

## DATASHEET

# CAR1212DCBLC DC-DC converter

**Input: -36V<sub>DC</sub> to -75V<sub>DC</sub>; Output: 12V<sub>DC</sub> @ 1200W; 5V<sub>DC</sub> @ 1A**



## Description

This CAR1212DC DC-DC Converter provides highly efficient isolated power from DC input mains in a compact 1U industry standard form factor at a power density of 16.2W/in<sup>3</sup>. This converter complements the CAR1212FP rectifier providing comprehensive solutions for systems connected either to commercial AC mains, 48/60V<sub>DC</sub> power plants or telecom central offices. This plug and play approach offers significant advantages since systems can be reconfigured and repositioned readily by simply replacing the power system

assembly. 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 I<sup>2</sup>C communications buss offers a full range of control and monitoring capabilities. The SMBusAlert signal pin alerts customers automatically of any state change within the power supply.

## Applications

- Cellular Base Stations
- Satellite Hubs
- Network Equipment
- Network Attached Storage
- Telecom Access Nodes
- Routers/Switches
- Broadband Switches
- ATE Equipment

## Features

- Input Or'ing
- Reverse input protection
- 3 front panel LEDs: 1-input; 2-output; 3 - fault
- Output programmable from 10.8 – 13.2V<sub>DC</sub>
- Remote ON/OFF control of the 12V<sub>DC</sub> output
- Remote sense (up to 0.25V) on the 12V<sub>DC</sub> output
- No minimum load requirements
- Redundant parallel operation
- Active load sharing (single wire)
- Hot pluggable
- Efficiency: typically 90%
- Standby 5V<sub>DC</sub>
- Auto recoverable OC & OT protection
- Operating temperature: -10 - 70°C (de-rated above 50°C)
- Digital status & control: I<sup>2</sup>C and PMBus serial bus
- UL and cUL approved to UL/CSA†62368-1, TUV (EN62368-1) Mark
- EMI: Meets FCC Part 15, EN55032 Class A standards
- Meets EN61000 immunity and transient standards
- Shock & vibration: Meets IPC 9592 Class II standards
- Compliant to RoHS Directive 2011/65/EU and amended Directive (EU) 2015/863
- Compliant to REACH Directive (EC) No 1907/2006

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CAR1212DC\_DS

Rev. 4.5

## Technical Specifications

### 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   | 75              | $V_{dc}$ |
| Operating Ambient Temperature                        | $T_A$     | -10 | 70 <sup>1</sup> | °C       |
| Storage Temperature                                  | $T_{stg}$ | -40 | 85              | °C       |
| I/O Isolation voltage (100% factory Hi - Pot tested) |           |     | 1500            | $V_{dc}$ |

### Electrical Specifications

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

#### INPUT

| Parameter   | Symbol   | Min  | Typ    | Max | Unit       |
|---|----------|------|--------|-----|------------|
| Operational Range   | $V_{IN}$ | -36  | -48/60 | -75 | $V_{DC}$   |
| 12V <sub>DC</sub> output turned OFF   |          |      |        | -35 |            |
| 12V <sub>DC</sub> turned ON   |          |      |        | -36 |            |
| Hysteresis between turn OFF and turn ON   |          | 2    |        |     |            |
| Input Overvoltage Protection (surge may last up to 100ms)   |          |      |        | 100 |            |
| Idle Power 12V <sub>DC</sub> output OFF   | W        |      |        | 35  | W          |
| 12V <sub>DC</sub> output ON   |          |      |        | 45  |            |
| Maximum Input Current ( $V_{IN} = -36V_{DC}$ , $V_{OUT} = V_{o, set}$ , $I_{OUT} = I_{o, max}$ )                      | $I_{IN}$ |      |        | 39  | $A_{DC}$   |
| Cold Start Inrush Current (Excluding x-caps, 25°C, <10ms, per ETSI 300-132)   | $I_{IN}$ |      |        | 40  | $A_{PEAK}$ |
| Efficiency, (including fan $T_{AMB}=25^{\circ}C$ , $V_{in}=-48V_{DC}$ , $V_{OUT}=12V_{DC}$ 60-80% load)               | $\eta$   |      | 90     |     | %          |
| Ride through time ( $V_{IN} = -48V_{DC}$ , $V_{OUT} \geq 10.8V_{dc}$ , $T_{AMB} 25^{\circ}C$ , $I_{OUT}=I_{o, max}$ ) | T        |      | 2.5    |     | ms         |
| Isolation: Input/ Output  |          | 1500 |        |     | $V_{DC}$   |
| Input/ Frame  |          | 1500 |        |     | $V_{DC}$   |
| Output/ Frame   |          | 100  |        |     | $V_{DC}$   |

#### 12V<sub>DC</sub> MAIN OUTPUT

| Parameter                              | Symbol    | Min  | Typ   | Max  | Unit              |
|--|-----------|------|-------|------|-------------------|
| Output power                           | $P_{OUT}$ | 0    |       | 1200 | W                 |
| Set point, @ 50% load                  | $V_{OUT}$ | 11.9 | 12.00 | 12.1 | $V_{DC}$          |
| Overall regulation (load, temperature) |           | -2   |       | +2   | %                 |
| Remote sense (sum of hot & return)     |           |      |       | 0.25 | $V_{DC}$          |
| Ripple and noise <sup>2</sup>          |           |      | 120   |      | mV <sub>p-p</sub> |

<sup>1</sup> Derated above 50°C at 2.5%/°C

<sup>2</sup> Measured across a 10µf tantalum and a 0.1µf ceramic capacitors in parallel. 20MHz bandwidth

## Technical Specifications (continued)

### Electrical Specifications (continued)

| 12V <sub>DC</sub> MAIN OUTPUT (continued)   |                  |      |     |      |                  |
|---|------------------|------|-----|------|------------------|
| Parameter   | Symbol           | Min  | Typ | Max  | Unit             |
| Turn-ON overshoot   | V <sub>OUT</sub> |      |     | 3    | %                |
| Turn-ON delay   | T                |      |     | 2    | sec              |
| Remote ON/OFF delay time  |                  |      |     | 40   | ms               |
| Turn-ON rise time (10 – 90% of V <sub>OUT</sub> )   |                  |      |     | 60   | ms               |
| Transient response 50% step [10%-60%, 50% - 100%] (dI/dt – 1A/μs, recovery 300μs)         | V <sub>OUT</sub> | -5   |     | +5   | %                |
| Programmable range (hardware <sup>3</sup> & software)                                     |                  | 10.8 |     | 13.2 | V <sub>DC</sub>  |
| Programmed voltage accuracy   |                  |      | 100 |      | mV <sub>DC</sub> |
| Overvoltage protection, latched_OFF (recovery by cycling OFF/ON via hardware or software) |                  | 14.5 |     | 15.5 | V <sub>DC</sub>  |
| Output current V <sub>OUT</sub> = 12V <sub>DC</sub>                                       | I <sub>OUT</sub> | 0    |     | 100  | A <sub>DC</sub>  |
| Current limit, Latched_OFF (programmable to auto restart)                                 | I <sub>OUT</sub> | 110  |     | 130  | A <sub>DC</sub>  |
| Short circuit protection Latched_OFF (programmable to auto restart)                       |                  |      |     |      |                  |
| Active current share  | I <sub>OUT</sub> | -5   |     | +5   | % of FL          |

| 5V <sub>DC</sub> STANDBY OUTPUT               |                  |     |     |                 |                   |
|---|------------------|-----|-----|-----------------|-------------------|
| Parameter                                     | Symbol           | Min | Typ | Max             | Unit              |
| Set point (optional 5V <sub>stb</sub> )       | V <sub>OUT</sub> | 4.9 | 5.0 | 5.1             | V <sub>DC</sub>   |
| Overall regulation (load, temperature, aging) | V <sub>OUT</sub> | -5  |     | +5              | %                 |
| Ripple and noise                              |                  |     | 50  | 66 <sup>4</sup> | mV <sub>p-p</sub> |
| Output current                                | I <sub>out</sub> | 0   |     | 1               | A <sub>DC</sub>   |

