Delphi DNL, Non-Isolated Point of Load DC/DC Power Modules: 8.3-14Vin, 0.75-5.0V/16A out

The Delphi series DNL, 8.3~14V input, single output, non-isolated point of load DC/DC converters are the latest offering from a world leader in power systems technology and manufacturing — Delta Electronics, Inc. The DNL series provides a programmable output voltage from 0.75V to 5.0V through an external trimming resistor. The DNL converters have flexible and programmable tracking and sequencing features to enable a variety of sequencing and tracking between several point of load power modules. This product family is available in a surface mount or SIP package and provides up to 16A of output current in an industry standard footprint and pinout. With creative design technology and optimization of component placement, these converters possess outstanding electrical and thermal performance and extremely high reliability under highly stressful operating conditions.
### TECHNICAL SPECIFICATIONS

\( T_a = 25°C, \) airflow rate = 300 LFM, \( V_{in} = 8.3Vdc \) and 14Vdc, nominal \( V_{out} \) unless otherwise noted.

#### ABSOLUTE MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>NOTES and CONDITIONS</th>
<th>DNL10S0A0R16NFD</th>
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<tbody>
<tr>
<td>Input Voltage (Continuous)</td>
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<td>15</td>
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<tr>
<td>Tracking Voltage</td>
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<td>Operating Temperature</td>
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<td>125</td>
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<tr>
<td>Storage Temperature</td>
<td>-55</td>
<td>125</td>
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#### INPUT CHARACTERISTICS

| Operating Input Voltage | Vo=set: 3.63Vdc | 8.3 | 12 | 14 | V |
| Vo=set: -3.63Vdc | 8.3 | 12 | 13.2 | V |
| Turn-On Voltage Lockout | 7.9 | V |
| Turn-Off Voltage Lockout | 7.8 | V |
| Maximum Input Current | Vin=Vin,min to Vin,max, Io=Io,max | 11 | A |
| No-Load Input Current | 100 | mA |
| Off Converter Input Current | 2 | mA |
| Inrush Transient | Vin=Vin.min to Vin.max, Io=Io.min to Io,max | 0.4 | A/S |

#### OUTPUT CHARACTERISTICS

| Output Voltage Over-shot at Start-up | Vout=3.3V | 1 | % Vo,set |
| Output DC Current-Limit Inception | Io.s/c | 3 | Adc |

#### DYNAMIC CHARACTERISTICS

| Dynamic Load Transient | 10µF Tan & 1µF ceramic load cap, 2.5A/jus, Vin=12V |
| Positive Step Change in Output Current | 50% Io, max to 100% Io, max | 200 | mVpk |
| Negative Step Change in Output Current | 100% Io, max to 50% Io, max | 200 | mVpk |
| Setting Time (Vo < 10% Peak Deviation) | 25 | µs |
| Turn-On Transient | Io=Io.max |
| Start-Up Time, From On/Off Control | Von/off, Vo=10% of Vo,set | 5 | ms |
| Start-Up Time, From Input | Vin=Vin,min, Vo=10% of Vo,set | 5 | ms |
| Output Voltage Rise Time | Time for Vo to rise from 10% to 90% of Vo,set | 4 | 6 | ms |
| Output Capacitive Load | Full load: ESR \( \leq 1mΩ \) | 1000 | µF |
| Full load: ESR \( \geq 10mΩ \), Vin<9.0V | 3500 | µF |
| Full load: ESR \( \geq 10mΩ \), Vin = 9.0V | 5000 | µF |

#### EFFICIENCY

| Vo=0.75V | Vin=12V, Io=Io,max | 79.5 | % |
| Vo=1.2V | Vin=12V, Io=Io,max | 85.0 | % |
| Vo=1.5V | Vin=12V, Io=Io,max | 89.0 | % |
| Vo=2.5V | Vin=12V, Io=Io,max | 91.0 | % |
| Vo=3.3V | Vin=12V, Io=Io,max | 92.0 | % |
| Vo=5.0V | Vin=12V, Io=Io,max | 94.0 | % |

