Texas Instruments

TPS2363 User's Guide

User's Guide

May 2005 *System Power*

SLUU221

TPS2363 User's Guide

User's Guide

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TEXAS INSTRUMENTS

TPS2363 PCIExpress Dual-Slot Hot-Plug Controller User's Guide

1.1 Introduction

The TPS2363 is controlled by the PCIExpress bus controller over either a direct-mode interface or by SMBus. TPS2363 turns on the slot voltage slowly to minimize inrush current. It also latches off the slot voltage for various over-current and under voltage conditions.

The demonstration system is a way for the user to observe hot plug signals and system operation. It has convenient test points and LED Indicators to verify results. Operator interaction is through a GUI or manual switch inputs.

This user's guide describes the TPS2363 demo system setup, direct and SMBus mode operations. Schematics and parts lists for the TPS2363 demo system and load board are in the appendix.

Materials Needed

2.1 TI Supplied

The TPS2363 User's Guide kit consists of:

- TPS2363 demo board – PR459
- TPS2363 load board – PR429
- Power cables for P1 and J1
- TPS2363 PCIExpress hot-plug controller demo system – user's guide
- TPS2363 datasheet
- TPS2363 demo system software CDROM
- EV2300 SMB interface and USB Cable

2.2 User Supplied

Power supplies included are as follows:

- 3.3 V, V_{AUX}, 3 A
- 3.3 V, 10 A
- 12 V, 10 A

2.3 Personal Computer

- USB port
- CDROM drive
- Network connection to download software

2.4 Test Equipment

- Digital oscilloscope
- Current probe
- Digital volt meter

System Operation

3.1 System Operation

The user's guide has graphical user interface software (GUI) allowing the operator to manually change the state of the TPS2363 control signals. The computer's USB port connects with a supplied cable to TI's EV2300. EV2300 is the SMB interface to TPS2363 and demo board. The GUI is an easy to use interface for SMBus control emulating the function of the bridge.

Figure 3-1 is a block diagram of the demo system. There are two PCI Express slots on the demo board. Slot A is X16, and Slot B is X8, Xn is the number of PCI Express signals available to the slot. A test load board is supplied so that full load, over-load and short circuit may be applied to slot momentarily. The load board is X4 and can fit into either slot. SW2 on the load board sets it to either X16 or X8 resistive load, only the 12-V current changes between the X16 and X8 slots. The user can test the controller functions and verify the timing.

The system board slots can accept any PCIExpress compatible module for hot swap power testing.

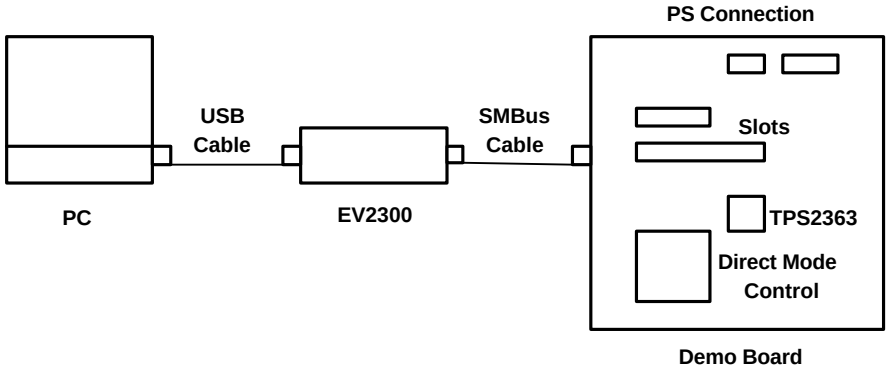

Figure 3-1. Demo System

3.2 Power Connections

Power cables are supplied. Identify the power cable and locate each connector pin 1 as indicated on the demo circuit board. Connect the cables to lab power supplies. Figure 3-2 is a connection diagram for the TPS2363 demo board to power supplies. Use the power supply capacities listed in the User Supplied section.

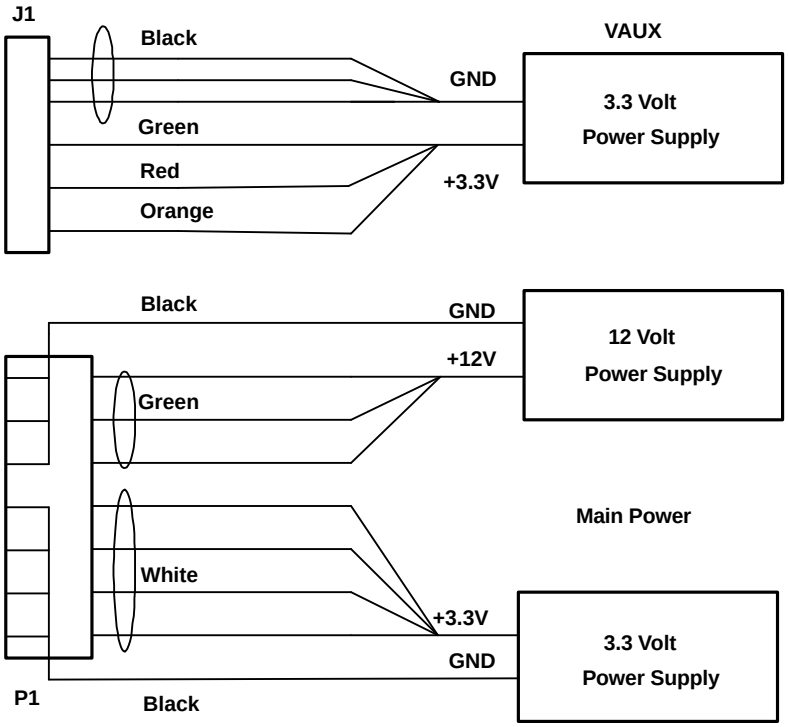

Figure 3-2. Connection Diagram

3.2.1 J1 Connector

Pin 1 on the J1 connector is marked on the connector body and on the printed circuit board. Table 3-1 shows the J1 cable connections.

Table 3-1. J1 Cable Connections

J1	VOLTAGE	COLOR
1	3.3 VAUX	Orange
2	3.3 VAUX	Red
3	3.3 VAUX	Green
4	GND	Black
5	GND	Black
6	GND	Black

3.2.2 P1 Connector

Pin 1 on the P1 connector is marked on the connector body and on the printed circuit board. Table 3-2 shows the P1 cable connections.

Table 3-2. P1 Cable Connections

P1	VOLTAGE	COLOR	P1	RETURN	COLOR
1	12 V	Green	8	GND (12)	Black
2	12 V	Green	9	GND (12)	Black
3	12 V	Green	10	GND (12)	Black
4	3.3 V	White	11	GND (3.3)	Black

Table 3-2. P1 Cable Connections (continued)

P1	VOLTAGE	COLOR	P1	RETURN	COLOR
5	3.3 V	White	12	GND (3.3)	Black
6	3.3 V	White	13	GND (3.3)	Black
7	3.3 V	White	14	GND (3.3)	Black

3.2.3 SMBus Connector

Solder the 4-wire cable supplied with the EV2300 to the demo board at the J9 connector outline. The cable colors are silk screened on the system board. The wire connections are shown in Figure 3-3. The user can connect his system SMB instead of EV2300 for debug and development.

