

## DC1842B and DC1680B LTC4290B/LTC4271 8-Port PSE with Digital Isolation

### DESCRIPTION

Demonstration kit DC1843B is an 8-port Ethernet Alliance™ certified IEEE 802.3at Type 2 power sourcing equipment (PSE) composed of a DC1842B daughter card and DC1680B motherboard. The kit is used for evaluation of the [LTC4290B](#) and [LTC4271](#) PSE chipset. Up to 8 powered devices (PDs) can be connected and powered from this system using a single power supply. A DC590 is connected to the DC1843 for I<sup>2</sup>C interfacing with QuikEval™. This demonstration manual provides a Quick Start Procedure, a DC1842B overview, a DC1680B overview, schematics, and layout

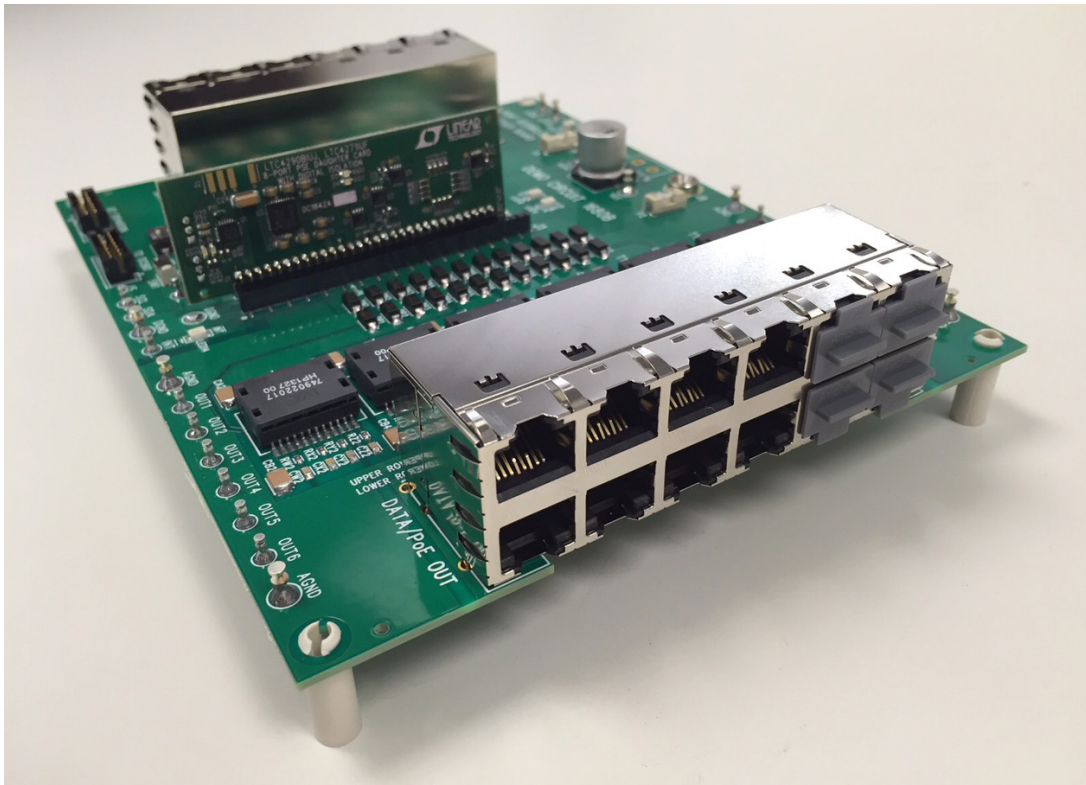
printouts. Refer to the Layout Guide for Demonstration Circuit 1842B when laying out the LTC4290B/LTC4271 circuit. Contact Analog Devices for this document.

The DC1842B has increased surge protection over the DC1842A. The DC1680B uses discrete Ethernet transformers while the DC1680A has an integrated 12-port RJ45 jack.

**[Design files for this circuit board are available.](#)**

All registered trademarks and trademarks are the property of their respective owners.

### BOARD PHOTO



## QUICK START PROCEDURE

Demonstration kit DC1843B includes the DC1842B daughter card and DC1680B motherboard. The kit is set up for evaluating the LTC4290B/LTC4271. Follow the procedure below and refer to Figures 1 through 4 for proper equipment setup.

NOTE (DC1843B Kit): Connector J1 on the DC1680B has four pegs blocking the unused last four pins to match the 30-pin connector of the DC1842B. Dust caps block the four unused ports at each RJ45 connector on the DC1680B for the 8-Port.

1. On the DC1842B set AUTO jumper JP1 to HI (Figure 1) to enable AUTO pin mode.
2. On the DC1842B set MID jumper JP2 to LO (Figure 1) to disable midspan mode.

3. Align pin 1 of the 30-pin male connector on the DC1842B with pin 1 of the 30-pin female connector on the DC1680B (Figure 2). Pin 12 is polarized to assist with the alignment. Carefully push the DC1842B straight down until the two 30-pin connectors are flush with each other.
4. On the DC1680B, connect a supply with the positive rail to POS and negative rail to NEG (Figure 3). Use a power supply capable of sourcing the maximum load expected ( $8 \text{ ports} \times 850\text{mA} \geq 6.8\text{A}$ ). Ramp the supply up to 51V to 57V.
5. Connect up to 8 PDs to ports 1-8 at the DC1680B, J4 (Figure 3).
6. The DC590 is optionally connected to the DC1680B connector J5 with a 14-pin ribbon cable (Figure 3). A GUI for the LTC4290B/LTC4271 is brought up by QuikEval for I<sup>2</sup>C interfacing from a PC (Figure 4).

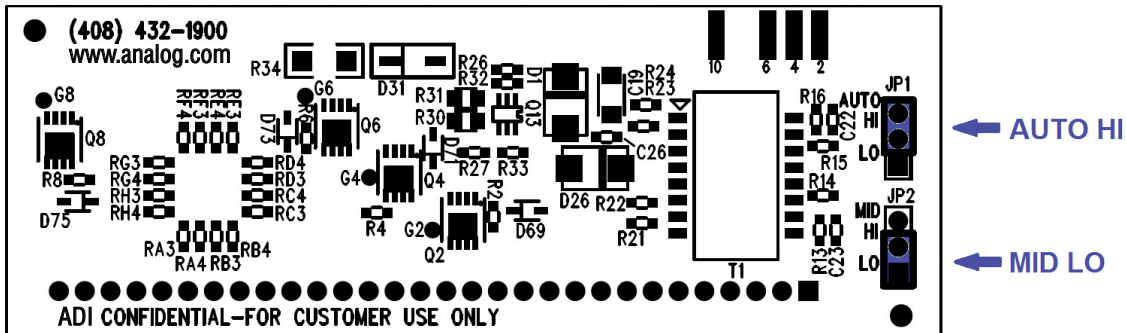


Figure 1. DC1842 Backside. Setting AUTO and MID Jumpers

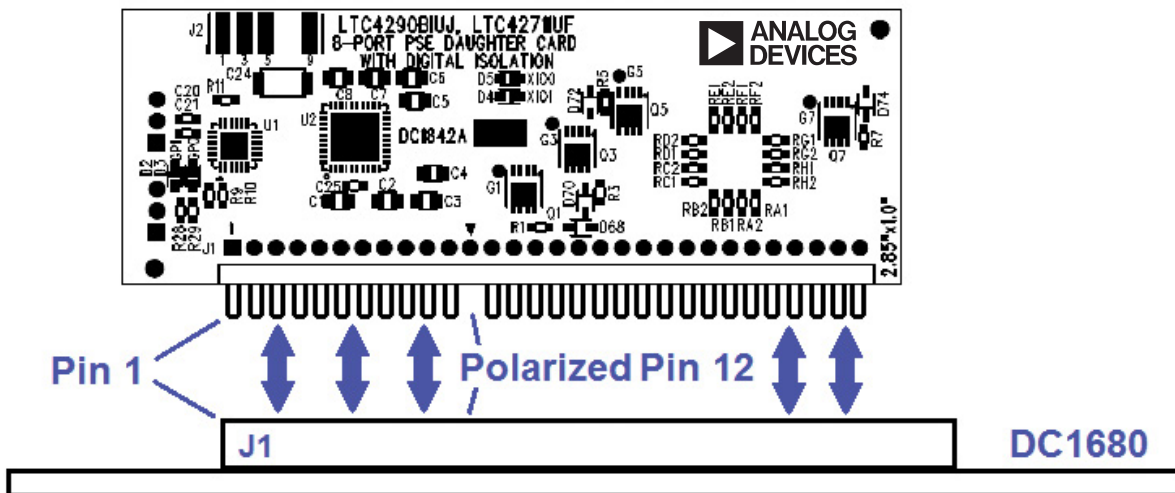


Figure 2. Inserting the DC1842 into J1 of the DC1680

**QUICK START PROCEDURE**

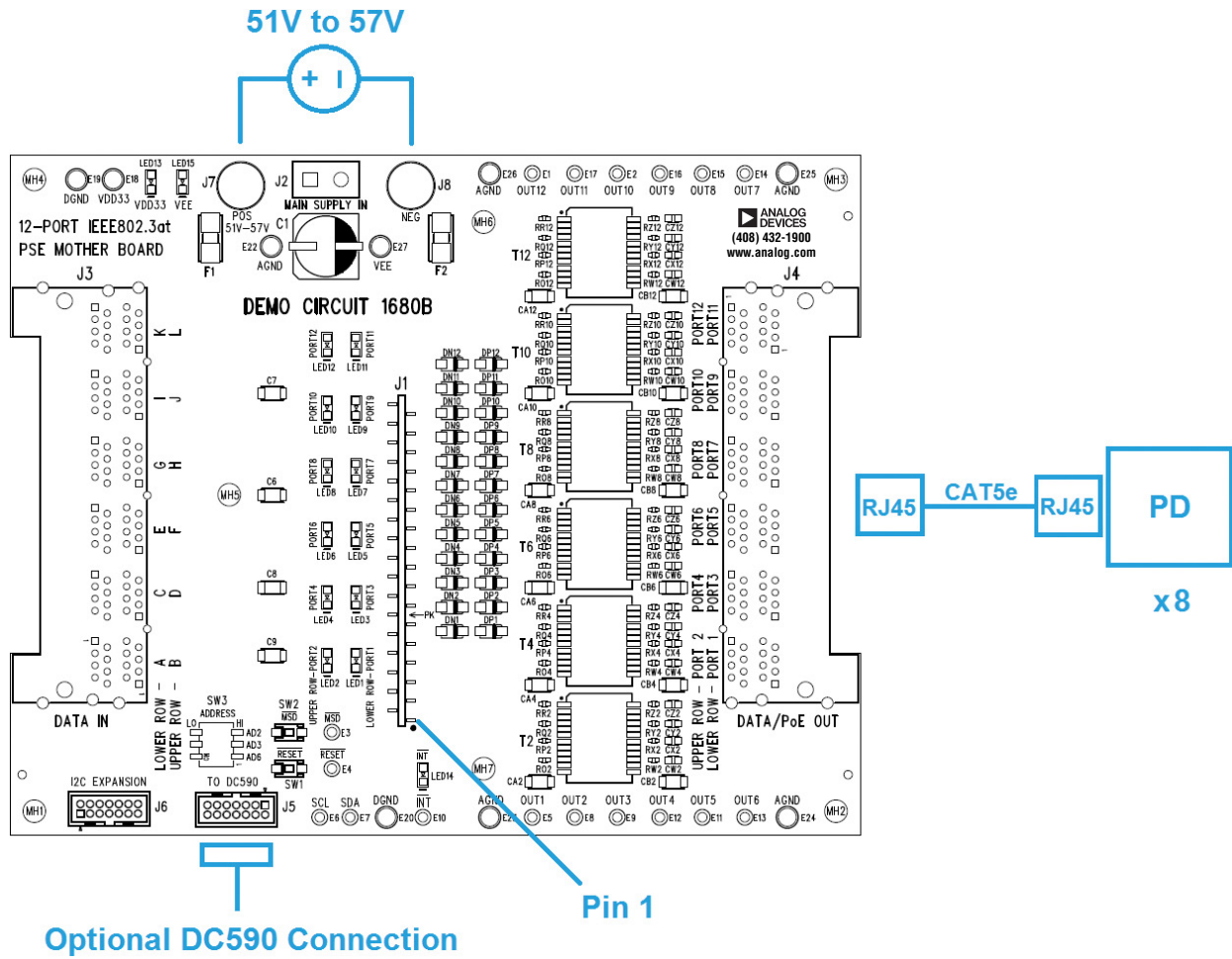


Figure 3. DC1843B Basic Setup

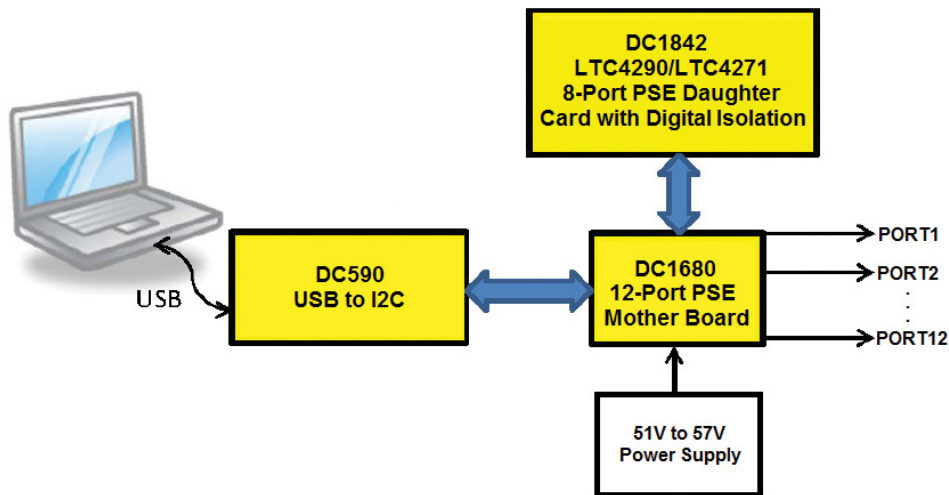


Figure 4. DC1843 System Setup with the DC590, DC1680, DC1842 and 51V to 57V Power Supply

## DEMONSTRATION CIRCUIT 1842B OPERATION

### 8-Port PSE Daughter Card with Digital Isolation

Demonstration circuit 1842B (Figure 5) features the LTC4290B/LTC4271 chipset on a compact daughter card with digital isolation. The LTC4290B/LTC4271 chipset is an 8-port power sourcing equipment (PSE) controller designed for use in IEEE 802.3at Type 1 and Type 2 (high power) compliant Power over Ethernet (PoE) systems. A transformer isolated communication protocol replaces expensive opto-couplers and complex isolated 3.3V supply resulting in significant BOM cost savings. The LTC4290B/LTC4271 chipset delivers lowest-in-industry heat dissipation by utilizing low  $R_{ON}$  external MOSFETs and  $0.25\Omega$  sense resistors, eliminating the need for expensive heat sinks.

