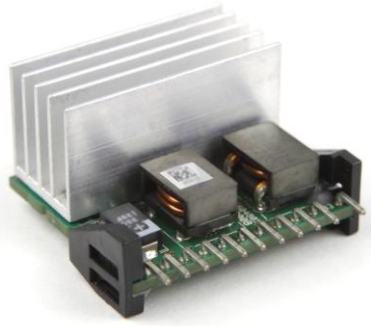
DELPHI SERIES



## FEATURES

- High Efficiency: 93.6% @ 12Vin, 5.0V/50A out
- Wide input range: 4.5V~13.8V
- Output voltage programmable from 0.6Vdc to 5.0Vdc via external resistors
- No minimum load required
- Fixed frequency operation
- Input UVLO, output SCP, OVP.
- Remote On/Off (Positive logic)
- Power Good Function
- RoHS 6
- ISO 9001, TL 9000, ISO 14001, QS9000, OHSAS18001 certified manufacturing facility

# Delphi D12S2R550 Non-Isolated Point of Load DC/DC Modules: 4.5V~13.8Vin, 0.6V~5.0Vout, 50A

The D12S2R550, 4.5~13.8V wide input, single output, non-isolated point of load DC/DC converter is the latest offering from a world leader in power systems technology and manufacturing -- Delta Electronics, Inc. The D12S2R550 and ND/NE product families are part of the second generation, non-isolated point-of-load DC/DC power modules which cut the module size by almost 50% in most of the cases compared to the first generation NC series POL modules for networking and data communication applications. D12S2R550 product provides up to 50A output current and the output can be resistor trimmed from 0.6Vdc to 5.0Vdc. It provides a highly efficient, high power and current density and very cost effective point of load solution. 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.

## APPLICATIONS

- Telecom / DataCom
- Distributed power architectures
- Servers and workstations
- LAN / WAN applications
- Data processing applications



Delta Electronics, Inc.

# TECHNICAL SPECIFICATIONS

**(Ambient Temperature=25°C, nominal $V_{in}$=12Vdc unless otherwise specified.)**

| PARAMETER | NOTES and CONDITIONS | D12S2R550 | | | |
|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Units |
| **ABSOLUTE MAXIMUM RATINGS** | | | | | |
| Input Voltage | | -0.3 | | 13.8 | Vdc |
| Operating Temperature | | 0 | | 70 | °C |
| Storage Temperature | | -40 | | 125 | °C |
| **INPUT CHARACTERISTICS** | | | | | |
| Operating Input Voltage | | 4.5 | | 13.8 | V |
| Input Under-Voltage Lockout | | | | | |
| Turn-On Voltage Threshold | | | 4.3 | | Vdc |
| Turn-Off Voltage Threshold | | | 4.0 | | Vdc |
| Maximum Input Current | Vin=12V, Vo=5V, Io=50A | | | 22.8 | A |
| No-Load Input Current | Vin=12V, Vo=5V, Io=0A | | 300 | 400 | mA |
| Off Converter Input Current | Remote OFF | | 17 | 20 | mA |
| Input voltage slew rate | dV/dt | | | 10 | V/mS |
| **OUTPUT CHARACTERISTICS** | | | | | |
| Output Voltage Adjustment Range | Refer to Fig.25 for the relations between input and output voltage | 0.6 | | 5.0 | Vdc |
| Output Voltage Set Point | With a 0.1% trim resistor | -1.0 | | +1.0 | %Vo |
| Output Voltage Regulation | | | | | |
| Over Load | Vo≦1.2Vdc | -20 | | +20 | mV |
| | Vo＞1.2Vdc | -1.5 | | +1.5 | %Vo |
| Over Line | Vin=Vin_min to Vin_max | -0.5 | | +0.5 | %Vo |
| Total output range | Over load, line, temperature regulation and set point | -3.0 | | +3.0 | %Vo |
| Output Voltage Ripple and Noise | 5Hz to 20MHz bandwidth | | | | |
| Peak-to-Peak | Full Load, 10uF Tan cap, total input & output range | | 20 | 50 | mV |
| Output Current Range | | 0 | | 50 | A |
| Output Voltage Under-shoot at Power-Off | Vin=12V, Turn OFF | | | 100 | mV |
| Output short-circuit current, RMS value | 12Vin, 5Vout | | 10 | | A |
| Over Current Protection | Hiccup mode | | 70 | | A |
| Over Voltage Protection | Non-latching shutdown | | 120 | | % |
| **DYNAMIC CHARACTERISTICS** | | | | | |
| Transient Response | 25% step load, Slew rate=10A/uS, 0.6V~1.8V output | | 120 | 150 | mVpk |
| | 25% step load, Slew rate=10A/uS, 2.5V~5.0V output | | 130 | 160 | mVpk |
| Output Dynamic Load Response | 12Vin, 2.5Vout, 1μF ceramic and 10μF Tan cap | | | | |
| Settling Time | Settling to be within regulation band (to 10% Vo deviation) | | 20 | 50 | μs |
| Turn-On Transient | | | | | |
| Rise Time | From 10% to 90% of Vo | | 2 | 5 | mS |
| Turn on Delay (power) | Vin=12V, Io=min-max. (Wthin 10% of Vo) | | 2 | 5 | mS |
| Turn on Delay (Remote on/off) | Vin=12V, Io=min-max. (Wthin 10% of Vo) | | 2 | 5 | mS |
| Turn on Transient (overshoot) | | | 0.5% | | Vo |
| Turn off Transient (undershoot) | | | | 100 | mV |
| Maximum Output Capacitance | ESR ≥ 10mΩ | 0 | | 20000 | μF |
| | ESR < 10mΩ | 0 | | 5000 | μF |
| **EFFICIENCY** | | | | | |
| Vo=0.6V | Vin=12V, Io=50A | | 79.0 | | % |
| Vo=1.1V | Vin=12V, Io=50A | | 85.0 | | % |
| Vo=1.2V | Vin=12V, Io=50A | | 86.5 | | % |
| Vo=1.5V | Vin=12V, Io=50A | | 87.3 | | % |
| Vo=1.8V | Vin=12V, Io=50A | | 88.9 | | % |
| Vo=2.5V | Vin=12V, Io=50A | | 90.7 | | % |
| Vo=3.3V | Vin=12V, Io=50A | | 93.1 | | % |
| Vo=5.0V | Vin=12V, Io=50A | | 93.6 | | % |
| **FEATURE CHARACTERISTICS** | | | | | |
| Switching Frequency | Fixed, per phase | | 500 | | KHz |
| ON/OFF Control | Positive logic (internally pulled high) | | | | |
| Logic High | Module On (or leave the pin open) | 1.2 | | Vinmax | V |
| Logic Low | Module Off | 0 | | 0.6 | V |
| Remote Sense Range | | | | 0.5 | V |
| Power Good | Vo is out off +/-10% Vo,set | 0 | | 0.4 | V |
| | Vo is within +/-10% Vo,set | 4.0 | | 5.1 | V |
| Power Good Delay | | | 0.2 | 2 | mS |
| Output to Power Good Delay Time | | | | 1 | mS |
| **GENERAL SPECIFICATIONS** | | | | | |
| Calculated MTBF | 25℃, 300LFM, 80% load | | 1 | | Mhours |
| Weight | | | 14 | | grams |