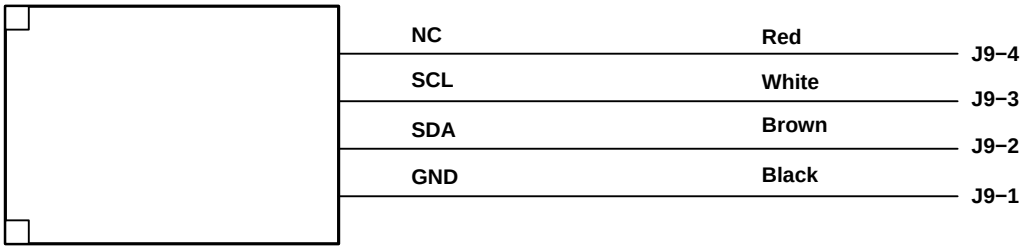

Figure 3-3. SMB Cable Connections

3.3 Jumper Plugs

Jumper plugs allow flexibility in testing. Jumper functions and usual position are listed in Table 3-3.

Table 3-3. System Board Jumper Configuration

JUMPER	FUNCTION	POSITION	COMMENT
J2	Force_On_B	OFF	ON to test Force_On_A
J3	A2	ON	A2 set for address 0, change for other SMB address. A0 is the LSB
J4	A1	ON	A1 set for address 0, change for other SMB address
J5	VAUX_B	ON	Connects VAUX_B to Slot B – Always ON
J6	A0	ON	A0 set for address 0, change for other SMB address
J7	Filter	ON	On to use RFILTER
J8	VAUX_A	ON	Connects VAUX_A to Slot A – Always ON
J10	Force_On_A	OFF	ON to test Force_On_B
J16	AUXHI_A	OFF	Only used to test AUXHI on TPS2363 -3 option
J18	AUXHI_B	OFF	Only used to test AUXHI on TPS2363 -3 option

3.4 Test Points

Table 3-4. Signal Test Points

SIGNAL	A - TEST POINT	B - TEST POINT
+12 V Sense	TP1, TP2	TP23, TP24
+12 V to Slot	TP3	TP22
+12 V Gate	TP7	TP18
+3.3 V Sense	TP4, TP5	TP20, TP21
+3.3 V to Slot	TP6	TP19
+3.3 V Gate	TP8	TP17
Slot VAUX	TP13	TP14
SDA (SMB)	TP15	
SCL (SMB)	TP16	

3.5 Demo Board Slots

There are two PCIExpress slots on the demo module. Slot A is a X16 connector with 12-V over-current set for 8.3 A nominal. Slot B is an X8 Connector with a 12-V over-current set for 4.2 A. No address, data and other control signals are active on these slots. Bus signals are each tied to a 47-Ω pull-down resistor.

Any PCIExpress compatible module can be installed and tested with respect to hot plug and power issues.

The load board's capacitive load is always connected to slot power but it's resistive load is on for only a short duty cycle. When a standard PCIExpress module is used in the slot, power is supplied to the load when the slot is turned on. The load board, is described in the next section.

3.6 Load Board

The load board allows the operator to apply power to the slots and check proper operation of the hot plug controller functions. The board is built in an X4 form factor allowing it to be plugged into all but X1 slots.

DIP switches control short circuit, over-current and full-load applied to main and auxiliary power (Table 3-5). Turn on only one switch position in a switch pack at one time. No damage will result but it may not be meaningful with the possible exception of full load setting on all positions.

The V+PULSE signal, TP11 is the applied load when the push button switch SW6 is activated. V+PULSE output occurs once when the switch is pushed. This is a good scope trigger and reference signal for measurement of fault time or power turn off from the load applied. Auxiliary or main power to the slot must be on for the V+PULSE signal to operate.

A pulse generator may drive the BNC connector J20 instead of using the push button, SW6. With the pulse generator, V+PULSE repeats once each second. The pulse width of the V+PULSE follows the high time of the input signal to a maximum of 20 ms. Note that V+PULSE will not repeat if it caused slot power to be turned off.

The load board has an LED for each slot voltage. These are the indicators listed in Table 3-5. Load Board Switches, Indicators and Test Points.

Table 3-5. Load Board Switches, Indicators and Test Points

PARAMETER	SWITCH PACK	SWITCH POSITION	FUNCTION	INDICATOR	TEST POINTS
3.3 VAUX	SW1	1	Short	D1	TP1, TP2
		2	Overload		
		3	Full load		
800 mA/400 mA	SW2	ON	800 mA		
		OFF	400 mA		

Table 3-5. Load Board Switches, Indicators and Test Points (continued)

PARAMETER	SWITCH PACK	SWITCH POSITION	FUNCTION	INDICATOR	TEST POINTS
3.3 V	SW3	1	Short	D2	TP3
		2	Overload		
		3	Full load		
12	SW4	1	Short	D3	TP4, TP5
		2	Overload		
		3	Full load		
X16/X8	SW5	ON	X16		
		OFF	X8		

Jumpers on the load board allow step additions of load capacitance for each slot voltage (Table 3-6). This is useful to verify slot turn on time is sufficient to keep inrush current low enough for the slot to power on. For example, to power on the 3.3 V with 670 µF, install jumpers J5, J6 and J8.

Table 3-6. Load Capacitance for Each Slot Voltage

VOLTAGE	CONNECTOR	CAPACITANCE
3.3 VAUX	J2	150 µF
3.3 V	J5	330 µF
	J6	330 µF
	J7	330 µF
	J8	10 µF
12 V X8 and X16	J11	330 µF
	J12	330 µF
	J13	330 µF
	J14	10 µF
12 V X16	J16	330 µF
	J17	330 µF
	J18	330 µF
	J19	10 µF

Operation

4.1 Direct Mode Operation

In direct mode the TPS2363 is controlled by switches on the demo system board. After all input power supplies are sufficient, the TPS2363 is initialized and all slot voltages remain off. The slot power is off regardless of the position of the ON or AUXEN switches (except when Force_On).

VAUX power is turned on by sliding AUXEN right and then left. If TPS2363 initialized with the switch to the right, just slide the switch left. To clear a fault that was caused by the auxiliary power, slide the AUXEN switch to the right to clear the fault. Slide the switch to the left again to turn on the auxiliary power to the slot.

Main power is controlled by the ON_A/B switch the way that auxiliary power is controlled by the AUXEN switch. Clear faults generated by main power using the ON_A/B switch. Switch operation is summarized in Table 4-1.

Table 4-1. Switch Operation Summary

SWITCH	FUNCTION	SWITCH	FUNCTION	COMMENTS
S6	ON_A	S2	ON_B	Slide right – OFF/Clear Main Fault, left - ON
S5	AUXEN_A	S1	ON_A	Slide right – OFF/Clear VAUX Fault, left - ON
S7, S8	GPI_A	S3, S4	GPI_B	Inputs need SMB to Read Data

4.2 Software

Software is distributed on CDROM or available on the TI Website. Installation for the CDROM is discussed here. The software consists of a GUI for the operator. It controls the SMBus over the USB port and EV2300 module. Other related documentation such as the datasheet and this document are in the software distribution pack.