Advanced power management features in the LTC4290B/LTC4271 chipset include: per port 12-bit current monitoring ADCs, DAC programmable current limit, and versatile quick shutdown of preselected ports. PD discovery uses a

proprietary dual mode 4-point detection mechanism ensuring excellent immunity from false PD detection. Midspan PSEs are supported with 2-event classification and a two second backoff timer. The LTC4290B/LTC4271 includes an I<sup>2</sup>C serial interface operable up to 1MHz.

The DC1842B demonstrates proper LTC4290B/LTC4271 board layout that is approximately the height and width of a  $2 \times 4$  RJ45 connector. The compact layout is made possible by the small package size of key components. The LTC4290B is in a  $6\text{mm} \times 6\text{mm}$  QFN, while the LTC4271 is in a  $4\text{mm} \times 4\text{mm}$  QFN. Each port has a PSMN075-100MSE MOSFET in a  $3\text{mm} \times 3\text{mm}$  LFPAK33 package.

The daughter card inserts in the DC1680B motherboard through J1, a polarized 30-pin connector. Isolated 3.3V and logic control signals are brought in on this connector. Also connected at J1 is the PoE  $V_{EE}$  supply from the motherboard and 8 PSE controlled outputs.

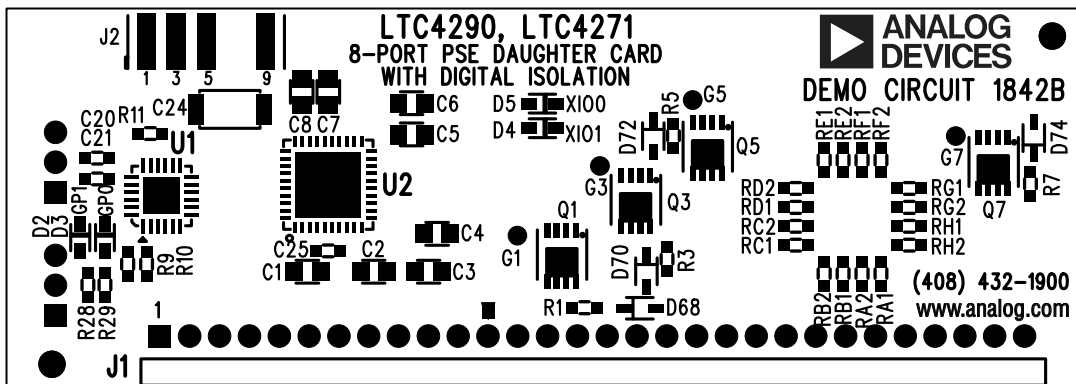


Figure 5. DC1842B 8-Port PSE Daughter Card with Digital Isolation Features the LTC4290B and LTC4271

## DEMONSTRATION CIRCUIT 1842B OPERATION

### Board Layout

Proper board layout is crucial for proper LTC4290B/LTC4271 chipset operation, robustness, and accuracy. When laying out, pay attention to parts placement, Kelvin sensing, power paths, and copper fill. It is imperative to follow the LTC4290B/LTC4271 Layout Guide document when laying out the board. Contact Analog Devices for this document.

### Isolation and Power Supplies

The LTC4290B/LTC4271 chipset provides communication across an isolation barrier through a data transformer (Figure 6). This eliminates the need for expensive optocouplers. All digital pins reside on the digital ground reference and are isolated from the analog PoE supply. A 3.3V supply for  $V_{DD}$  and an isolated  $V_{EE}$  supply are connected to the DC1842B through the 30-pin connector.

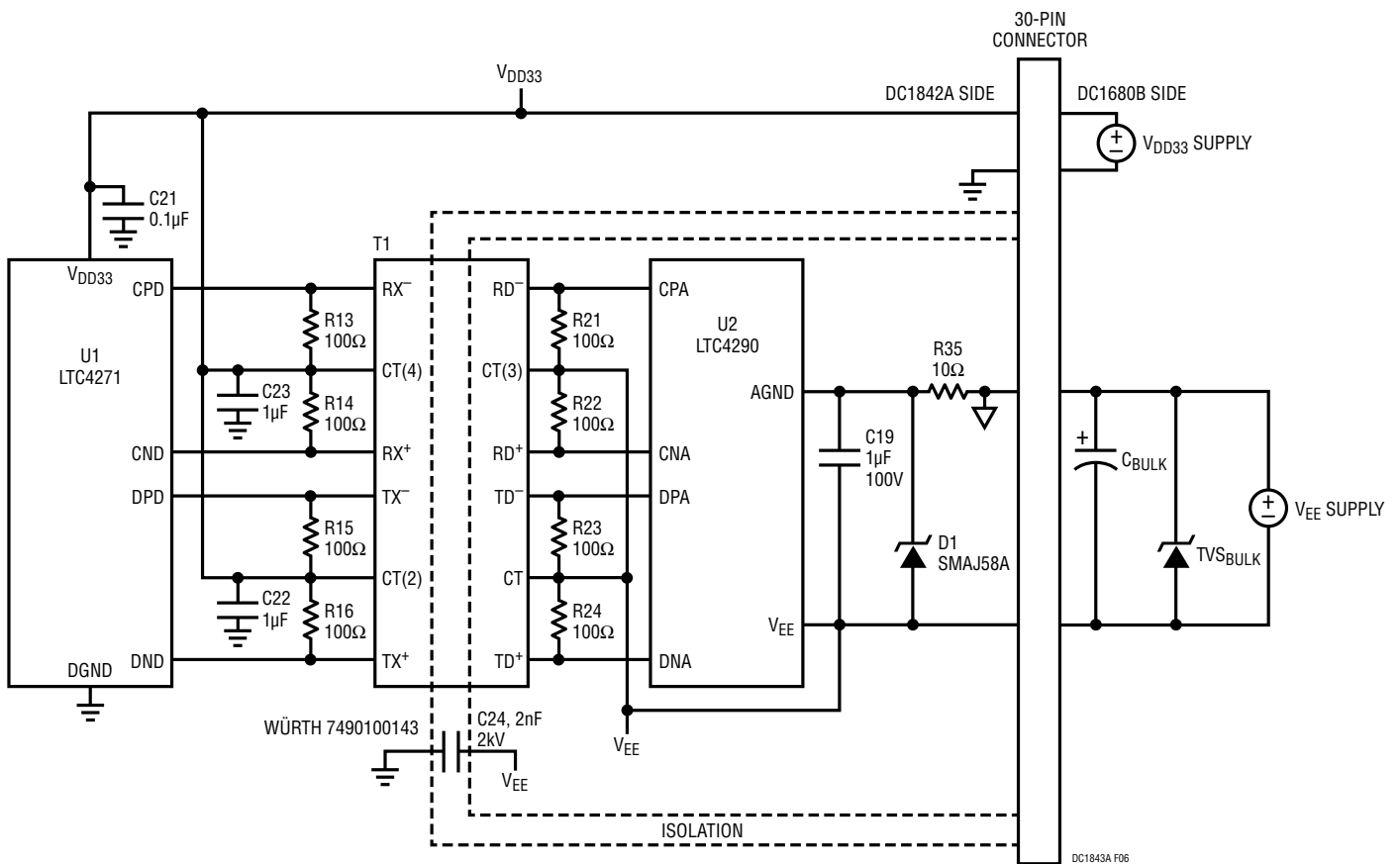


Figure 6. DC1842B Digital and Analog Isolation

## DEMONSTRATION CIRCUIT 1842B OPERATION

### I<sup>2</sup>C Communication and Addressing

The LTC4271 internal registers are accessed via I<sup>2</sup>C to read and/or write configuration, status, and interrupt registers. The I<sup>2</sup>C lines SDAOUT, SDAIN and SCL connect to the 30-pin connector (Figure 7). Subsequently, the I<sup>2</sup>C bus is accessed on the DC1680B.

The LTC4290B/LTC4271 chipset has an address of (A<sub>6</sub>A<sub>3</sub>A<sub>2</sub>A<sub>1</sub>A<sub>0</sub>b), where A<sub>6</sub>, A<sub>3</sub>, A<sub>2</sub>, A<sub>1</sub>, and A<sub>0</sub> are the logic state of the AD<sub>6</sub>, AD<sub>3</sub>, AD<sub>2</sub>, AD<sub>1</sub>, and AD<sub>0</sub> pins respectively. On the DC1842B, AD<sub>0</sub> and AD<sub>1</sub> are tied low with pull-down resistors. AD<sub>2</sub>, AD<sub>3</sub> and AD<sub>6</sub> are brought out to the 30-pin connector (Figure 7) and set with three switches on the DC1680B.

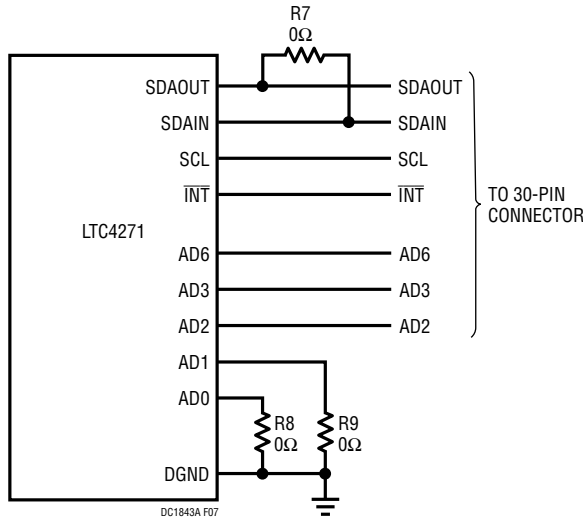


Figure 7. DC1842B, LTC4271 I<sup>2</sup>C and Address Connections

### I/O LED Indicators

The DC1842B features four LEDs to indicate the states of the LTC4290B/LTC4271 chipset general purpose input output pins. These pins are configured as inputs or outputs via I<sup>2</sup>C. GP1 and GP0 are referenced to DGND and driven by the LTC4271 when set as outputs (Figure 8). XIO0 and XIO1 are referenced to V<sub>EE</sub> and are driven by the LTC4290B when set as outputs (Figure 9). J2 provides test points for access to these I/Os.

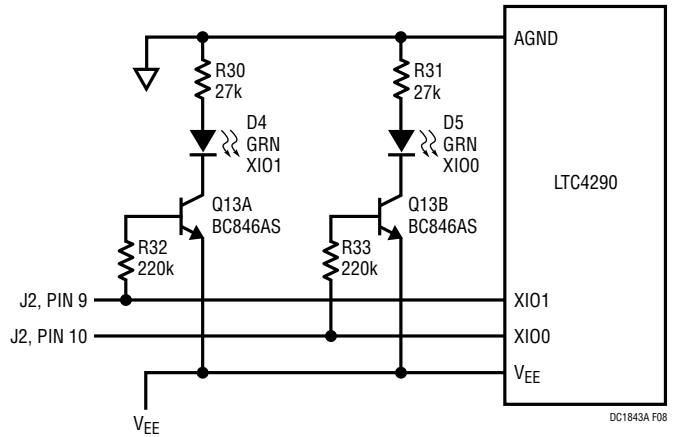


Figure 8. DC1842B, LTC4290B General Purpose I/O LED Indicators

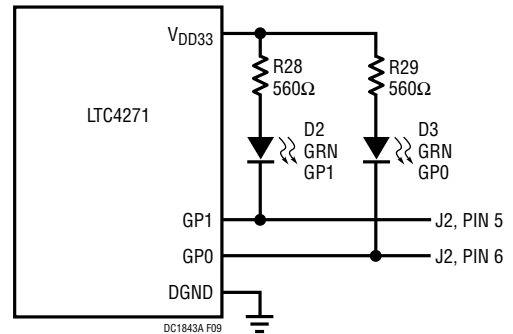


Figure 9. DC1842B, LTC4271 General Purpose I/O LED Indicators

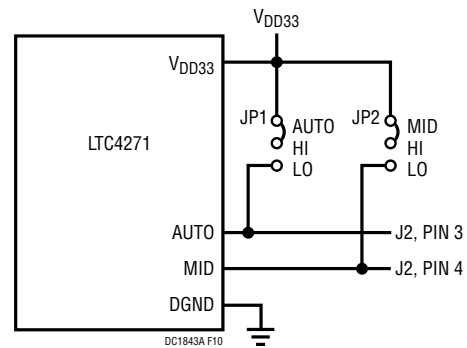


Figure 10. DC1842B AUTO and MID Jumpers

## DEMONSTRATION CIRCUIT 1842B OPERATION

### AUTO and MID Jumpers

The AUTO and MID pins of the LTC4271 are set by jumpers JP1 and JP2 respectively on the DC1842B (Figure 10). Setting JP1 to HI enables the AUTO pin mode in the LTC4290B/LTC4271 chipset. J2 provides test points for access to AUTO and MID.