## ELECTRICAL CHARACTERISTICS CURVES

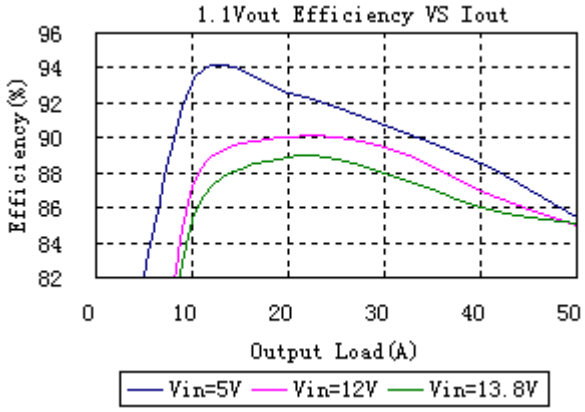



***Figure 1:*** *Converter efficiency vs. output current (1.1V output voltage, 5V&12V input)*

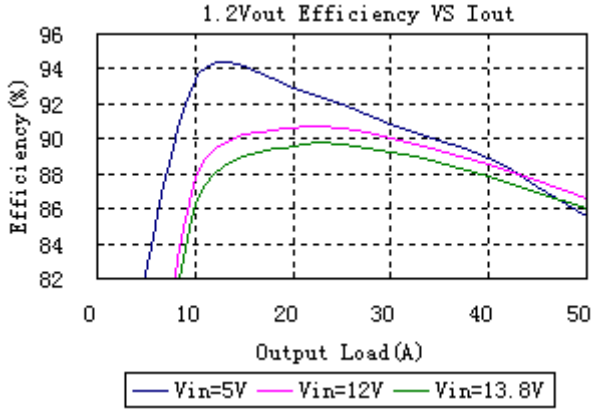



***Figure 2:*** *Converter efficiency vs. output current (1.2V output voltage, 5V&12V input)*

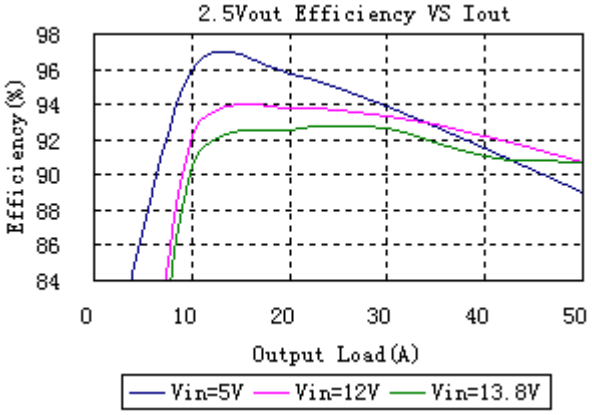



***Figure 3:*** *Converter efficiency vs. output current (2.5V output voltage, 5V&12V input)*

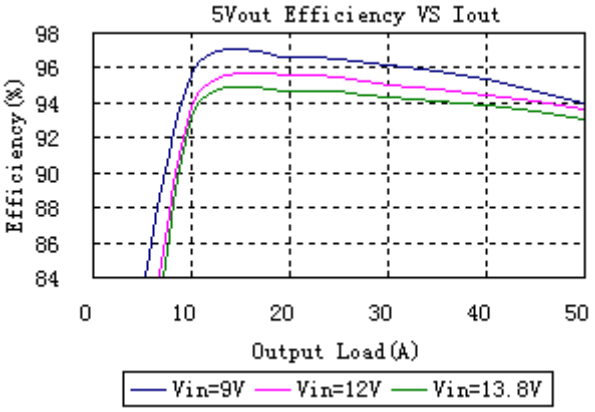



***Figure 4:*** *Converter efficiency vs. output current (5V output voltage, 9V&12V input)*

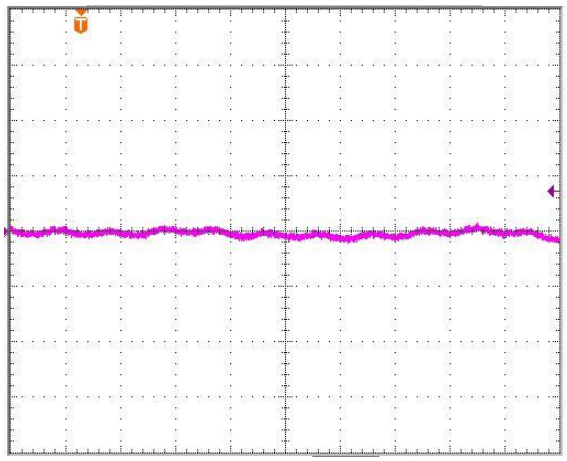


***Figure 5:*** *Output ripple & noise at 12Vin, 1.1V/50A out (10mv/div, 2uS/div)*

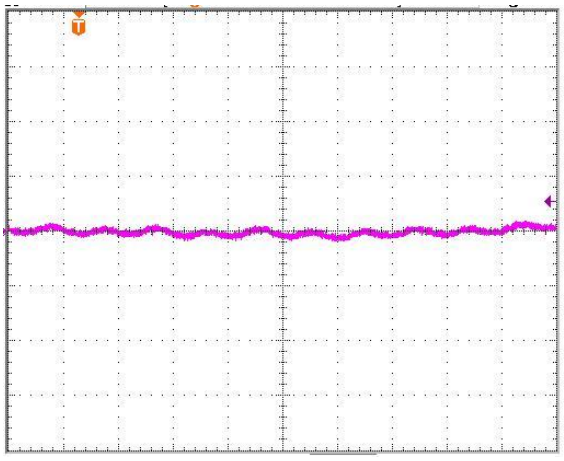