#### FEATURE CHARACTERISTICS

| Switching Frequency | 300 | kHz |
| Logic Low Voltage | Module On, Von/off | -0.2 | V |
| Logic High Voltage | Module Off, Von/off | 2.5 | Vin,max |
| Logic Low Current | Module On, Ion/off | 10 | µA |
| Logic High Current | Module Off, Ion/off | 0.2 | 1 | mA |
| Logic High Voltage | Module On, Von/off | Vin,max | V |
| Logic Low Voltage | Module Off, Von/off | -0.2 | 0.3 | V |
| Logic High Current | Module On, Ion/off | 0.2 | 10 | µA |
| Logic Low Current | Module Off, Ion/off | 0.2 | 1 | mA |
| Tracking Slew Rate Capability | 0.1 | 2 | V/msec |
| Tracking Delay Time | Delay from Vin:min to application of tracking voltage | 10 | ms |
| Tracking Accuracy | Power-up, subject to 2V/mS | 100 | 200 | mV |
| Power-down, subject to 1V/mS | 200 | 400 | mV |
| Remote Sense Range | 0.1 | V |

#### GENERAL SPECIFICATIONS

| MfBR | Io=80%Io, max, Ta=25°C | 4.28 | M hours |
| Weight | 12 | grams |
| Over-Temperature Shutdown | Refer to Figure 31 for the measuring point | 130 | °C |

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ELECTRICAL CHARACTERISTICS CURVES

Figure 1: Converter efficiency vs. output current (0.75V output voltage)

Figure 2: Converter efficiency vs. output current (1.2V output voltage)

Figure 3: Converter efficiency vs. output current (1.5V output voltage)

Figure 4: Converter efficiency vs. output current (1.8V output voltage)

Figure 5: Converter efficiency vs. output current (2.5V output voltage)

Figure 6: Converter efficiency vs. output current (3.3V output voltage)
**ELECTRICAL CHARACTERISTICS CURVES**

**Figure 7:** Converter efficiency vs. output current
(5.0V output voltage)

**Figure 8:** Output ripple & noise at 12Vin, 2.5V/16A out

**Figure 9:** Output ripple & noise at 12Vin, 5.0V/16A out

**Figure 10:** Turn on delay time at 12vin, 5.0V/16A out

**Figure 11:** Turn on delay time at Remote On/Off, 5.0V/16A out
**ELECTRICAL CHARACTERISTICS CURVES**

*Figure 12:* Turn on Using Remote On/Off with external capacitors (Co= 5000 µF), 5.0V/16A out

*Figure 13:* Typical transient response to step load change at 2.5A/µS from 100% to 50% of Io, max at 12Vin, 5.0V out (Cout = 1µF ceramic, 10µF tantalum)

*Figure 14:* Typical transient response to step load change at 2.5A/µS from 50% to 100% of Io, max at 12Vin, 5.0V out (Cout = 1µF ceramic, 10µF tantalum)

*Figure 15:* Output short circuit current 12Vin, 0.75Vout (10A/div)

*Figure 16:* Turn on with Prebias 12Vin, 5V/0A out, Vbias =3.3Vdc
TEST CONFIGURATIONS

Note: Input reflected-ripple current is measured with a simulated source inductance. Current is measured at the input of the module.

Figure 17: Input reflected-ripple test setup

DESIGN CONSIDERATIONS

Input Source Impedance

To maintain low-noise and ripple at the input voltage, it is critical to use low ESR capacitors at the input to the module. Figure 20 shows the input ripple voltage (mVp-p) for various output models using 6x47uF low ESR tantalum capacitors (SANYO P/N:16TQC47M, 47uF/16V or equivalent) and 6x22 uF very low ESR ceramic capacitors (TDK P/N:C3225X7S1C226MT, 22uF/16V or equivalent).

The input capacitance should be able to handle an AC ripple current of at least:

\[
I_{\text{rms}} = I_{\text{out}} \sqrt{\frac{V_{\text{out}}}{V_{\text{in}}} \left(1 - \frac{V_{\text{out}}}{V_{\text{in}}} \right)} \text{ Arms}
\]

Figure 20: Input ripple voltage for various output models, \(I_o = 16A\) (\(C_{\text{in}} = 6x47uF\) tantalum capacitors and \(6x22uF\) ceramic capacitors at the input)

Note: All measurements are taken at the module terminals. When the module is not soldered (via socket), place Kelvin connections at module terminals to avoid measurement errors due to contact resistance.

\[
\eta = \left(\frac{V_o \times I_o}{V_i \times I_i}\right) \times 100 \% 
\]

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DESIGN CONSIDERATIONS (CON.)