In AUTO pin mode (JP1 high), the LTC4290B/LTC4271 chipset internal I<sup>2</sup>C registers default to the AUTO pin high state after a software or hardware reset, or system power on. The LTC4290B/LTC4271 chipset autonomously detects, powers on and disconnects power to PDs without the need for I<sup>2</sup>C host control.

Setting JP1 to LO disables AUTO pin mode and sets the LTC4290B/LTC4271 chipset to a low current shutdown mode. An I<sup>2</sup>C host controller can then be used to configure the LTC4290B/LTC4271 chipset to semi-auto mode for controlled PSE operation or to manual mode for test purposes.

Setting JP2 to HI enables the midspan mode detection backoff timer in the LTC4290B/LTC4271 chipset. For endpoint PSEs, set JP2 to LO to disable midspan mode.

For quick PSE evaluation in AUTO pin mode with MIDSPAN disabled, set JP1 HI and JP2 LO on the DC1842B.

### Surge Protection

Ethernet ports can be subject to significant cable surge events. To keep PoE voltages below a safe level and protect the application against damage, protection components, as shown in Figure 11, are required at the main supply, at the LTC4270 supply pins and at each port.

Bulk transient voltage suppression (TVS<sub>BULK</sub>) and bulk capacitance (C<sub>BULK</sub>) are required across the main PoE supply and should be sized to accommodate system level surge requirements.

Each LTC4290 requires a 10Ω, 0805 resistor (R1) in series from supply AGND to the LTC4290 AGND pin. Across the LTC4290 AGND pin and V<sub>EE</sub> pin are an SMAJ58A, 58V TVS (D1) and a 1μF, 100V bypass capacitor (C19). These components must be placed close to the LTC4290 pins.

Finally, each port requires a pair of S1B clamp diodes: one from OUT<sub>n</sub> to supply AGND and one from OUT<sub>n</sub> to supply V<sub>EE</sub>. The diodes at the ports steer harmful surges into the supply rails where they are absorbed by the surge suppressors and the V<sub>EE</sub> bypass capacitance. The layout of these paths must be low impedance. These S1B diodes are placed on the DC1680 mother board of the DC1843 kit.

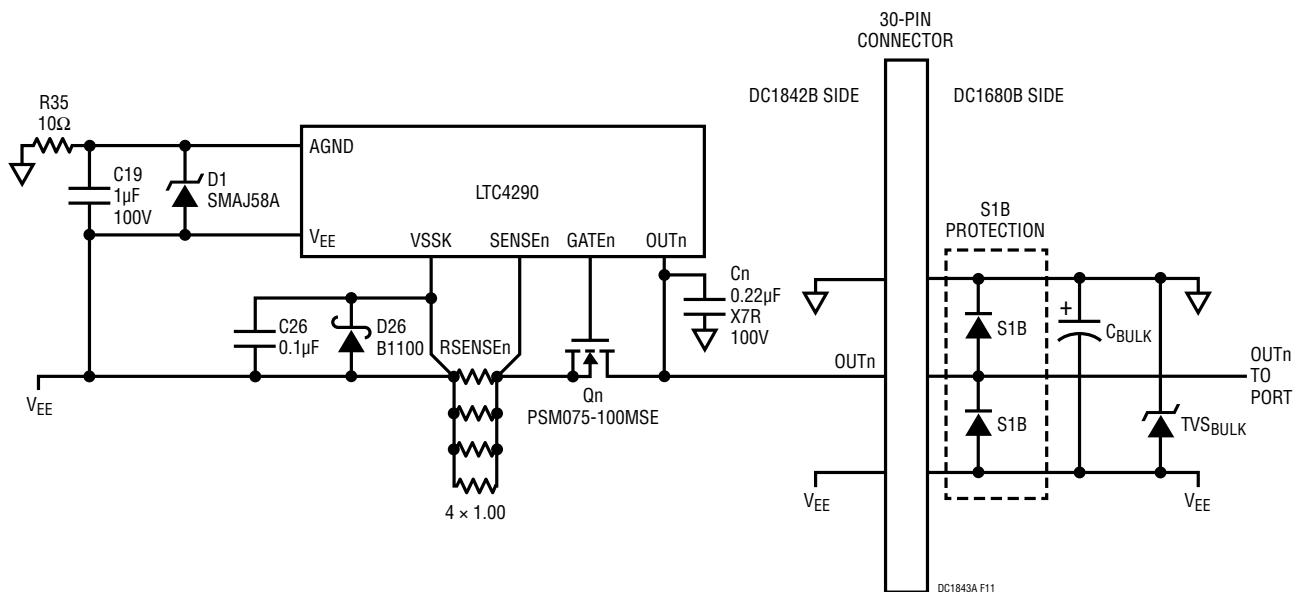


Figure 11. DC1842B, 1 of 8 Port Outputs. Surge Protection

## DEMONSTRATION CIRCUIT 1680B OPERATION

Demonstration circuit 1680B is configured as an 8-Port, IEEE802.3at Type 1 and Type 2 PoE PSE motherboard in the DC1843B kit. This board accepts various PSE daughter cards featuring Analog Devices PSE controllers. The DC1680B is capable of powering up to 8 PDs.

### Daughter Card Insertion Precautions

When inserting or removing the daughter card into the DC1680B, verify all supplies and LEDs are off. Push the card straight down for insertion or pull straight up for removal to avoid bending the connector pins. Follow the instructions in the Quick Start Procedure for alignment.

### V<sub>EE</sub> Supply

Connect a power supply for V<sub>EE</sub> with the positive rail to POS and negative rail to NEG as shown in Figure 3 of the Quick Start Procedure. Set the voltage within the range in Table 1 depending on whether the application is a Type 1 or Type 2. Choose a power supply rating and set the current limit high enough to provide power for the maximum number of PDs connected and to meet each PD power requirements.

**Table 1. DC1843B V<sub>EE</sub> Power Range for Type 1 and Type 2 PSEs**

PSE TYPE	V <sub>EE</sub> SUPPLY RANGE	MAX DELIVERED PORT POWER	POWER SUPPLY*
Type 1	45V to 57V	13W	200W
Type 2	51V to 57V	25.5W	400W

\*Recommended DC1843B power supply minimum to avoid drooping in a worst-case scenario with I<sub>LIM</sub> current at all 8 ports.

### PD Connection

PDs are connected using an Ethernet cable to any of the 8 ports at the 2x6, RJ45 connector J4 on the DC1680B (Figure 3). Test points for port outputs OUT1 through OUT8 are provided.

### 8-Port Configuration

The DC1680B is configured for an 8-port PSE motherboard for the DC1843B kit. Four RJ45 dust caps at J3 and four dust caps at J4 are inserted to block off the four unused

Ethernet ports. Additional pegs are placed in the last 4 pins of connector J1 to block off the unused pins when the DC1842B daughter card is inserted.

### DC1680B USER FEATURES

Refer to Figure 12 and Figure 13 for the following user features.

#### Onboard 3.3V Supply

The DC1680B has an onboard V<sub>DD33</sub> digital supply generated from the V<sub>EE</sub> supply. DGND is a negative voltage referenced to AGND. If an external 3.3V supply is to be used, contact Analog Devices Applications for proper connection.

#### V<sub>EE</sub> and V<sub>DD33</sub> LED Indicators

LEDs for V<sub>EE</sub> and V<sub>DD33</sub> indicate if voltage is present at these supplies. Verify these LEDs are off before inserting or removing the daughter card.

#### Digital Connections

The DC1680B has connections for I<sup>2</sup>C control from a host controller. The DC590 is optionally connected to the DC1680B at J5 through a 14-pin ribbon cable. The QuikEval software will automatically detect the DC1680B and open the LTC4271 GUI. A second 14-pin ribbon cable can be connected to J6 for I<sup>2</sup>C expansion to another DC1680B board with slight board modifications. Contact Analog Devices Applications for instructions.

Digital test points include SCL, SDA, DGND,  $\overline{\text{INT}}$ ,  $\overline{\text{MSD}}$ , and  $\overline{\text{RESET}}$ . I<sup>2</sup>C address pin AD6, AD3, and AD2 are set with a 3-bit switch SW3.

#### Midspan PSE

The DC1843B can be configured as a midspan PSE. Upstream switch data comes in to J3. Data and PoE go out to a PD at J4. Set both MID and AUTO pins logic high.



## DEMONSTRATION CIRCUIT 1680B OPERATION

### MSD and RESET Pushbuttons

Pushbutton switch SW1, when pressed, pulls the  $\overline{\text{RESET}}$  pin of the daughter card logic low. The PSE controller is then held inactive with all ports off and all internal registers reset to their power-up states. When SW1 is released,  $\overline{\text{RESET}}$  is pulled high, and the PSE begins normal operation.

Pushbutton switch SW2 when pressed pulls the maskable shutdown input ( $\overline{\text{MSD}}$ ) pin of the daughter card logic low. When pressed, all ports that have their corresponding mask bit set in the mconfig register of the PSE controller will be shutdown. These ports must then be manually re-enabled via I<sup>2</sup>C or by resetting the PSE.

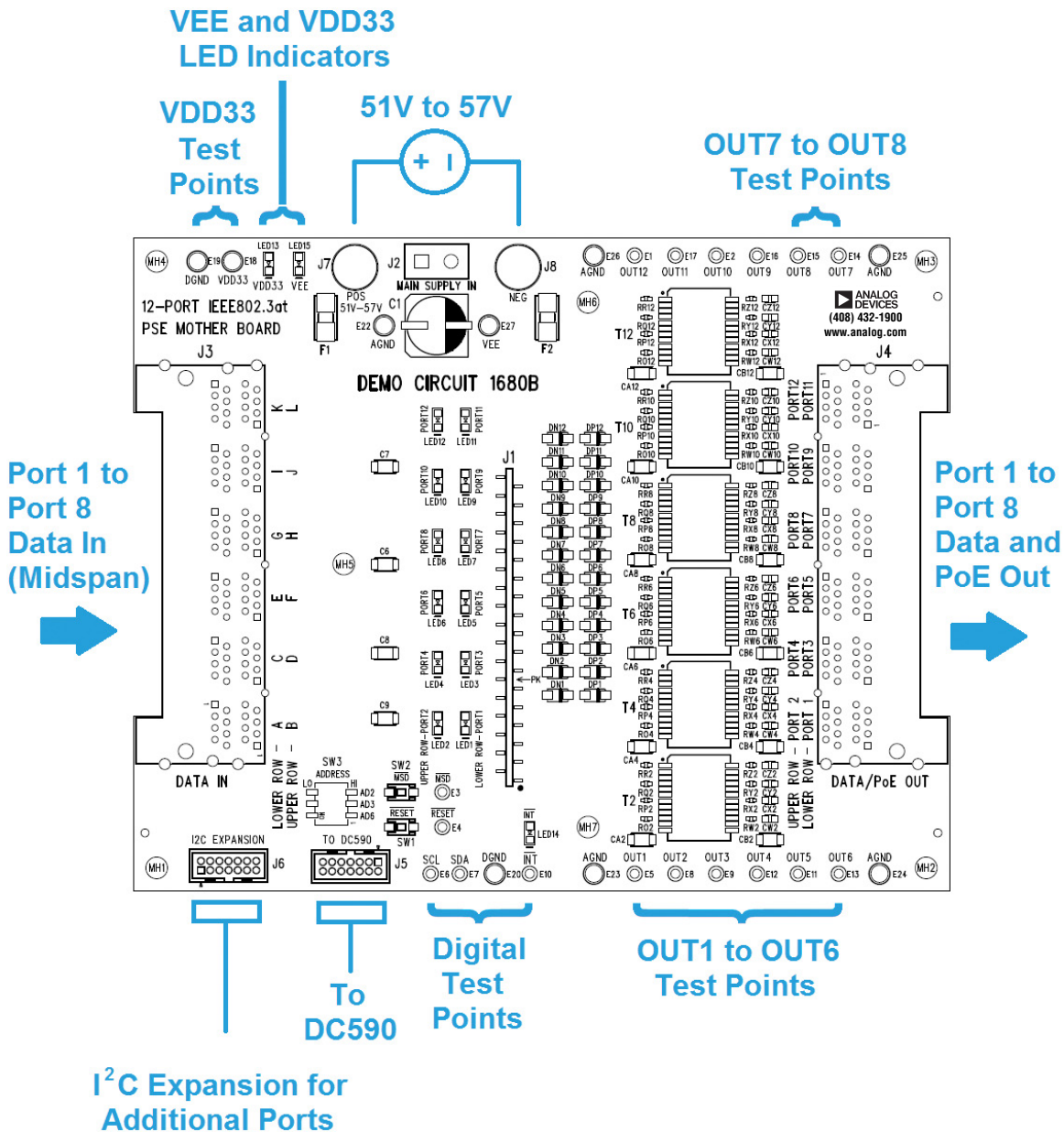


Figure 12. DC1680B Connections and Supply LEDs

## DEMONSTRATION CIRCUIT 1680B OPERATION

### Interrupt LED

A red LED indicates when the  $\overline{INT}$  line is pulled logic low by the daughter card. When the interrupt is cleared (high) via I<sup>2</sup>C servicing, the LED is turned off.

### Port 1 Through 8 Power LED Indicators

Each PSE port has a green LED indicator to show when PoE power is present at the port. The LEDs are driven by the respective port OUT voltage.