***Figure 6:*** *Output ripple & noise at 12Vin, 1.2V/50A out (10mv/div, 2uS/div)*

## ELECTRICAL CHARACTERISTICS CURVES (CONTINUED)

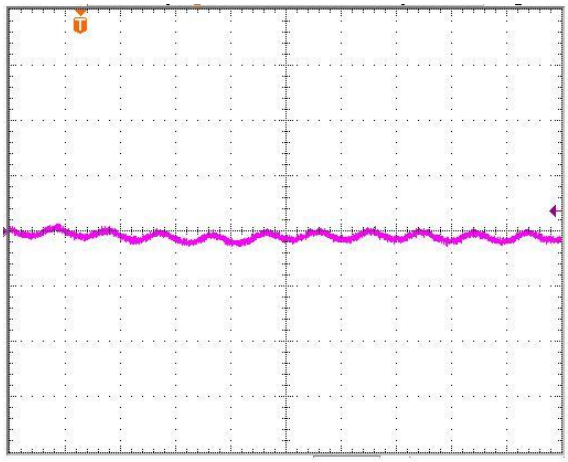


***Figure 7:*** *Output ripple & noise at 12Vin, 1.8V/50A out (10mv/div, 2uS/div)*

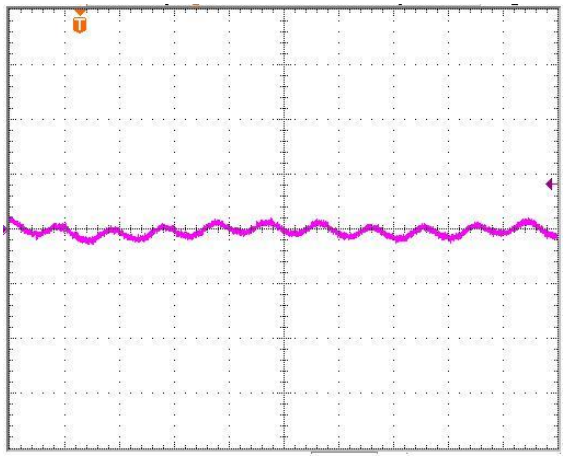


***Figure 8:*** *Output ripple & noise at 12Vin, 2.5V/50A out (10mv/div, 2uS/div)*

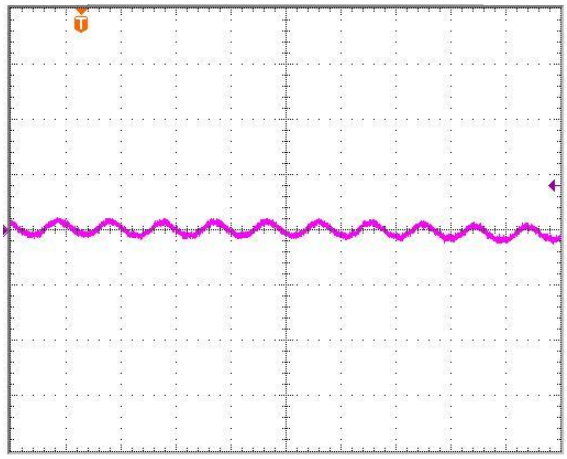


***Figure 9:*** *Output ripple & noise at 12Vin, 3.3V/50A out (10mv/div, 2uS/div)*

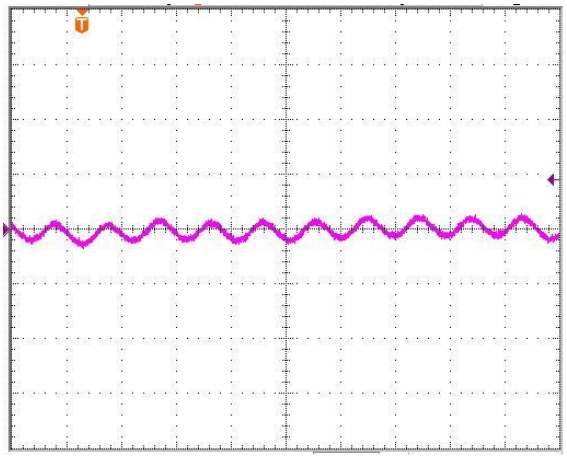


***Figure 10:*** *Output ripple & noise at 12Vin, 5.0V/50A out (10mv/div, 2μS/div)*

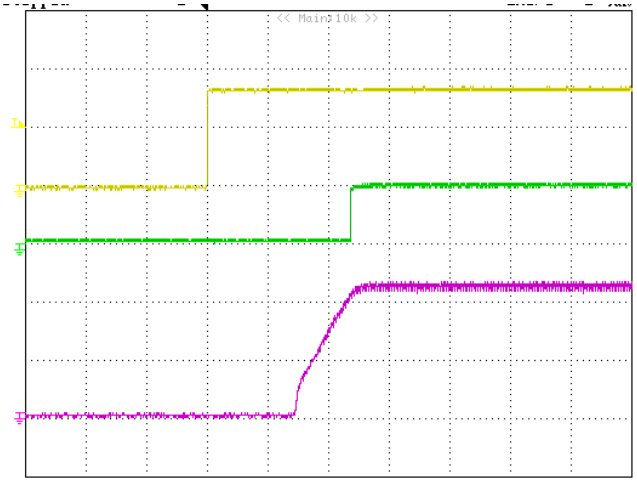


***Figure 11:*** *Turn on delay time at 12Vin, 1.1V/50A out (1mS/div) Top trace: Enable, middle trace: PG, bottom trace: Vo*