The power module should be connected to a low ac-impedance input source. Highly inductive source impedances can affect the stability of the module. An input capacitance must be placed close to the modules input pins to filter ripple current and ensure module stability in the presence of inductive traces that supply the input voltage to the module.

Safety Considerations

For safety-agency approval the power module must be installed in compliance with the spacing and separation requirements of the end-use safety agency standards.

For the converter output to be considered meeting the requirements of safety extra-low voltage (SELV), the input must meet SELV requirements. The power module has extra-low voltage (ELV) outputs when all inputs are ELV.

The input to these units is to be provided with a maximum 15A of glass type fast-acting fuse in the ungrounded lead.

FEATURES DESCRIPTIONS

Remote On/Off

The DNL series power modules have an On/Off pin for remote On/Off operation. Both positive and negative On/Off logic options are available in the DNL series power modules.

For positive logic module, connect an open collector (NPN) transistor or open drain (N channel) MOSFET between the On/Off pin and the GND pin (see figure 21). Positive logic On/Off signal turns the module ON during the logic high and turns the module OFF during the logic low. When the positive On/Off function is not used, leave the pin floating or tie to Vin (module will be On).

For negative logic module, the On/Off pin is pulled high with an external pull-up resistor (see figure 22) Negative logic On/Off signal turns the module OFF during logic high and turns the module ON during logic low. If the negative On/Off function is not used, leave the pin floating or tie to GND. (module will be On)

Figure 21: Positive remote On/Off implementation

Figure 22: Negative remote On/Off implementation

Over-Current Protection

To provide protection in an output over load fault condition, the unit is equipped with internal over-current protection. When the over-current protection is triggered, the unit enters hiccup mode. The units operate normally once the fault condition is removed.
FEATURES DESCRIPTIONS (CON.)

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 shut down again. This restart trial will continue until the temperature is within specification.

Remote Sense

The DNL provide Vo remote sensing to achieve proper regulation at the load points and reduce effects of distribution losses on output line. In the event of an open remote sense line, the module shall maintain local sense regulation through an internal resistor. The module shall correct for a total of 0.1V of loss. The remote sense line impedance shall be < 10Ω.

Output Voltage Programming

The output voltage of the DNL can be programmed to any voltage between 0.75Vdc and 5.0Vdc by connecting one resistor (shown as Rtrim in Figure 24) between the TRIM and GND pins of the module. Without this external resistor, the output voltage of the module is 0.7525 Vdc. To calculate the value of the resistor Rtrim for a particular output voltage Vo, please use the following equation:

\[
R_{\text{trim}} : = \left( \frac{10500}{Vo - 0.7525} - 1000 \right) \Omega
\]

Rtrim is the external resistor in Ω
Vo is the desired output voltage

For example, to program the output voltage of the DNL module to 3.3Vdc, Rtrim is calculated as follows:

\[
R_{\text{trim}} = 3.122 \, k\Omega
\]

DNL can also be programmed by applying a voltage between the TRIM and GND pins (Figure 25). The following equation can be used to determine the value of Vtrim needed for a desired output voltage Vo:

\[
V_{\text{trim}} : = 0.7 - \left( Vo - 0.7525 \right) \cdot 0.0667
\]

Vtrim is the external voltage in V
Vo is the desired output voltage

For example, to program the output voltage of a DNL module to 3.3 Vdc, Vtrim is calculated as follows

\[
V_{\text{trim}} = 0.530V
\]

Vtrim = 0.530V
The amount of power delivered by the module is the voltage at the output terminals multiplied by the output current. When using the trim feature, the output voltage of the module can be increased, which at the same output current would increase the power output of the module. Care should be taken to ensure that the maximum output power of the module must not exceed the maximum rated power (\(V_{\text{set}} \times I_{\text{max}} \leq P_{\text{max}}\)).

**Voltage Margining**

Output voltage margining can be implemented in the DNL modules by connecting a resistor, \(R_{\text{margin-up}}\), from the Trim pin to the ground pin for margining-up the output voltage and by connecting a resistor, \(R_{\text{margin-down}}\), from the Trim pin to the output pin for margining-down. Figure 26 shows the circuit configuration for output voltage margining. If unused, leave the trim pin unconnected. A calculation tool is available from the evaluation procedure which computes the values of \(R_{\text{margin-up}}\) and \(R_{\text{margin-down}}\) for a specific output voltage and margin percentage.