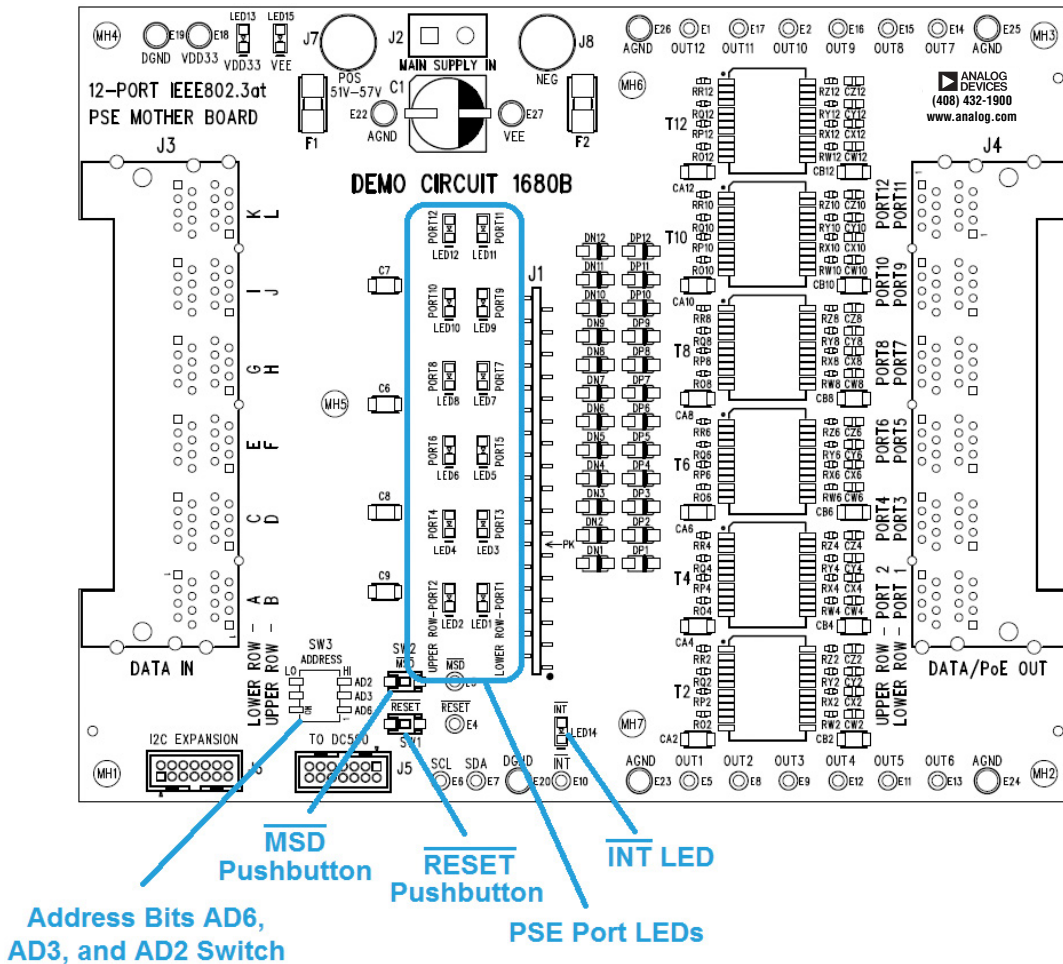


Figure 13. DC1680B Address Switch, Pushbutton Switches, INT LED, and Port Power LEDs

## DEMONSTRATION CIRCUIT 1843B SYSTEM

### DC1843B System Setup

Figure 14 shows a basic DC1843B system setup. The DC1842B daughter card is inserted in the 30-pin connector J1 on the DC1680B motherboard. A power supply is connected to  $V_{EE}$  with banana cables. The DC590 connects

with a 14-pin ribbon cable to the DC1680B and to a PC via USB. On the PC, a GUI communicates with the board. At the PSE output, PDs are connected. A sample PD demo board is shown in Figure 14.

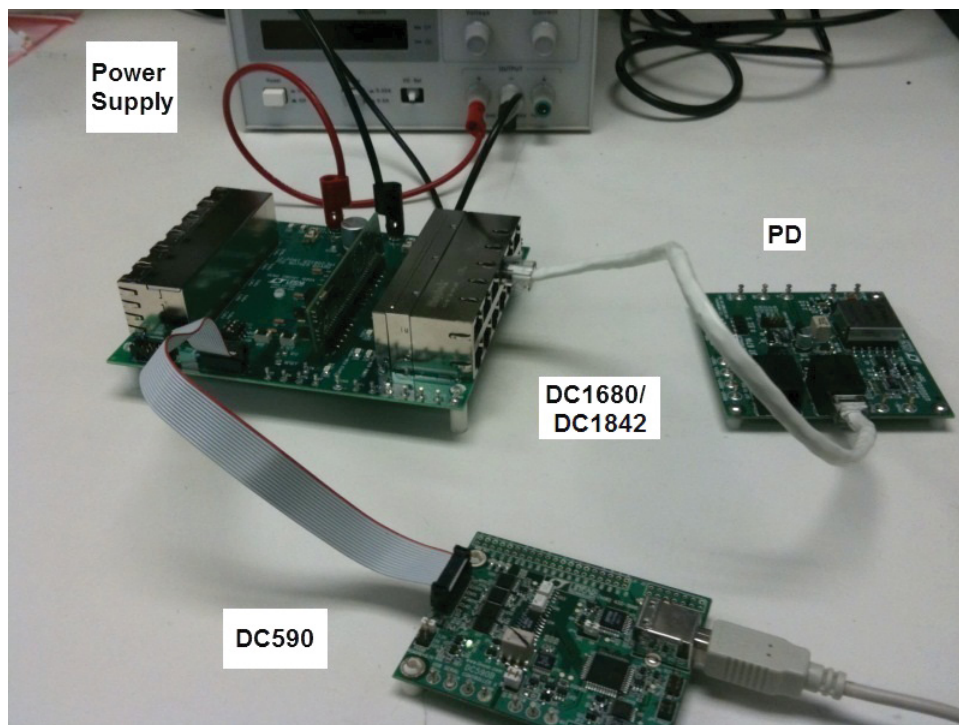


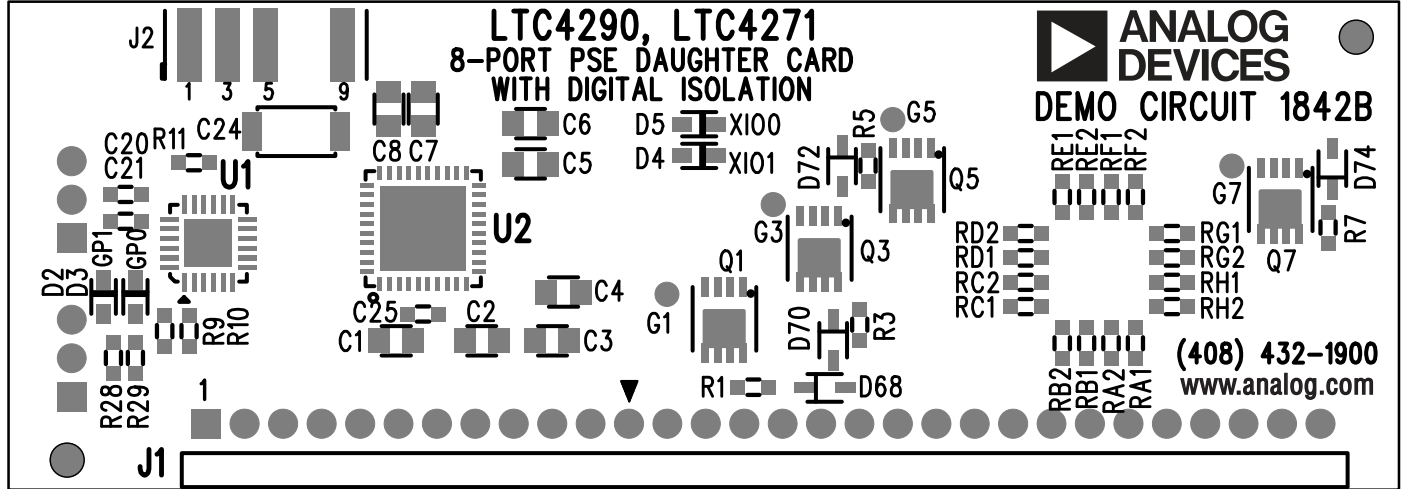
Figure 14. DC1680B and DC1842B System Setup with Power Supply, DC590 and PD Demo Board

Table 2. DC1843 Kit Versions

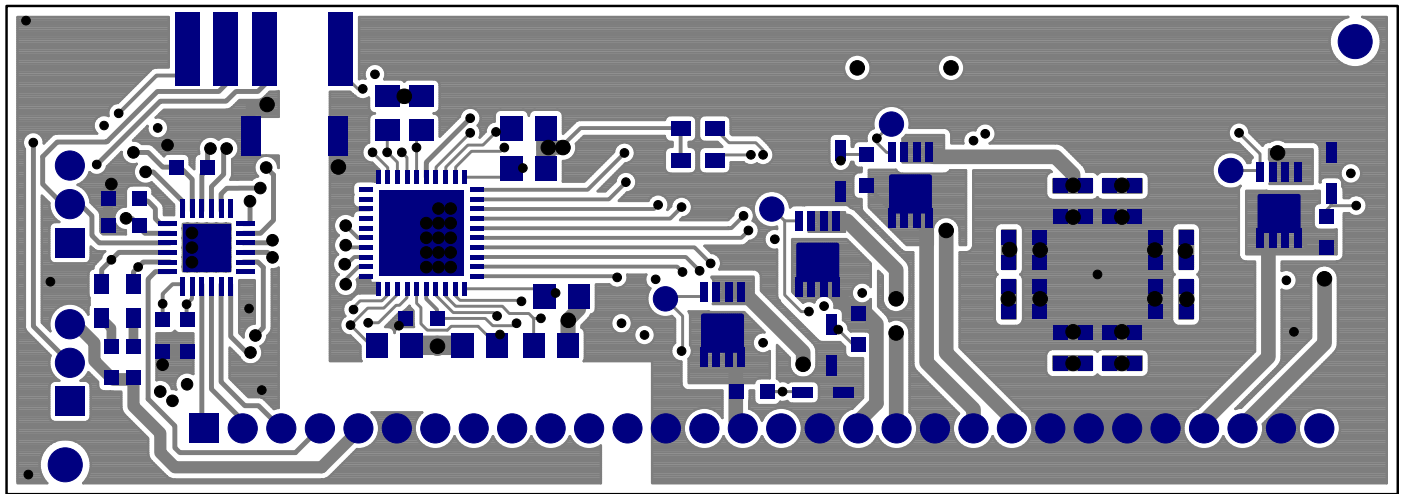
VERSION	FEATURES
DC1843A	DC1680A: Motherboard with Integrated Magjack DC1842A: 8-Port PSE Daughter Card
DC1843B	DC1680B: Motherboard with Discrete Ethernet Transformers DC1842B: 8-Port PSE Daughter Card with Increased Surge Protection