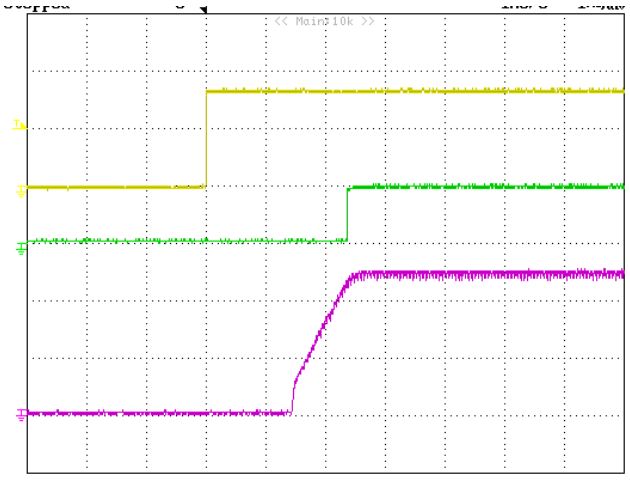


***Figure 12:*** *Turn on delay time at 12Vin, 1.2V/50A out (1mS/div) Top trace: Enable, middle trace: PG, bottom trace: Vo*

## ELECTRICAL CHARACTERISTICS CURVES (CONTINUED)

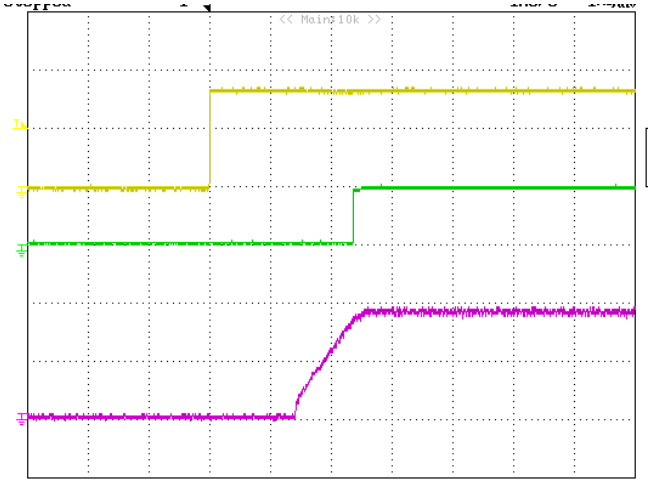


***Figure 13:*** *Turn on delay time at 12Vin, 1.8V/50A out (1mS/div)*
*Top trace: Enable, middle trace: PG, bottom trace: Vo*

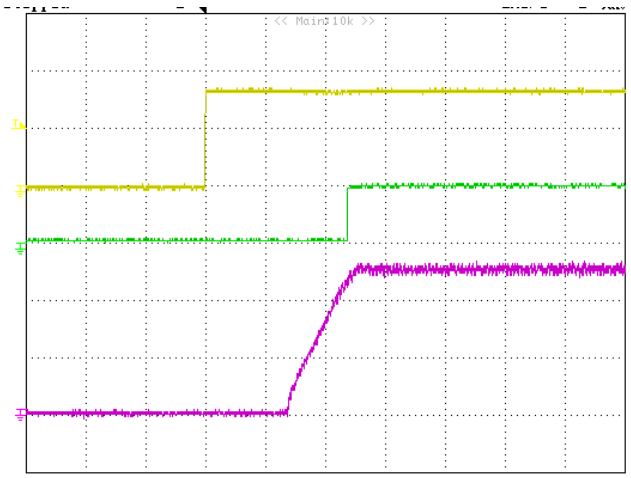


***Figure 14:*** *Turn on delay time at 12Vin, 2.5V/50A out (1mS/div)*
*Top trace: Enable, middle trace: PG, bottom trace: Vo*

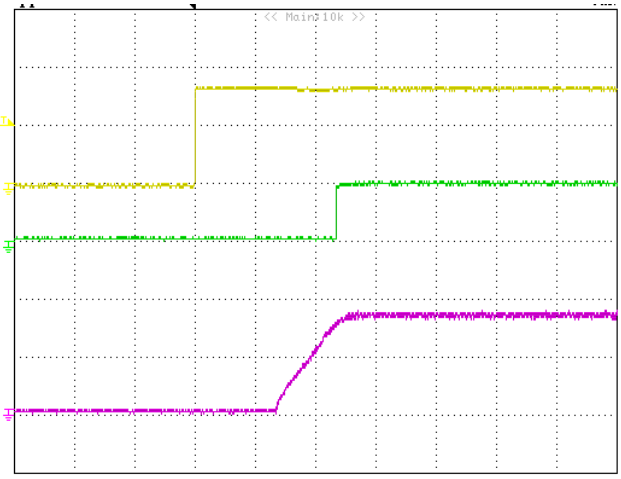


***Figure 15:*** *Turn on delay time at 12Vin, 3.3V/50A out (1mS/div)*
*Top trace: Enable, middle trace: PG, bottom trace: Vo*