4.2.1 Software Installation

- Insert the CDROM.
- Open the CDROM and copy the folder TPS2363EVM Distribution to any path.
- Keep the files in this folder together.
- Double click on the TPS2363EVM.exe file to start the GUI.
- The GUI appears on your screen as in Figure 4-1.

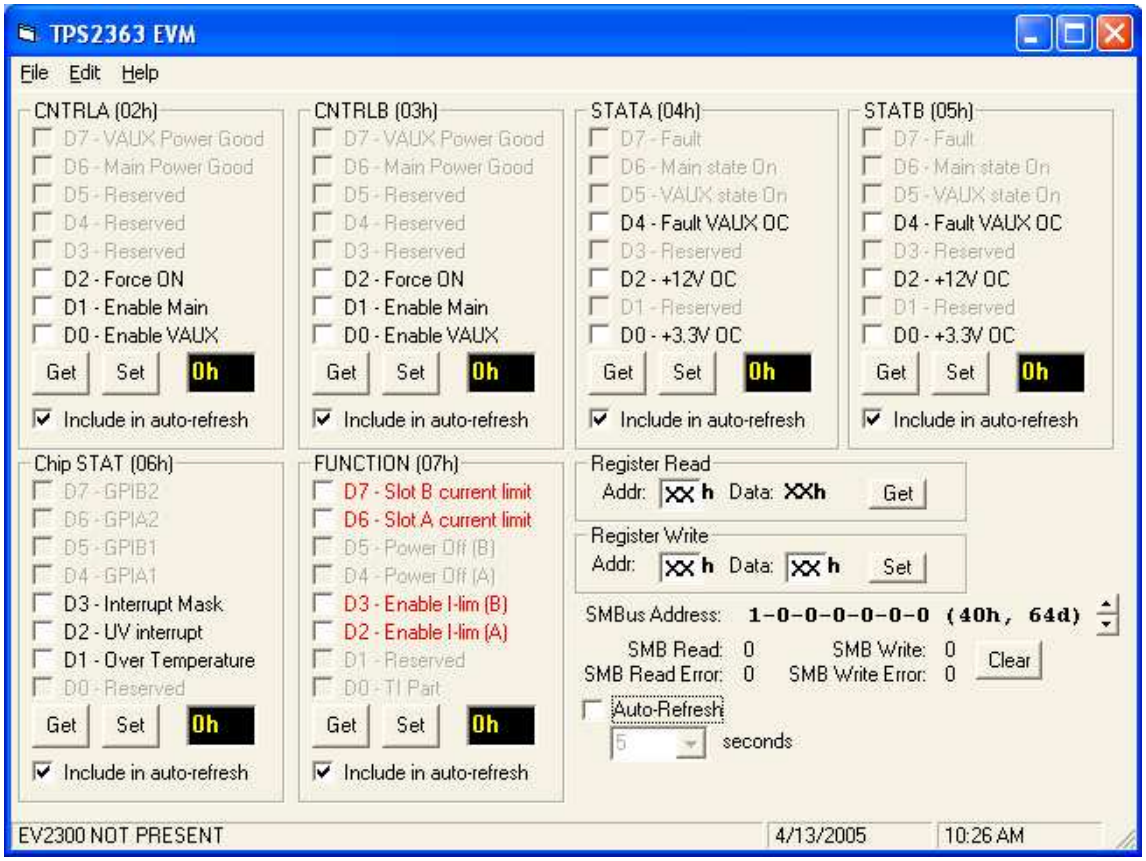

Figure 4-1. GUI Screen

The TPS2363 registers described in the datasheet are shown in the GUI screen. Register bits that can be written have a white box that can be checked to write a one. Positions that are Read only or reserved are grayed out. Write a register by selecting Set and read a register selecting Get. The lower right hand corner allows access to any register manually. Note that some of the STATUS bits are writable because of the echo reset required to clear the status bit after the fault is removed.

If the TPS2363 is operated in direct mode, the GUI can be used with the SMBus to read status. This may provide information that is helpful during development. In direct mode, do not attempt to control power with the GUI. The ON, AUXEN, and FORCE_ON register bits must be 0. When controlling power with the GUI, do not use the direct mode switches. The ON, AUXEN, and FORCE_ON switches must be turned off. Switch and jumper configurations for GUI control are shown in Table 4-2.

Table 4-2. Switch and Jumper Positions for GUI Operation

SWITCH/JUMPER	FUNCTION	POSITION
S6	ON_A	Slide right
S5	AUXEN_A	Slide right
S2	ON_B	Slide right
S5	AUXEN_B	Slide right
J10	Force_On_A	Jumper plug Off
J2	Force_On_B	Jumper plug Off
J3	A2	Jumper plug ON
J4	A1	Jumper plug ON
J6	A0	Jumper plug ON

5.1 Load Board List of Materials(1)(2)(3)(4)

(1) These assemblies are ESD sensitive, ESD precautions shall be observed.
(2) These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.
(3) These assemblies must comply with workmanship standards IPC-A-610 Class 2.
(4) Refernce designators cannot be substituted. All other components can be substituted with equivalent MFG's components.

REF	COUNT	DESCRIPTION	MFR	PART NUMBER
Q14	1	Bipolar, PNP, 40 V, 200 mA, 225 mW, SOT23	On Semi	MMBT3906LT1
C6, C11, C16	3	Capacitor, aluminum, 10 µF, 16 V, 20%, 0.177 x 0.177	Panasonic	EEV-FC1C100R
C2	1	Capacitor, aluminum, 150 µF, 16 V, 20%, FK series, 0.268 x 0.307 (D-case)	Panasonic	EEV-FK1C151XP
C3, C4, C5, C8, C9, C10, C13, C14, C15, C20	10	Capacitor, aluminum, 330 µF, 16 V, 20%, 10 mm x 12 mm (G-case)	Panasonic	EEV-FC1C331P
C1, C7, C12, C21, C22, C23, C24, C26, C27	9	Capacitor, ceramic, 0.1 µF, 16 V, X7R, 10%, 0805	Vishay	STD
C17, C18, C25	3	Capacitor, ceramic, 1.5 µF, 16 V, X7R, 10%, 1206	Panasonic	ECJ-3YB1C155K
C19	1	Capacitor, ceramic, 22 pF, 50 V, COG, 5%, 0805	Vishay	Std
J21	1	Connector, PCB edge fingers, mates with PCI-Express X8 slot connector, 0.300 x 2205		
J20	1	Connector, right angle BNC, PCB mount, 1.15 x 0.56	AMP	226978-1
D4, D5, D6, D7	4	Diode, schottky, 200 mA, 30 V, SOT23	Vishay-Liteon	BAT54
D1, D2, D3	3	Diode. LED, RED, 2.1 V, 10 mA-25 mA, 0.250" x 0.250"	Lumex	SSF-LXH101ID-01
J2, J5, J6, J7, J8, J11, J12, J13, J14, J16, J17, J18, J19	13	Header, 2 pin, 100-mil spacing, (36-pin strip), 0.100" x 2"	Sullins	PTC36SAAN
U7	1	IC, CMOS Hex Inverting Schmitt Trigger, SO14	TI	CD40106BM
U6	1	IC, CMOS Precision Monostable Multivibrator, SO-16	TI	CD14538BM
U4	1	IC, Low Power DC-DC Boost Converter, SOT23-5 (DBV)	TI	TPS61041DBV
U1, U2, U3	3	IC, MOSFET Driver, Single-Channel, Non-inverting, SOT23-5	TI	TPS2829DBV
U5	1	IC, Supply-Voltage Supervisor, PW-8	TI	TL7700CPW
L1	1	Inductor, SMT, 10 µH, 760 mA, 230 mΩ, 0.150 x 0.162	Sumida	CR32-100
Q6, Q9	2	MOSFET, N-channel, 16 V, 25 A, 3.3 mΩ, SO8	Vishay	Si4862DY
Q1, Q2, Q3, Q4, Q5, Q7, Q8, Q10, Q11, Q12, Q13	11	MOSFET, N-channel, 20 V, 4.4 A, 40 mΩ, SOT23	Vishay	Si2312DS
Q15	1	MOSFET, N-channel, 50 V, 0.17A, 3.5 Ω, SOT23	Zetex	BSS138
R17, R18, R19	3	Resistor, chip, 1.2 Ω, 1 W, 5%, 2512	Vishay	CRCW2512-1R2J
R51, R56, R57, R61	4	Resistor, chip, 10 kΩ, 1/10 W, 1%, 0805	Std	Std

