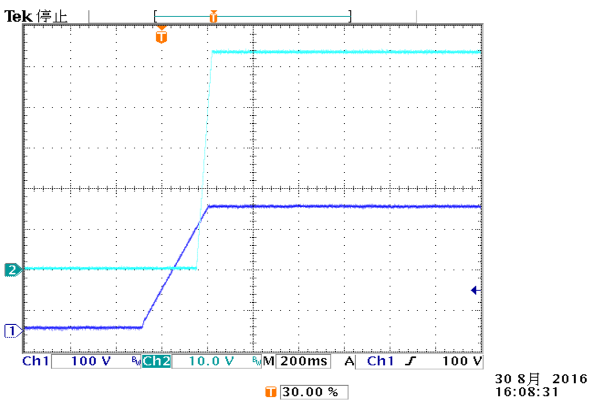


__Figure 5:__ Turn-on transient at zero load current (200ms/div).
Top Trace: Vout; 10V/div;
Bottom Trace: input voltage: 100V/div.

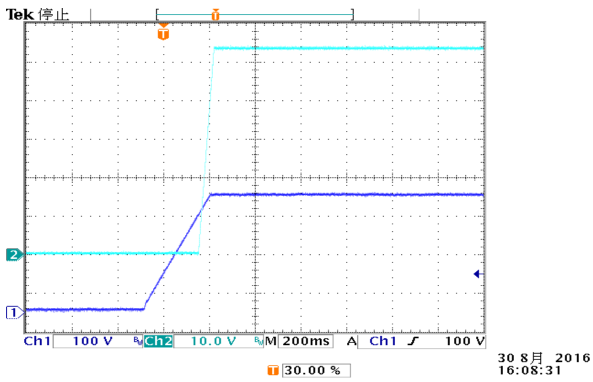
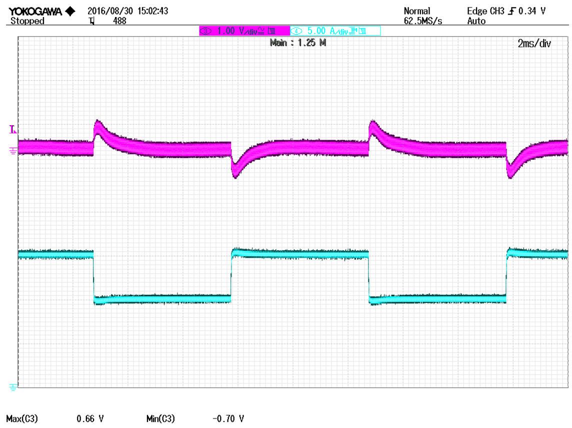


__Figure 6__: Turn-on transient at full load current (200ms/div).
Top Trace: Vout; 10V/div;
Bottom Trace: input voltage: 100V/div

ELECTRICAL CHARACTERISTICS CURVES

Figure 7: *Output voltage response to step-change in load current (50%-75%-50% of full load; di/dt = 0.1A/µs).*
Top Trace: Vout , AC 1000mV/div; Time: 2ms/div
Bottom Trace: Iout , 5A/div; Time: 2ms/div



igure 8: *Output voltage response to step-change in load current (50%-75%-50% of full load; di/dt = 2.5A/µs).*
Top Trace: Vout , AC 1000mV/div; Time: 2ms/div
Bottom Trace: Iout , 5A/div; Time: 2ms/div
Output connected 3300uF capacitor

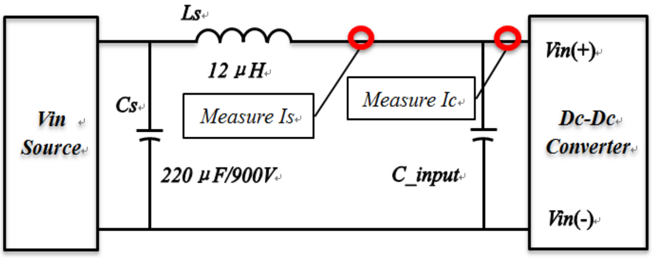


Figure 9: *Test set-up diagram showing measurement points for Input Terminal Ripple Current (Is)and Input Reflected Ripple Current(Ic).*
Note: Measured input reflected-ripple current with a simulated source Inductance (Ls) of 12 µH.
Capacitor :C_input = 200uF/900V