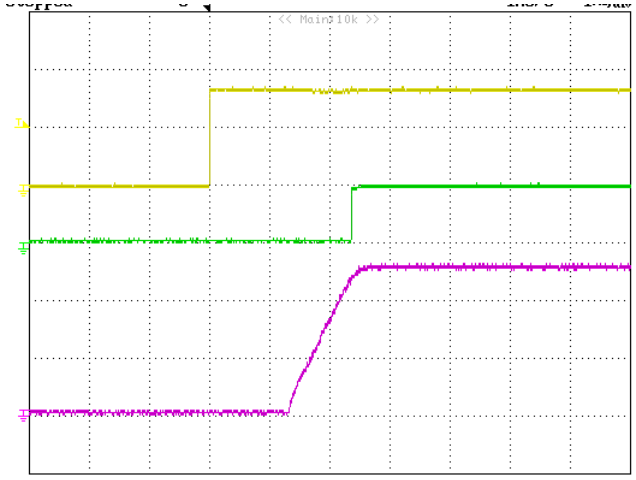


***Figure 16:*** *Turn on delay time at 12Vin, 5.0V/50A out (1mS/div)*
*Top trace: Enable, middle trace: PG, bottom trace: Vo*

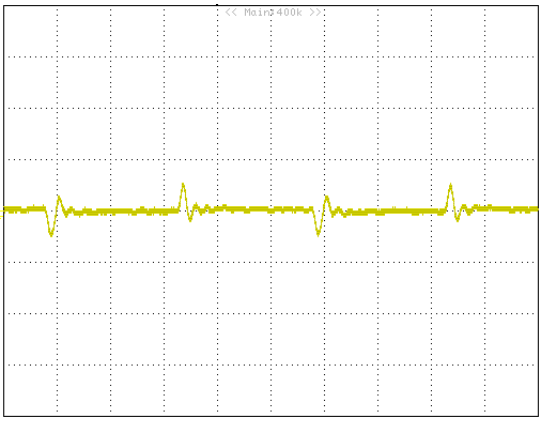


***Figure 17:*** *Transient Response at 12Vin, 1.1V/50A out (200uS/div)*
*Top trace: Vo(50mV/div),Io from 25A to 37.5A*

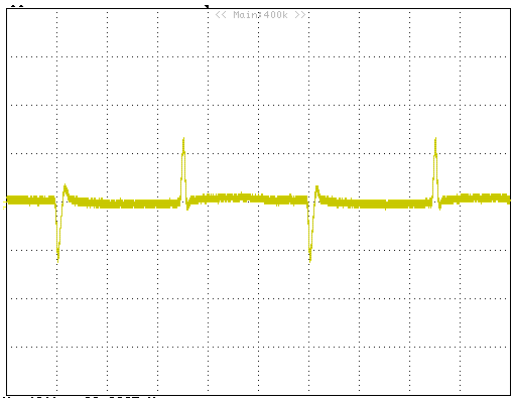


***Figure 18:*** *Transient Response at 5Vin, 1.2V/50A out (200uS/div)*
*Top trace: Vo(50mV/div),Io from 25A to 37.5A*

## ELECTRICAL CHARACTERISTICS CURVES (CONTINUED)

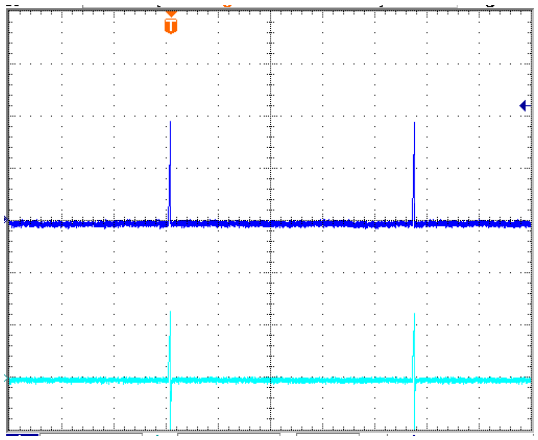


***Figure 19:*** *Short Circuit Protection at 12Vin, 1.1V out (40mS/div), Top trace: Vo(10mV/div), bottom trace: Io(50A/div)*

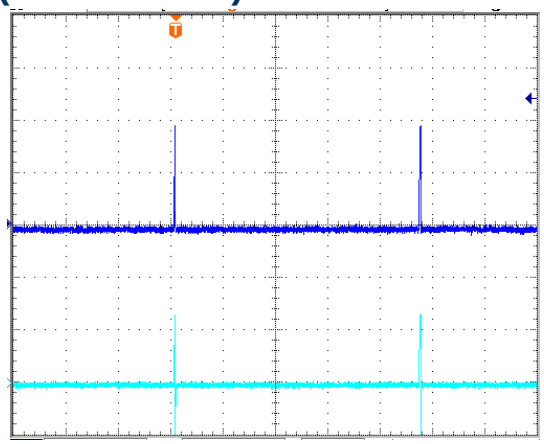


***Figure 20:*** *Short Circuit Protection at 12Vin, 1.2V out (40mS/div), Top trace: Vo(10mV/div), bottom trace: Io(50A/div)*

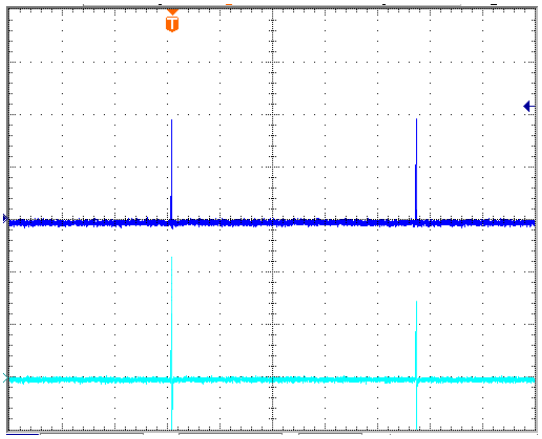


***Figure 21:*** *Short Circuit Protection at 12Vin, 1.8V out (40mS/div), Top trace: Vo(10mV/div), bottom trace: Io(50A/div)*

