CAR2512TE Front-End

Input: 90V_{AC} to 264V_{AC}; Output: 12V_{DC}@ 2500W; 3.3/5V_{DC} standby @ 15W

Applications

- 12Vdc distributed power architectures
- Datacom and Telecom applications
- Mid to high-end Servers
- Routers/Switches
- Broadband Switches
- ATE Equipment

Features

- Efficiency meets 80plus 'Platinum' requirements
- Universal input with PFC
- Constant power characteristic
- 2 front panel LEDs: 1-input;2-[DC_OK, fault, warning]
- Remote ON/OFF control of the 12Vdc output
- Remote sense on the 12Vdc output
- No minimum load requirements
- Active load sharing (single wire)
- Hot Plug-ability
- Standby orderable either as 3.3Vdc or 5Vdc
- Auto recoverable OC & OT protection
- Operating temperature: -10 - 70°C (de-rated above 50°C)
- Digital status & control: I²C and PMBus serial bus
- EN/IEC/UL60950-1 2nd edition; UL, CSA, VDE , and CCC
- EMI: class A FCC docket 20780 part 15, EN55022
- Meets EN61000 immunity and transient standards
- Shock & vibration: Meets IPC 9592 Class II standards

Description

The CAR2512TE Front-End provides highly efficient isolated power from worldwide input mains in a compact 1U industry standard form factor in an unprecedented power density of 25W/in³. Ideal for applications where mid to light load efficiency is of key importance. This front-end is complemented by the CAR2512DC dc/dc converter designed to convert 48/60Vdc power of telecom central offices. This plug and play approach offers rapid system reconfiguration by simply replacing the power supply.

The high-density, front-to-back airflow is designed for minimal space utilization and is highly expandable for future growth. The industry standard PMBus compliant I²C communications buss offers a full range of control and monitoring capabilities. The SMBAlert signal pin alerts customers automatically of any state change within the power supply.

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† CSA is a registered trademark of Canadian Standards Association.
‡ VDE is a trademark of Verband Deutscher Elektrotechniker e.V.
§ Intended for integration into end-user equipment. All the required procedures for CE marking of end-user equipment should be followed. (The CE mark is placed on selected products.)
** ISO is a registered trademark of the International Organization of Standards.
\+ PMBus name and logo are registered trademarks of the System Management Interface Forum (SMIF)

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Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause permanent damage to the device. These are absolute stress ratings only, functional operation of the device is not implied at these or any other conditions in excess of those given in the operations sections of the data sheet. Exposure to absolute maximum ratings for extended periods can adversely affect the device reliability.

Parameter	Symbol	Min	Max	Unit
Input Voltage: Continuous	V_{IN}	0	264	V_{AC}
Operating Ambient Temperature	T_A	-10	70[1]	°C
Storage Temperature	T_{STG}	-40	85	°C
I/O Isolation voltage to Frame (100% factory Hi-Pot tested)			2121	V_{DC}

Electrical Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, load, and temperature conditions.

INPUT

Parameter	Symbol	Min	Typ	Max	Unit
Operational Range	V_{IN}	90	115/230	264	V_{AC}
Frequency Range (ETSI 300-132-1 recommendation)	F_{IN}	47	50/60	63	Hz
Main Output Turn_OFF	V_{IN}			80	V_{AC}
Maximum Input Current (V_{OUT}= $V_{O, set}$, I_{OUT}=$I_{O, max}$) V_{IN}= 100V_{AC} V_{IN}= 180V_{AC}	I_{IN}			14 16	A_{AC}
Cold Start Inrush Current (Excluding x-caps, 25°C, <10ms, per ETSI 300-132)	I_{IN}			40	A_{PEAK}
Efficiency (T_{AMB}=25°C, V_{IN} = HL, V_O = 12V_{DC}), 100% load 50% load 20% load	η		**115V / 230V** 89 / 91 89 / 94 80 / 90		%
Power Factor (V_{IN}=230V_{AC}, I_{OUT}=$I_{O, max}$)	PF		0.99		
Holdup time[2] (V_{OUT}= 12V_{DC}, Tamb 25°C, I_{OUT}=$I_{O, max}$) V_{in}= 230V_{AC} V_{in}= 100V_{AC}	T		12 15		ms
Early warning prior to output falling below 10.8Vdc (DC_OK signal goes LO)		2			ms
Ride through	T		10		ms
Leakage Current (V_{IN}= 250V_{AC}, Fin = 60Hz)	I_{IN}		3		mA
Isolation Input/Output		3000			V_{AC}
Input/Frame		1500			V_{AC}
Output/Frame		100			V_{DC}

12V_{dc} MAIN OUTPUT

Parameter	Symbol	Min	Typ	Max	Unit
Output Power HL / LL [180 – 264 / 90-132 V_{AC}] V_{DC} ≥ 12V_{DC}	W	0	-	2500/1200	W
V_{DC} = 10.8V_{DC}	W	0	-	2246/1078	W
Set point	V_{OUT}	11.9	12.00	12.1	V_{DC}
Overall regulation (load, temperature, aging)	V_{OUT}	-3		+3	%
Ripple and noise[3]	V_{OUT}			120	mV_{P-P}
Turn-ON overshoot	V_{OUT}			+3	%
Turn-ON delay	T		2	3	sec

[1] Derated above 50°C at 2.5%/°C

[2] 12V output can decay down to 10.8V

[3] Measured across a 10µf tantalum and a 0.1µf ceramic capacitors in parallel. 20MHz bandwidth

12V$_{dc}$ MAIN OUTPUT (continued)

