

# DELPHI SERIES



## FEATURES

- ◆ High Efficiency: 92.7% @ 28V/16A
- ◆ Size: 61.0x57.9x12.7mm (2.40"×2.28"×0.50")
- ◆ Standard footprint
- ◆ Industry standard pin out
- ◆ Fixed frequency operation
- ◆ Metal baseplate (heatspreader)
- ◆ Input UVLO, Output OCP, OVP, OTP
- ◆ Basic insulation
- ◆ 1500V isolation
- ◆ 2:1 Input voltage range
- ◆ ISO 9001, TL 9000, ISO 14001, QS9000, OHSAS18001 certified manufacturing facility
- ◆ UL/cUL 60950-1 (US & Canada) recognized

## Delphi Series H48SA, 450W Half Brick Family DC/DC Power Modules: 48V in, 28V/16A out

The Delphi Series H48SA Half Brick, 48V input, single output, isolated DC/DC converters are the latest offering from a world leader in power systems technology and manufacturing -- Delta Electronics, Inc. The H48SA28016 product provides up to 450 watts of power or 28V/16A in an industry standard footprint. It provides 92.7% efficiency for 28V at full load. With creative design technology and optimization of component placement, these converters possess outstanding electrical and thermal performance, as well as extremely high reliability under highly stressful operating conditions. All models are fully protected from abnormal input/output voltage, current, and temperature conditions. The Delphi Series converters meet all safety requirements with basic insulation. A variety of optional heatsinks are available for extended thermal operation as well as for use in higher air flow applications: 200 to 400 LFM.

## OPTIONS

- ◆ Positive on/off logic
- ◆ Output OVP hiccup option

## APPLICATIONS

- ◆ Telecom / Datacom
- ◆ Wireless Networks
- ◆ Optical Network Equipment
- ◆ Server and Data Storage
- ◆ Industrial / Testing Equipment

DATASHEET

DS\_H48SA28016\_11272018



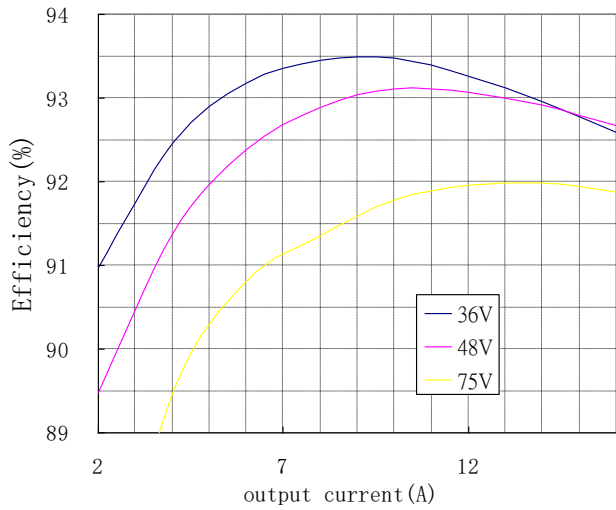
# TECHNICAL SPECIFICATIONS

(T<sub>A</sub>=25°C, airflow rate=300 LFM, V<sub>in</sub>=48Vdc, nominal V<sub>out</sub> unless otherwise noted.)