Load Board List of Materials[(1)(2)(3)(4)]

REF	COUNT	DESCRIPTION	MFR	PART NUMBER
R5, R9, R10, R13, R16, R22, R26, R27, R34, R39, R40, R45, R48	13	Resistor, chip, 10 Ω, 1/10 W, 1%, 0805	Std	Std
R1, R12	2	Resistor, chip, 10 Ω, 1 W, 5%, 2512	Vishay	CRCW2512-100J
R30, R42, R43, R44	4	Resistor, chip, 12 Ω, 1 W, 5%, 2512	Vishay	CRCW2512-120J
R3, R20	2	Resistor, chip, 150 Ω, 1/10 W, 1%, 0805	Std	Std
R29	1	Resistor, chip, 15 Ω, 1 W, 5%, 2512	Vishay	CRCW2512-150J
R49	1	Resistor, chip, 1 kΩ, 1/10 W, 1%, 0805	Std	Std
R60	1	Resistor, chip, 1 MΩ, 1/10 W, 1%, 0805	Std	Std
R2, R11, R28, R41	4	Resistor, chip, 2.2 Ω, 1 W, 5%, 2512	Vishay	CRCW2512-2R2J
R53	1	Resistor, chip, 200 kΩ, 1/10 W, 1%, 0805	Visahy	Std
R55, R58	2	Resistor, chip, 2 kΩ, 1/10 W, 1%, 0805	Std	Std
R4, R21	2	Resistor, chip, 332 Ω, 1/10 W, 1%, 0805	Std	Std
R6, R7, R8, R14, R15, R23, R24, R25, R36, R37, R38, R46, R47	13	Resistor, chip, 5.11 kΩ, 1/10 W, 1%, 0805	Std	Std
R50	1	Resistor, chip, 51.1 kΩ, 1/10 W, 1%, 0805	Std	Std
R31, R33	2	Resistor, chip, 511 Ω, 1/10 W, 1%, 0805	Std	Std
R59	1	Resistor, chip, 51 Ω, 1 W, 5%, 2512	Vishay	CRCW2512-510J
R32, R35	2	Resistor, chip, 619 Ω, 1/10 W, 1%, 0805	Std	Std
R54	1	Resistor, chip, 665 kΩ, 1/10 W, 1%, 0805	Vishay	Std
R52	1	Resistor, chip, 73.2 kΩ, 1/10 W, 1%, 0805	Std	Std
J1, J3, J4, J9, J10, J15	6	Screw terminal, 0.310 x 0.310	Keystone	7693
SW1, SW3, SW4	3	Switch, 3 POS, SPST, DIP6, 0.380" x 0.385"	CTS	206-3
SW2, SW5	2	Switch, DPST, DIP SMT, 0.286 x 0.410	CTS	204-211ST
SW6	1	Switch, SPDT, push button, momentary, 400 mA, 0.270 x 0.800	C & K	8121SD9AV2GE
TP1, TP3, TP4, TP6, TP7, TP8, TP9, TP10, TP11	9	Test point, 0.062 Hole, 0.25	Keystone	5012
TP2, TP5	2	Test point, SM, 0.150" x 0.090", 0.185" x 0.135""	Keystone	5016

5.2 System Board List of Materials(5)(6)(7)(8)

(5) These assemblies are ESD sensitive, ESD precautions shall be observed.
(6) These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.
(7) These assemblies must comply with workmanship standards IPC-A-610 Class 2.
(8) Ref designators marked cannot be substituted. All other components can be substituted with equivalent MFG's components.

REF	COUNT	DESCRIPTION	MFR	PART NUMBER
C1, C2, C3, C23, C24, C25	6	Capacitor, Aluminum, SM, 470uF, 16V, 20% FC series, G-Case	Panasonic	EEV-FC1C471P
C4, C22	2	Capacitor, Ceramic, 6800pF, 50V, X7R, 10%, 0805	Vishay	STD
C5, C6, C7, C11, C19, C20, C21	7	Cap, Alum, 1000-uF, 20%, 6.3-V,FC-Series, G-Case	Panasonic	EEV-FC0J102P
C8, C12, C13, C14, C15, C18	6	Capacitor, Ceramic, 0.1-uF, 16V, X7R, 10%, 0805	Vishay	STD
C9, C10, C16, C17, C26, C27	6	Capacitor, Ceramic, 0.022-uF, 50V, X7R, 10%, 0805	Vishay	STD
D1, D2, D3, D4, D5	5	Diode, LED, Green, S-type, S-type	Panasonic	LN1371G
J1	1	Connector, Header, Vertical, 6-pin w/lock, 0.600 x 0.250	Molex	22-23-2061
J11	1	Connector, PCI Express System, X8, 0.349 x 2205	Molex	87715-3202
J12	1	Connector, PCI Express System, X16, 0.349 x 3504	Molex	87715-3302
J13, J14, J15	3	Header, 6-pin, 100mil spacing, (36-pin strip), 0.100 x 6	Sullins	PTC36SAAN
J2, J3, J4, J5, J6, J7, J8, J10, J16, J18	10	Header, 2-pin, 100mil spacing, (36-pin strip), 0.100 x 2	Sullins	PTC36SAAN
J9	1	Header, Friction Lock Ass'y, 4-pin Right Angle, 0.400 x 0.500	Molex	22-05-3041
P1	1	Connector, Header, 14-Pin, Dual Row, Vertical, 1.200 x 0.378	Molex	39-28-1143
Q1, Q4	2	MOSFET, P-ch, 30-V, 8.0-A, 20-milliohm, SO8	Siliconix	Si4435BDY
Q2, Q3	2	MOSFET, N-ch, 30-V, 10-A, 0.010-Ohm, SOIC-8	IRF	IRF7413
R1, R3, R16, R18, R19	5	Res,0.012 Ohm,1W,1%, 2512	Panasonic	ERJ-M1WSF12MU
R10, R11, R27, R28	4	Resistor, Chip, 10K-Ohms, 1/10-W,1%, 0805	Vishay	Std
R2, R4, R15, R17	4	Resistor, Chip, 15-Ohms, 1/10W, 1% , 0805	Panasonic	Std
R20, R21	2	Res, 1.0K, 0.1W, 1%, 0805	Panasonic	ERJ-6ENF101
R5, R14, R22, R23, R24, R25, R26, R29, R30, R31, R32, R33, R34, R35, R36	15	Resistor, Chip, 100K-Ohms, 1/10-W,1%, 0805	Vishay	Std
R6, R7, R8, R12, R13	5	Resistor, Chip,130-Ohms, 1/10-W, 1%, 0805	Panasonic	ERJ6ENF1300
R9	1	Resistor, Chip, 110K-Ohms, 1/10-W,1%, 0805	Vishay	Std
RP1, RP2, RP3, RP4, RP5, RP6	6	Resistor Pack, 47-Ohms, 62-mW, 5%, 8X, 0.083 x 0.158	Panasonic	EXB-E10C470J
S1, S2, S3, S4, S5, S6, S7, S8	8	Switch, SPDT, Slide, PC-mount, 500-mA, 0.400 x 0.100""	EAO	09-03201-02
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22, TP23, TP24, TP25, TP26	22	Test Point, 0.062 Hole, 0.25	Keystone	5012
TP9, TP10, TP11, TP12	4	Test Point, SM, 0.150 x 0.090, 0.185 x 0.135	Keystone	5016
U1	1	IC, Dual Slot PCI-Express Hot Plug Controller, PQFP48	TI	TPS2363PFB
XU1	1	Socket, Open-Top, 48pin, QFP, 1047 x 1047	Yamaichi Electronics Co.	IC234-0484-039N