Parameter	Symbol	Min	Typ	Max	Unit
Remote ON/OFF delay time				40	ms
Turn-ON rise time (10 – 90% of V_{OUT})				50	ms
Transient response 50% step [10%-60%, 50% - 100%] (dI/dt – 1A/µs, recovery 300µs)	V_{OUT}	-5		+5	%V_{OUT}
Programmable range (hardware & software)	V_{OUT}	10.8		13.2	V_{DC}
Overvoltage protection, latched (recovery by cycling OFF/ON via hardware or software)	V_{OUT}	13.8	14.8	15.8	V_{DC}
Output current V_{IN} = HL V_{IN} = LL	I_{OUT}	0		208 100	A_{DC}
Current limit, Hiccup (programmable level) HL / LL	I_{OUT}	105/105		130/140	% of FL
Active current share (I_{OUT} ≥ 20% of FL)	I_{OUT}	-5		+5	% of FL

STANDBY OUTPUT

Parameter	Symbol	Min	Typ	Max 3.3 / 5 / 12	Unit
Set point	V_{OUT}		3.3 / 5.0 / 12		V_{DC}
Factory set point accuracy (25°C, 50% load)	V_{OUT}	-3		+3	%
Overall regulation (line, load, temperature, aging)	V_{OUT}	-5		+5	%
Ripple and noise	V_{OUT}			50 / 50 / 120	mV_{P-P}
Output power	I_{OUT}	0		15	W_{DC}
Overload protection -					
Overvoltage protection			110		%
Isolation Output/Frame		100			V_{DC}

General Specifications

Parameter	Min	Typ	Max	Units	Notes
Reliability		400,000		Hrs	Full load, 25°C ; MTBF per SR232 Reliability protection for electronic equipment, method I, case III,
Service Life		10		Yrs	Full load, excluding fans
Weight			5.2 /2.36	Lbs/kg	

Feature Specifications

Unless otherwise indicated, specifications apply over all operating input voltage, resistive load, and temperature conditions. See Feature Descriptions for additional information.

Parameter	Symbol	Min	Typ	Max	Unit
Remote ON/OFF (pulled up internally within the module to V_{stdby})					
Logic High (Module ON)		2.5		5	V_{DC}
Logic Low (Module OFF, internal resistance 9kΩ)	I_{IL}	—	—	1	mA
	V_{IL}	0	—	0.8	V_{DC}

Feature Specifications (continued)

Parameter	Symbol	Min	Typ	Max	Unit
Output Voltage programming (Vprog)					
Equation: Vout = 10.8 + (Vprog * 0.96)					
Vprog range	V_{PROG}	0	—	2.5	V_{DC}
Programmed output voltage range	V_{OUT}	10.8	—	13.2	V_{DC}
Voltage adjustment resolution (8-bit A/D)	V_{OUT}	—	10	—	mV_{DC}
Output configured to 13.2V$_{DC}$	V_{PROG}	2.5		3.0	V_{DC}
Output configured to the 12V$_{DC}$ set-point	V_{PROG}	3.0	—	—	V_{DC}
Interlock [short pin controlling presence of the 12V$_{DC}$ output]					
12V output OFF	V_I	2.5	—	5	V_{DC}
12V output ON	V_I	0	—	0.8	V_{DC}
INPUT(AC)_OK (pulled up internally via 10kΩ to 3.3V)					
Logic High (Input within normal range; $V_{IN} \geq 80V_{AC}$)	I_{OH}		—	20	μA
	V_{OH}	2.1	—	3.5	V_{DC}
Logic Low (Input out of range; $V_{IN} \leq 75V_{AC}$)	I_{OL}	—	—	20	mA
	V_{OL}	0	—	0.4	V_{DC}
DC_OK (pulled up internally via 10kΩ to 3.3V)					
Logic High (Output voltage is present; $V_{OUT} \geq 10.7V_{DC}$)	I_{OH}		—	20	μA
	V_{OH}	2.1	—	3.5	V_{DC}
Logic Low (Output voltage is not present; $V_{OUT} \leq$ 10.2V$_{DC}$, and	I_{OL}	—	—	20	mA
Early_warning if output is about to go out of regulation)	V_{OL}	0	—	0.4	V_{DC}
Over_Temperature_Warning# (pulled internally via 10kΩ to 3.3V)					
Logic High (temperature within normal range)	I_{OH}		—	20	μA
	V_{OH}	2.1	—	3.5	V_{DC}
Logic Low (temperature is too high)	I_{OL}	—	—	20	mA
	V_{OL}	0	—	0.4	V_{DC}
Delayed shutdown after Logic Low transition	Tdelay	10			sec
Fault# (pulled up internally via 10kΩ to 3.3V)					
Logic High (No fault is present)	I_{OH}		—	20	μA
	V_{OH}	2.1	—	3.5	V_{DC}
Logic Low (Fault is present)	I_{OL}	—	—	20	mA
	V_{OL}	0	—	0.4	V_{DC}
PS_Present#					
Logic High (Power supply is not plugged in)					
Logic Low (Power supply is present)	V_{IL}	0	—	0.4	V_{DC}

Feature Specifications (continued)

Parameter	Symbol	Min	Typ	Max	Unit
SMBAlert# (Interrupt) (pulled up internally via 10kΩ to 3.3V)					
Logic High (No Alert - normal)	V_{OH}	2.1	—	3.5	V_{DC}
Logic Low (Alert is set)	I_{OL}	—	—	20	mA
	V_{OL}	0	—	0.4	V_{DC}
Current monitor (Imon) Resolution			15		mV/A
Measurement range	I_{OUT}	0		208	A_{DC}
Measurement accuracy, load > 25% of FL, V_O = 12V_{DC}		-5		+5	% of FL
Analog output range	V_{mon}	0		3.3	V_{DC}
Sourced output current	I_{OUT}			5	mA_{DC}