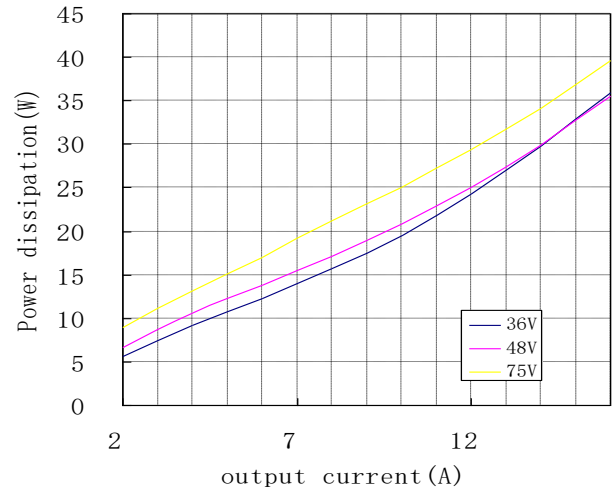
| PARAMETER  | NOTES and CONDITIONS  | H48SA28016 (Standard) |       |       |                  |
|--|---|-----------------------|-------|-------|------------------|
|  |   | Min.                  | Typ.  | Max.  | Units            |
| <b>ABSOLUTE MAXIMUM RATINGS</b>                    |   |                       |       |       |                  |
| <b>Input Voltage</b>                               |   |                       |       |       |                  |
| Continuous   |   |                       |       | 80    | Vdc              |
| Transient  | 100ms   |                       |       | 100   | Vdc              |
| Operating Temperature                              | Please refer to Fig. 21 for measuring point   | -40                   |       | 98    | °C               |
| Storage Temperature                                |   | -55                   |       | 125   | °C               |
| Input/Output Isolation Voltage                     |   |                       |       | 1500  | Vdc              |
| <b>INPUT CHARACTERISTICS</b>                       |   |                       |       |       |                  |
| Operating Input Voltage                            |   | 36                    | 48    | 75    | Vdc              |
| Input Under-Voltage Lockout                        |   |                       |       |       |                  |
| Turn-On Voltage Threshold                          |   | 33                    |       | 35    | Vdc              |
| Turn-Off Voltage Threshold                         |   | 31                    |       | 33    | Vdc              |
| Lockout Hysteresis Voltage                         |   |                       | 2     |       | Vdc              |
| Maximum Input Current                              | 100% Load, 36Vin  |                       |       | 16    | A                |
| Minimum -Load Input Current                        |   |                       | 100   |       | mA               |
| Off Converter Input Current                        | Per ETSI EN300 132-2  |                       | 15    |       | mA               |
| Inrush Current(I <sup>2</sup> t)                   |   |                       |       | 1     | A <sup>2</sup> s |
| Input Reflected-Ripple Current                     | P-P thru 12µH inductor, 5Hz to 20MHz  |                       | 12    |       | mA               |
| Input Voltage Ripple Rejection                     | 120 Hz  |                       | 60    |       | dB               |
| <b>OUTPUT CHARACTERISTICS</b>                      |   |                       |       |       |                  |
| Output Voltage Set Point                           | V <sub>in</sub> =48V, I <sub>o</sub> =I <sub>o,max</sub> , T <sub>c</sub> =25°C                   | 27.58                 | 28.00 | 28.42 | Vdc              |
| Output Voltage Regulation                          |   |                       |       |       |                  |
| Over Load  | I <sub>o</sub> =I <sub>o,min</sub> to I <sub>o,max</sub>  |                       | ±28   | ±56   | mV               |
| Over Line  | V <sub>in</sub> =36V to 75V   |                       | ±28   | ±56   | mV               |
| Over Temperature                                   | T <sub>c</sub> =-40°C to 100°C  |                       | ±140  | ±280  | mV               |
| Total Output Voltage Range                         | over sample load, line and temperature  | 27.16                 | 28.00 | 28.84 | V                |
| Output Voltage Ripple and Noise                    | 5Hz to 20MHz bandwidth  |                       |       |       |                  |
| Peak-to-Peak                                       | Full Load, 1µF ceramic, 10µF Low ESR cap  |                       | 280   | 560   | mV               |
| RMS  | Full Load, 1µF ceramic, 10µF Low ESR cap  |                       |       | 100   | mV               |
| Operating Output Current Range                     |   |                       |       | 16    | A                |
| Output DC Current-Limit Inception                  | Output Voltage 10% Low  | 105                   | 120   | 140   | %                |
| <b>DYNAMIC CHARACTERISTICS</b>                     |   |                       |       |       |                  |
| Output Voltage Current Transient                   | 48V, Tested with 10µF aluminum, Low ESR cap and 1µF Ceramic load cap. ΔI <sub>o</sub> /Δt=1A/10µS |                       |       |       |                  |
| Positive Step Change in Output Current             | 50% to 75% I <sub>o,max</sub>   |                       |       | 560   | mV               |
| Negative Step Change in Output Current             | 75% to 50% I <sub>o,max</sub>   |                       |       | 560   | mV               |
| Settling Time (within 1% V <sub>out</sub> nominal) |   |                       | 300   |       | µs               |
| Turn-On Transient                                  |   |                       |       |       |                  |
| Start-Up Time, From On/Off Control                 |   |                       | 20    | 50    | ms               |
| Start-Up Time, From Input                          |   |                       | 20    | 50    | ms               |
| Output Capacitive Load                             | Full load; 5% overshoot of V <sub>out</sub> at startup  | 220                   |       | 5000  | µF               |
| <b>EFFICIENCY</b>                                  |   |                       |       |       |                  |
| 100% Load  |   |                       | 92.7  |       | %                |
| 80% Load   |   |                       | 93    |       | %                |
| <b>ISOLATION CHARACTERISTICS</b>                   |   |                       |       |       |                  |
| Input to Output                                    |   |                       |       | 1500  | Vdc              |
| Input to Case                                      |   |                       |       | 1500  | Vdc              |
| Output to Case                                     |   |                       |       | 500   | Vdc              |
| Isolation Resistance                               |   | 10                    |       |       | MΩ               |
| Isolation Capacitance                              |   |                       | 1900  |       | pF               |
| <b>FEATURE CHARACTERISTICS</b>                     |   |                       |       |       |                  |
| Switching Frequency                                |   |                       | 280   |       | kHz              |
| ON/OFF Control Negative Remote On/Off logic        |   |                       |       |       |                  |
| Logic Low (Module On)                              | V <sub>on/off</sub> at I <sub>on/off</sub> =1.0mA   | 0                     |       | 1.2   | V                |
| Logic High (Module Off)                            | V <sub>on/off</sub> at I <sub>on/off</sub> =0.0 µA  | 2.4                   |       | 15    | V                |
| ON/OFF Control, Positive Remote On/Off logic       |   |                       |       |       |                  |
| Logic Low (Module Off)                             | V <sub>on/off</sub> at I <sub>on/off</sub> =1.0mA   | 0                     |       | 1.2   | V                |
| Logic High (Module On)                             | V <sub>on/off</sub> at I <sub>on/off</sub> =0.0 µA  | 2.4                   |       | 15    | V                |
| ON/OFF Current                                     | I <sub>on/off</sub> at V <sub>on/off</sub> =0.0V  |                       |       | 1     | mA               |
| Leakage Current                                    | Logic High, V <sub>on/off</sub> =15V  |                       |       | 50    | µA               |
| Output Voltage Trim Range                          | Across Pins 9 & 5, V <sub>in</sub> =48V   | -50                   |       | +18   | %                |
| Output Voltage Remote Sense Range                  | P <sub>out</sub> ≤ max rated power  |                       |       | 0.5   | V                |
| Output Over-Voltage Protection                     |   |                       |       | 140   | %                |
| <b>GENERAL SPECIFICATIONS</b>                      |   |                       |       |       |                  |
| MTBF   | I <sub>o</sub> =80% of I <sub>o,max</sub> ; T <sub>a</sub> =25°C                                  |                       | 1.6   |       | M hours          |
| Weight   |   |                       | 97    |       | grams            |
| Over-Temperature Shutdown                          | Please refer to Fig.21 for measuring point  |                       | 104   |       | °C               |