Appendix A

A.1 Demo Board Schematics

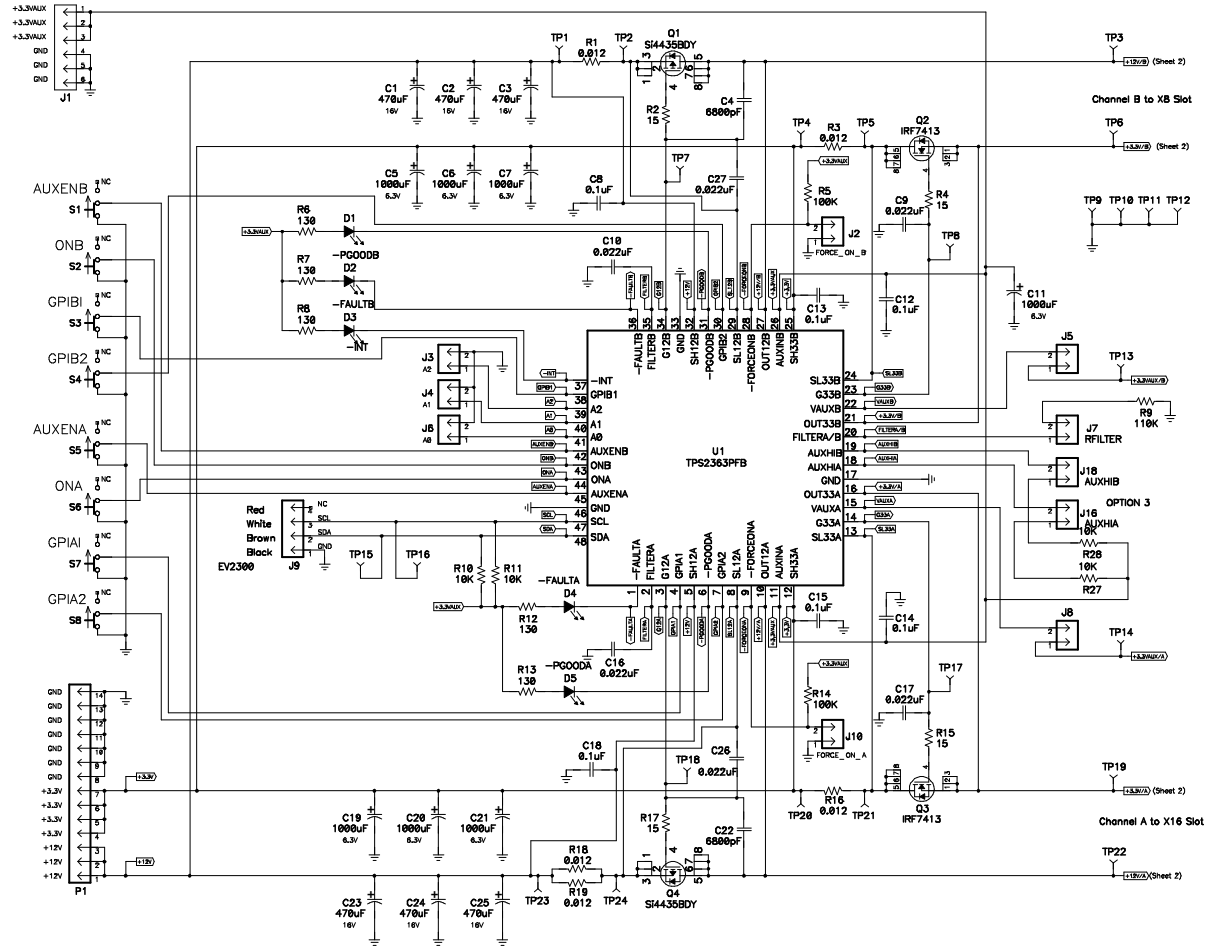

Figure A-1. Schematic System Demo Board Sheet 1 of 2

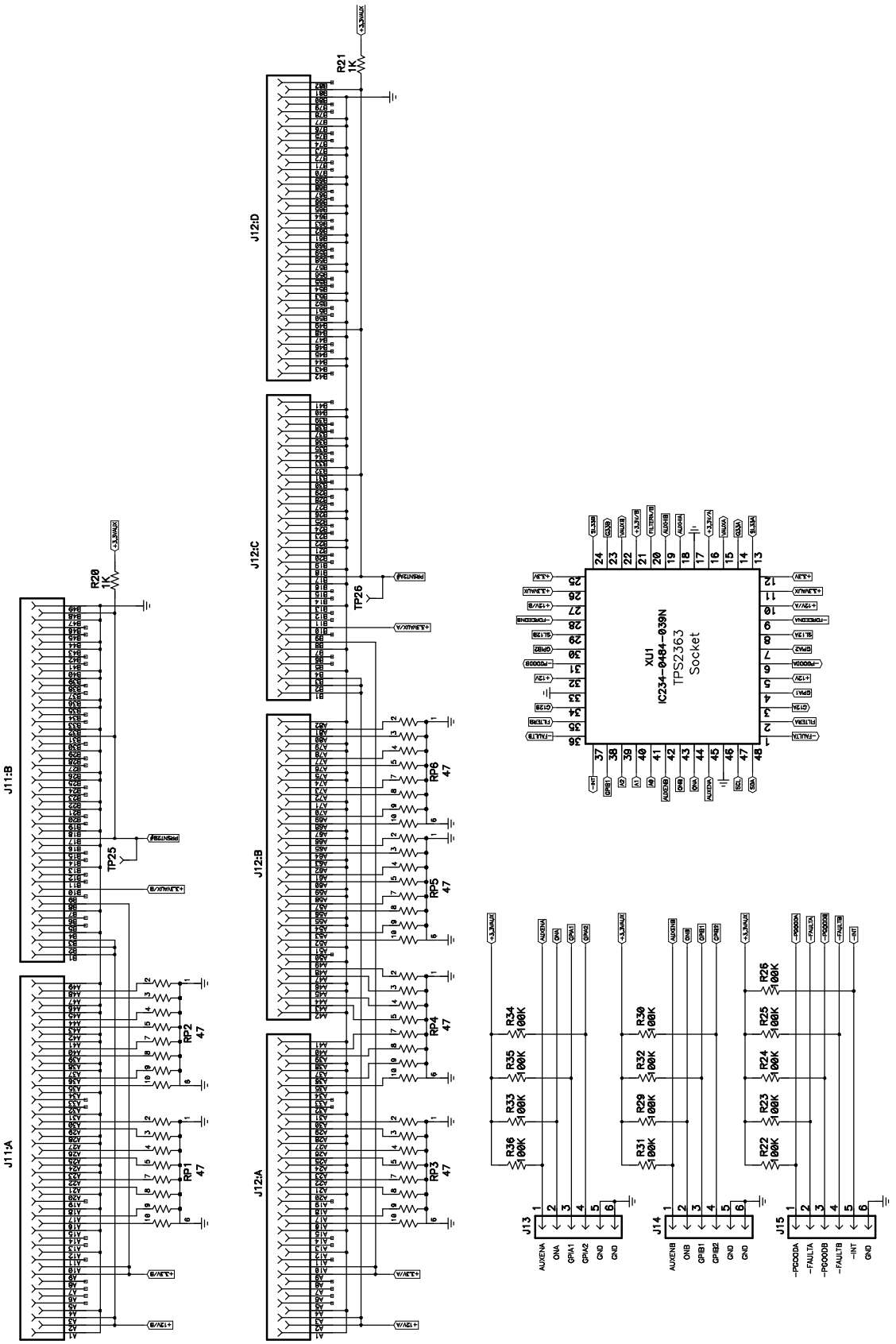