Figure 10*: Input Reflected Ripple Current, ic, at full rated output current and 600V input voltage with 12µH source impedance and 200µF electrolytic capacitor (500mA/div，2us/div).*

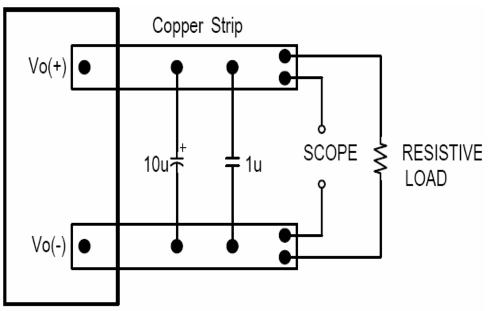


Figure 11: *Output voltage noise and ripple measurement test setup*

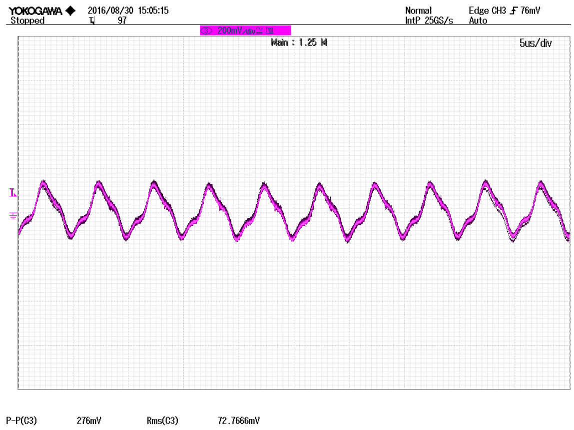


Figure 12: *Output voltage ripple at nominal input voltage and max load current (200 mV/div, 5us/div) Bandwidth: 20 MHz.*

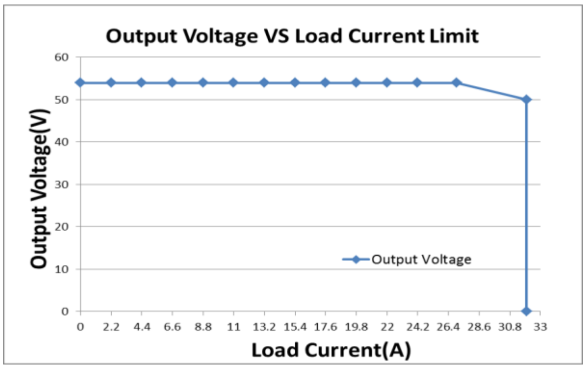


Figure 13: *Output voltage vs. load current showing typical current limit curves and converter shutdown points (Resistive Load).*

DESIGN CONSIDERATIONS

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 200μF electrolytic capacitor (ESR < 0.7 Ω 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. Below is the reference design for an input filter tested with FG5SR54022NRFA to meet class B in EN55022(CISPR 22).

Schematic and Components List

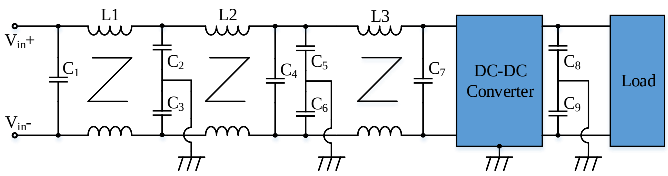


Figure14: EMI test schematic

Test Result:
At T = +25°C , Vin = 600V and full load
blue line is peak mode;

TBD

Figure 15: EMI test positive line

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., UL60950-1,2nd Edition +A2(2014),CAN/CSA C22.2 NO. 60950-1-07+A2(2014) and IEC 60950-1 2005 +A1+A2 and EN 60950-1 2006+A11+A1+A12+A2: if the system in which the power module is to be used must meet safety agency requirements.
Reinforce insulation based on 4242 Vdc input is provided between the input and output of the module for the purpose of applying insulation requirements when the input to this DC-to-DC converter is identified as TNV-2 or SELV. An additional evaluation is needed if the source is other than TNV-2 or SELV..