### General Specifications

| Parameter                  | Min | Typ          | Max | Units      | Notes   |
|----------------------------|-----|--------------|-----|------------|---|
| Reliability 25C, full load |     | 250,000      |     | Hrs        | MTBF per SR232 Reliability protection for electronic equipment, method I, case III, |
| Service Life               |     | 10           |     | Yrs        | Full load, excluding fans   |
| Weight                     |     | 1.65/( 3.7 ) |     | Kgs/ (Lbs) |   |

### Feature Specifications

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

| Parameter  | Symbol          | Min | Typ | Max | Unit            |
|--|-----------------|-----|-----|-----|-----------------|
| Remote ON/OFF( Pulled HI internally within the module ≈ 40kΩ to 3.3V <sub>DC</sub> ) |                 |     |     |     |                 |
| Logic High (Module ON)- either N/C or apply V > 3V <sub>DC</sub>                     | V <sub>IH</sub> | 2.0 | —   | 3.5 | V <sub>DC</sub> |
| Logic Low (Module OFF)   | V <sub>IL</sub> | —   | —   | 1   | mA              |
|  | V <sub>IL</sub> | 0   | —   | 0.8 | V <sub>DC</sub> |

<sup>3</sup> Setpoint can be voltage programmable or programmed by a resistor divider. An internal 20kΩ from V<sub>prog</sub> to 3.3V<sub>dc</sub> is provided. Add a resistor to complete the divider from V<sub>prog</sub> to output\_return.

<sup>4</sup> Measured at the output with 0.1μf ceramic and a 10μf tantalum capacitor in parallel. 20mHz bandwidth limitation.

## Technical Specifications (continued)

### Feature Specifications (continued)

| Parameter   | Symbol      | Min  | Typ | Max  | Unit       |
|---|-------------|------|-----|------|------------|
| Output Voltage programming ( $V_{prog}$ )<br>Equation: $V_{OUT} = 10.8 + (V_{prog} * 0.96)$ |             |      |     |      |            |
| $V_{prog}$ range  | $V_{prog}$  | 0    | —   | 2.5  | $V_{DC}$   |
| Programmed output voltage range   | $V_o$       | 10.8 | —   | 13.2 | $V_{DC}$   |
| Voltage adjustment resolution (8-bit A/D)   | $V_o$       | —    | 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  | —   | —    | $V_{DC}$   |
| Enable [ Pulled up internally via a 10K $\Omega$ resistor to 3.3V ]                         |             |      |     |      |            |
| 12V output OFF  | $V_I$       | 2.0  | —   | 3.5  | $V_{DC}$   |
| 12V output ON   | $V_I$       | 0    | —   | 0.8  | $V_{DC}$   |
| Write protect (Wp) ( Pulled up internally via a 10K $\Omega$ resistor to 3.3V )             |             |      |     |      |            |
| Write protect enabled   | $V_I$       | 2.0  | —   | 3.5  | $V_{DC}$   |
| Write protect disabled  | $V_I$       | 0    | —   | 0.8  | $V_{DC}$   |
| INPUT-OK ( Pulled up internally via a 10K $\Omega$ resistor to 3.3V )                       |             |      |     |      |            |
| Logic High (Input within normal range)  | $V_{OH}$    | 2.0  | —   | 3.5  | $V_{DC}$   |
| Logic Low (Input out of range)  | $I_{OL}$    | —    | —   | 20   | mA         |
|   | $V_{OL}$    | 0    | —   | 0.8  | $V_{DC}$   |
| DC-OK ( Pulled up internally via a 10K $\Omega$ resistor to 3.3V )                          |             |      |     |      |            |
| Logic High (Output voltage is present)  | $V_{OH}$    | 2.0  | —   | 3.5  | $V_{DC}$   |
| Logic Low (Output voltage is not present)   | $I_{OL}$    | —    | —   | 20   | mA         |
|   | $V_{OL}$    | 0    | —   | 0.8  | $V_{DC}$   |
| Temperature OK (Pulled up internally via a 10k $\Omega$ resistor to 3.3V)                   |             |      |     |      |            |
| Logic High (temperature within normal range)  | $V_{OH}$    | 2.0  | —   | 3.5  | $V_{DC}$   |
| Logic Low (temperature is too high)   | $I_{OL}$    | —    | —   | 20   | mA         |
|   | $V_{OL}$    | 0    | —   | 0.8  | $V_{DC}$   |
| Delayed shutdown after Logic Low transition   | $T_{delay}$ | 10   | —   | —    | sec        |
| Fault ( Pulled up internally via a 10K $\Omega$ resistor to 3.3V )                          |             |      |     |      |            |
| Logic High (No fault is present)  | $V_{OH}$    | 2.0  | —   | 3.5  | $V_{DC}$   |
| Logic Low (Fault is present)  | $I_{OL}$    | —    | —   | 20   | mA         |
|   | $V_{OL}$    | 0    | —   | 0.8  | $V_{DC}$   |
| PS Present  |             |      |     |      |            |
| Logic High (Power supply is not plugged in)   |             |      |     |      |            |
| Logic Low (Power supply is present)   | $V_{IL}$    | 0    | —   | 0.1  | $V_{DC}$   |
| SMBAlert# (Interrupt) ( Pulled up internally via a 10K $\Omega$ resistor to 3.3V )          |             |      |     |      |            |
| Logic High (No Alert - normal)  | $V_{OH}$    | 2.0  | —   | 3.5  | $V_{DC}$   |
| Logic Low (Alert is set)  | $I_{OL}$    | —    | —   | 20   | mA         |
|   | $V_{OL}$    | 0    | —   | 0.8  | $V_{DC}$   |
| Output current monitor ( $I_{mon}$ )  |             |      |     |      |            |
| Resolution  |             |      | 100 |      | mV/A       |
| Accuracy  |             | -250 |     | +250 | mV         |
| Measurement range   | $I_o$       | 0    |     | 100  | A $_{DC}$  |
| Analog output range   | $V_{mon}$   | 0    |     | 10   | $V_{DC}$   |
| Sourced output current  | $I_o$       |      |     | 5    | mA $_{DC}$ |