# DEMONSTRATION CIRCUIT 1842B LAYOUT

Top Assembly

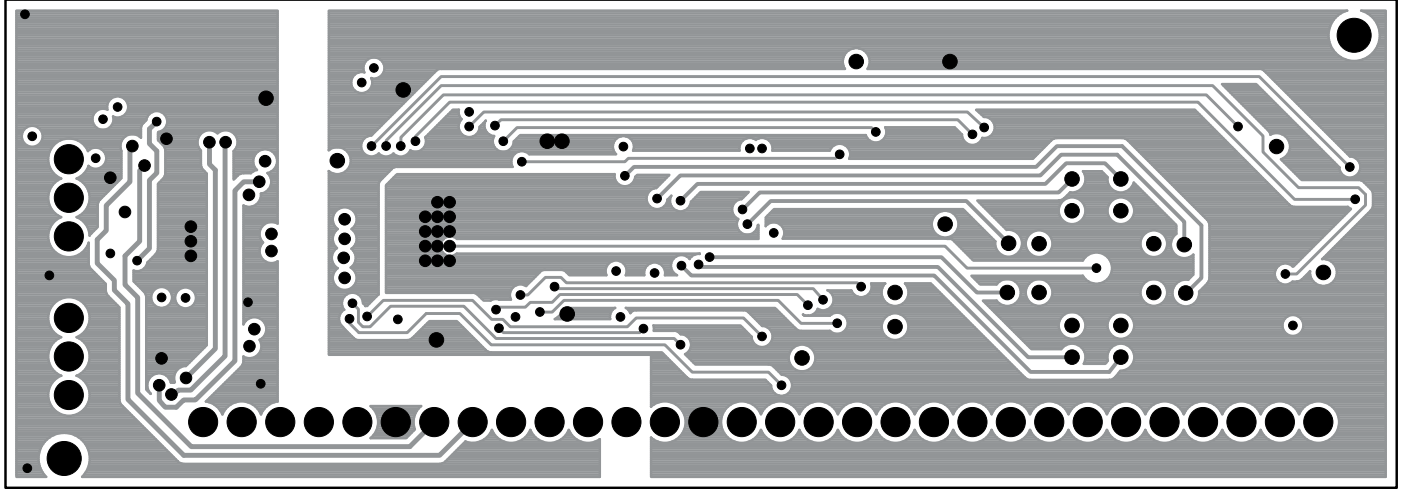


Layer 1: Top Layer

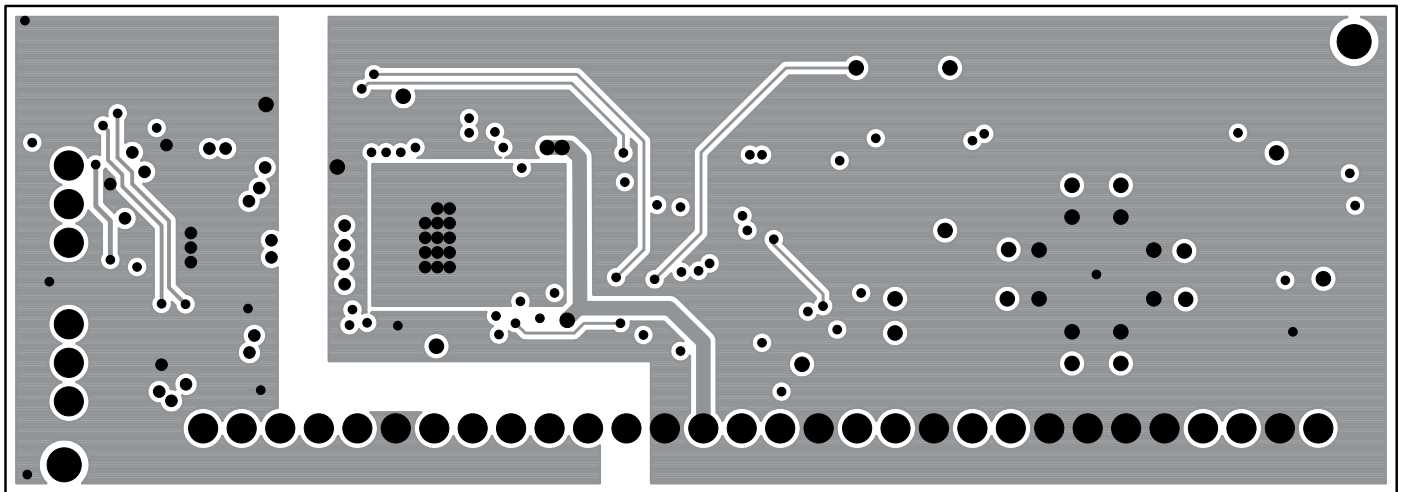


## DEMONSTRATION CIRCUIT 1842B LAYOUT

Layer 2:  $V_{EE}$  Plane 1

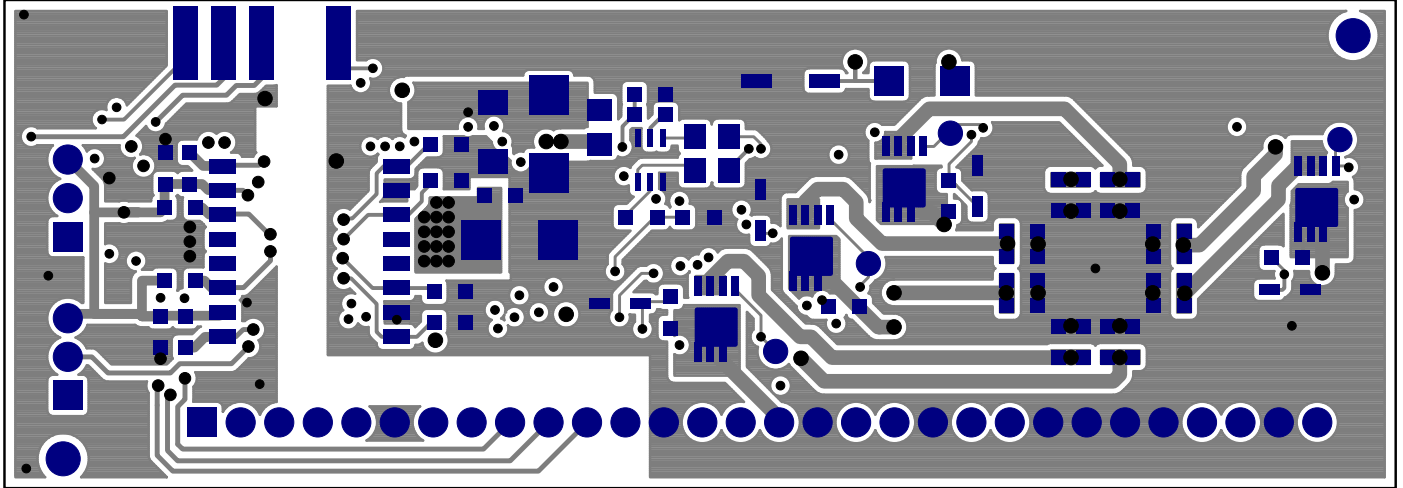


Layer 3:  $V_{EE}$  Plane 2

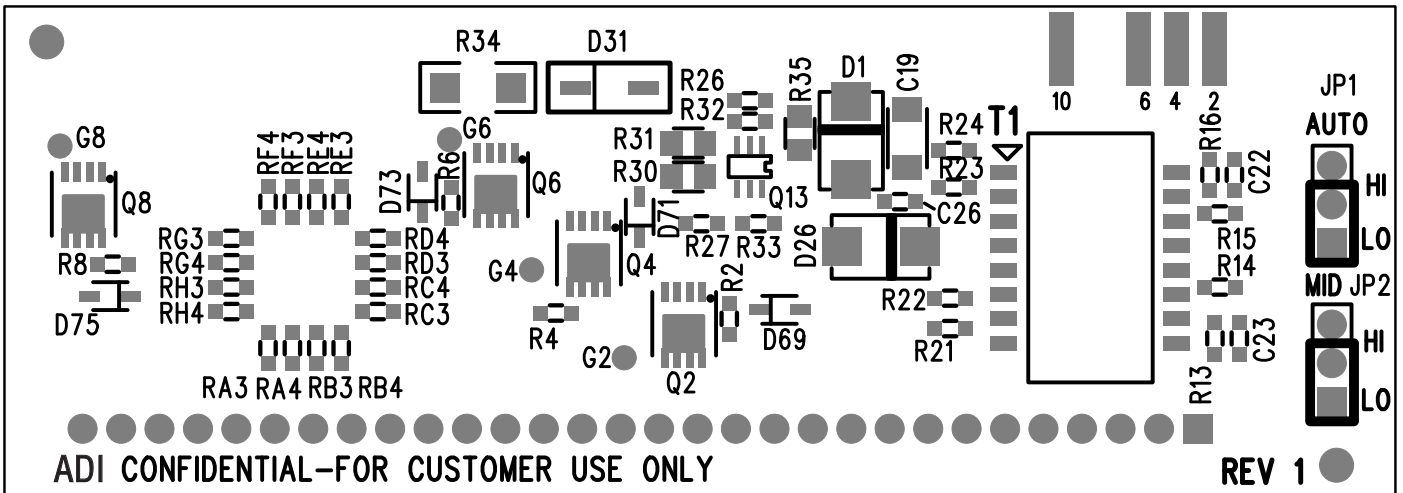


# DEMONSTRATION CIRCUIT 1842B LAYOUT

Layer 4: Bottom Layer

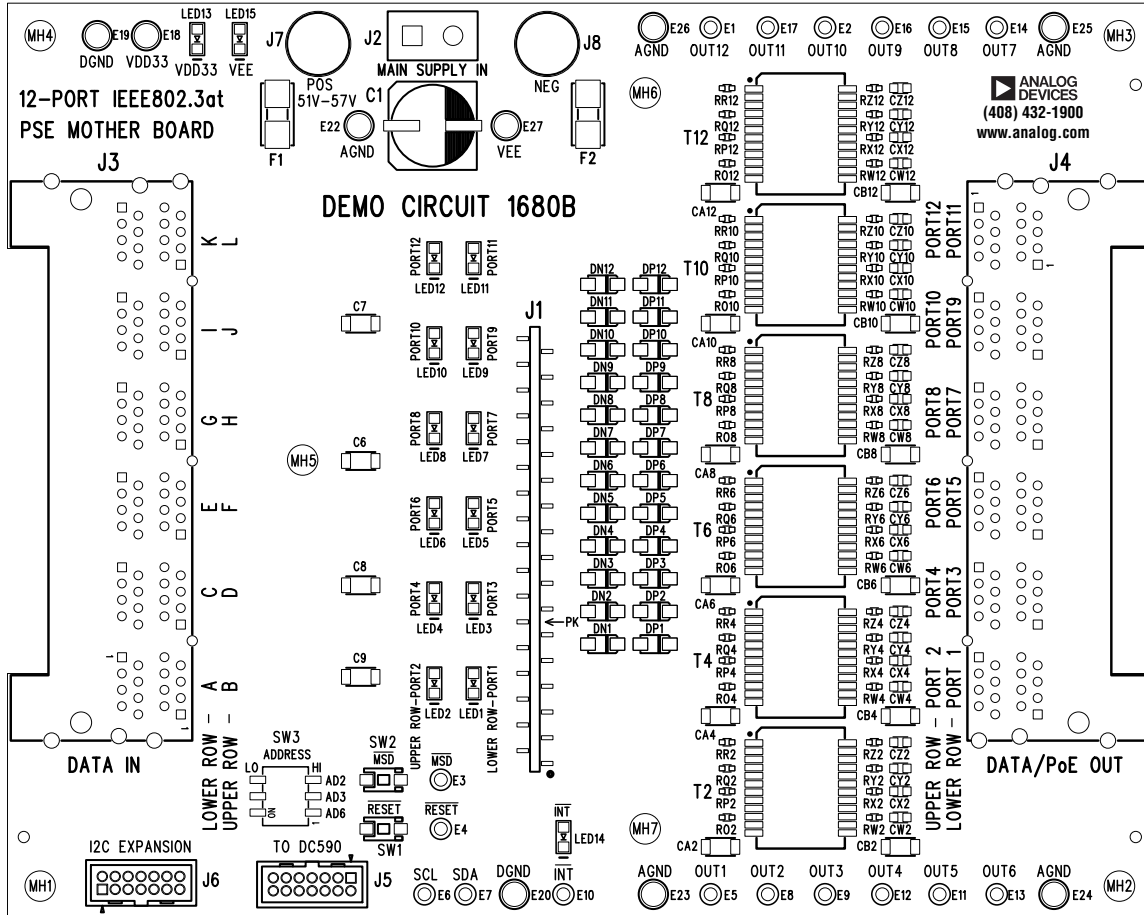


Bottom Assembly



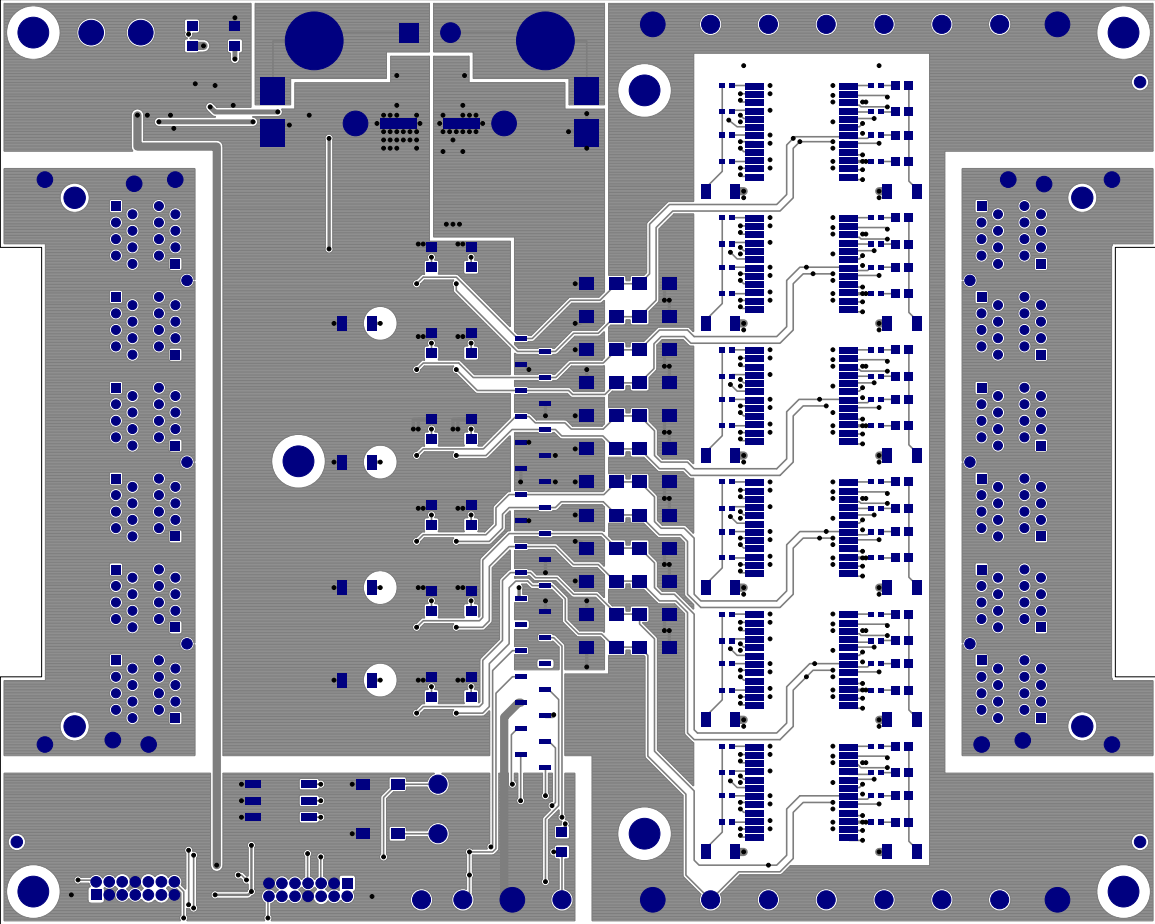
DEMONSTRATION CIRCUIT 1680B LAYOUT

Top Assembly



**DEMONSTRATION CIRCUIT 1680B LAYOUT**

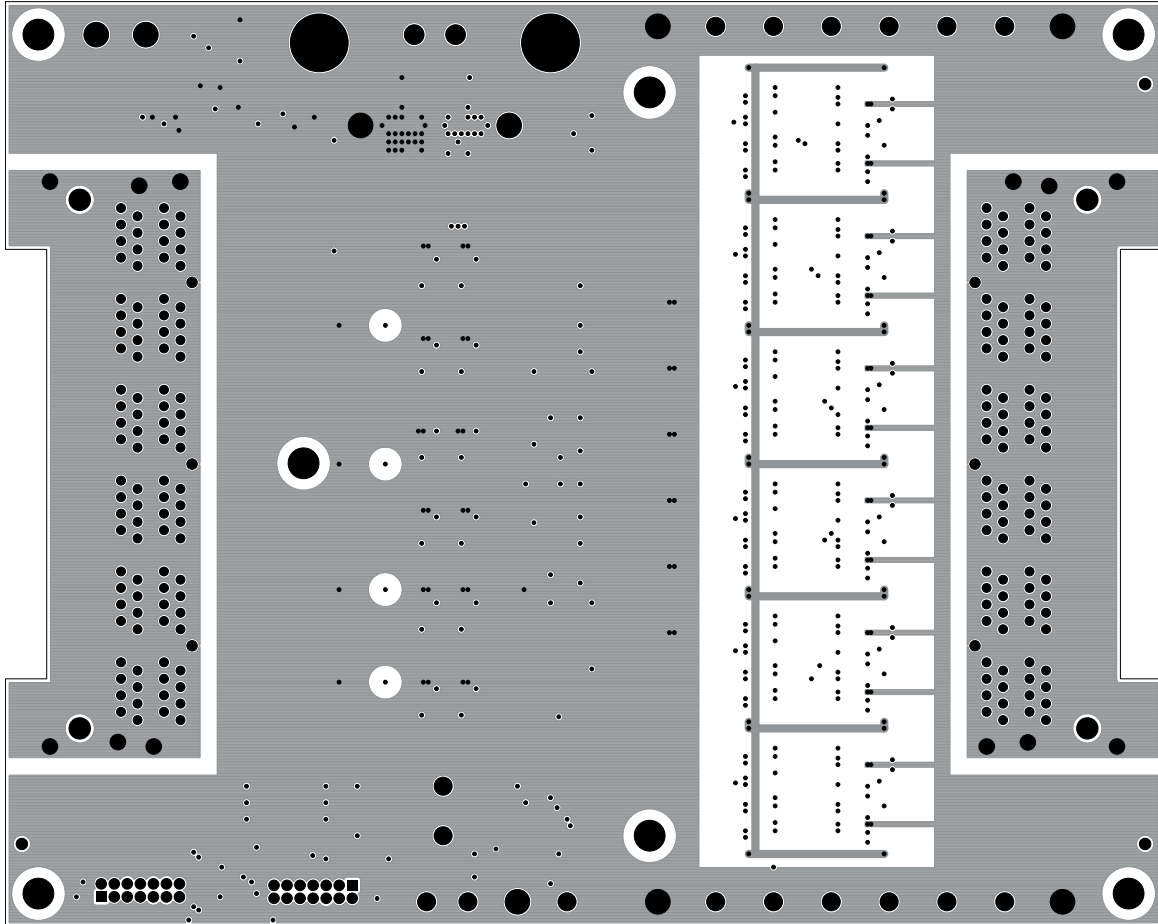
Layer 1: Top Layer





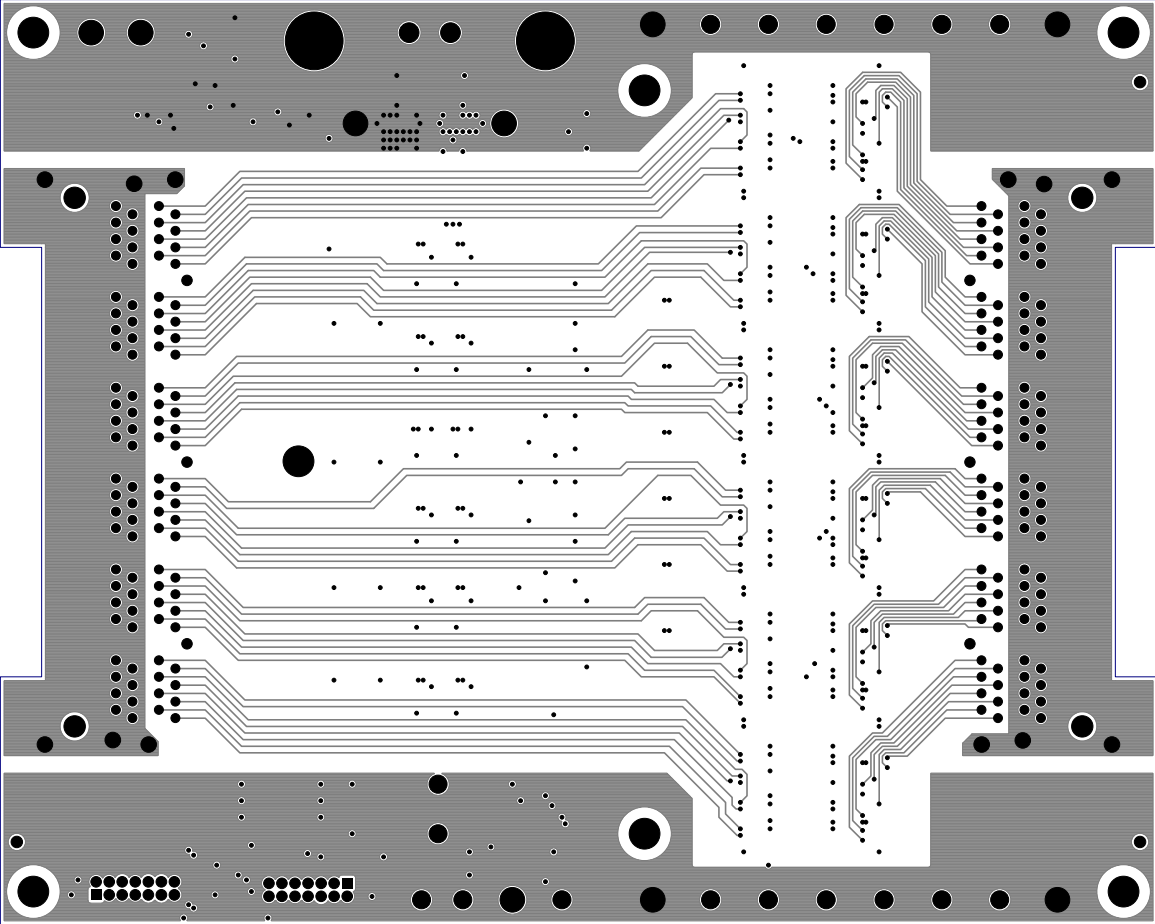
# DEMONSTRATION CIRCUIT 1680B LAYOUT

Layer 2: AGND, CGND Plane 1