When the input source is SELV circuit, the power module meets SELV (safety extra-low voltage) requirements. If the input source is a hazardous voltage which is greater than 800 Vdc and less than or equal to 850 Vdc, for the module's output to meet SELV requirements, all of the following must be met:

- The input source must be insulated from the ac mains by reinforced or double insulation.
- The input terminals of the module are not operator accessible.
- A SELV reliability test is conducted on the system where the module is used, in combination with the module, to ensure that under a single fault, hazardous voltage does not appear at the module's output.

Designator	Quantity	Value	Part Number	Manufacturer	Description
C1, C4, C7	3	2uF			
C2, C3, C5, C6	4	4700pF			
C8, C9	2	4700pF * 2			
L1	1	47uH			
L2	1	5.4mH			
L3	1	4.0mH			

Table 1 : **Bill of materials of EMC filter**

When installed into a Class II equipment (without grounding), spacing consideration should be given to the end-use installation, as the spacing between the module and mounting surface have not been evaluated.

The power module has extra-low voltage (ELV) outputs when all inputs are ELV.

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 5A 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.

FEATURES DESCRIPTIONS

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 will try to restart after shutdown(hiccup mode). If the overload condition still exists, the module will shut down again. This restart trial will continue until the overload condition is corrected.

Over-Voltage Protection

The modules include an internal output over-voltage protection circuit, which monitors the voltage on the output terminals. If this voltage exceeds the over-voltage set point, the protection circuit will constrain the max duty cycle to limit the output voltage, if the output voltage continuously increases the modules will shut down, and latched up (latch mode). Operator need to power on again to turn on the module.

Over-Temperature Protection

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

Remote On/Off

The remote on/off feature on the module can be 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.

Remote on/off can be controlled by an external switch between the on/off terminal and the Vi (-) 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 Vi (-). For positive logic if the remote on/off feature is not used, please leave the on/off pin to floating.

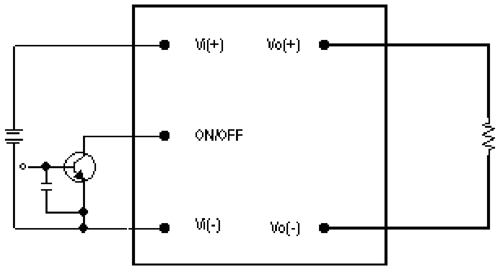


Figure 16: *Remote on/off implementation*

Remote sense compensates for voltage drops on the output by sensing the actual output voltage at the point of load. The voltage between the remotesense pins and the output terminals must not exceed the output voltage sense range given

[Vo(+) –Vo(–)] –[SENSE(+) –SENSE(–)] ≤ 10% x Vout

This limit includes any increase in voltage due to remotesense compensation and output voltage set point adjustment (trim).

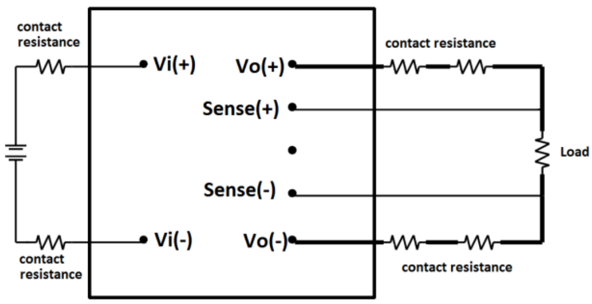


Figure 17: *Effective circuit configuration for remote sense operation*

If the remotesense feature is not used to regulate the output at the point of load, please connect SENSE(+) to Vo(+) and SENSE(–) to Vo(–) at the module

Output Voltage Adjustment (TRIM)

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

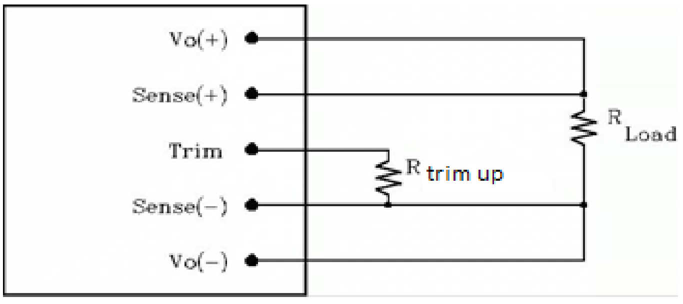


Figure 18: *Circuit configuration for trim-up (increase output voltage)*

If the external resistor is connected between the TRIM and SENSE (-) pins, the output voltage set point decreases (Fig. 18). The external resistor value required to obtain a percentage of output voltage change △% is defined as:

Ex. When Trim-up +10%(54V×1.05=56.7V)

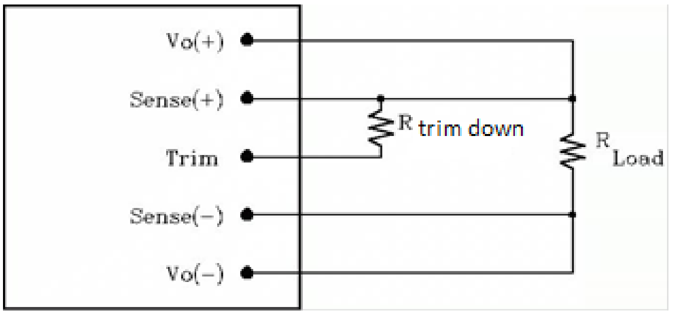


Figure 19: *Circuit configuration for trim-down (decrease output voltage)*

If the external resistor is connected between the TRIM and SENSE (+) the output voltage set point increases (Fig. 19). The external resistor value requiredto obtain a percentage output voltage change △% is defined as:

Ex. When Trim-up -20%(54V×0.85=45.9V)

The output voltage can be increased by both the remote sense and the trim, however the maximum increase is the larger of either the remote sense or the trim, not the sum of both.

When using remote sense and trim, the output voltage of the module is usually increased, which increase the output power of the module with the same output current.

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

Parallel and Active Current Sharing

The modules are capable of operating in parallel, and realizing current sharing by auto master current sharing method. The current sharing pin of parallel module are connected together to create a current sharing bus.

If system has no redundancy requirement, the module can be parallel directly for higher power without adding external oring-fet;
The current sharing accuracy equation is:
X% = | Io – (Itotal / N) | / Irated, Where,
Io is the output current of per module;
Itotal is the total load current;
N is parallel module numbers;
Irated is the rated full load current of per module.

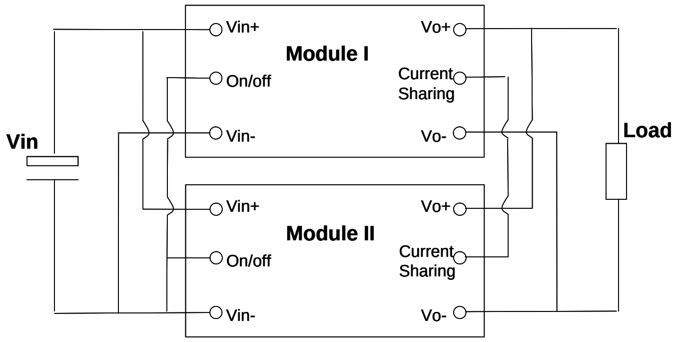


Figure 20: *Parallel and average current sharing configuration for no redundancy requirement system*

In order to keep the good stability of the parallel system, below 2 items layout guideline should be followed:

1. The trace connected the current sharing pin of Module I and Module II should be as short as possible.
2. The layout loop from Module I current sharing pin to Module II current sharing pin, to Module II Vo- pin, and come back to Module I Vo- pin should be as small as possible.

The pin was difine as follow in figure 25 ,we will explain the pin function:

Pin function

VIN+, VIN- .DC voltage inputs.

ON/OFF . The ON/OFF pin on a driver module may be used as a logic enable/disable input.When ON/OFF is pull low (<1.5V,referenced to –Vin),the module is turned on .when ON/OFF is floating (open collector) ,the module is turned off.The open circuit voltage of ON/OFF PIN is less than 5V.

VOUT+, VOUT- .DC voltage outputs.

TRIM. Provides fixed or variable adjustment of the module output.

CS/SS(Current Sharing/SYNC-Start).Provides for parallel operation. Customer can connect the modules together to get more output power. And connected all the CS/SYNC pin together to get current sharing.

Sense+, Sense-. Provides for locating the point of optimal voltage regulation external to the converter.

THERMAL CONSIDERATIONS

The thermal curve is based on the test setup shown as Figure 21. The module is mounted on an Al plate and was cooled by cooling liquid.