Digital Interface Specifications

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
PMBus Signal Interface Characteristics						
Input Logic High Voltage (CLK, DATA)		V_{IH}	2.1		3.6	V
Input Logic Low Voltage (CLK, DATA)		V_{IL}	0		0.8	V
Input high sourced current (CLK, DATA)		I_{IH}	0		10	μA
Output Low sink Voltage (CLK, DATA, SMBALERT#)	I_{OUT}=3.5mA	V_{OL}			0.4	V
Output Low sink current (CLK, DATA, SMBALERT#)		I_{OL}	3.5			mA
Output High open drain leakage current (CLK,DATA, SMBALERT#)	V_{OUT}=3.6V	I_{OH}	0		10	μA
PMBus Operating frequency range	Slave Mode	F_{PMB}	10		400	kHz

Digital Interface Specifications (continued)

Parameter	Type	Symbol	Min	Typ	Max	Unit
Measurement System Characteristics						
Clock stretching		$t_{STRETCH}$			25	ms
I_{OUT} measurement range	Linear	I_{RNG}	0		210	A
I_{OUT} measurement accuracy 25°C		I_{ACC}	-5		+5	%
V_{OUT} measurement range	Linear	$V_{OUT(rng)}$	0		14	V_{DC}
V_{OUT} measurement accuracy		$V_{OUT(acc)}$	-5		+5	%
Temp measurement range	Linear	$Temp_{(rng)}$	0		120	°C
Temp measurement accuracy[4]		$Temp_{(acc)}$	-5		+5	%
I_{IN} measurement range	Linear	$I_{IN(rng)}$	0		40	A_{AC}
I_{IN} measurement accuracy		$I_{IN(acc)}$	-5		+5	%
V_{IN} measurement range	Linear	$V_{IN(rng)}$	0		300	V_{AC}
V_{IN} measurement accuracy		$V_{IN(acc)}$	-5		+5	%
P_{IN} measurement range	Linear	$P_{N(rng)}$	0		3000	W
P_{IN} measurement accuracy		$P_{IN(acc)}$	-5		+5	%
Fan Speed measurement range	Linear		0		30k	RPM
Fan Speed measurement accuracy			-10		10	%
Fan speed control range	Linear		0		100	%

[4] Temperature accuracy reduces non-linearly with decreasing temperature

Environmental Specifications

Parameter	Min	Typ	Max	Units	Notes
Ambient Temperature	-10		70[5]	°C	Derated above 50°C
Storage Temperature	-40		85	°C	
Operating Altitude			2250/7382	m/ft	Meet CCC at 5000m
Non-operating Altitude			8200/30k	m / ft	
Power Derating with Temperature			2.5	%/°C	50°C to 70°C(60°C max where TUV/VDE is required)
Power Derating with Altitude			2.0	°C/301 m °C/1000 ft	Above 2250 m/7382 ft
Acoustic noise			55	dbA	Full load
Over Temperature Protection		125/110		°C	Shutdown / restart
Humidity Operating Storage	 30 10		 95 95	%	Relative humidity, non-condensing
Shock and Vibration acceleration			2.4	Grms	Meet IPC-9592B Class II

EMC Compliance

Parameter	Criteria	Standard	Level	Test
AC input	Conducted emissions	EN55022, FCC Docket 20780 part 15, subpart J EN61000-3-2(line harmonics)	A	0.15 – 30MHz 0 – 2 KHz
	Radiated emissions**	EN55022	A	30M – 1GHz
AC input immunity	Voltage dips	EN61000-4-11	B	-30%, 10ms
			B	-60%, 100ms
			B	-100%, 5sec
	Voltage surge	EN61000-4-5	A	4kV, 1.2/50µs, common mode
			A	2kV, 1.2/50µs, differential mode
	Fast transients	EN61000-4-4	B	5/50ns, 2kV (common mode)
Enclosure immunity	Conducted RF fields	EN61000-4-6	A	130dBµV, 0.15-80MHz, 80% AM
	Radiated RF fields	EN61000-4-3	A	10V/m, 80-1000MHz, 80% AM
		ENV 50140	A	
	ESD	EN61000-4-2	3	6kV contact, 8kV air

[5] 60°C max where TUV/VDE is required

Control and Status

Control hierarchy: Some features, such as output voltage, can be controlled both through hardware and firmware. For example, the output voltage is controlled both by the signal pin (Vprog) and the PMBus command, (Vout_command) .

Using output voltage as an example; the Vprog signal pin has ultimate control of the output voltage until the Vprog is either > 3V_{DC} or a no connect. When the programming signal via Vprog is either a no connect or > 3V_{DC}, it is ignored, the output voltage is set at its nominal 12V_{DC} and the unit output voltage can be controlled via the PMBus command, (Vout_command).

Analog controls: Details of analog controls are provided in this data sheet under Signal Definitions.

Common ground: All signals and outputs are referenced to Output return. These include 'V_{STDBY} return' and 'Signal return'.

reset the soft start circuitry of the individual power supplies.

Auto_restart: Auto-restart is the default configuration for recovering from over-current and over-temperature shutdowns.
An overvoltage shutdown is followed by three attempted restarts, each restart delayed 1 second, within a 1 minute window. If within the 1 minute window three attempted restarts failed, the unit will latch OFF. If less than 3 shutdowns occur within the 1 minute window then the count for latch OFF resets and the 1 minute window starts all over again.

Restart after a lachoff: To restart after a latch_off either of four restart mechanisms are available. The hardware pin **Remote ON/OFF** may be turned OFF and then ON**.** The unit may be commanded to restart via i2c through the *Operation* command by first turning OFF then turning ON . The third way to restart is to remove and reinsert the unit. The fourth way is to turn OFF and then turn ON ac power to the unit. The fifth way is by changing firmware from **latch off** to **restart.** Each of these commands must keep the power supply in the OFF state for at least 2 seconds, with the exception of changing to **restart**.

A successful restart shall clear all alarm registers.

A power system that is comprised of a number of power supplies could have difficulty restarting after a shutdown event because of the non-synchronized behavior of the individual power supplies. Implementing the latch-off mechanism permits a synchronized restart that guarantees the simultaneous restart of the entire system.