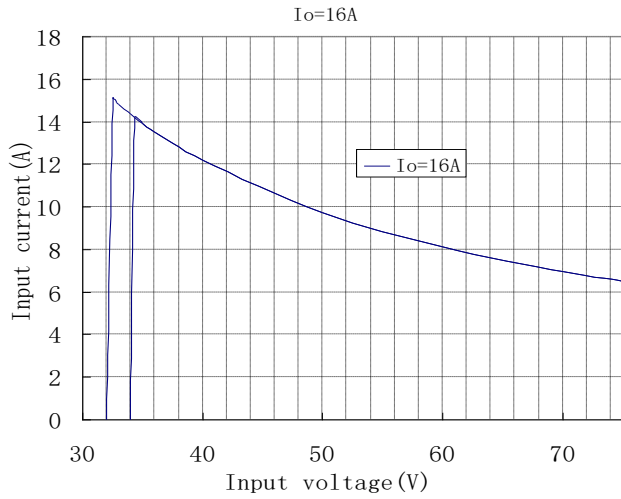
# ELECTRICAL CHARACTERISTICS CURVES



**Figure 1:** Efficiency vs. load current for minimum, nominal, and maximum input voltage at 25°C.



**Figure 2:** Power dissipation vs. load current for minimum, nominal, and maximum input voltage at 25°C.

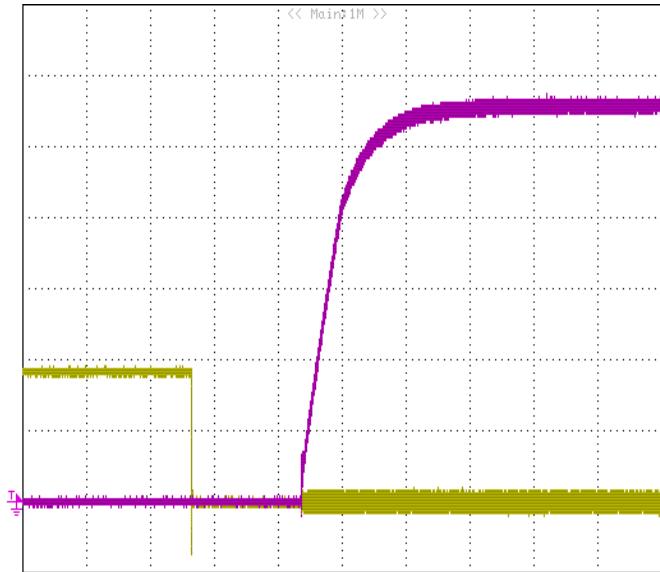


**Figure 3:** Typical input characteristics at room temperature

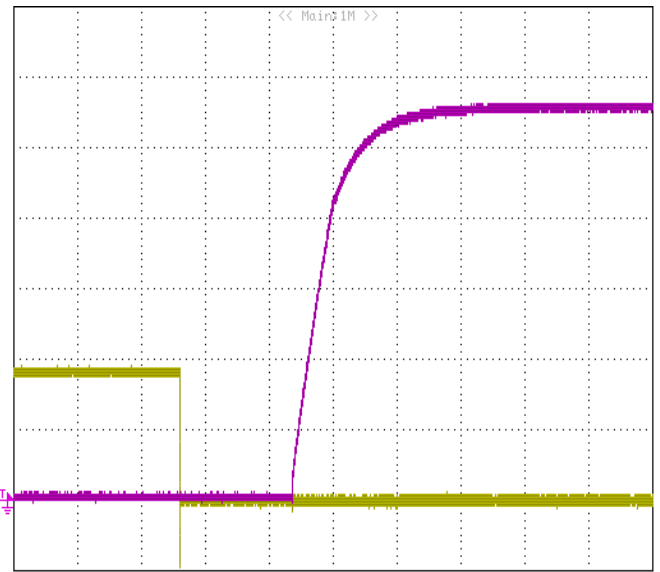


# ELECTRICAL CHARACTERISTICS CURVES

## For Negative Remote On/Off Logic

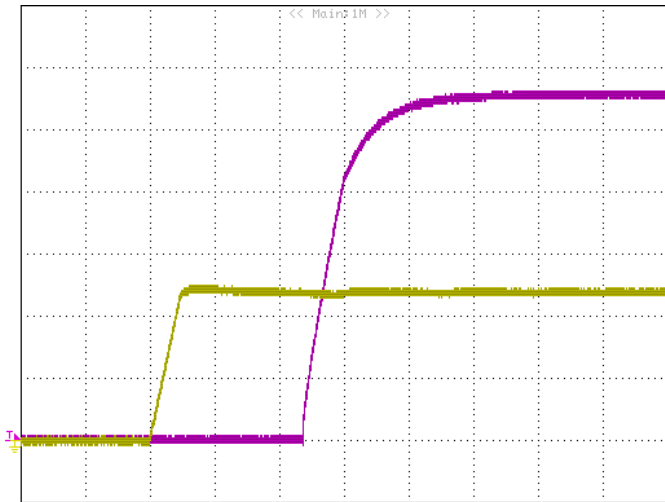


**Figure 4:** Turn-on transient at full load current (resistive load) (10ms/div). CH3: Vout; 5V/div; CH1: ON/OFF input; 2V/div