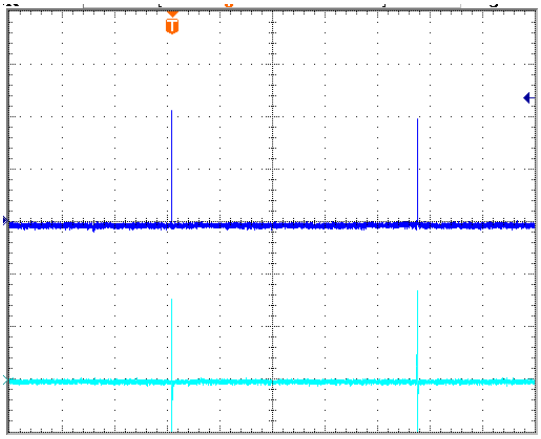


***Figure 22:*** *Short Circuit Protection at 12Vin, 2.5V out (40mS/div), Top trace: Vo(10mV/div), bottom trace: Io(50A/div)*

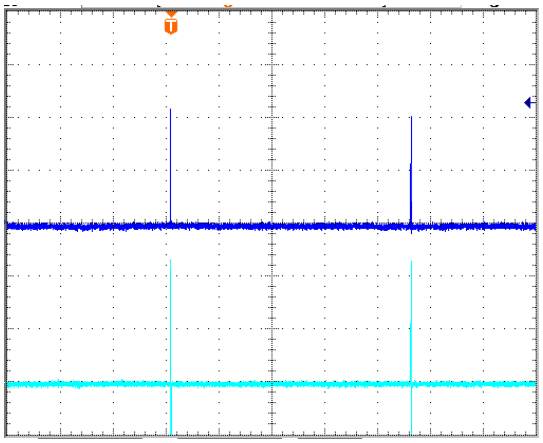


***Figure 23:*** *Short Circuit Protection at 12Vin, 3.3V out(40mS/div), Top trace: Vo(10mV/div), bottom trace: Io(50A/div)*

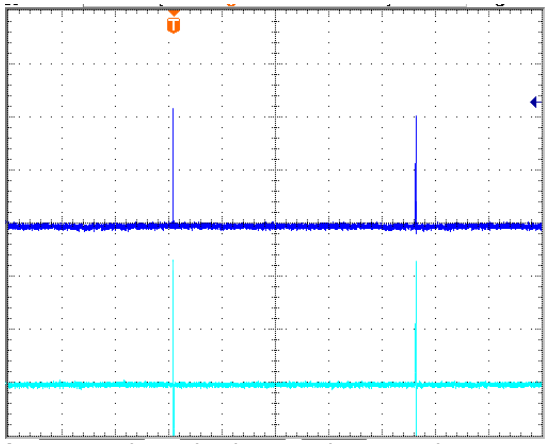


***Figure 24:*** *Short Circuit Protection at 12Vin, 5.0V out (40mS/div), Top trace: Vo(10mV/div), bottom trace: Io(50A/div)*

# DESIGN CONSIDERATIONS

The D12S2R550 uses a two phase and voltage mode controlled buck topology. The output can be trimmed in the range of 0.6Vdc to 5.0Vdc by a resistor from Trim pin to Ground.

The converter can be turned ON/OFF by remote control. Positive on/off (ENABLE pin) logic implies that the converter DC output is enabled when the signal is driven high (greater than 1.2V) or floating and disabled when the signal is driven low (below 0.6V).

The converter provides an open collector Power Good signal. The power good signal is pulled low when output is not within ±10% of Vout or Enable is OFF.

For output voltages above 1.8V, please refer to Figure 29 below for minimum input voltage requirement for proper module operations.

The converter can protect itself by entering hiccup mode against over current and short circuit condition.

### Safety Considerations

It is recommended that the user to provide a fuse in the input line for safety. The output voltage set-point and the output current in the application could define the amperage rating of the fuse.

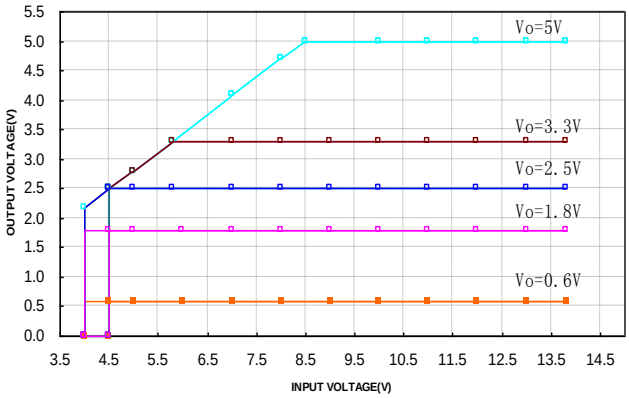



***Figure 25:*** *minimum input voltage required for output voltages above 1.8V*

# FEATURES DESCRIPTIONS

### Enable (On/Off)

The ENABLE (on/off) input allows external circuitry to put the D12S2R550 converter into a low power dissipation (sleep) mode. Positive ENABLE is available as standard.

Positive ENABLE units of the D12S2R550 series are turned on if the ENABLE pin is high or floating. Pulling the pin low will turn off the unit. With the active high function, the output is guaranteed to turn on if the ENABLE pin is driven above 1.2V. The output will turn off if the ENABLE pin voltage is pulled below 0.6V.

### Input Under-Voltage Lockout

The input under-voltage lockout prevents the converter from being damaged while operating when the input voltage is too low. The under-voltage lockout is adjustable by adding a resistor (Figure 30) between Enable pin and ground pin per the following equation:

$$\mathrm{Re}\,n(K\Omega) = \frac{315}{14Ven + 3.8}$$

Default lockout range is between 4.3V and 4.0V.