Figure 22 shows the location to monitor the temperature of the module's baseplate. The baseplate temperature in thermal curve is a reference for customer to make thermal evaluation and make sure the module is operated under allowable temperature. (Thermal curves shown in Figure 23 are based on different input voltage).

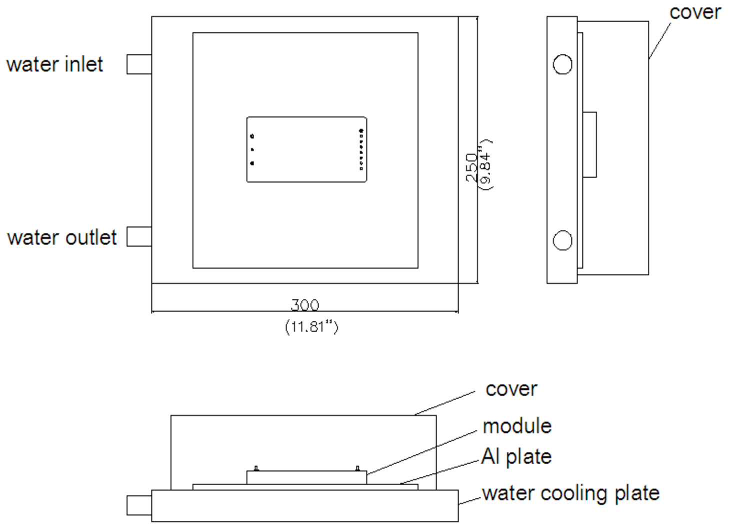


Figure 21: *Test setup*

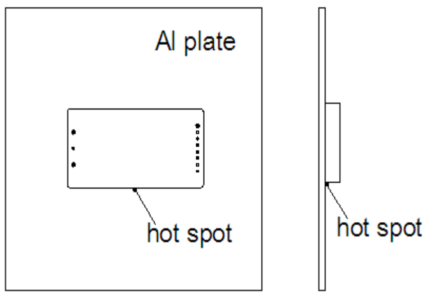


Figure 22: *Baseplate temperature measured point*

THERMAL DERATING CURVES

TBD

Figure 23: *Output Power vs Baseplate temperature @Vin=480V～800V*

DELTA

DIGITAL FEATURE DESCRIPTIONS

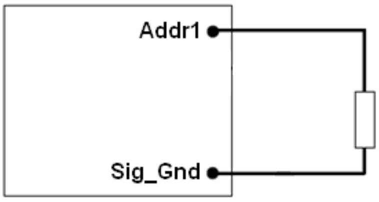
The module has a digital PMBus interface to allow the module to be monitored, controlled and configured by the system. The module supports 3 PMBus signal lines, Data, Clock, and 1 Address line Addr.More detail PMBus information can be found in the PMBus Power Management Protocol Specification, Part I 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.

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 Addr1 pin to GND pin, 14 possible addresses can be acquired.



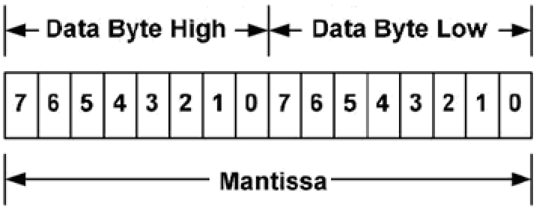
Different PMBUS address is defined by the value of the resistor as below, and +/-1% resistors accuracy can be accepted. If there is any resistance exceeding the requested range, address 127 will be return.

PMBUS address	Resistor (Kohm)
96	10
97	15
98	21
99	28
100	35.7
101	45.3
102	56.2
103	69.8
104	88.7
105	107
106	130
107	158
108	191
109	232

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 -9. The format of the two data bytes is shown below:



The equation can be written as:

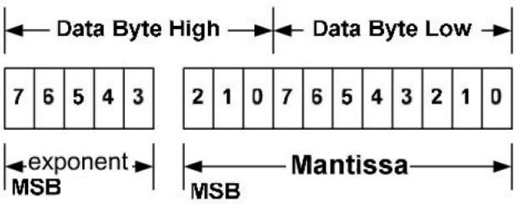
Vout = Mantissa x $2^{(-9)}$

For example, considering set Vout to 54V by VOUT_COMMAND, the read/write data can be calculated refer to below process:

Mantissa =Vout/$2^{(-9)}$= 54/$2^{(-9)}$=27648;

Converter the calculated Mantissa to hexadecimal 0x6C00.