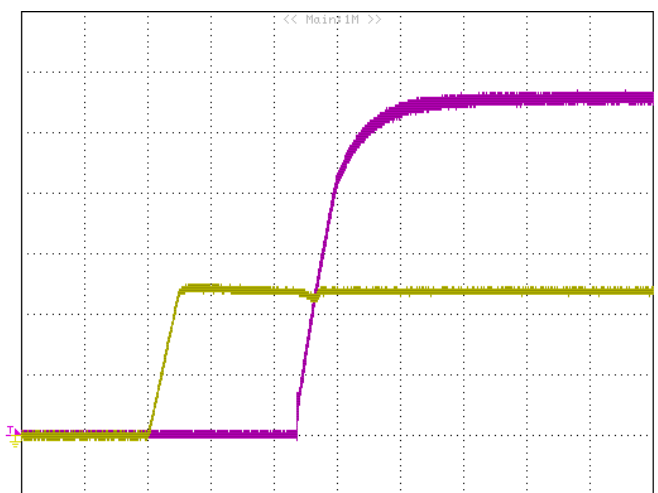


**Figure 5:** Turn-on transient at minimum load current (10ms/div). CH3: Vout; 5V/div; CH1: ON/OFF input; 2V/div

## For Positive Remote On/Off Logic

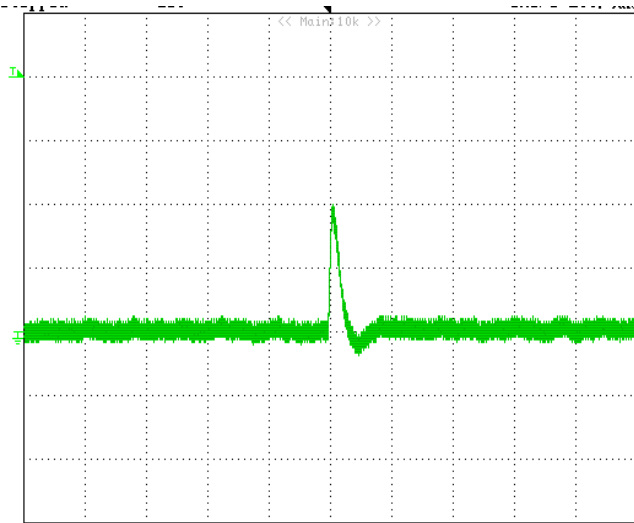


**Figure 6:** Turn-on transient at full load current (resistive load) (10ms/div). CH3 Vout; 5V/div; CH1: Vin; 20V/div

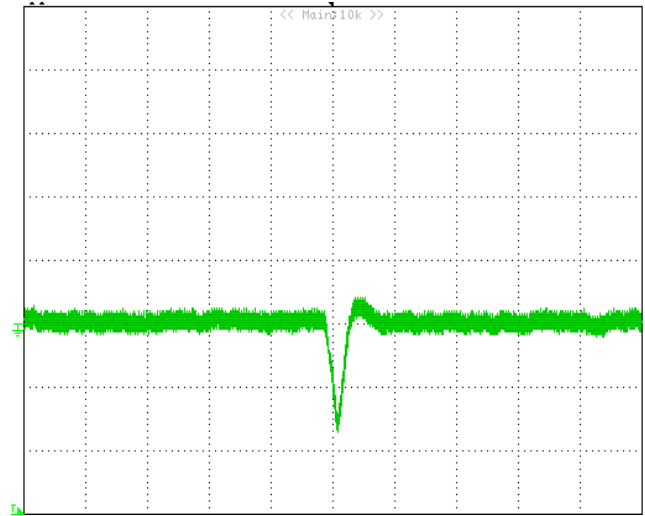


**Figure 7:** Turn-on transient at zero load current (10ms/div). CH3 Vout; 5V/div; CH1: Vin; 20V/div

## ELECTRICAL CHARACTERISTICS CURVES

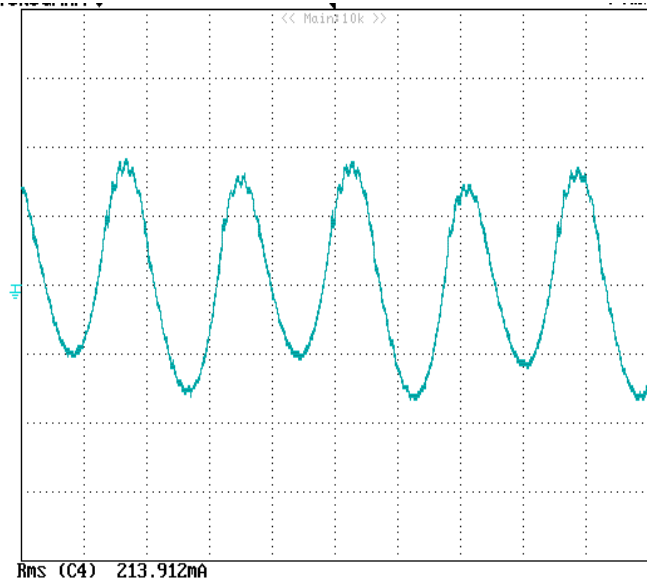


**Figure 8:** Output voltage response to step-change in load current (75%-50% of  $I_o$ , max;  $di/dt = 1A/10\mu S$ ). Load cap: 220 $\mu F$  aluminum, 10 $\mu F$  Low ESR capacitor and 1 $\mu F$  ceramic capacitor. Top Trace:  $V_{out}$  (100mV/div), Scope measurement should be made using a BNC cable (length shorter than 20 inches). Position the load between 51 mm to 76 mm (2 inches to 3 inches) from the module.

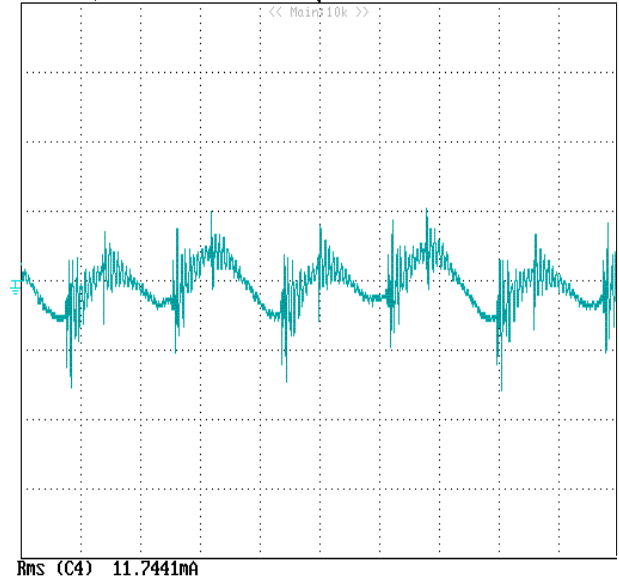


**Figure 9:** Output voltage response to step-change in load current (50%-75% of  $I_o$ , max;  $di/dt = 1A/10\mu S$ ). Load cap: 220 $\mu F$  aluminum, 10 $\mu F$  Low ESR capacitor and 1 $\mu F$  ceramic capacitor. Top Trace:  $V_{out}$  (100mV/div), Scope measurement should be made using a BNC cable (length shorter than 20 inches). Position the load between 51 mm to 76 mm (2 inches to 3 inches) from the module.