Figure A-2. Schematic System Demo Board Sheet 2of 2

A.2 Demo Board Layout

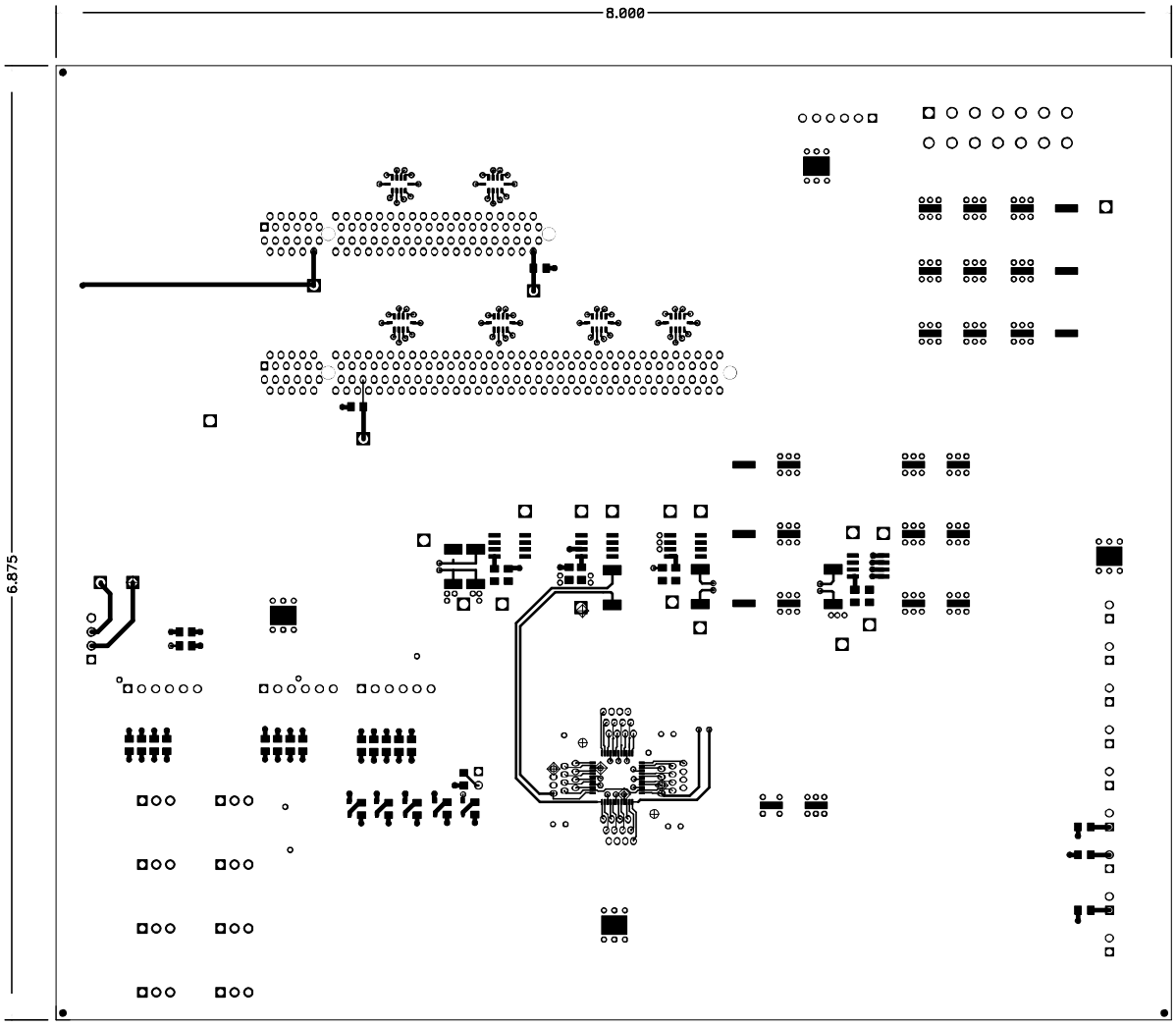

Figure A-3. Layout System Demo Board, Top Layer