A synchronous restart can be implemented by;

1. Issuing a GLOBAL OFF and then ON command to all power supplies,
2. Toggling Off and then ON the **Remote ON/OFF** signal
3. Removing and reapplying input commercial power to the entire system.

It is good practice to turn OFF the power supplies for about 20 – 30 seconds in order to discharge all internal bias supplies and reset the soft start circuitry of the individual power supplies.

Control Signals

All signals are referenced to 'Signal Return'.

Device addressing: The microcontroller (MCU) and the EEPROM have the following addresses:

Device	Address	Address Bit Assignments (Most to Least Significant)							
MCU	0xBx	1	0	1	1	A2	A1	A0	R/W
Broadcast	0x00	0	0	0	0	0	0	0	0
EEPROM	0xAx	1	0	1	0	A2	A1	A0	R/W

Address lines (A2, A1, A0): These signal pins allow up to eight (8) modules to be addressed on a single I²C bus. The pins are pulled HI internally. For logic LO connect to 'Output Return'.

Global broadcast: This is a powerful command because it instruct all power supplies to respond simultaneously. A ***read*** instruction should never be accessed globally. The power supply should issue an 'invalid command' state if a 'read' is attempted globally.

For example, changing the 'system' output voltage requires the global broadcast so that all paralleled power supplies change their output simultaneously. This command can also turn OFF the 'main' output or turn ON the 'main' output of all power supplies simultaneously. Unfortunately, this command does have a side effect. Only a single power supply needs to pull down the ninth *acknowledge* bit. To be certain that each power supply responded to the global instruction, a *READ* instruction should be executed to each power supply to verify that the command properly executed. The GLOBAL BROADCAST command should only be executed for write instructions to slave devices.

Voltage programming (Vprog): An analog voltage on this signal can vary the output voltage ± 10% of nominal, from 10.8V_{DC} to 13.2V_{DC}. The equation of this signal is:

$V_{OUT} = 10.8 \div (Vprog * 0.96)$ where Vprog = 0 to 2.5V_{DC}

Between 2.5 and 3V the output stays at 13.2V_{DC}. If Vprog is > 3V, or left open, the programming signal is ignored and the unit output is set at the setpoint of 12V_{DC}.

Load share (Ishare): This is a single wire analog signal that is generated and acted upon automatically by power supplies connected in parallel. The Ishare pins should be tied together for power supplies if active current share among the power supplies is desired. No resistors or capacitors should get connected to this pin.

Remote_ON/OFF: Controls presence of the 12V_{DC} output voltage. A logic LO on this signal pin turns OFF the 12V_{DC} output.

Interlock: This is a short signal pin that controls the presence of the 12V_{DC} main output. This pin should be connected to 'output return' on the system side of the output connector. The purpose of this pin is to ensure that the output turns ON after engagement of the power blades and turns OFF prior to disengagement of the power blades.

Remote sense: The two sense pins regulate the 12Vdc output at the termination point external to the power supply. Up to 0.5V of total load cable voltage drop to the sense point is tolerable.

Status Signals

Current monitor (Imon): A voltage level proportional to the delivered output current is present on this pin. The signal level is typically 15mV per amp.

Input_OK: A TTL compatible status signal representing whether the input voltage is within the anticipated range. This signal is pulled HI internally through a 10kΩ resistor.

DC_OK: A TTL compatible status signal representing whether the output voltage is present. This signal needs is pulled HI internally through a 10kΩ resistor.

Over_temp_warning#: A TTL compatible status signal representing whether an over temperature exists This signal is pulled HI internally through a 10kΩ resistor.

If an over temperature should occur, this signal would pull LO approximately 10 seconds prior to shutting down the power supply. The unit would restart if internal temperatures recover within normal operational levels. At that time the signal reverts back to its open collector (HI) state.

Fault#: A TTL compatible status signal representing whether a Fault occurred. This signal is pulled HI internally through a 10kΩ resistor.

This signal activates for OTP, OVP, OCP, INPUT fault or No output.

PS_Present#: This pin is connected to 'output return' within the power supply. Its intent is to indicate to the system that a power supply is present. This signal may need to be pulled HI externally through a resistor.

SMBAlert# (Interrupt): A TTL compatible status signal, representing the SMBusAlert# feature of the PMBus compatible i²C protocol in the power supply. This signal is pulled HI internally through a 10kΩ resistor.

Serial Bus Communications

The I²C interface facilitates the monitoring and control of various operating parameters within the unit and transmits these on demand over an industry standard I²C Serial bus.

Serial Clock (SCL): Clock pulses are host generated initiating communications across the I²C Serial bus. Pulled up internally to 3.3V by a 10kΩ resistor. The end user should add additional pull up resistance as necessary to ensure that rise and fall time timing and the maximum sink current is in compliance to the I²C specifications.

Serial Data (SDA): This is a bi-directional data line. . Pulled up internally to 3.3V by a 10kΩ resistor. The end user should add additional pull up resistance as necessary to ensure that rise and fall time timing and the maximum sink current is in compliance to the I²C specifications.

Basic Operation

PMBus™ compliance: The power supply is fully compliant to the Power Management Bus (PMBus™) rev1.2 requirements.

Manufacturer specific commands located between addresses 0xD0 to 0xEF provide instructions that either do not exist in the general PMBus specification or make the communication interface simpler and more efficient.

Master/Slave: The 'host controller' is always the MASTER. Power supplies are always SLAVES. SLAVES cannot initiate communications or toggle the Clock. SLAVES also must respond expeditiously at the command of the MASTER as required by the clock pulses generated by the MASTER.

Clock stretching: The 'slave' µController inside the power supply may initiate clock stretching if it is busy and it desires to delay the initiation of any further communications. During the clock stretch the 'slave' may keep the clock LO until it is ready to receive further instructions from the host controller. The maximum clock stretch interval is 25ms.