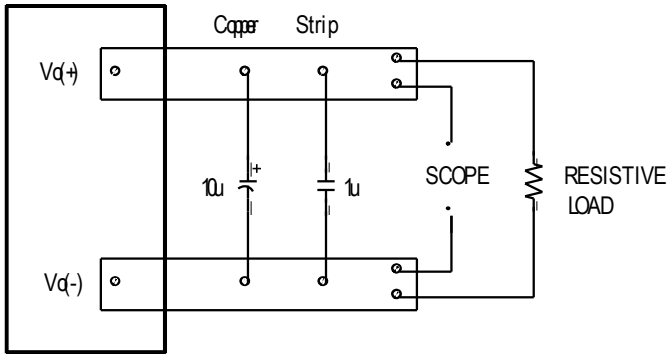
# ELECTRICAL CHARACTERISTICS CURVES



**Figure 10:** Input Terminal Ripple Current,  $i_c$ , at full rated output current and nominal input voltage with  $12\mu\text{H}$  source impedance and  $220\mu\text{F}$  electrolytic capacitor ( $1\text{A/div}$ ).

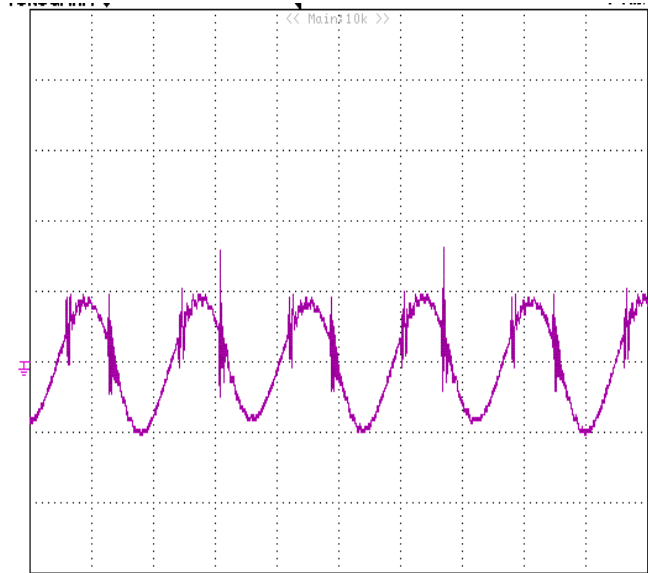
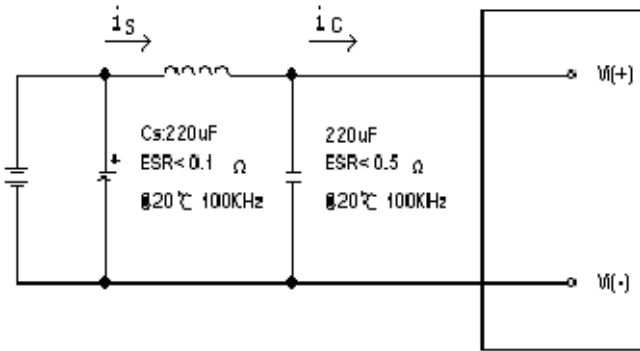


**Figure 11:** Input reflected ripple current,  $i_s$ , through a  $12\mu\text{H}$  source inductor at nominal input voltage and rated load current ( $10\text{ mA/div}$ )



**Figure 12:** Output voltage noise and ripple measurement test setup

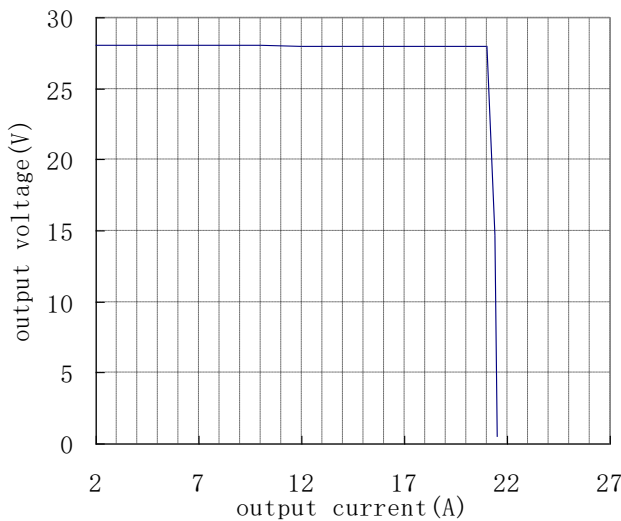
# ELECTRICAL CHARACTERISTICS CURVES



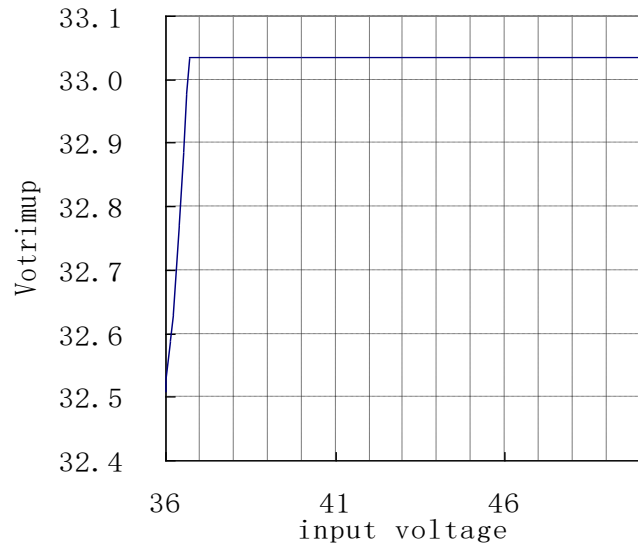
**Figure 13:** Test set-up diagram showing measurement points for Input Terminal Ripple Current and Input Reflected Ripple Current.

Note: Measured input reflected-ripple current with a simulated source Inductance ( $L_{TEST}$ ) of 12  $\mu$ H. Capacitor  $C_s$  offset possible battery impedance. Measure current as shown above.