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:
Value = Mantissa x $2^{(exponent)}$
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 Vin, -3; whose binary is 11101
Mantissa =Vin/$2^{(-3)}$=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.

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	Command Code	Command description	Transf -er type	Compatible with standard PMBUS or not?	Data Format	Default value	Range limit	Data units	Expon -ent	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	Yes	Bit field	0x1F	/	/	/	0x1D (Neg Logic); 0x1F (Pos Logic);
CLEAR_FAULTS	0x03	Clear any fault bits that have been set	Send byte	Yes	/	/	/	/	/	/
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	0x17	/	/	/	/
VOUT_COMMAND	0x21	Set the output voltage normal value	R/W word	Yes	Vout Linear	54	45.9 ~56.7	Volts	-9	/
FREQUENCY_SWITCH	0x33	Set the switching frequency	R/W word	Yes	Frequency linear	100	90 ~ 110	KHz	-2	Write command need module off condition

Command	Command Code	Command description	Transf-er type	Compatible with standard PMBUS or not?	Data Format	Default value	Range limit	Data units	Expon-ent	Note
VIN_ON	0x35	Set the turn on voltage threshold of Vin under voltage lockout	R/W word	Yes	Vin Linear	470	470~480	V	-1	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	460	460~470	V	-1	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	60	60~ 62	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	58	58~ 62	V	-9	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	32	28~ 32	A	-4	Must be greater than IOUT_OC_WARN_LIMIT value
IOUT_OC_WARN_LIMIT	0x4A	Set a threshold causing an output current high warning.	R/W word	Yes	Iout Linear	30	26~ 32	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	110~ 135	Deg.C	-2	Must be greater than OT_WARN_LIMIT value

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	100~130.	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	820	810~830	V	-1	/
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	20~100	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	75	75~500	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_VOUT	0x7A	Returns the information of the module's output voltage related fault/warning	Read byte	Refer to below description;	Bit field	/	/	/	/	/
STATUS_IOUT	0x7B	Returns the information of the module's output current related fault/warning	Read 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	Read byte	Refer to below description;	Bit field	/	/	/	/	/
STATUS_TEMPERATURE	0x7D	Returns the information of the module's temperature related fault/warning	Read byte	Refer to below description;	Bit field	/	/	/	/	/
STATUS_CML	0x7E	Returns the information of the module's communication related faults.	Read byte	Refer to below description;	Bit field	/	/	/	/	/
READ_VIN	0x88	Returns the input voltage of the module	Read word	Yes	Vin Linear	/	/	V	-1	/
READ_VOUT	0x8B	Returns the output voltage of the module	Read word	Yes	Vout Linear	/	/	V	-9	/
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	0x22	/	/	/	/
PMBUS_CMD_FLASHKEY_WRITE	0xEC	Write the key to unlock theFlash before Storing operating parameters from RAM to data flash	R/W	No	/	0xA5A5A5A5		/	/	A data Block: 7E,15,DC,42 Should be send to unlock the FLASH

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]