The host controller needs to recognize this clock stretching, and refrain from issuing the next clock signal, until the clock line is released, or it needs to delay the next clock pulse beyond the clock stretch interval of the power supply.

Note that clock stretching can only be performed after completion of transmission of the 9th ACK bit, the exception being the START command.

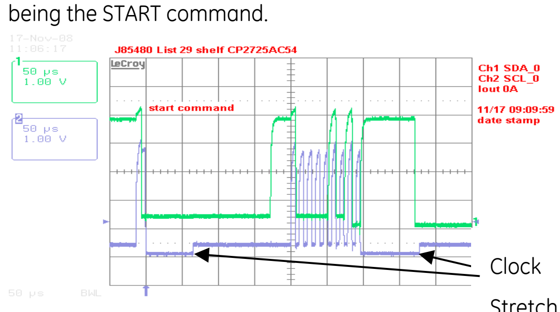


Figure 1. Example waveforms showing clock st

I²C Bus Lock-Up detection: The device will abort any transaction and drop off the bus if it detects the bus being held low for more than 35ms.

Communications speed: Both 100kHz and 400kHz clock rates are supported. The power supplies default to the 100kHz clock rate. The minimum clock speed specified by SMBus is 10 kHz.

Packet Error Checking (PEC): Although the power supply will respond to commands with or without the trailing PEC, it is highly recommended that PEC be used in all communications. The integrity of communications is compromised if packet error correction is not employed. There are many functional features, including turning OFF the main output, that should require validation to ensure that the correct command is executed.

PEC is a CRC-8 error-checking byte, based on the polynomial $C(x) = x^8 + x^2 + x + 1$, in compliance with PMBus™ requirements. The calculation is based in all message bytes, including the originating write address and command bytes preceding read instructions. The PEC is appended to the message by the device that supplied the last byte.

SMBAlert#: The µC driven SMBAlert# signal informs the 'master/host' controller that either a STATE or ALARM change has occurred. Normally this signal is HI. The signal will change to its LO level if the power supply has changed states and the signal will be latched LO until the power supply receives a 'clear' instruction as outlined below. If the alarm state is still present after the 'clear_faults' command has been received, then the signal will revert back into its LO state again and will latch until a subsequent 'clear_faults' signal is received from the host controller.

The signal will be triggered for any state change, including the following conditions;

- VIN under or over voltage
- Vout under or over voltage
- IOUT over current
- Over Temperature warning or fault
- Fan Failure
- Communication error
- PEC error
- Invalid command
- Detected internal faults

The power supply will clear the SMBusAlert# signal (release the signal to its HI state) upon the following events:

- Receiving a CLEAR_FAULTS command
- The main output recycled (turned OFF and then ON) via the REMOTE ON/OFF signal pin
- The main output recycled (turned OFF and then ON) by the OPERATION command

Read back delay: The power supply issues the SMBAlert # notification as soon as the first state change occurred. During an event a number of different states can be transitioned to before the final event occurs. If a read back is implemented rapidly by the host a successive SMBAlert# could be triggered by the transitioning state of the power supply. In order to avoid successive SMBAlert# s and read back and also to avoid reading a transitioning state, it is prudent to wait more than 2 seconds after the receipt of an SMBAlert# before executing a read back. This delay will ensure that only the final state of the power supply is captured.

Successive read backs: Successive read backs to the power supply should not be attempted at intervals faster than every one second. This time interval is sufficient for the internal processors to update their data base so that successive reads provide fresh data.

Invalid commands or data: The power supply notifies the MASTER if a non-supported command has been sent or invalid data has been received. Notification is implemented by setting the appropriate STATUS and ALARM registers and setting the SMBAlert# flag.

If a non-supported read is requested the power supply will return all 0x00h.

PMBus™ Commands

Standard instruction: Up to two bytes of data may follow an instruction depending on the required data content. Analog data is always transmitted as LSB followed by MSB. PEC is optional and includes the address and data fields.

1	8		1	8	1
S	Slave address	Wr	A	Command Code	A

8	1	8	1	8	1	1
Low data byte	A	High data byte	A	PEC	A	P

Master to Slave   Slave to Master

SMBUS annotations; S – Start , Wr – Write, Sr – re-Start, Rd – Read,

A – Acknowledge, NA – not-acknowledged, P – Stop

Standard READ: Up to two bytes of data may follow a READ request depending on the required data content. Analog data is always transmitted as LSB followed by MSB. PEC is mandatory and includes the address and data fields. PEC is optional and includes the address and data fields.

1	7	1	1	8	1
S	Slave address	Wr	A	Command Code	A

1	7	1	1	8	1
Sr	Slave Address	Rd	A	LSB	A

8	1	8	1	1
MSB	A	PEC	No-ack	P

Block communications: When writing or reading more than two bytes of data at a time, BLOCK instructions for WRITE and READ commands must be used instead of the Standard Instructions

Block write format:

1	7	1	1		8	1
S	Slave address	Wr	A		Command Code	A

8	1	8	1	8		1
Byte count = N	A	Data 1	A	Data 2		A

8	1	8	1	8	1	1
....	A	Data 48	A	PEC	A	P

Block read format:

1	7	1	1		8	1
S	Slave address	Wr	A		Command Code	A

1	7	1	1
Sr	Slave Address	Rd	A

8	1	8	1	8		1
Byte count = N	A	Data 1	A	Data 2		A

8	1	8	1	8	1	1
....	A	Data 48	A	PEC	NoAck	P

Linear Data Format The definition is identical to Part II of the PMBus Specification. All standard PMBus values, with the exception of output voltage related functions, are represented by the linear format described below. Output voltage functions are represented by a 16 bit mantissa. Output voltage has a E=9 constant exponent.

The Linear Data Format is a two byte value with an 11-bit, two's complement mantissa and a 5-bit, two's complement exponent or scaling factor, its format is shown below.