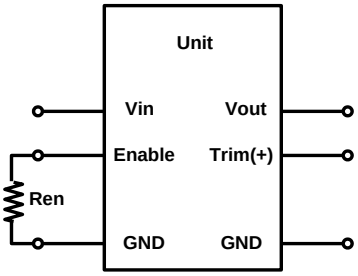
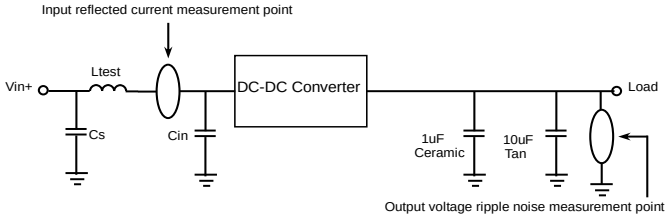



**Figure 26:** *Enable input drive circuit example.*

### Reflected Ripple Current and Output Ripple and Noise Measurement

The measurement set-up outlined in Figure 31 has been used for both input reflected/ terminal ripple current and output voltage ripple and noise measurements on D12S2R550 converters.




Cs=330μF OS-con cap x1, Ltest=1μH, Cin=330μF OS-con cap x1

***Figure 27:*** *Input reflected ripple/ capacitor ripple current and output voltage ripple and noise measurement setup for D12S2R550*

# FEATURES DESCRIPTIONS (CON.)

### Over-Current and Short-Circuit Protection

The D12S2R550 modules have non-latching over-current and short-circuit protection circuitry. When over current condition occurs, the module goes into the non-latching hiccup mode. When the over-current condition is removed, the module will resume normal operation.

An over current condition is detected by measuring the voltage drop across the inductor. The voltage drop across the inductor is also a function of the inductor's DCR.

Note that none of the module specifications are guaranteed when the unit is operated in an over-current condition.

### Output Over Voltage Protection (OVP)

The converter will shut down when an output over voltage protection is detected. Once the OVP condition is detected, controller will stop all PWM outputs and turn on low-side MOSFET to prevent any damage to load.

### Remote Sense

The D12S2R550 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 0.5V of loss. The remote sense connects as shown in Figure 32.

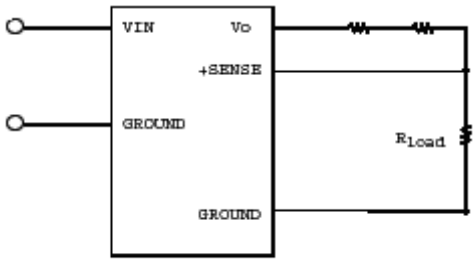



***Figure 28:*** *Circuit configuration for remote sense*

### Output Capacitance

There are internal output capacitors on the D12S2R550 modules. Hence, no external output capacitor is required for stable operation.

### Output Voltage Programming

The output voltage of the D12S2R550 is trimmable by connecting an external resistor between the trim pin and output ground as shown Figure 33 and the typical trim resistor values are shown in Table 1.

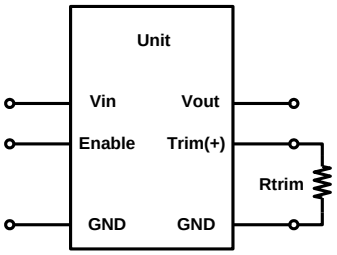



***Figure 29:*** *Trimming Output Voltage*

The D12S2R550 module has a trim range of 0.6V to 5.0V. The trim resistor equation for the D12S2R550 is:

$$Rtrim(\Omega) = \frac{1200}{Vout - 0.6}$$

Vout is the output voltage setpoint
Rtrim is the resistance between Trim and Ground
Rtrim values should not be less than 270Ω

| Output | Rtrim (Ω) |
|---|---|
| 0.6V | open |
| +1.1 V | 2.4K |
| +1.2V | 2K |
| +1.5 V | 1.33K |
| +1.8V | 1K |
| +2.5 V | 631.6 |
| +3.3 V | 444.4 |
| +5.0V | 272.7 |

***Table 1:*** *Typical trim resistor values*

### Power Good

The converter provides an open collector signal called Power Good. This output pin uses positive logic and is open collector. This power good output is able to sink 4mA and set high when the output is within ±10% of output set point. The power good signal is pulled low when output is not within
±10% of Vout or Enable is OFF.

### Paralleling

D12S2R550 converters do not have built-in current sharing (paralleling) ability. Hence, paralleling of multiple D12S2R550 converters is not recommended.

# THERMAL CONSIDERATION

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.

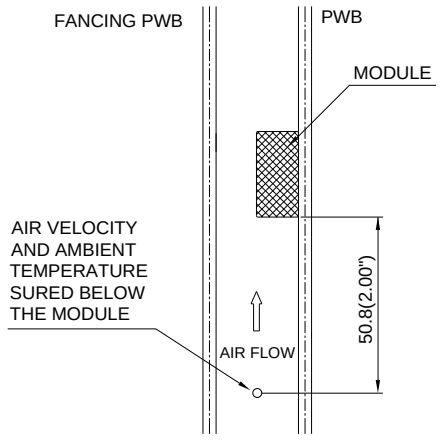
### Thermal Testing Setup

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").

### 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.




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

***Figure 30:*** *Wind tunnel test setup*

# THERMAL CURVES

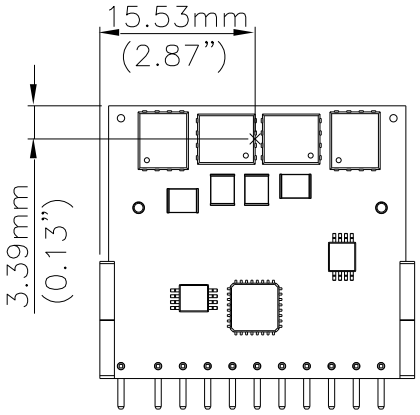



***Figure 35:*** *Temperature measurement location* The allowed maximum hot spot temperature is defined at 120℃*

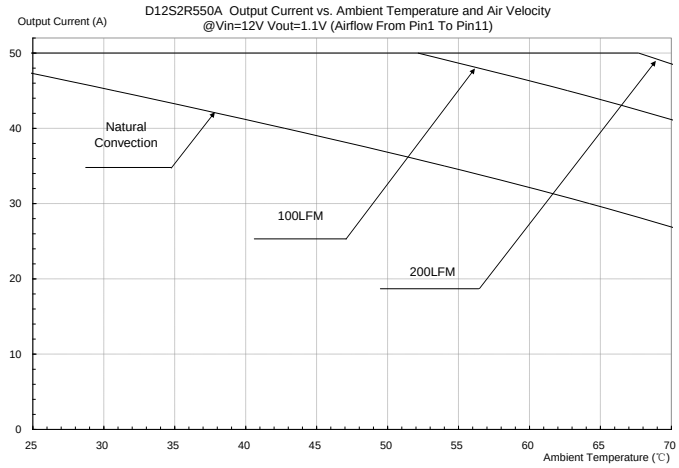



***Figure 31:*** *Output current vs. ambient temperature and air velocity @Vin=12V, Vout=1.1V (Airflow from Pin1 to Pin11)*