## Technical Specifications (continued)

### Digital Interface Specification

| Parameter   | Conditions      | Symbol         | Min | Typ | Max | Unit     |
|---|-----------------|----------------|-----|-----|-----|----------|
| <b>PMBus Signal Interface Characteristics</b>                 |                 |                |     |     |     |          |
| Input Logic High Voltage (CLK, DATA)                          |                 | $V_{IH}$       | 2.1 |     | 3.6 | $V_{DC}$ |
| Input Logic Low Voltage (CLK, DATA)                           |                 | $V_{IL}$       | 0   |     | 0.8 | $V_{DC}$ |
| Input high sourced current (CLK, DATA)                        |                 | $I_{IH}$       | 0   |     | 10  | $\mu A$  |
| Output Low sink Voltage (CLK, DATA, SMBALERT#)                | $I_{OUT}=3.5mA$ | $V_{OL}$       |     |     | 0.4 | $V_{DC}$ |
| 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  | $\mu A$  |
| PMBus Operating frequency range                               | Slave Mode      | $F_{PMB}$      | 10  |     | 400 | kHz      |
| <b>Measurement System Characteristics</b>                     |                 |                |     |     |     |          |
| Clock stretching  |                 | $t_{STRETCH}$  |     |     | 25  | ms       |
| $I_{OUT}$ measurement range                                   | Linear          | $I_{RNG}$      | 0   |     | 100 | $A_{DC}$ |
| $I_{OUT}$ measurement accuracy 25°C                           |                 | $I_{ACC}$      | -10 |     | +10 | %        |
| $V_{OUT}$ 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 <sup>5</sup>                        |                 | $Temp_{(acc)}$ | -5  |     | +5  | %        |

<sup>5</sup> Temperature accuracy reduces non-linearly with decreasing temperature

## Technical Specifications (continued)

### Environmental Specification

| Parameter                                    | Min   | Typ | Max       | Units                | Notes  |
|--|---|-----|-----------|----------------------|--|
| Ambient Temperature                          | -10 <sup>6</sup>                                |     | 70        | °C                   | Air inlet from sea level to 5,000 feet.      |
| Storage Temperature                          | -40   |     | 85        | °C                   |  |
| Operating Altitude                           |   |     | 2250/7382 | m/ft                 |  |
| Non-operating Altitude                       |   |     | 8200/30k  | m / ft               |  |
| Power Derating with Temperature              |   |     | 2.5       | %/°C                 | 50°C to 70°C <sup>7</sup>                    |
| Operating Temperature Derating with Altitude |   |     | 2.0       | C/305 m<br>C/1000 ft | Above 2250 /7382 m / ft; 3962/13000 m/ft max |
| Acoustic noise                               |   | 55  |           | dbA                  | 25°C ,Half load                              |
| Humidity                                     |   |     |           |                      |  |
| Operating                                    | 30  |     | 95        | %                    | Relative humidity, non-condensing            |
| Storage                                      | 10  |     | 95        | %                    |  |
| Shock and Vibration                          | Meet IPC 9592 Class II . Section 5 requirements |     |           |                      |  |

### EMC Specification

| EMC                |                     |  |       |          |                                  |
|--------------------|---------------------|--|-------|----------|----------------------------------|
| Parameter          | Function            | Standard                                       | Level | Criteria | Test                             |
| DC input           | Conducted emissions | EN55032, FCC Part 15<br>Telcordia GR1089-CORE  | A     |          | 0.15 – 30MHz                     |
|                    | Radiated emissions  | EN55032  | A     |          | 30 – 10000MHz                    |
| DC input immunity  | Voltage dips        | IEC 61000-4-29 [VIN start: 50V <sub>dc</sub> ] |       | A        | -30%, 10ms                       |
|                    |                     |  |       | B        | -60%, 100ms                      |
|                    |                     |  |       | A        | -100%, 2.5ms                     |
|                    |                     |  |       | B        | -100%, 5sec                      |
|                    | Voltage surge       | EN61000-4-5                                    | 3     | A        | 2kV, 1.2/50µs, common mode       |
|                    |                     |  | 3     | A        | 1kV, 1.2/50µs, differential mode |
|                    | Fast transients     | EN61000-4-4                                    | 2     | A        | 5/50ns, 1kV (common mode)        |
| Enclosure immunity | Conducted RF fields | EN61000-4-6                                    | A     |          | 130dBµV, 0.15-80MHz, 80% AM      |
|                    | Radiated RF fields  | EN61000-4-3, level 3                           | A     |          | 10V/m, 80-1000MHz, 80% AM        |
|                    |                     | ENV50140                                       | A     |          |                                  |
|                    | ESD                 | EN61000-4-2, level 3                           | B     |          | 6kV contact, 8kV air             |

#### Criteria Performance

- A No performance degradation
- B Temporary loss of function or degradation not requiring manual intervention
- C Temporary loss of function or degradation that may require manual intervention
- D Loss of function with possible permanent damage

<sup>6</sup> Designed to start at an ambient down to -30°C; meet spec after 30 min warm up period, may not meet operational limits below -10°C.

<sup>7</sup> The maximum operational ambient is reduced in Europe in order to meet certain power cord maximum ratings of 70°C. The maximum operational ambient where 70°C rated power cords are utilized is reduced to 60°C until testing demonstrates that a higher level is acceptable.

## Technical Specifications (continued)

### Characteristic Curves

The following figures provide typical characteristics for the CAR1212DC converter at 25°C.

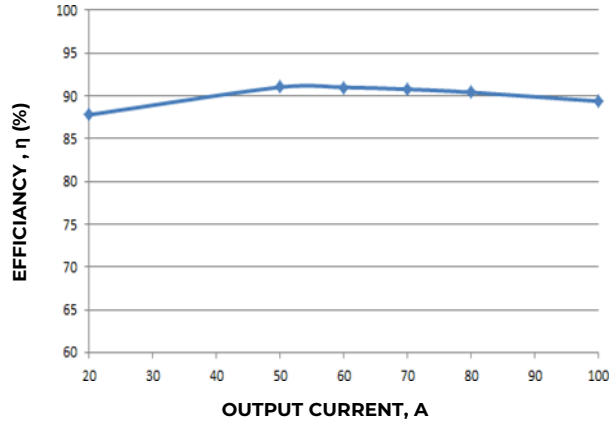


Figure 1. Converter Efficiency versus Output Current.