	Data Byte High								Data Byte Low							
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
	Exponent (E)					Mantissa (M)										

The relationship between the Mantissa, Exponent, and Actual Value (V) is given by the following equation:

$$V = M * 2^E$$

Where: V is the value, M is the 11-bit, two's omplement mantissa, *E* is the 5-bit, two's complement exponent

PMBus™ Command set:

Command	Hex Code	Data Byte		Function
Operation	01	1	W	Output ON/OFF
ON_OFF_config	02	1	R	Set at 1D, can't change
Clear_faults	03	0		Clear Status
Write_protect	10	1	W	Write control
Store_default_all	11	0	W	Store permanently
Restore_default_all	12	0	R	Reset defaults
Capability	19	1	R	30h, 400kHz, SMBAlert
Vout_mode	20	1	R	Vout constants
Vout_command	21	2	W	Set Vout
Fan_command_1	3B	2	W	Set fan speed in RPM
Vout_OV_fault_limit	40	2	W	Set OV fault limit
Vout_OV_fault_response	41	1	W	
Vout_OV_warn_limit	42	2	W	Set OV warn limit
Vout_UV_warn_limit	43	2	W	Set UV warn limit
Vout_UV_fault_limit	44	2	W	
Vout_UV_fault_response	45	1	W	
Iout_OC_fault_limit	46	2	W	
Iout_OC_fault_response	47	1	W	Latch or hiccup
Iout_OC_warn_limit	4A	2	W	Set OC warn limit
OT_fault_limit	4F	2	W	
OT_fault_response	50	1	W	Latch or hiccup
OT_warn_limit	51	2	W	Set OT warn limit
Vin_OV_fault_limit	55	2	W	
Vin_OV_warn_limit	57	2	W	Set OV warn limit
Vin_UV_warn_limit	58	2	W	Set UV warn limit
Vin_UV_fault_limit	59	2	W	Set UV shutdown
Status_byte	78	1	R	
Status_word	79	2	R	
Status_Vout	7A	1	R	
Status_Iout	7B	1	R	
Status_input	7C	1	R	
Status_temperature	7D	1	R	
Status_CML	7E	1	R	
Status_other	7F	1	R	

Command	Hex Code	Data Field		Function
Status_mfr_specific	80	1	R	
Status_fan_1_2	81	1	R	
Read_Vin	88	2		Read input voltage
Read Iin	89	2		Read input current
Read_Vout	8B	2		Read output voltage
Read_Iout	8C	2		Read output current
Read_temperature	8D	2		Read Temperature
Read_fan_speed_1	90	2		In RPM
Read_fan_speed_2	91	2		In RPM
Read_Pout	96	2		
Read_Pin	97	2		
PMBus revision	98	1		
Mfr_ID	99	5		FRU_ID
Mfr_model	9A	16	R	
Mfr_serial	9E	15		
Mfr_Vin_min	A0	2		
Mfr_Vin_max	A1	2		
Mfr_Iin_max	A2	2		
Mfr_Pin_max	A3	2		
Mfr_Vout_min	A4	2		
Mfr_Vout_max	A5	2		
Mfr_Iout_max	A6	2		
Mfr_Pout_max	A7	2		
Mfr_Tambient_max	A8	2		
Mfr_Tambient_min	A9	2		
User_data_00	B0	48	W	User memory space
User_data_01	B1	48	W	User memory space
Read_mfr_revision	D5	4	R	
Fan_duty_cycle	D6	1	W	Duty_cycle in %
Fan_speed	D7	1	W	Control in duty cycle
Vprog_ext	D8	2	W	

Notes: Settings and read backs above support the 12Vdc main output. There are no adjustments or read backs of the standby output. Failure of the standby output is reported by the STATUS_MFR_SPECIFIC register. The code does not check the validity of, or whether the data being changed is within the expected boundary. The user is responsible to make sure that data placed in the registers is within the monitored range.

Status Register Bit Allocation:

Register	Code	Bit	Function
Status_Byte	78	7	Busy
		6	DC_ OFF
		5	Output OV Fault detected
		4	Output OC Fault detected
		3	Input UV Fault detected
		2	Temperature Fault/warning detected
		1	CML (communication fault) detected
		0	None of Below

Register	Code	Bit	Function
Status_word (includes Status_byte)	79	7	OV Fault/Warning detected
		6	OC Fault/Warning detected
		5	Input Fault/Warning detected
		4	Mfr_specific register change detected
		3	nPower_Good
		2	Fan Fault or Warning detected
		1	Other fault
		0	Unknown
Status_Vout	7A	7	Vout OV Fault
		6	Vout OV Warning
		5	Vout UV Warning
		4	Vout UV Fault
		3	N/A
		2	N/A
		1	N/A
		0	N/A
Status_Iout	7B	7	IOUT OC Fault
		6	N/A
		5	IOUT OC Warning
		4	N/A
		3	N/A
		2	N/A
		1	N/A
		0	N/A
Status_input	7C	7	Vin OV Fault
		6	Vin OV Warning
		5	Vin UV Warning
		4	Vin UV Fault
		3	N/A
		2	N/A
		1	N/A
		0	N/A
Status_temperature	7D	7	OT Fault
		6	OT Warning
		5	N/A
		4	N/A
		3	N/A
		2	N/A
		1	N/A
		0	N /A
Status_fan_1_2	81	7	Fan 1 Fault
		6	Fan 2 Fault
		5	N/A
		4	N/A
		3	Fan 1 Speed Overridden
		2	Fan 2 Speed Overridden
		1	N/A
		0	N/A
Status_mfr_specific	80	7	3.3V_fault
		6	OVSD
		5	Interrupt
		4	Fault detected
		3	PS_remote_OFF
		2	DC Fault
		1	Input Fault
		0	0 – AC high line, 1 – AC low line

Command Descriptions

Operation (01) : By default the Power supply is turned **ON** at power up as long as *Power ON/OFF* signal pin is active HI. The Operation command is used to turn the Power Supply ON or OFF via the PMBus. The data byte below follows the OPERATION command.