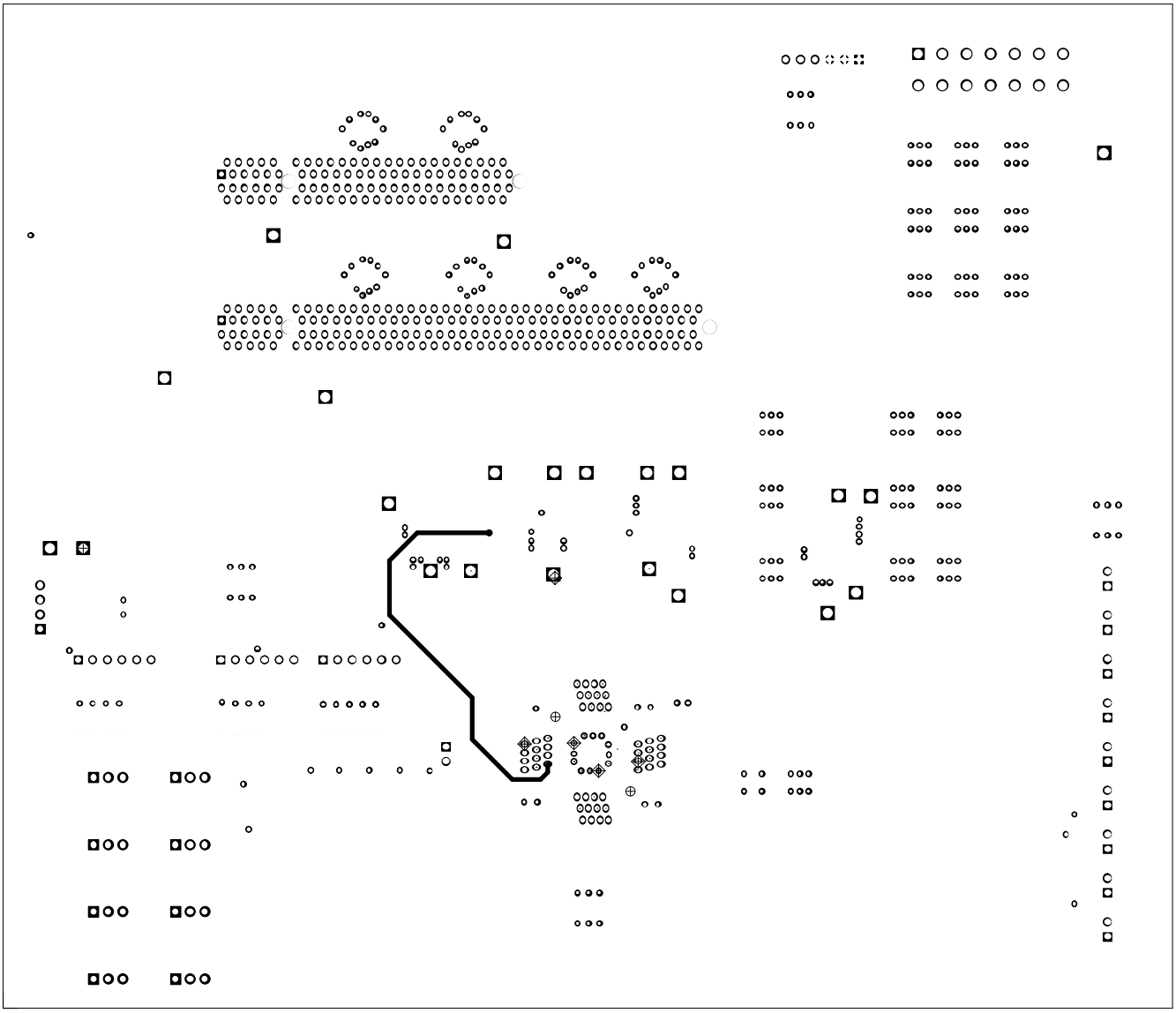

Figure A-4. Layout System Demo Board, Layer 1

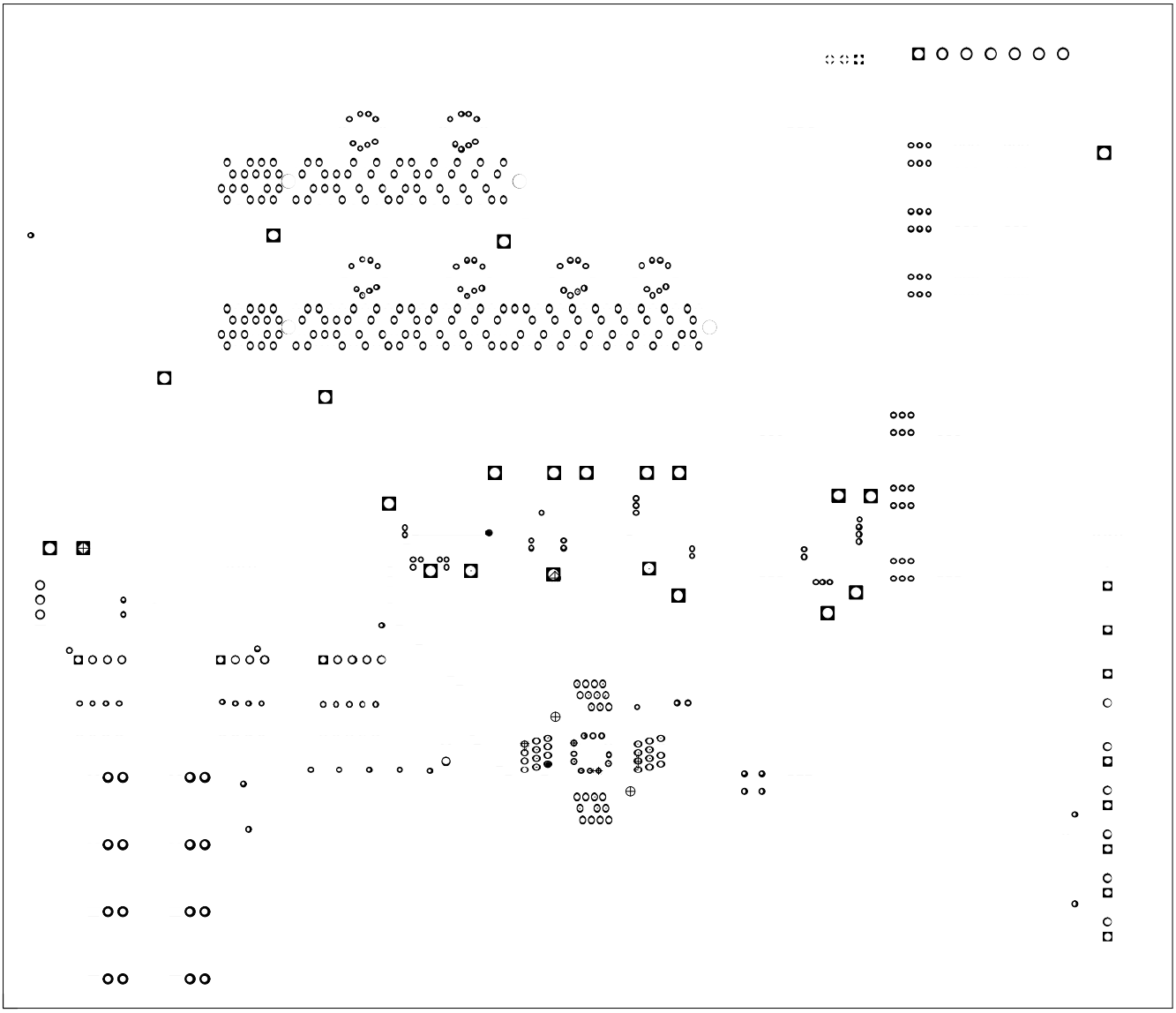

Figure A-5. Layout System Demo Board, Layer 2