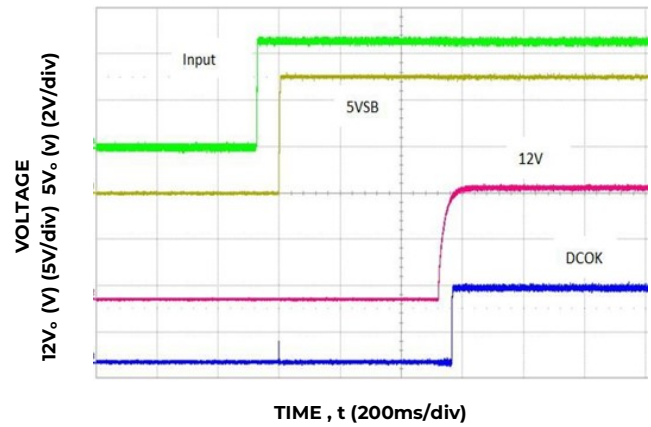


Figure 2. Input Start up ( $V_{in} = -48V_{DC}$ , full load)

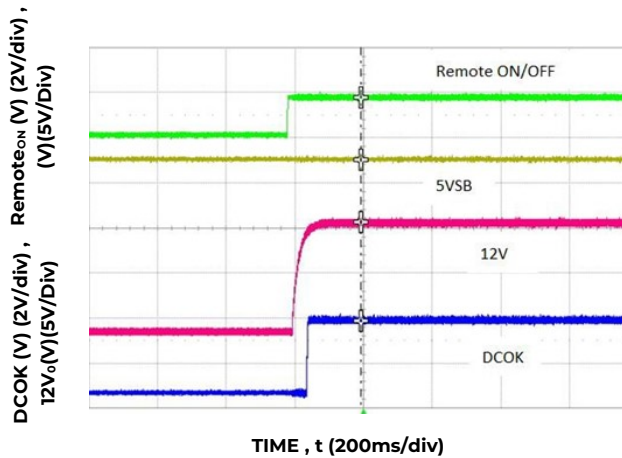


Figure 3. Start-up Using Remote On/OFF ( $V_{in} = -48V_{DC}$ , full load).

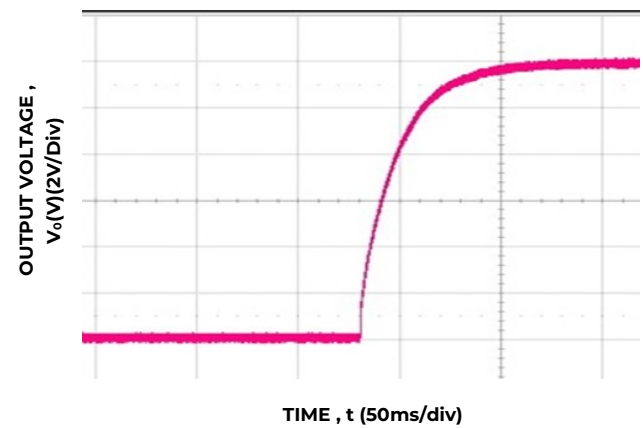


Figure 4. 12V start-up ( $V_{in} = -48V_{DC}$ , full load)

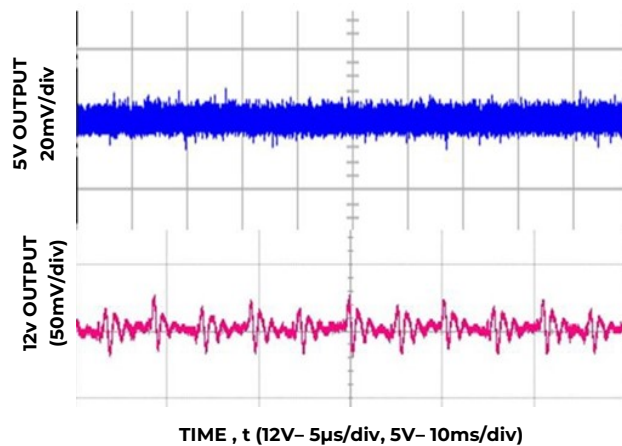


Figure 5. 12V output ripple and noise ( $V_{in} = -48V_{dc}$ , full load)

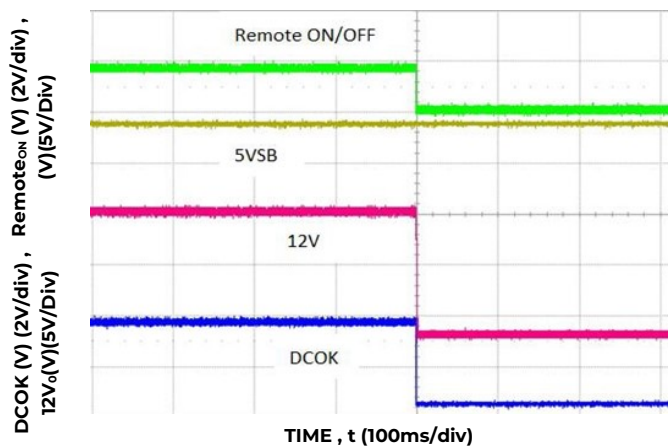


Figure 6. Turn - OFF via remote ON/OFF ( $V_{in} = -48V_{dc}$ , full load)



## Technical Specifications (continued)

### Characteristic Curves (continued)

The following figures provide typical characteristics for the CAR1212DC converter at 25°C.

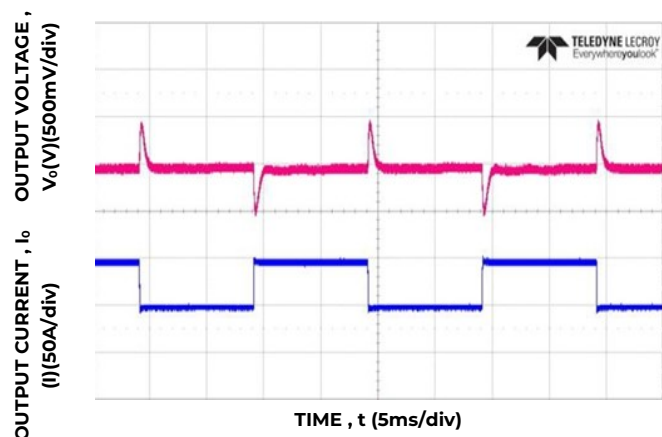


Figure 7. Transient response 12V<sub>DC</sub> output load step 10 – 60A, V<sub>IN</sub> = -48V<sub>DC</sub>.

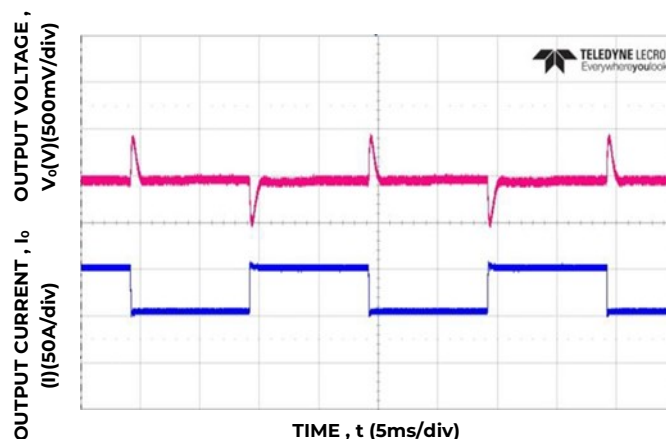


Figure 8. Transient response 12V<sub>DC</sub> output load step 50 – 100A, V<sub>IN</sub> = -48V<sub>DC</sub>.

| SYSTEM CURRENT STEPS | %LOAD  | I total (A) | I UNIT #1 | I UNIT #2 | % I share |
|----------------------|--|-------------|-----------|-----------|-----------|
|                      | 100  | 200         | 96.89     | 102.6     | 2.8%      |
|                      | 75   | 150         | 72.56     | 78.21     | 2.8%      |
|                      | 50   | 100         | 47.46     | 52.64     | 2.5%      |
|                      | 30   | 60          | 28.41     | 32.61     | 2.1%      |
|                      | 20   | 40          | 18.42     | 21.83     | 1.7%      |
|                      | TOTAL & INDIVIDUAL CURRENT READINGS / %SHARE |             |           |           |           |