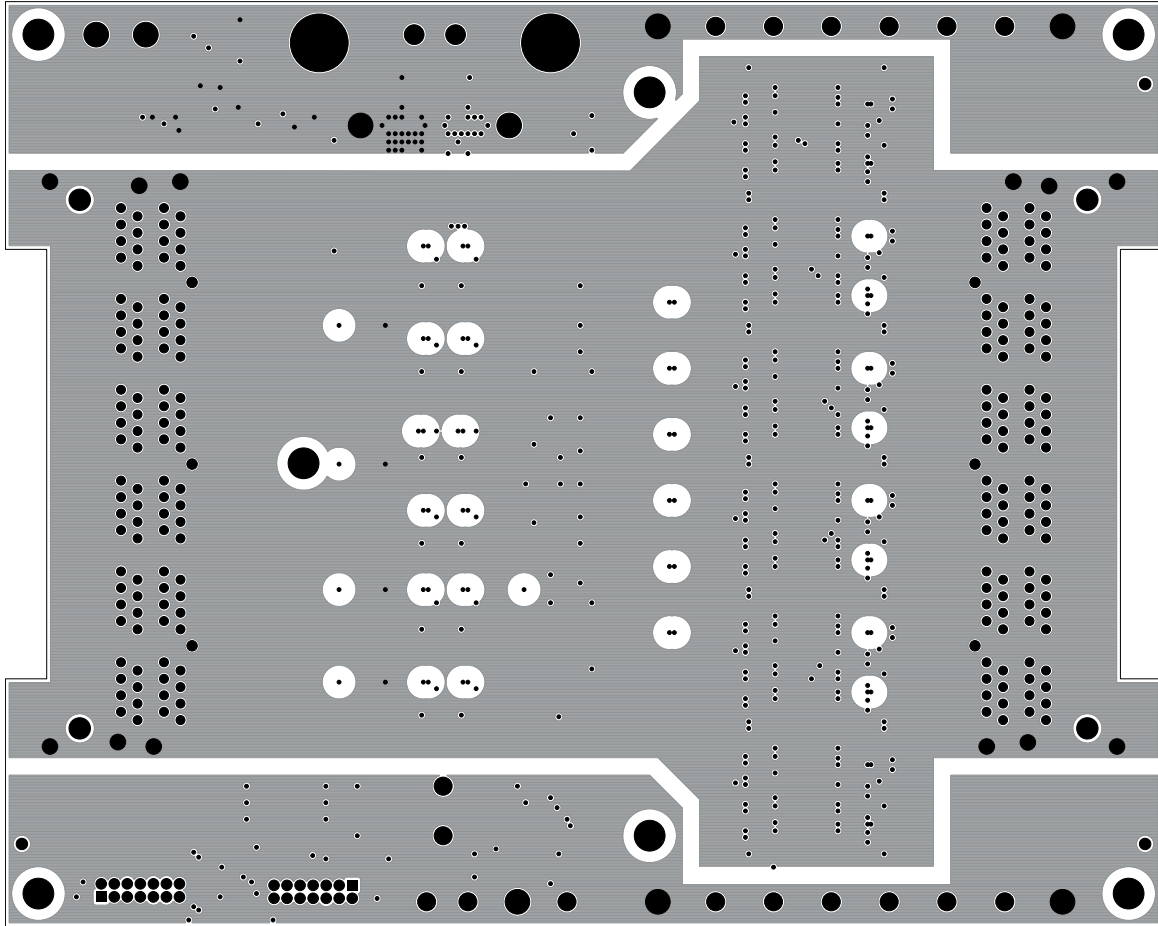
**DEMONSTRATION CIRCUIT 1680B LAYOUT**

Layer 3: SIG, AGND, CGND Plane 2



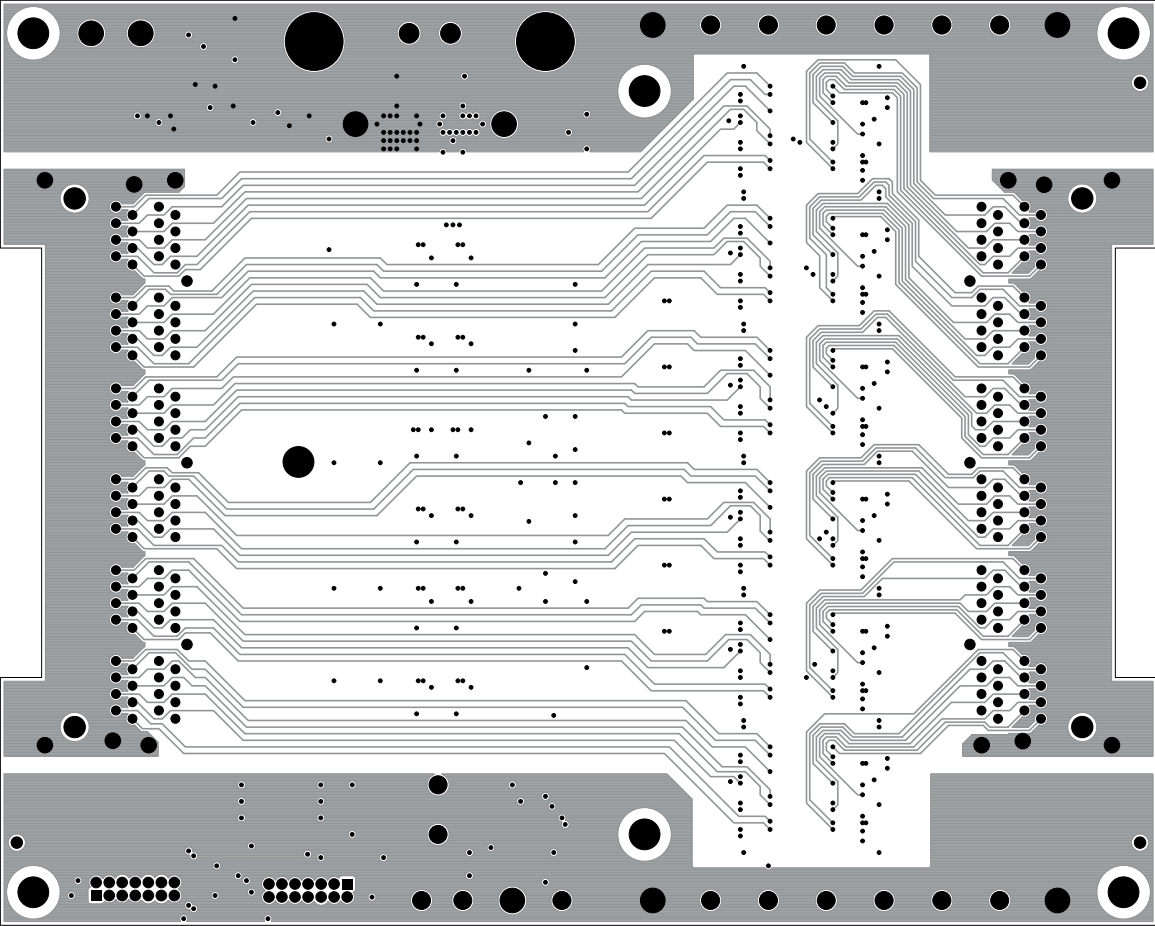
# DEMONSTRATION CIRCUIT 1680B LAYOUT

Layer 4: SIG, AGND, CGND Plane 3



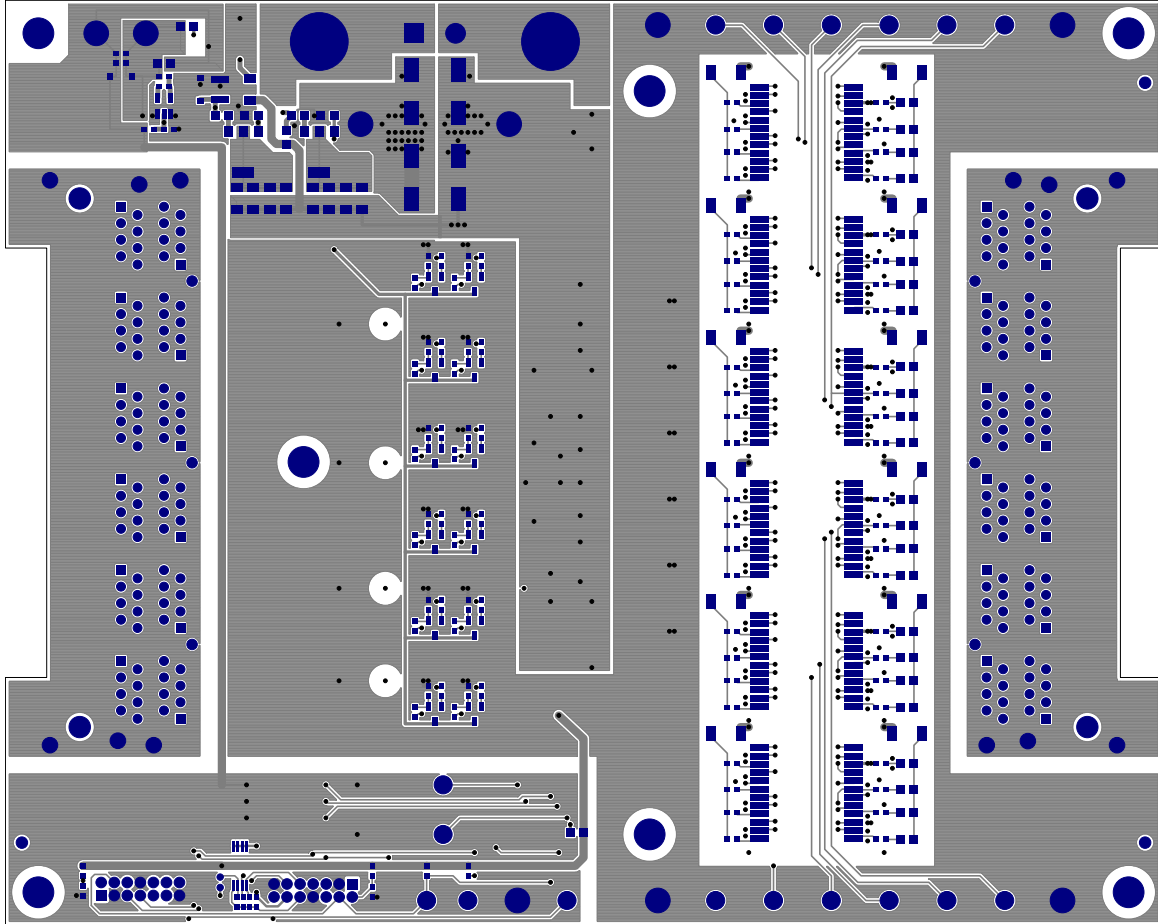
**DEMONSTRATION CIRCUIT 1680B LAYOUT**

Layer 5: SIG, AGND, CGND Plane 4



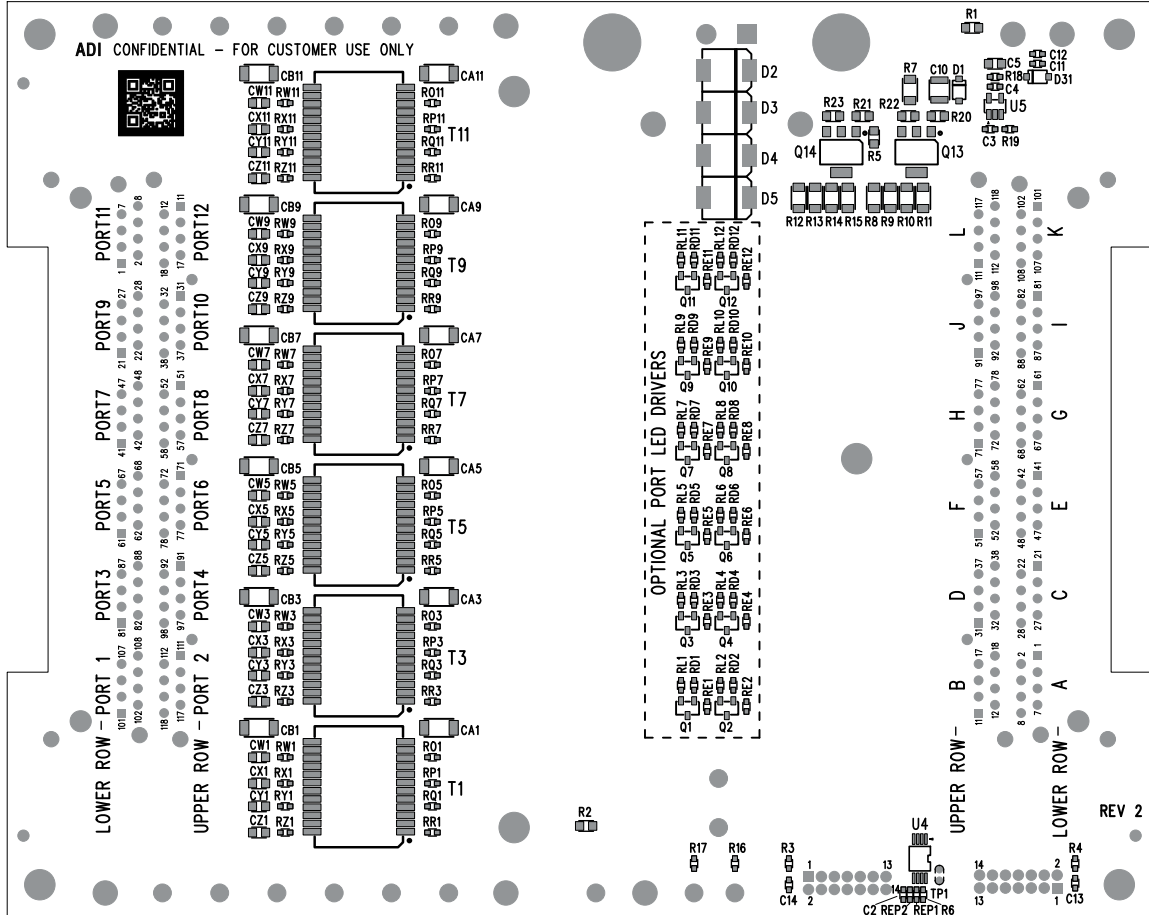
# DEMONSTRATION CIRCUIT 1680B LAYOUT

Layer 6: Bottom Layer

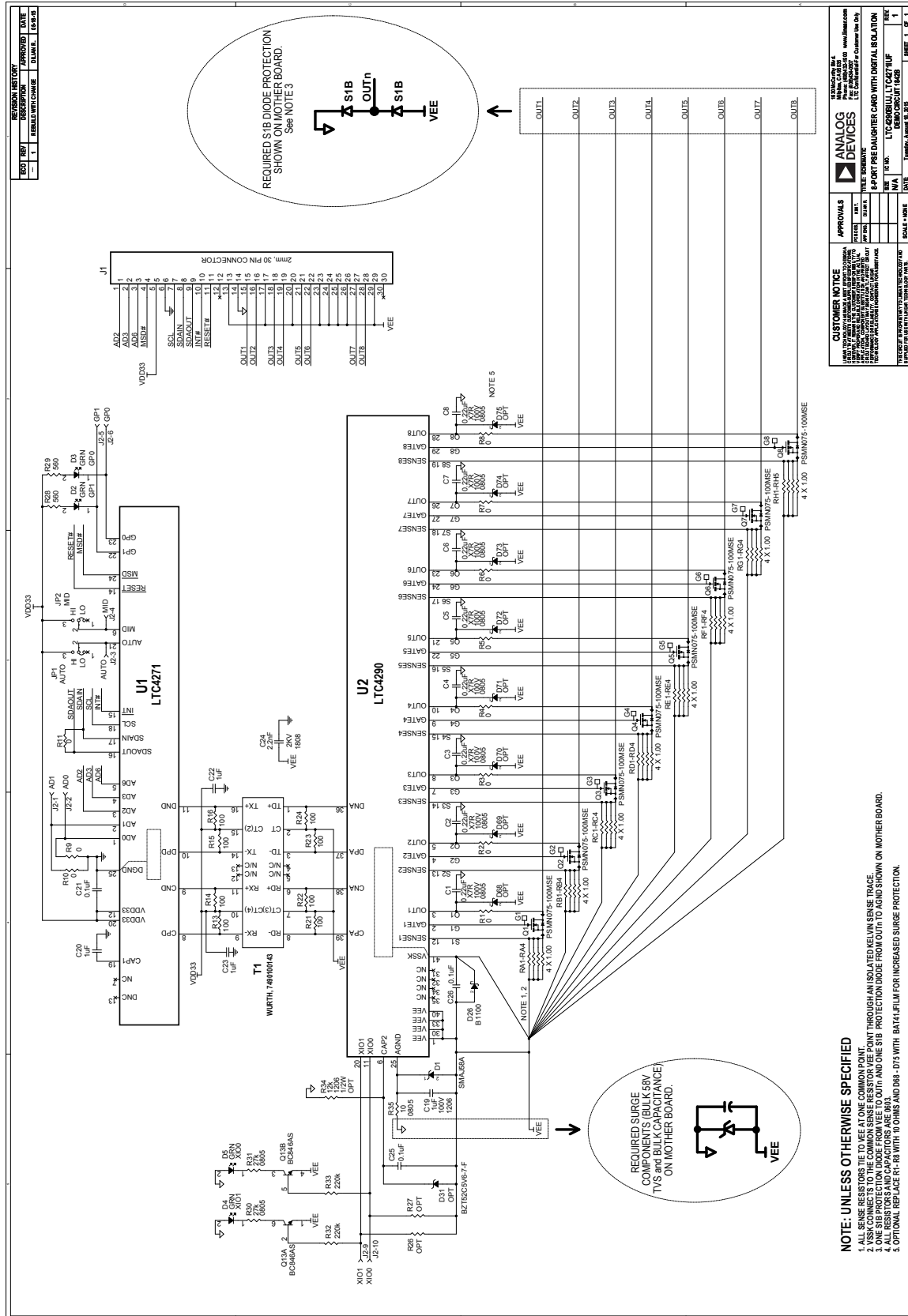


DEMONSTRATION CIRCUIT 1680B LAYOUT

Bottom Assembly



DC1842B SCHEMATIC DIAGRAM



REV	DESCRIPTION	APPROVED DATE
1	REWORK WITH CHANGE	01/11/11

CUSTOMER NOTICE		APPROVALS	