**Figure 14:** Output voltage ripple at nominal input voltage and rated load current (100mV/div). Load capacitance: 330 $\mu$ F aluminum, 1 $\mu$ F ceramic capacitor and 10 $\mu$ F ESR capacitor. Bandwidth: 20 MHz. Scope measurement should be made using a BNC cable (length shorter than 20 inches). Position the load between 51 mm to 76 mm (2 inches to 3 inches) from the module.



**Figure 15:** Output voltage vs. load current showing typical current limit curves and converter shutdown points.



**Figure 16:** maximum trim up output voltage vs input voltage under full load

## DESIGN CONSIDERATIONS

### Input Source Impedance

The impedance of the input source connecting to the DC/DC power modules will interact with the modules and affect the stability. A low ac-impedance input source is recommended. If the source inductance is more than a few  $\mu\text{H}$ , we advise adding a 220 to 470  $\mu\text{F}$  electrolytic capacitor ( $\text{ESR} < 0.1 \Omega$  at 100 kHz) mounted close to the input of the module to improve the stability.

### Layout and EMC Considerations

Delta's DC/DC power modules are designed to operate in a wide variety of systems and applications. For design assistance with EMC compliance and related PWB layout issues, please contact Delta's technical support team. An external input filter module is available for easier EMC compliance design. Application notes to assist designers in addressing these issues are pending release.

### Safety Considerations

The power module must be installed in compliance with the spacing and separation requirements of the end-user's safety agency standard, i.e., UL60950-1, CAN/CSA-C22.2, No. 60950-1 and EN60950-1+A11 and IEC60950-1, if the system in which the power module is to be used must meet safety agency requirements.

Basic insulation based on 75 Vdc input is provided between the input and output of the module for the purpose of applying insulation requirements when the input to this DC-to-DC converter is identified as TNV-2 or SELV. An additional evaluation is needed if the source is other than TNV-2 or SELV.

When the input source is SELV, the power module meets SELV (safety extra-low voltage) requirements. If the input source is a hazardous voltage which is greater than 60 Vdc and less than or equal to 75 Vdc, for the module's output to meet SELV requirements, all of the following must be met:

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

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

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

This power module is not internally fused. To achieve optimum safety and system protection, an input line fuse is highly recommended. The safety agencies require a normal-blow fuse with 50A maximum rating to be installed in the ungrounded lead. A lower rated fuse can be used based on the maximum inrush transient energy and maximum input current.

### Soldering and Cleaning Considerations

Post solder cleaning is usually the final board assembly process before the board or system undergoes electrical testing. Inadequate cleaning and/or drying may lower the reliability of a power module and severely affect the finished circuit board assembly test. Adequate cleaning and/or drying is especially important for un-encapsulated and/or open frame type power modules. For assistance on appropriate soldering and cleaning procedures, please contact Delta's technical support team.



## FEATURES DESCRIPTIONS

### Over-Current Protection

The module provides two over current protection levels. When the output current exceeds the low current limit level, the module will endure current limiting till the output voltage is lower than 10V. If the output current exceeds the high current limit level, the module will shut down immediately.

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

### Over-Voltage Protection

The modules include an internal output over-voltage protection circuit, which monitors the voltage on the output terminals. If this voltage exceeds the over-voltage set point, the module will shut down and latch off. The over-voltage latch is reset by either cycling the input power or by toggling the on/off signal for one second.

### Over-Temperature Protection

The over-temperature protection consists of circuitry that provides protection from thermal damage. If the temperature exceeds the over-temperature threshold the module will shut down.

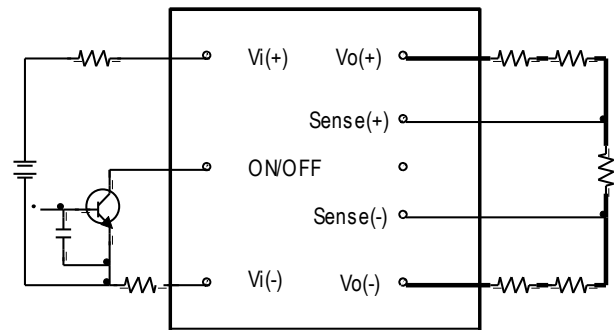
The module will try to restart after shutdown. If the over-temperature condition still exists during restart, the module will not start up. This restart trial will continue until the temperature is within specification.

### Remote On/Off

The remote on/off feature on the module can be either negative or positive logic. Negative logic turns the module on during logic low and off during logic high. Positive logic turns the modules on during logic high and off during logic low.

Remote on/off can be controlled by an external switch between the on/off terminal and the Vi(-) terminal. The switch can be an open collector or open drain.

For negative logic if the remote on/off feature is not used, please short the on/off pin to Vi(-). For positive logic if the remote on/off feature is not used, please leave the on/off pin to floating.



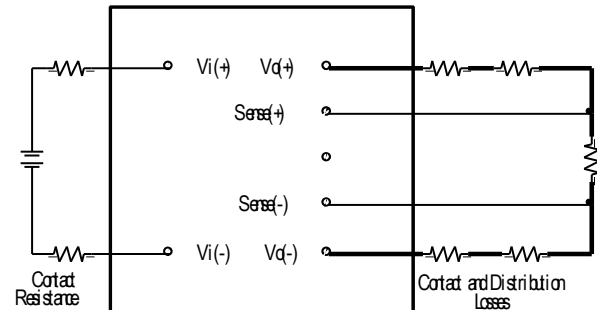
**Figure 16:** Remote on/off implementation

### Remote Sense

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

$$[Vo(+) - Vo(-)] - [SENSE(+) - SENSE(-)] \leq 10\% \times V_{out}$$

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



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

If the remote sense feature is not used to regulate the output at the point of load, please connect SENSE(+) to Vo(+) and SENSE(-) to Vo(-) at the module.