TOTAL & INDIVIDUAL CURRENT READINGS / %SHARE

Table 9. Current share between two modules

|                   | NO LOAD | FULL LOAD |
|-------------------|---------|-----------|
|                   | 25°C    | 25°C      |
| Turn on point (V) | 34.9    | 34.9      |
| Turn on point (V) | 30.5    | 30.8      |
| Hysteresis (V)    | 4.4     | 4.1       |

Table 10. Input Turn OFF and Turn ON

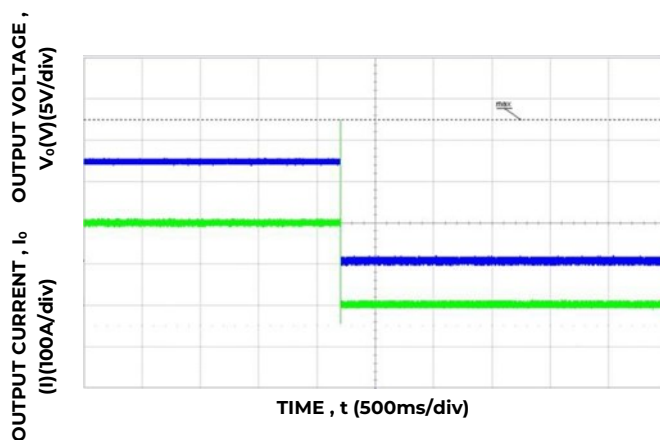


Figure 11. Overload: output short circuit performance, the unit is in latch\_OFF mode, V<sub>IN</sub> = -48V<sub>DC</sub>.

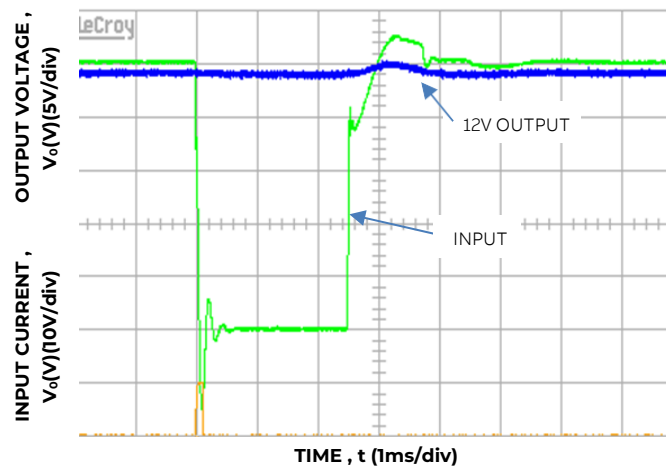


Figure 12. Ride through: full load V<sub>in</sub> = -48V<sub>DC</sub>



## Technical Specifications (continued)

### 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 ( $V_{prog}$ ) and the PMBus command, ( $V_{out\_command}$ ).

Using output voltage as an example; the  $V_{prog}$  signal pin has ultimate control of the output voltage until the  $V_{prog}$  is either  $> 3V_{DC}$  or a no connect. When the programming signal via  $V_{prog}$  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, ( $V_{out\_command}$ ).

**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 'Vstb return' and 'Signal return'.

### Control Signals

**Voltage programming ( $V_{prog}$ ):** An analog voltage on this signal can vary the output voltage from  $10.8V_{DC}$  to  $13.2V_{DC}$ . The equation of this signal is:

$$V_{OUT} = 10.8 + (V_{prog} * 0.96) \text{ where } V_{prog} = 0.1 \text{ to } 2.5V$$

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

**Load share ( $I_{share}$ ):** This is a single wire analog signal that is generated and acted upon automatically by power supplies connected in parallel. The  $I_{share}$  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 main  $12V_{DC}$  output voltage on the output connector. This signal is pulled HI internally. Leaving this pin a no-connect turns ON the  $12V_{DC}$  output. Applying a Logic 0 (TTL LO level) to this pin turns OFF the  $12V_{DC}$  output. A turn OFF command either through this signal (Remote ON/OFF) or firmware commanded would turn OFF the  $12V_{DC}$  output.

**Enable:** This is a short signal pin that controls the presence of the  $12V_{DC}$  on the output connector. 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.

**Write protect (WP):** This signal protects the contents of the EEPROM from accidental over writing. When left open the EEPROM is write protected. A LO (TTL compatible) permits writing to the EEPROM. This signal is pulled HI internally by the power supply.

### Status Signals

**Output current monitor ( $I_{mon}$ ):** A voltage level proportional to the delivered output current is present on this pin. The signal level is  $0.1V \text{ per amp} \pm 0.25V$ .

**Input OK:** A TTL compatible status signal representing whether the input voltage is within the anticipated range. This signal needs to be pulled HI externally through a resistor. Open collector (HI) on this signal indicates that the input voltage is applied within the specified input range.

**DC\_OK:** A TTL compatible status signal representing whether the output voltage is present. This signal needs to be pulled HI externally through a resistor. Open collector (HI) on this signal indicates that the output voltage is present.

**Temperature Ok:** A TTL compatible status signal representing whether an over temperature exists. This signal needs to be pulled HI externally through a resistor. Open collector (HI) on this signal indicates that temperatures are normal.

If an over temperature should occur, this signal would pull LO for approximately 10 seconds prior to shutting down the power supply. The unit would restart if internal temperatures reduce 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 needs to be pulled HI externally through a resistor. Open collector (HI) on this signal indicates that no Fault is present.

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 to detect a missing module.

## Technical Specifications (continued)

### Control Signals (continued)

**Interrupt (SMBAlert):** A TTL compatible status signal, representing the SMBusAlert# feature of the PMBus compatible I2C protocol in the power supply. This signal needs to be pulled HI externally through a resistor. Open collector (HI) on this signal indicates that no Interrupt has been triggered.

### Serial Bus Communications

The I<sup>2</sup>C interface incorporated within the CAR1212DC modules facilitates the monitoring and control of various operating parameters within the unit and transmits these on demand over an industry standard I<sup>2</sup>C Serial bus. All signals are referenced to 'Signal Return'.

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

| Device    | Address | Address Bit Assignments |   |   |   |    |    |    |     |
|-----------|---------|-------------------------|---|---|---|----|----|----|-----|
| 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 |

The **Global Broadcast** instruction executes a simultaneous write instruction to all power supplies. A **read** instruction cannot be accessed globally. The three programmable address bits are the same for all I<sup>2</sup>C accessible devices within the power supply.

**Address lines (A2, A1, A0):** These signal pins allow up to eight (8) CAR1212DC modules to be addressed on a single I<sup>2</sup>C bus. The pins are pulled HI internal to the power supply. For a logic LO these pins should be connected to 'Output Return'

**Serial Clock (SCL):** The clock pulses on this line are generated by the host that initiates communications across the I<sup>2</sup>C Serial bus. This signal is 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 I<sup>2</sup>C specifications.