LITTON TECHNOLOGY, INC. 10000 W. 16TH AVENUE, SUITE 100, DENVER, CO 80202 TEL: 303.751.1000 FAX: 303.751.1001 WWW.LITTON.COM © 2011 LITTON TECHNOLOGY, INC. ALL RIGHTS RESERVED. THIS DOCUMENT IS UNCLASSIFIED AND NOT FOR DISTRIBUTION OUTSIDE THE COMPANY.		NAME: _____ TITLE: _____ DATE: _____	NAME: _____ TITLE: _____ DATE: _____

ANALOG DEVICES	
10000 W. 16TH AVENUE, SUITE 100, DENVER, CO 80202 TEL: 303.751.1000 FAX: 303.751.1001 WWW.LITTON.COM © 2011 LITTON TECHNOLOGY, INC. ALL RIGHTS RESERVED. THIS DOCUMENT IS UNCLASSIFIED AND NOT FOR DISTRIBUTION OUTSIDE THE COMPANY.	NAME: _____ TITLE: _____ DATE: _____

CUSTOMER NOTICE	
LITTON TECHNOLOGY, INC. 10000 W. 16TH AVENUE, SUITE 100, DENVER, CO 80202 TEL: 303.751.1000 FAX: 303.751.1001 WWW.LITTON.COM © 2011 LITTON TECHNOLOGY, INC. ALL RIGHTS RESERVED. THIS DOCUMENT IS UNCLASSIFIED AND NOT FOR DISTRIBUTION OUTSIDE THE COMPANY.	