FUNCTION	DATA BYTE
Unit ON	80
Unit OFF	00

To **RESET** the power supply cycle the power supply OFF, wait at least 2 seconds, and then turn back ON. All alarms and shutdowns are cleared during a restart.

Clear_faults (03): This command clears all STATUS and FAULT registers and resets the SMBAlert# line.

If a fault still persists after the issuance of the clear_faults command the specific registers indicating the fault are reset and the SMBAlert# line is activated again.

WRITE_PROTECT register (10): Used to control writing to the PMBus device. The intent of this command is to provide protection against accidental changes. All supported command parameters may have their parameters read, regardless of the write_protect settings. The contents of this register can be stored to non-volatile memory using the Store_default_code command. The default setting of this register is disable_all_writes except write_protect 0x80h.

FUNCTION	DATA BYTE
Enable all writes	00
Disable all writes except write_protect	80
Disable all writes except write_protect and OPERATION	40

Vout_Command (21) : This command is used to change the output voltage of the power supply. Changing the output voltage should be performed simultaneously to all power supplies operating in parallel using the Global Address (Broadcast) feature. If only a single power supply is instructed to change its output, it may attempt to source all the required power which can cause either a power limit or shutdown condition.

Software programming of output voltage permanently overrides the set point voltage configured by the **Vprog** signal pin. The program no longer looks at the '**Vprog** pin' and will not respond to any hardware voltage settings. If power is removed from the μController it will reset itself into its default configuration looking at the **Vprog** signal for output voltage control. In many applications, the **Vprog** pin is used for setting initial conditions, if different that the factory setting. Software programming then takes over once I^{2}C communications are established.

To properly hot-plug a power supply into a live backplane, the system generated voltage should get re-configured into either the factory adjusted firmware level or the voltage level reconfigured by the margin pin. Otherwise, the voltage state of the plugged in power supply could be significantly different than the powered system.

Vout_OV_warn_limit (42): **OV_warning** is extremely useful because it gives the system controller a heads up that the output voltage is drifting out of regulation and the power supply is close to shutting down. Pre-amative action may be taken before the power supply would shut down and potentially disable the system.

OC and OT_fault_ response (47, 50): The default response for both OC and OT is auto_restart (hiccup). Each register, individually, can be reconfigured into a latched state. Latched and hiccup are the only supported states.

Restart after a latch off: Either of four restart possibilities are available. The hardware pin **Remote ON/OFF** may be turned OFF and then ON**.** The unit may be commanded to restart via i2c through the *Operation* command by first turning OFF then turning ON . The third way to restart is to remove and reinsert the unit. The fourth way is to turn OFF and then turn ON ac power to the unit. Each of these commands must keep the power supply in the OFF state for at least 2 seconds, with the exception of changing to **restart**.

A power system that is comprised of a number of power supplies could have difficulty restarting after a shutdown event because of the non-synchronized behavior of the individual power supplies. Implementing the latch-off mechanism permits a synchronized restart that guarantees the simultaneous restart of the entire system.

A synchronous restart can be implemented by;

1. Issuing a GLOBAL OFF and then ON command to all power supplies,
2. Toggling Off and then ON the **Remote ON/OFF** signal
3. Removing and reapplying input commercial power to the entire system.

The power supplies should be turned OFF for at least 20 – 30 seconds in order to discharge all internal bias supplies and

Vin_UV_warn_limit (58): This is another warning flag indicating that the input voltage is decreasing dangerously close to the low input voltage shutdown level.

Status_word (79): returns two bytes of information. The upper byte bit functionality is tabulated in the Status_word section. The lower byte bit functionality is identical to Status_byte.

Mfr_ID (99): Manufacturer in ASCII – 5 characters maximum,

General Electric – Critical Power represented as,

GE-CP

Mfr_Model (9A): Total 16 bytes: CAR2512TEXXXZ01

Mfr_serial (9E): Product serial number includes the manufacturing date, manufacturing location in up to 15 characters. For example:

13KZ51018193xxx, is decoded as;

13 – year of manufacture, 2013

KZ – manufacturing location, in this case Matamoros

51 – week of manufacture

018193xxx – serial #, mfr choice

note: if the additional xxx space is not utilized then F's are filled in, (i.e. 018193FFF), ensuring that the actual serial number is clearly identified.

Read_mfr_rev (D5): Total 4 bytes

Each byte is partitioned into high and low nibbles.

Example: FF is read as 16.16
11 is read as 1.1

Series	Hardware Rev	Primary µC	Secondary µC

Fan_speed (D7): This register can be used to 'read' the fan speed in adjustment percent (0 – 100%) or set the fan speed in adjustment percent (0 – 100%). The speed of the fan cannot be reduced below what the power supply requires for its operation. The register value is the percent number, it is not in linear format.

EEPROM

The microcontroller has 96 bytes of EEPROM memory available for the system host.

LEDs

Two LEDs are located on the front faceplate. The INPUT OK LED provides INPUT signaling function. When the LED is ON GREEN the power supply input is within normal design limits.