**Serial Data (SDA):** This line is a bi-directional data line. This signal is 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 I<sup>2</sup>C specifications.

### Digital Feature Descriptions

**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.

**I<sup>2</sup>C 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.

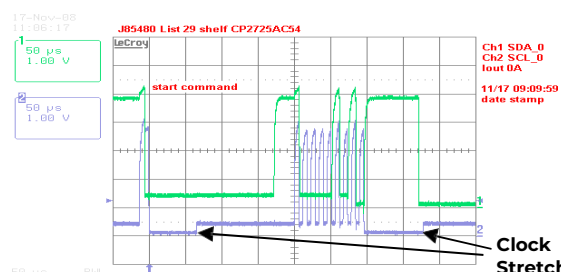


Figure 1.3. Example waveforms showing clock stretching

**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.

## Technical Specifications (continued)

### Digital Feature Descriptions (continued)

**Packet Error Checking (PEC):** Although Commands issued without the correct trailing PEC will not be executed. 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 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 The  $\mu$ C 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 either receives a 'clear' instruction as outlined below or executes a READ STATUS\_WORD. If the alarm state is still present after the STATUS registers were reset, then the signal will revert back into its LO state again and will latch until a subsequent reset signal is received from the host controller.

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

- $V_{IN}$  and under or over voltage
- $I_{OUT}$  over current
- Over Temperature warning or fault
- Fan Failure
- Communication error
- PEC error
- Invalid command
- Internal faults

The power supply will clear the SMBAlert# 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 ENABLE signal pin
- The main output recycled (turned OFF and then ON) by the OPERATION command

**Global broadcast:** This is a powerful command because it can instruct all power supplies to respond simultaneously in one command. But it does have a serious disadvantage. 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.



**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 the triggering of successive SMBAlert# s and thus 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.

### 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

## Technical Specifications (continued)

### PMBus™ Commands (continued)

**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 instruction:** 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 |
| ..... | A | Data 48 | A | PEC | 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 |
| ..... | A | Data 48 | A | PEC | 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 complement mantissa, E is the 5-bit, two's complement exponent

### PMBus™ Commands Set:

| Command                | Hex Code | Data Byte | Write | Function / Default |
|------------------------|----------|-----------|-------|--------------------|
| Operation              | 01       | 1         | W     | 0 x 80             |
| ON_OFF_config          | 02       | 1         |       | 0 x 1F             |
| Clear_faults           | 03       | 0         |       | Clear Status       |
| Write_protect          | 10       | 1         | W     | 0 x 80             |
| Store_default_all      | 11       | 0         | W     | Store permanently  |
| Restore_default_all    | 12       | 0         |       | Reset defaults     |
| Vout_mode              | 20       | 1         |       | 0 x 17             |
| Vout_command           | 21       | 2         | W     | Set Vout           |
| Fan_config_1_2         | 3A       | 1         | W     | RPM or duty cycle  |
| Fan_speed_control      | 3B       | 2         | W     | Set fan speed      |
| Vout_OV_fault_limit    | 40       | 2         | W     | 14                 |
| Vout_OV_fault_response | 41       | 1         |       | 0 x 80             |
| Vout_OV_warn_limit     | 42       | 2         | W     | 13.5               |
| Iout_OC_fault_limit    | 46       | 2         | W     | 115                |
| Iout_OC_fault_response | 47       | 1         | W     | 0x41               |
| Iout_OC_warn_limit     | 4A       | 2         | W     | 105                |
| OT_fault_limit         | 4F       | 2         | W     | 115                |
| OT_fault_response      | 50       | 1         | W     | 0 x C0             |
| OT_warn_limit          | 51       | 2         | W     | 112                |
| Vin_OV_fault_limit     | 55       | 2         | W     | 80                 |
| Vin_OV_fault_response  | 56       | 1         |       | 0 x C0             |
| Vin_OV_warn_limit      | 57       | 2         | W     | 77                 |
| Vin_UV_warn_limit      | 58       | 2         | W     | 35                 |
| Vin_UV_fault_limit     | 59       | 2         | W     | 32                 |
| Vin_UV_fault_response  | 5A       | 1         |       | 0 x C0             |
| Status_byte            | 78       | 1         |       |                    |
| Status_word            | 79       | 2         |       |                    |
| Status_Vout            | 7A       | 1         |       |                    |
| Status_Iout            | 7B       | 1         |       |                    |
| Status_input           | 7C       | 1         |       |                    |
| Status_temperature     | 7D       | 1         |       |                    |
| Status_CML             | 7E       | 1         |       |                    |
| Status_mfr_specific    | 80       | 1         |       |                    |
| Status_fan_1_2         | 81       | 1         |       |                    |
| Read_Vin               | 88       | 2         |       | Read input voltage |

## Technical Specifications (continued)

### PMBus™ Commands Set: (continued)

| Command                         | Hex Code | Data Byte | Write | Function / Default    |
|---------------------------------|----------|-----------|-------|-----------------------|
| Read_Vout                       | 8B       | 2         |       | Read output voltage   |
| Read_Iout                       | 8C       | 2         |       | Read output current   |
| Read_temperature_1              | 8D       | 2         |       | Read temperature      |
| Read_Pin                        | 97       | 2         |       | Read input power      |
| PMBus revision                  | 98       | 1         |       |                       |
| Read fan_speed                  | 90       | 2         |       | Reads in RPM          |
| Mfr_ID                          | 99       | 5         |       | FRU_ID                |
| Mfr_model                       | 9A       | 15        |       |                       |
| Mfr_revision                    | 9B       | 4         |       |                       |
| Mfr_location                    | 9C       | 4         |       |                       |
| Mfr_date                        | 9D       | 6         |       |                       |
| Mfr_serial                      | 9E       | 15        |       |                       |
| Mfr_Vin_min                     | A0       | 2         |       | 36V (linear format)   |
| Mfr_Vin_max                     | A1       | 2         |       | 75V (linear format)   |
| Mfr_Iin_max                     | A2       | 2         |       | 40A (linear format)   |
| Mfr_Pin_max                     | A3       | 2         |       | 1400W (linear format) |
| Mfr_Vout_min                    | A4       | 2         |       | 10V (linear format)   |
| Mfr_Vout_max                    | A5       | 2         |       | 15V (linear format)   |
| Mfr_Iout_max                    | A6       | 2         |       | 100A (linear format)  |
| Mfr_Pout_max                    | A7       | 2         |       | 1200W (linear format) |
| Mfr_Tambient_max                | A8       | 2         |       | 70C (linear format)   |
| Mfr_Tambient_min                | A9       | 2         |       | -10C (linear format)  |
| FRW_revision                    | D0       | 1         |       |                       |
| Fan_duty_cycle_I <sup>2</sup> C | D6       | 1         |       | Duty_cycle read in %  |
| DCOKHI_I <sup>2</sup> C         | E6       | 2         |       | (1/512V)              |
| DCOKLO_I <sup>2</sup> C         | E7       | 2         |       | (1/512V)              |