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		

LEAD FREE (SAC) PROCESS RECOMMEND TEMP. PROFILE

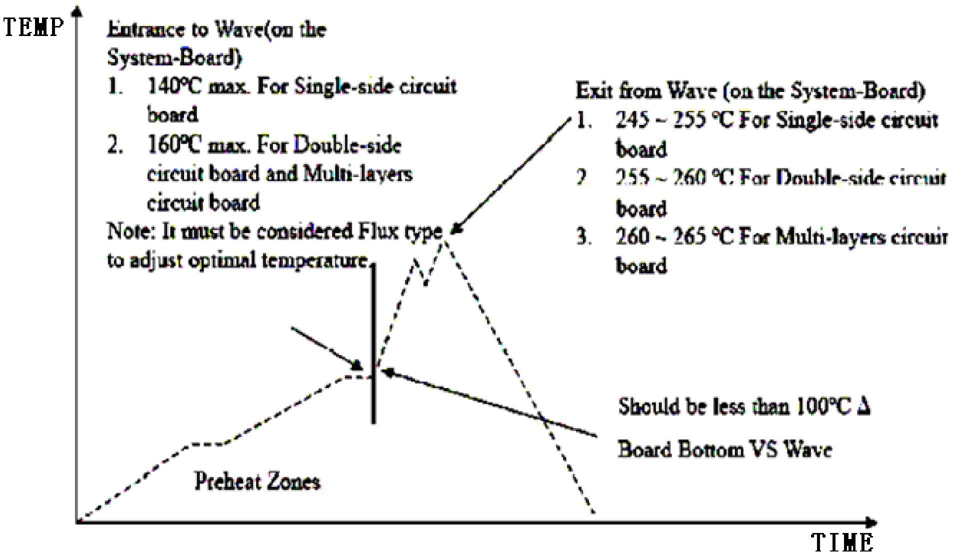
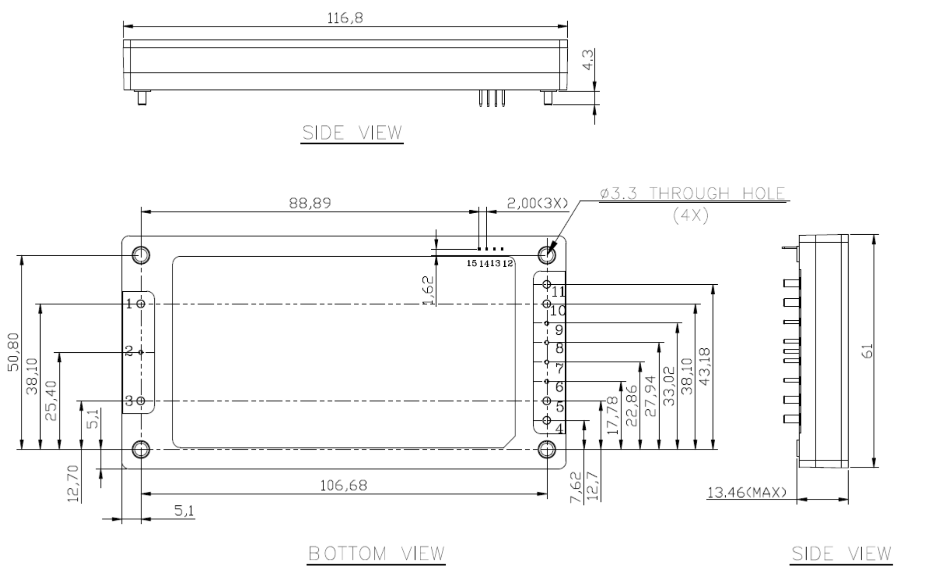


Figure 24 : recommended temperature profile for lead-free wave soldering

MECHANICAL DRAWING(BASEPLATE)



PIN#	FUNCTION
1	Vin−
2	ON/OFF
3	Vin+
4	Vout+
5	
6	Sense+
7	Trim
8	CS/SS
9	Sense−
10	Vout−
11	
12	GND
13	DATA
14	CLK
15	ADD

DIMENSIONAL TOLERANCE
X : ±0.5mm
X.X : ±0.25mm
X.XX : ±0.15mm

Figure 25 :the pin function and mechanical drawing

PART NUMBERING SYSTEM

F	G5	S	R	540	22	N	R	F	A
Form Factor	Input Voltage	Number of Outputs	Product Series	Output Voltage	Output Current	ON/OFF Logic	Pin Length		Option Code
F - Full Brick	G5 - 750V	S - Single	R - Family	540 - 54V	22 - 22A	N - Negative P - Positive	R - 0.170"	F - RoHS 6/6 (Lead Free) Space - RoHS5/6	A - Baseplate

MODEL LIST

MODEL NAME	INPUT		OUTPUT		EFF @ 100% LOAD
FG5SR54022NRFA	480V~800V	2.58A	54V	22A	96.4%

Default remote on/off logic is negative and pin length is 0.170"
For different remote on/off logic and pin length, please refer to part numbering system above or contact your local sales office.
For modules with through-hole pins and the optional heatspreader, they are intended for wave soldering assembly onto system boards; please do not subject such modules through reflow temperature profile.