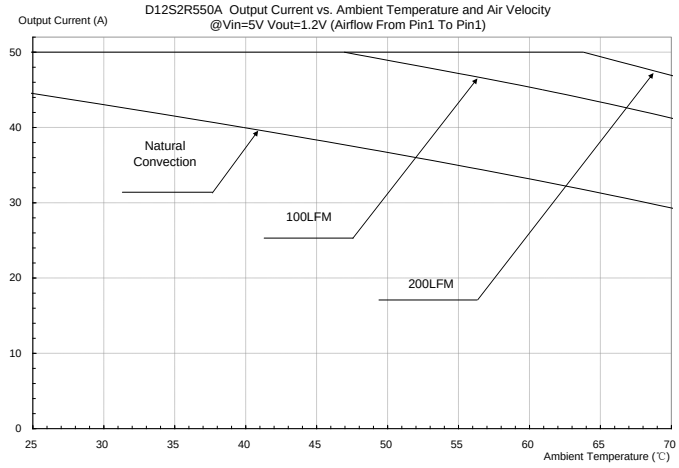
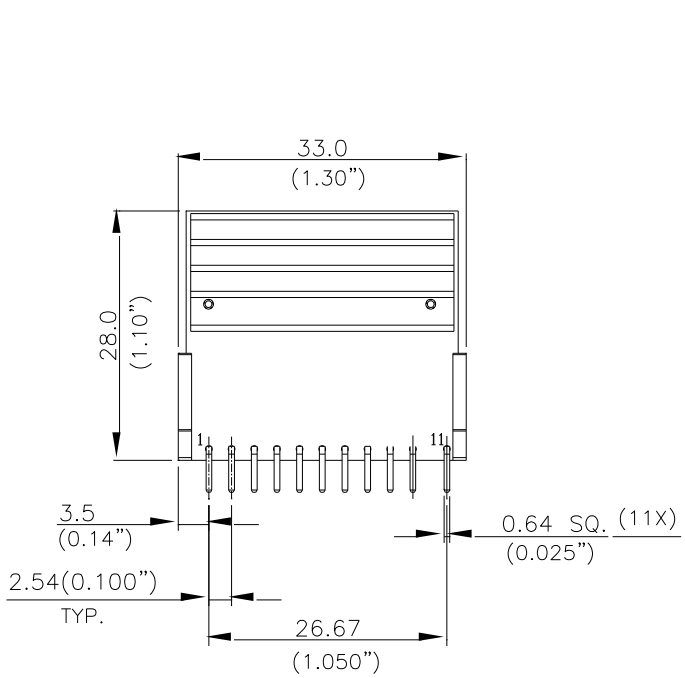
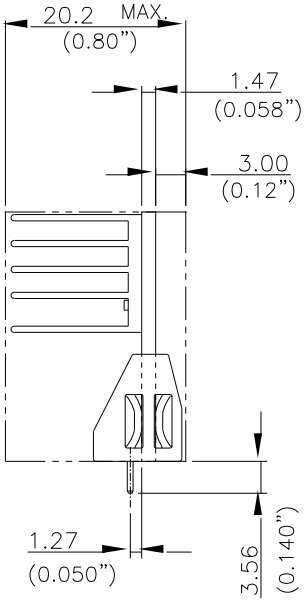


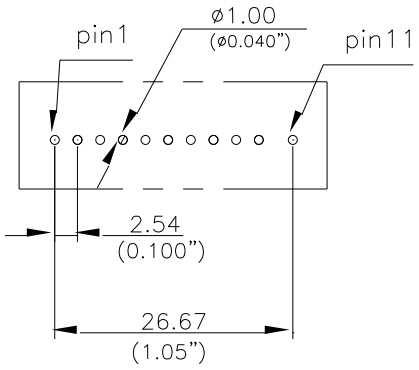

***Figure 32:*** *Output current vs. ambient temperature and air velocity@ Vin=5V, Vout=1.2V (Airflow from Pin1 to Pin11)*

## MECHANICAL DRAWING




| PIN# | Function | PIN# | Function |
|---|---|---|---|
| 1 | Vout | 7 | GROUND |
| 2 | Vout | 8 | GROUND |
| 3 | Vout | 9 | +SENSE |
| 4 | TRIM | 10 | Vin |
| 5 | ENABLE | 11 | Vin |
| 6 | PG | | |




RECOMMENDED P.W.B LAYOUT

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.)

## PART NUMBERING SYSTEM

| D | 12 | S | 2R5 | 50 | A |
|---|---|---|---|---|---|
| **Type of Product** | **Input Voltage** | **Product Series** | **Output voltage** | **Output current** | **Option Code** |
| D - DC/DC modules | 12 - 4.5 ~13.8V | S - Single | 2R5 - 0.6~5V | 50A | A (0.140”)<br>D (0.165”) |

## MODEL LIST

| Model Name | Input Voltage | Output Voltage | Output Current | Lead Free | Efficiency, 12Vin |
|---|---|---|---|---|---|
| D12S2R550A | 4.5V~ 13.8Vdc | 0.6V ~ 5.0V | 50A | RoHs 6 | 93.6% @ 5V/50A |
| D12S2R550D | 4.5V~ 13.8Vdc | 0.6V ~ 5.0V | 50A | RoHs 6 | 93.6% @ 5V/50A |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