### Status Register Bit Allocation:

| Register  | Hex Code | Data Byte | Function                     |
|---|----------|-----------|------------------------------|
| Status_Byte [0 – normal 1-fault]                        | 78       | 7         | Busy                         |
|   |          | 6         | DC_OFF                       |
|   |          | 5         | Output OV Fault              |
|   |          | 4         | Output OC Fault              |
|   |          | 3         | Input UV Fault               |
|   |          | 2         | Temp Fault/warning           |
|   |          | 1         | CML (communication fault)    |
|   |          | 0         | None of Below                |
| Status_word (includes Status_byte) [0 – normal 1-fault] | 79       | 7         | VOUT Fault/Warning detected  |
|   |          | 6         | OC Fault/Warning detected    |
|   |          | 5         | Input Fault/Warning          |
|   |          | 4         | Mfr_specific register change |
|   |          | 3         | nPower_Good                  |
|   |          | 2         | Fan Fault or Warning         |
|   |          | 1         | Other fault                  |
|   |          | 0         | Unknown                      |

| Register                                 | Hex Code | Data-Byte | Function                    |
|--|----------|-----------|-----------------------------|
| Status_Vout [0 – normal 1-fault]         | 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 [0 – normal 1-fault]         | 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 [0 – normal 1-fault]        | 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 [0 – normal 1-fault]  | 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_cml [0 – normal 1-fault]          | 7E       | 7         | Invalid/Unsupported Command |
|  |          | 6         | Invalid/Unsupported Data    |
|  |          | 5         | Packet Error Check Failed   |
|  |          | 4         | Memory Fault Detected       |
|  |          | 3         | Processor Fault Detected    |
|  |          | 2         | Reserved                    |
|  |          | 1         | Other Communications Fault  |
|  |          | 0         | Other Memory or Logic Fault |
| Status_mfr_specific [1 – normal 0-fault] | 80       | 7         | 5V_fault                    |
|  |          | 6         | OVSD                        |
|  |          | 5         | Interrupt                   |
|  |          | 4         | Fault detected              |
|  |          | 3         | PS_remote_OFF               |
|  |          | 2         | DC_fault                    |
|  |          | 1         | INPUT_fault                 |
|  |          | 0         | N/A                         |
| Status_fan_1_2 [0 – normal 1-fault]      | 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                         |



## Technical Specifications (continued)

### 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. This default cannot be changed

| FUNCTION  | DATA BYTE |
|---|-----------|
| Enable all writes                                     | 0 × 00    |
| Disable all writes except write_protect               | 0 × 80    |
| Disable all writes except write_protect and OPERATION | 0 × 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  $V_{prog}$  signal pin. The program no longer looks at the 'V<sub>prog</sub> pin' and will not respond to any hardware voltage settings. If power is removed from the  $\mu$ Controller it will reset itself into its default configuration looking at the  $V_{prog}$  signal for output voltage control. In many applications, the  $V_{prog}$  pin is used for setting initial conditions, if different that the factory setting. Software programming then takes over once I<sup>2</sup>C communications are established.

**Vout\_OV[OT]\_warn\_limit (42[51]):** Provides the capability to change the OV[OT] shutdown limit. The unit ensures that the changed value is within adjustable levels and within the max/min limits. If the requested value is not within max/min limits the change should not take place and a CML error should be issued.

**Vout\_OV[OT]\_warn\_limit (42[51]):** OV[OT]\_warning is extremely useful because it gives the system controller a heads up that the output voltage/temperature is drifting out of regulation and the power supply is close to shutting down. Preemptive 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 OC and OT is shown in the tables. Each register, individually, can be reconfigured into the opposite state. Latched\_OFF 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 i<sup>2</sup>c 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.

## Technical Specifications (continued)

### Command Descriptions (continued)

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 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.

**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.

**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.

**FRU\_ID** all in ASCII except mfr\_revision

**Mfr\_ID (99):** 5 characters: OmniOn—CP (OmniOn - Critical Power)

**Mfr\_model (9A):** product name example: CAR1212DCBLCZ1A

**Mfr-revision (9B):** Total 4 hex bytes

Each byte is partitioned into high and low nibbles.

Example: 99 is read as 9.9 [numerical digits only]

11 is read as 1.1

| Series | Hardware Rev | Primary $\mu$ C | Secondary $\mu$ C |
|--------|--------------|-----------------|-------------------|
|        |              |                 |                   |

**Mfr\_location (9C):** up to 4 bytes identifying country of manufacture.

**Mfr\_date (9D):** Follows standard PMBus format YYMMDD

**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\_'s (spaces) are filled in, (i.e. 018193\_\_), ensuring that the actual serial number is clearly identified.

**Note: The actual data in the FRU\_ID registers may deviate from the above representation at the discretion of the manufacturing location.**

**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. An invalid command always returns a value of 0 x 00.



## Technical Specifications (continued)

### Control and Read accuracy:

The estimates below are believed to be reasonable under most operating conditions. However, these are typical numbers and not hard bound values that cannot be exceeded. In most nominal operating conditions the returned values are significantly better than these estimates.

| FUNCTION                          | ACCURACY                |
|-----------------------------------|-------------------------|
| Vout_command                      | $\pm 2\%$               |
| Vout_OV_fault_limit               | $\pm 3\%$               |
| Iout_OC_warn_limit                | $\pm 4\%$ of FL         |
| OT_warn_limit (see note below)    | $\pm 5^{\circ}\text{C}$ |
| Vin_UV_warn_limit                 | $\pm 3\%$               |
| Vin_UV_fault_limit                | $\pm 3\%$               |
| Read_Vout                         | $\pm 2\%$               |
| Read_Iout                         | $\pm 4\%$ of FL         |
| Read_temperature (see note below) | $\pm 5^{\circ}\text{C}$ |

Note: Temperature accuracy is estimated near the shutdown point around  $100^{\circ}\text{C}$ . At lower temperatures the accuracy is much reduced

Fan speed: Speed control can vary from 0 – 100% duty cycle, where 100% is 16,000 RPM. Internal control is designed to minimize fan speed to that level that is required, thereby ensuring quiet operational levels.

### EEPROM

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

Another separate EEPROM IC will provide another 128 bytes of memory with write protect feature. This EEPROM is only for customer.

### LEDs

Three LEDs are located on the front faceplate. When the LEDs are ON GREEN then input and output are normal.

When the FAULT\_LED is RED, then a fault condition exists and the power supply may not provide output power. The following ALARM table further defines these states:

### FOOTNOTES

\* UL is a registered trademark of Underwriters Laboratories, Inc.