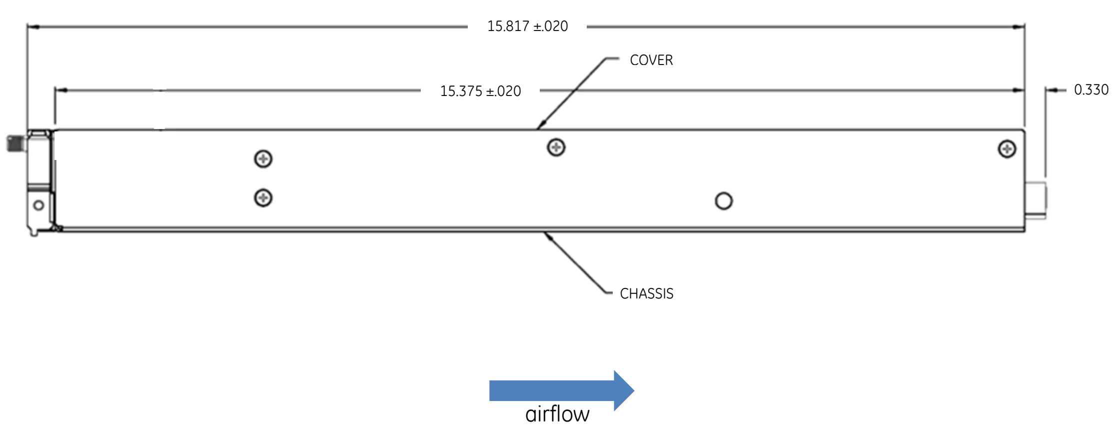
The second LED DC/FLT indicates three states. When the LED is GREEN then there are no faults and the DC output is present. When the LED is AMBER then a fault condition exists but the power supply still provides output power. When the LED is RED then a fault condition exists and the power supply does not provide output power.

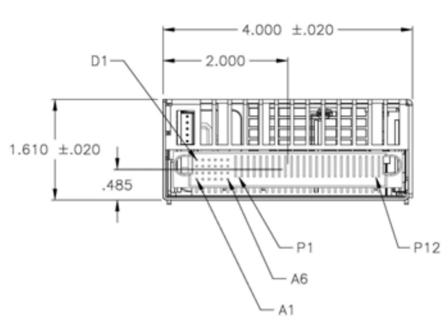
Alarm Table

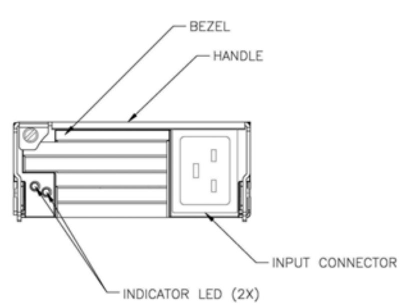
		LED Indicator		Monitoring Signals			
Test Condition		LED1 AC	Tri-Color LED2 DC / FLT	FAULT	DC_OK	INPUT_OK	TEMP_OK
1	Normal Operation	Green	Green	High	High	High	High
2	Low or NO INPUT	Off	Red	Low	Low	Low	High
3	OVP	Green	Red	Low	Low	High	High
4	Over Current	Green	Red	Low	Low	High	High
5	Temp Alarm Warning	Green	Orange	High	High	High	Low
6	Fault Over Temp	Green	Red	Low	Low	High	Low
7	Remote ON/OFF	Green	Red	Low	Low	High	High

Notes: Test condition #2 had 2 modules plug in. One module is running and the other one is with no AC.

Outline Drawing



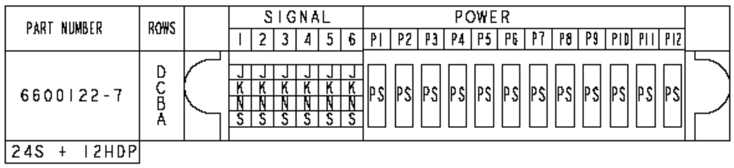




Connector Pin Assignments

Input Connector: IEC320, C20; mating connector: IEC320, C19 type

Output Connector: Tyco P/N 6600122-7 or equivalent
Mating connector: Primary Source: FCI berg P/N 51915-176LF
Secondary Source: Tyco P/N 6450171-5



Pin	Function	Pin	Function	Pin	Function	Pin	Function
A1	V_{STDBY}	B1	Fault	C1	IShare	D1	VProg
A2	PS Present	B2	Current Monitor (Imon)	C2	V_{STDBY}	D2	OVP Test Point[6]
A3	V_{STDBY} Return	B3	Interlock	C3	Over_Temp_Warning	D3	Remote ON/OFF
A4	n/c	B4	V_{STDBY} Return	C4	I^2C Address (A0)	D4	DC_OK
A5	Remote Sense (+)	B5	SDA (I^2C bus)	C5	I^2C Address (A1)	D5	AC_OK
A6	Remote Sense (-)	B6	SCL (I^2C bus)	C6	I^2C Address (A2)	D6	SMBAlert
P1 – P6	Output Return					P7– P12	+12V_{OUT}

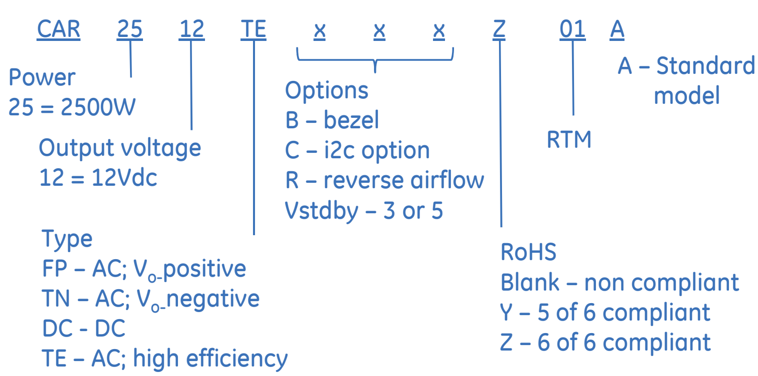
[6] For factory use

Ordering Information

Please contact your GE Sales Representative for pricing, availability and optional features.

PRODUCT	DESCRIPTION	PART NUMBER
2500W Front-End	+12V_{OUT} , 3.3V_{STDBY}, face plate, PMBus interface, RoHS 6 of 6	CAR2512TEBXXZ01A
2500W Front-End	+12V_{OUT} , 5V_{STDBY}, face plate, PMBus interface, RoHS 6 of 6	CAR2512TEBX5Z01A

PART NUMBER DEFINITION GUIDE EXAMPLE



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