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

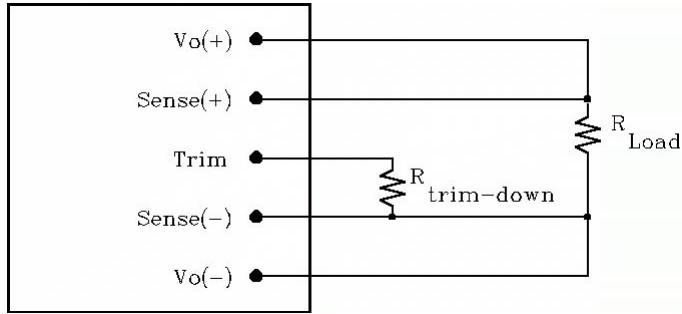
When using remote sense and trim, the output voltage of the module is usually increased, which increases the power output of the module with the same output current.

Care should be taken to ensure that the maximum output power does not exceed the maximum rated power.

## FEATURES DESCRIPTIONS (CON.)

### Output Voltage Adjustment (TRIM)

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



**Figure 18:** Circuit configuration for trim-down (decrease output voltage)

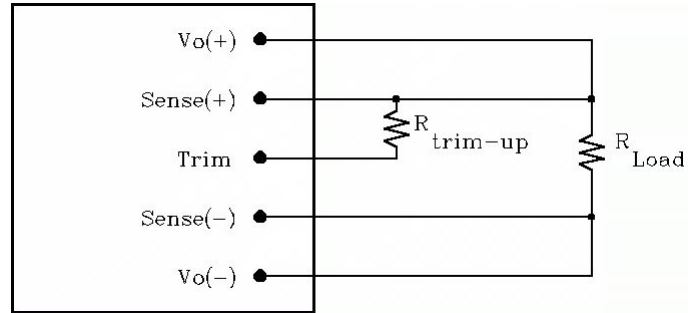
If the external resistor is connected between the TRIM and SENSE (-) pins, the output voltage set point decreases (Fig. 18). The external resistor value required to obtain a percentage of output voltage change  $\Delta\%$  is defined as:

$$R_{\text{trim down}} = \left( \frac{100}{\Delta} - 2 \right) \text{K}\Omega$$

Ex. When Trim-down 40% ( $28.0\text{V} \times 0.6 = 16.8\text{V}$ )

$$V_o := 28.0 \text{ V} \quad \Delta := 40$$

$$\frac{100}{\Delta} - 2 = 0.5 \text{K}\Omega$$



**Figure 19:** Circuit configuration for trim-up (increase output voltage)

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

$$R_{\text{trim up}} = \left[ \frac{V_o \cdot (100 + \Delta)}{1.225 \cdot \Delta} - \frac{100 + 2\Delta}{\Delta} \right] \text{K}\Omega$$

Ex. When Trim-up +10% ( $28.0\text{V} \times 1.1 = 30.8\text{V}$ )

$$V_o := 28.0 \text{ V} \quad \Delta := 10$$

$$\frac{V_o \cdot (100 + \Delta)}{1.225 \cdot \Delta} - \frac{100 + 2 \cdot \Delta}{\Delta} = 239.429 \text{ K}\Omega$$

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

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

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

# THERMAL CONSIDERATIONS

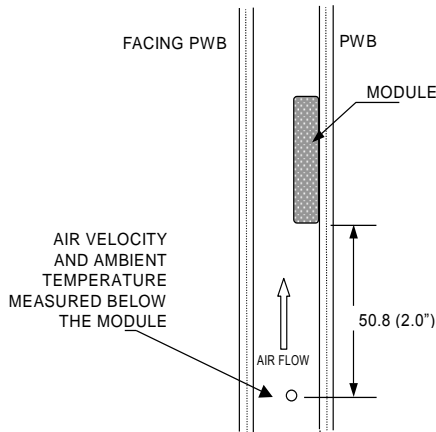
Thermal management is an important part of the system design. To ensure proper, reliable operation, sufficient cooling of the power module is needed over the entire temperature range of the module. Convection cooling is usually the dominant mode of heat transfer.

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

## Thermal Testing Setup

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

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



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

Figure 20: Wind Tunnel Test Setup

## Thermal Derating

Heat can be removed by increasing airflow over the module. To enhance system reliability, the power module should always be operated below the maximum operating temperature. If the temperature exceeds the maximum module temperature, reliability of the unit may be affected.

## THERMAL CURVES

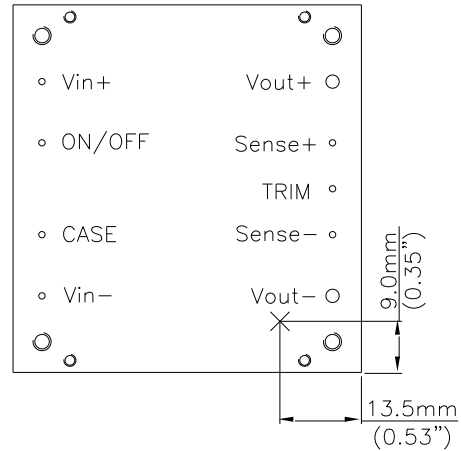


Figure 21: Temperature measurement location viewed from top side.