† 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)

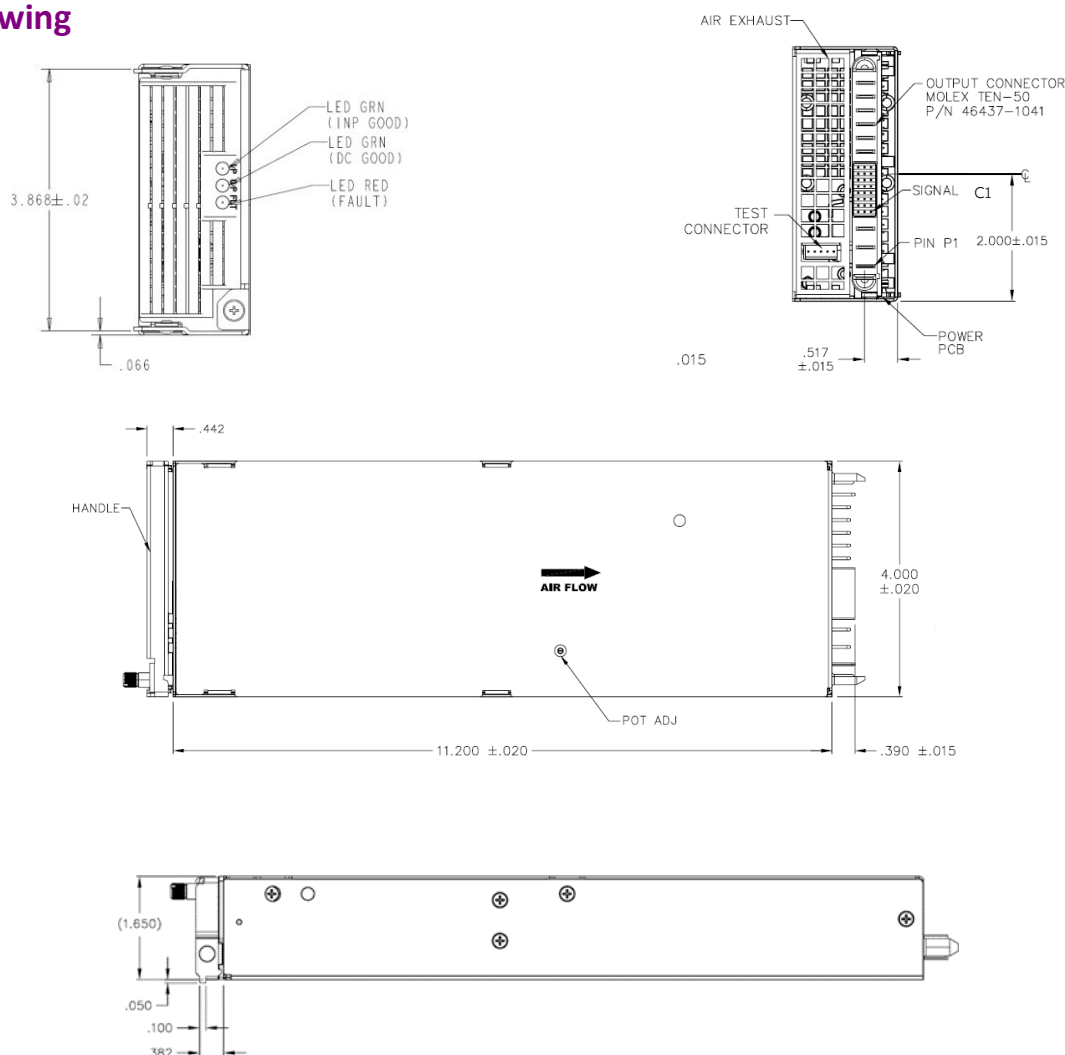
## Technical Specifications (continued)

### Alarm Table

| Test Condition |                  | LED Indicator |       |       | Monitoring Signals |       |          |         |
|----------------|------------------|---------------|-------|-------|--------------------|-------|----------|---------|
|                |                  | INPUT OK      | DC OK | FAULT | FAULT              | DC OK | INPUT OK | TEMP OK |
| 1              | Normal Operation | Green         | Green | OFF   | High               | High  | High     | High    |
| 2              | Low or NO INPUT  | OFF           | OFF   | RED   | Low                | Low   | Low      | High    |
| 3              | OVP              | Green         | OFF   | RED   | Low                | Low   | High     | High    |
| 4              | Over Current     | Green         | OFF   | RED   | Low                | Low   | High     | High    |
| 5              | Over Temp Fault  | Green         | OFF   | RED   | Low                | Low   | High     | Low     |

Note: Test condition #2 has 2 modules working in parallel. One module is running and the other has no input

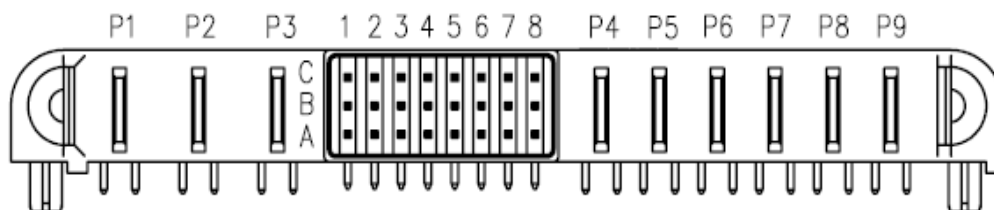
### Outline Drawing



## Technical Specifications (continued)

### Connector Pin Assignment

**Input/Output** Molex P/N: 46437-1041 Mating connector: Molex P/N: 46436-1041



| Pin | Function           | Pin | Function                  | Pin | Function                      | Pin     | Function                       |
|-----|--------------------|-----|---------------------------|-----|-------------------------------|---------|--------------------------------|
| A1  | V <sub>prog</sub>  | B1  | Write Protect (WP)        | C1  | Remote ON/OFF                 | P1      | V <sub>IN</sub> ( + )          |
| A2  | PS Present         | B2  | DC OK                     | C2  | SDA (I <sup>2</sup> C bus)    | P2      | V <sub>IN</sub> ( - ) [return] |
| A3  | OVP Test Point     | B3  | INPUT OK                  | C3  | SCL (I <sup>2</sup> C bus)    | P3      | GND                            |
| A4  | Fault              | B4  | V <sub>STDBY</sub> return | C4  | V <sub>stb</sub> return       |         |                                |
| A5  | Remote Sense ( + ) | B5  | SMBAlert (Interrupt)      | C5  | I <sup>2</sup> C Address (A2) | P4 – P6 | +12V <sub>DC</sub>             |
| A6  | Temperature OK     | B6  | I Monitor (IMON)          | C6  | I <sup>2</sup> C Address (A1) | P7 – P9 | Power Return                   |
| A7  | N/C                | B7  | V <sub>STDBY</sub> [5V]   | C7  | I <sup>2</sup> C Address (A0) |         |                                |
| A8  | Remote Sense ( - ) | B8  | Enable (short pin)        | C8  | Ishare                        |         |                                |

### Ordering Information

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

| PRODUCT         | DESCRIPTION  | PART NUMBER      |
|-----------------|--|------------------|
| 1200W converter | 12V <sub>DC</sub> DC-DC converter w/Bezel, 5Vaux   | CAR1212DCBLCZ01A |
| 1200W converter | 12V <sub>DC</sub> DC-DC converter w/Bezel, 3.3Vaux | CAR1212DCBLCZ02A |

### Contact Us

For more information, call us at

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1-972-244-9288 (Int'l)

## Change History (excludes grammar & clarifications)

| Revision | Date       | Description of the change            |
|----------|------------|--------------------------------------|
| 4.3      | 12/11/2021 | Updated as per template              |
| 4.4      | 06/24/2023 | Missing content added on page 9 & 12 |
| 4.5      | 11/01/2023 | Updated as per OmniOn template       |

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