![Figure 26: Circuit configuration for output voltage margining](image)

**Voltage Tracking**

The DNL family was designed for applications that have output voltage tracking requirements during power-up and power-down. The devices have a TRACK pin to implement three types of tracking method: sequential start-up, simultaneous and ratio-metric. TRACK simplifies the task of supply voltage tracking in a power system by enabling modules to track each other, or any external voltage, during power-up and power-down.

By connecting multiple modules together, customers can get multiple modules to track their output voltages to the voltage applied on the TRACK pin.
FEATURE DESCRIPTIONS (CON.)

The output voltage tracking feature (Figure 27 to Figure 29) is achieved according to the different external connections. If the tracking feature is not used, the TRACK pin of the module can be left unconnected or tied to Vin.

For proper voltage tracking, input voltage of the tracking power module must be applied in advance, and the remote on/off pin has to be in turn-on status. (Negative logic: Tied to GND or unconnected. Positive logic: Tied to Vin or unconnected)

**Figure 27: Sequential start-up**

**Figure 28: Simultaneous**

**Figure 29: Ratio-metric**
FEATURE DESCRIPTIONS (CON.)

Sequential Start-up
Sequential start-up (Figure 27) is implemented by placing an On/Off control circuit between \( V_{oPS1} \) and the On/Off pin of PS2.

Simultaneous
Simultaneous tracking (Figure 28) is implemented by using the TRACK pin. The objective is to minimize the voltage difference between the power supply outputs during power up and down.

The simultaneous tracking can be accomplished by connecting \( V_{oPS1} \) to the TRACK pin of PS2. Please note the voltage apply to TRACK pin needs to always higher than the \( V_{oPS2} \) set point voltage.

Ratio-Metric
Ratio–metric (Figure 29) is implemented by placing the voltage divider on the TRACK pin that comprises R1 and R2, to create a proportional voltage with \( V_{oPS1} \) to the Track pin of PS2.

For Ratio-Metric applications that need the outputs of PS1 and PS2 reach the regulation set point at the same time

The following equation can be used to calculate the value of R1 and R2.

\[
\frac{V_{o,PS2}}{V_{o,PS1}} = \frac{R_2}{R_1 + R_2}
\]
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 height of this fan duct is constantly kept at 25.4mm (1”).

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.

Figure 30: Wind tunnel test setup
**Figure 31**: Temperature measurement location

*The allowed maximum hot spot temperature is defined at 125 °C.

**Figure 32**: DNL10S0A0R16 (Standard) Output current vs. ambient temperature and air velocity @ Vin=12V, Vout=3.3V (Either Orientation)

**Figure 33**: DNL10S0A0R16 (Standard) Output current vs. ambient temperature and air velocity @ Vin=12V, Vout=2.5V (Either Orientation)

**Figure 34**: DNL10S0A0R16 (Standard) Output current vs. ambient temperature and air velocity @ Vin=12V, Vout=1.8V (Either Orientation)
MECHANICAL DRAWING

SMD PACKAGE (OPTIONAL)

SIP PACKAGE

SIDE VIEW

BOTTOM VIEW

BACK VIEW

SIDE VIEW

RECOMMENDED P.W.B PAD LAYOUT

RECOMMENDED P.W.B PAD LAYOUT

NOTES:

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

DS_DNL10SIP16_07182012
## PART NUMBERING SYSTEM

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<th>Product Series</th>
<th>Input Voltage</th>
<th>Numbers of Outputs</th>
<th>Output Voltage</th>
<th>Package Type</th>
<th>Output Current</th>
<th>On/Off logic</th>
<th>Option Code</th>
<th>Option Code</th>
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<tbody>
<tr>
<td>DNL - 16A</td>
<td>04 - 2.8V ~ 5.5V</td>
<td>S - Single</td>
<td>0A0 - Programmable</td>
<td>R - SIP</td>
<td>16 -16A</td>
<td>N- Negative (Default)</td>
<td>F- RoHS 6/6 (Lead Free)</td>
<td>D- Standard Function B-VOID PIN9(SIP)</td>
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## MODEL LIST

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<td>16A</td>
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