The allowed maximum hot spot temperature is defined at 98°C

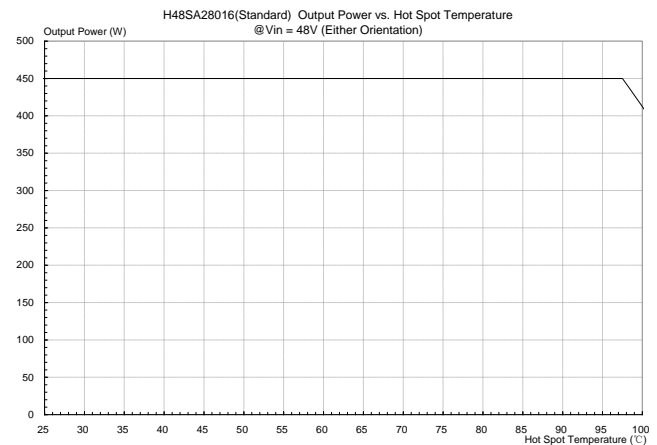
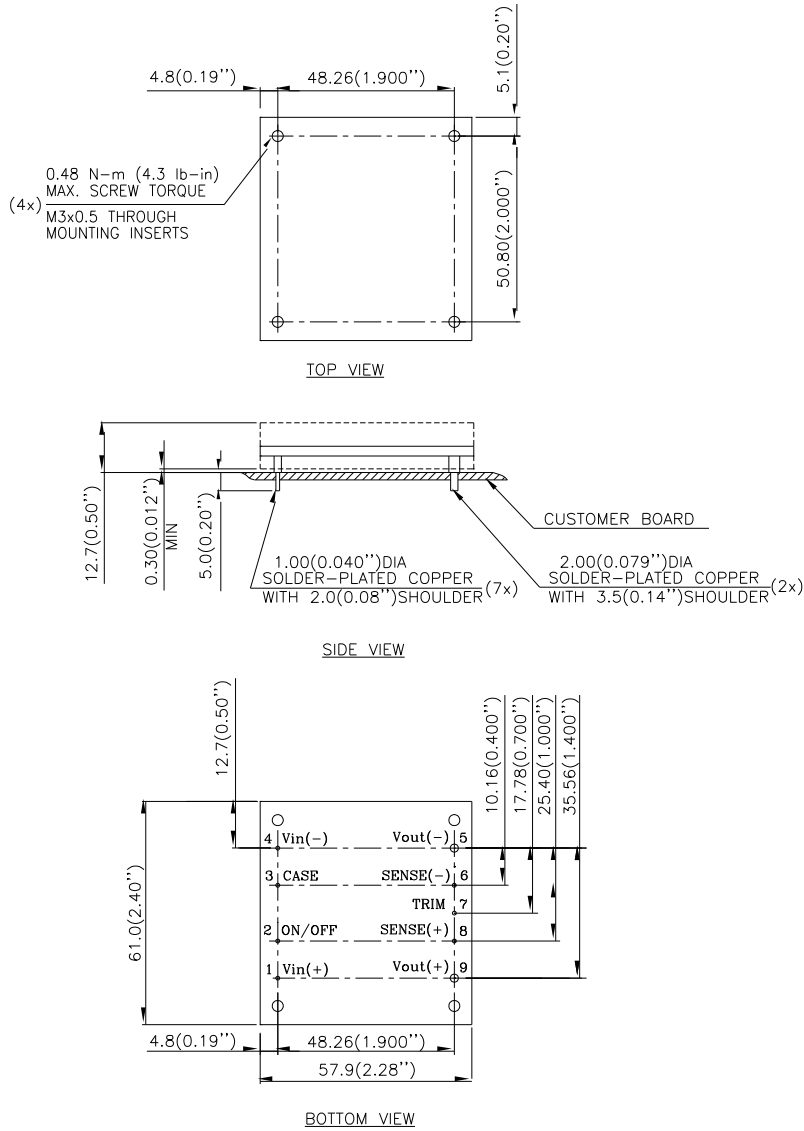


Figure 22: Output power vs. Hot spot temperature @Vin=48V (Either Orientation)

# MECHANICAL DRAWING



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

| <u>Pin No.</u> | <u>Name</u> | <u>Function</u>         |
|----------------|-------------|-------------------------|
| 1              | +Vin        | Positive input voltage  |
| 2              | ON/OFF      | Remote ON/OFF           |
| 3              | CASE        | Case ground             |
| 4              | -Vin        | Negative input voltage  |
| 5              | -Vout       | Negative output voltage |
| 6              | -SENSE      | Negative remote sense   |
| 7              | TRIM        | Output voltage trim     |
| 8              | +SENSE      | Positive remote sense   |
| 9              | +Vout       | Positive output voltage |

## Pin Specification:

Pins 1-4, 6-8 1.00mm (0.040") diameter  
Pins 5 & 9 2.00mm (0.079") diameter

All pins are copper with Tin plating.

## PART NUMBERING SYSTEM

| H              | 48            | S                 | A              | 280            | 16             | N                            | Y          | F   | H                     |
|----------------|---------------|-------------------|----------------|----------------|----------------|------------------------------|------------|---|-----------------------|
| Form Factor    | Input Voltage | Number of Outputs | Product Series | Output Voltage | Output Current | ON/OFF Logic                 | Pin Length |   | Option Code           |
| H - Half Brick | 48 - 36~75V   | S - Single        | A - Advanced   | 280 - 28V      | 16- 16A        | N - Negative<br>P - Positive | Y - 0.200" | F - RoHS 6/6<br>(Lead Free)<br>space - RoHS 5/6 | H - with heatspreader |

## RECOMMENDED PART NUMBER

| MODEL NAME     | INPUT   |     | OUTPUT |     | EFF @ 100% LOAD |
|----------------|---------|-----|--------|-----|-----------------|
| H48SA28016NYFH | 36V~75V | 16A | 28V    | 16A | 92.7%           |

Default remote on/off logic is negative and pin length is 0.170"

For different remote on/off logic and pin length, please refer to part numbering system above or contact your local sales

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

**CONTACT:** [www.deltaww.com/dcdc](http://www.deltaww.com/dcdc)

**Email:** [dcdc@deltaww.com](mailto:dcdc@deltaww.com)

**USA:**

Telephone:  
East Coast: 978-656-3993  
West Coast: 510-668-5100  
Fax: (978) 656 3964

**Europe:**

Phone: +31-20-655-0967  
Fax: +31-20-655-0999

**Asia & the rest of world:**

Telephone: +886 3 4526107  
ext 6220~6224  
Fax: +886 3 4513485

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Телефон: 8 (812) 309-75-97 (многоканальный)

Факс: 8 (812) 320-03-32

Электронная почта: [ocean@oceanchips.ru](mailto:ocean@oceanchips.ru)

Web: <http://oceanchips.ru/>

Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А