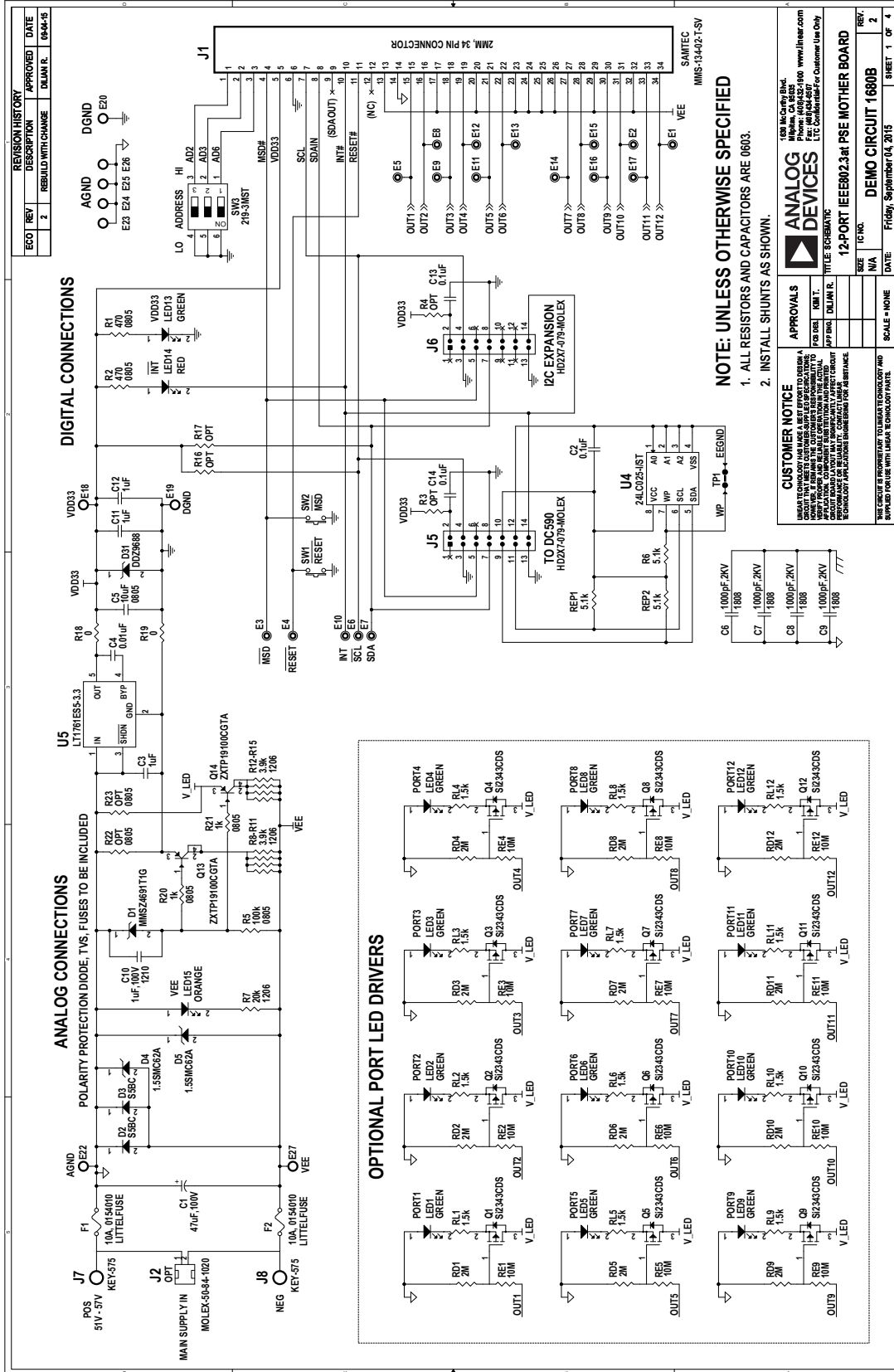
ANALOG DEVICES	
10000 W. 16TH AVENUE, SUITE 100, DENVER, CO 80202 TEL: 303.751.1000 FAX: 303.751.1001 WWW.LITTON.COM © 2011 LITTON TECHNOLOGY, INC. ALL RIGHTS RESERVED. THIS DOCUMENT IS UNCLASSIFIED AND NOT FOR DISTRIBUTION OUTSIDE THE COMPANY.	NAME: _____ TITLE: _____ DATE: _____

CUSTOMER NOTICE	
LITTON TECHNOLOGY, INC. 10000 W. 16TH AVENUE, SUITE 100, DENVER, CO 80202 TEL: 303.751.1000 FAX: 303.751.1001 WWW.LITTON.COM © 2011 LITTON TECHNOLOGY, INC. ALL RIGHTS RESERVED. THIS DOCUMENT IS UNCLASSIFIED AND NOT FOR DISTRIBUTION OUTSIDE THE COMPANY.	

ANALOG DEVICES	
10000 W. 16TH AVENUE, SUITE 100, DENVER, CO 80202 TEL: 303.751.1000 FAX: 303.751.1001 WWW.LITTON.COM © 2011 LITTON TECHNOLOGY, INC. ALL RIGHTS RESERVED. THIS DOCUMENT IS UNCLASSIFIED AND NOT FOR DISTRIBUTION OUTSIDE THE COMPANY.	NAME: _____ TITLE: _____ DATE: _____

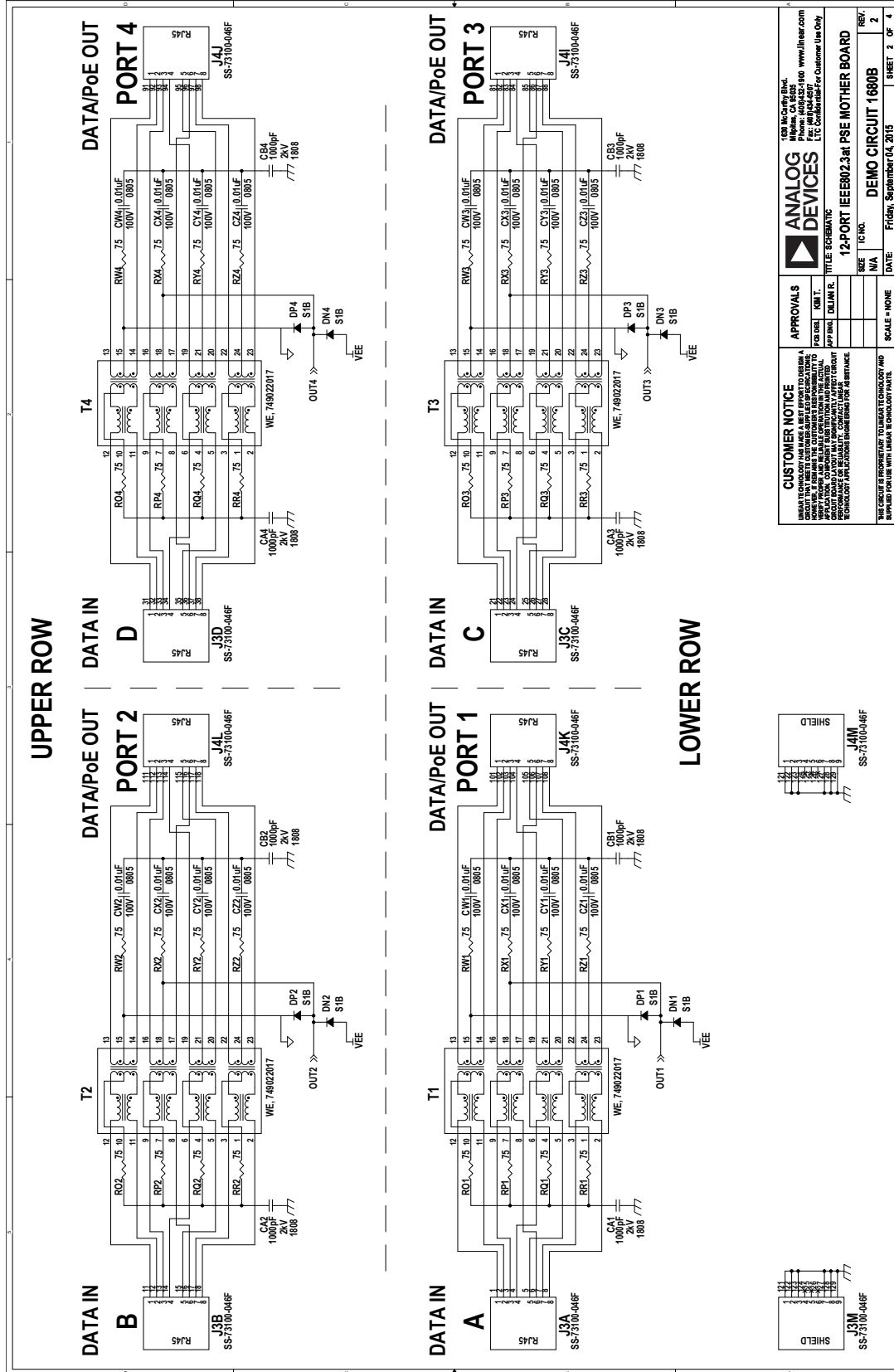
CUSTOMER NOTICE	
LITTON TECHNOLOGY, INC. 10000 W. 16TH AVENUE, SUITE 100, DENVER, CO 80202 TEL: 303.751.1000 FAX: 303.751.1001 WWW.LITTON.COM © 2011 LITTON TECHNOLOGY, INC. ALL RIGHTS RESERVED. THIS DOCUMENT IS UNCLASSIFIED AND NOT FOR DISTRIBUTION OUTSIDE THE COMPANY.	

## DC1680B SCHEMATIC DIAGRAM



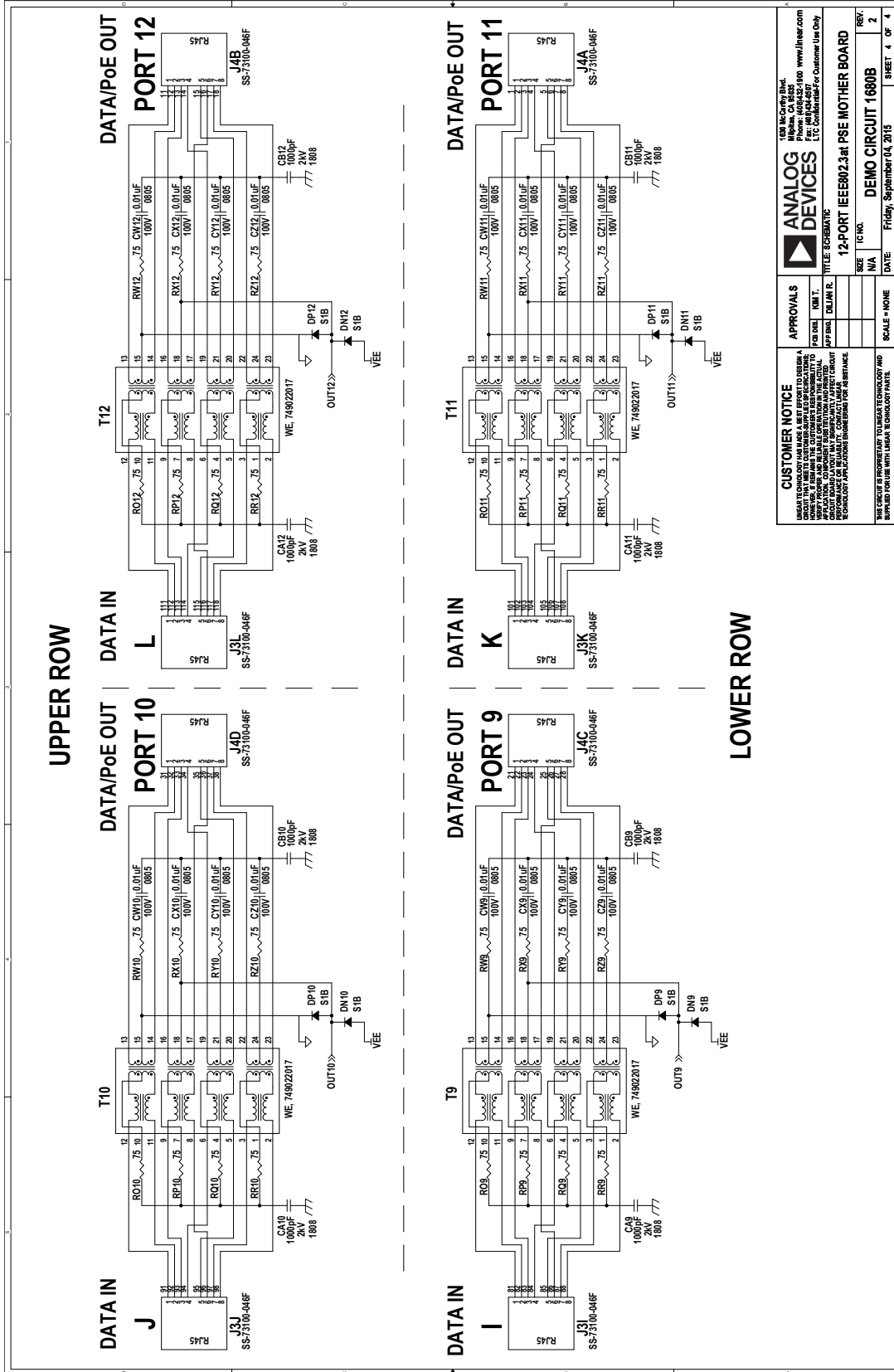


DC1680B SCHEMATIC DIAGRAM





DC1680B SCHEMATIC DIAGRAM



**CUSTOMER NOTICE**  
 THE SCHEMATIC OF THIS BOARD IS PROVIDED AS A REFERENCE ONLY. ANALOG DEVICES DOES NOT WARRANT THE ACCURACY OF THIS SCHEMATIC. ANALOG DEVICES DOES NOT WARRANT THE ACCURACY OF THIS SCHEMATIC. ANALOG DEVICES DOES NOT WARRANT THE ACCURACY OF THIS SCHEMATIC. ANALOG DEVICES DOES NOT WARRANT THE ACCURACY OF THIS SCHEMATIC.

**APPROVALS**  
 APPROVED: [Signature] DATE: [Date]  
 CHECKED: [Signature] DATE: [Date]  
 DESIGNED: [Signature] DATE: [Date]

**TITLE SCHEMATIC**  
 TITLE: 12-PORT IEEE802.3at PSE MOTHER BOARD  
 SHEET: 4 OF 4

**ANALOG DEVICES**  
 12-PORT IEEE802.3at PSE MOTHER BOARD  
 DATE: Friday, September 10, 2015  
 REV: 2

**ESD Caution**

**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

**Legal Terms and Conditions**

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS (\$100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.