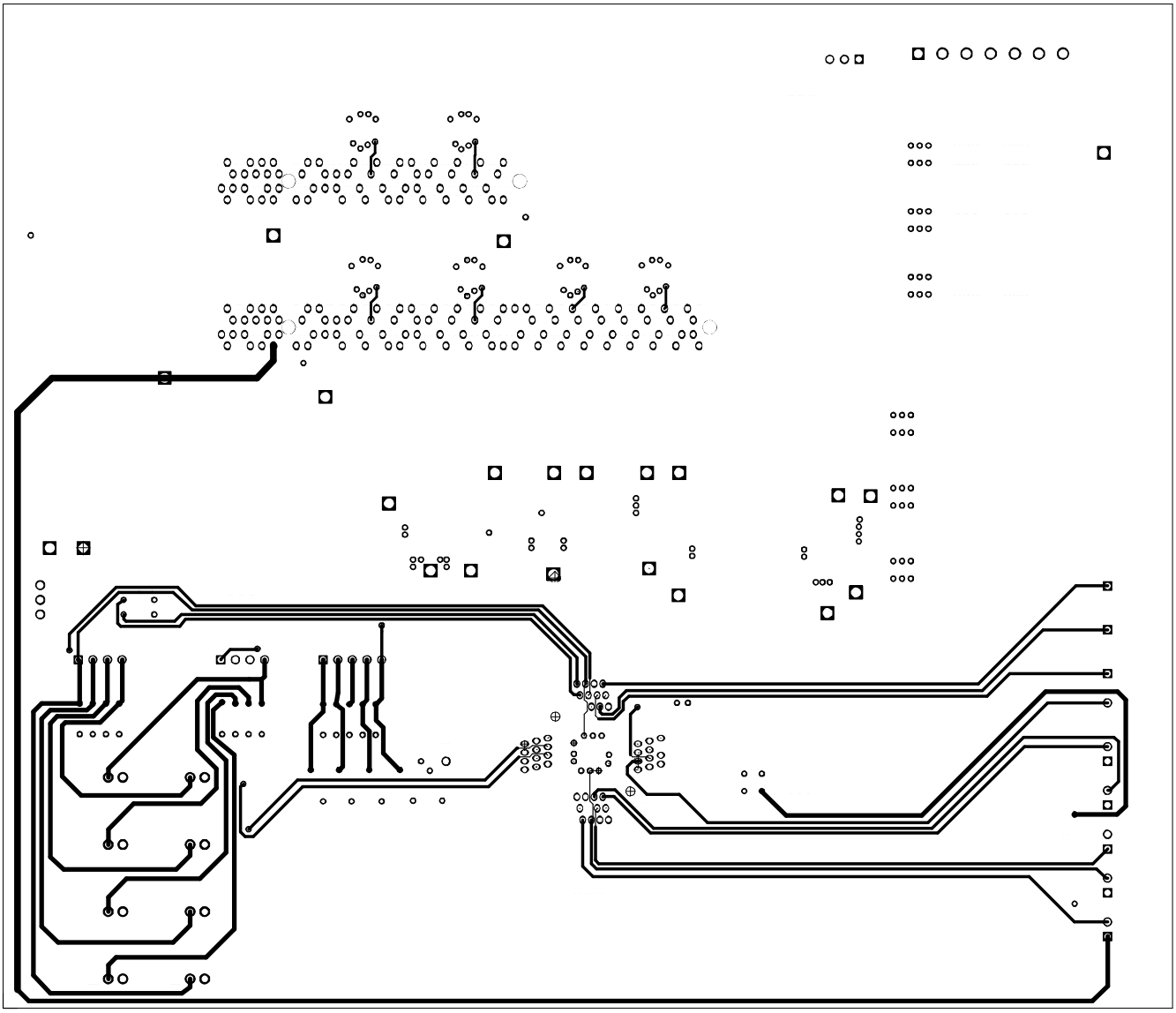

Figure A-6. Layout System Demo Board, Layer 3

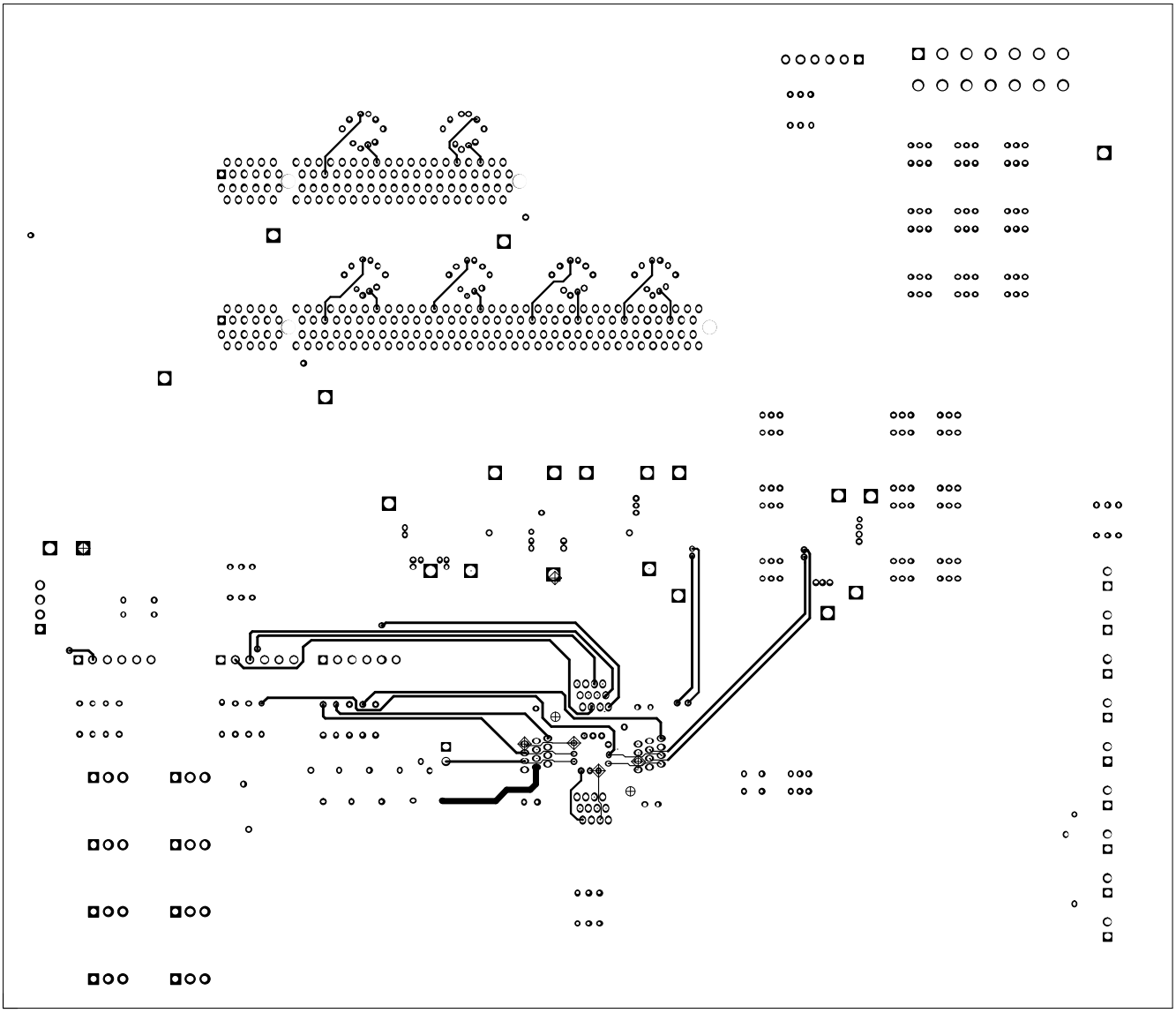

Figure A-7. Layout System Demo Board, Layer 4

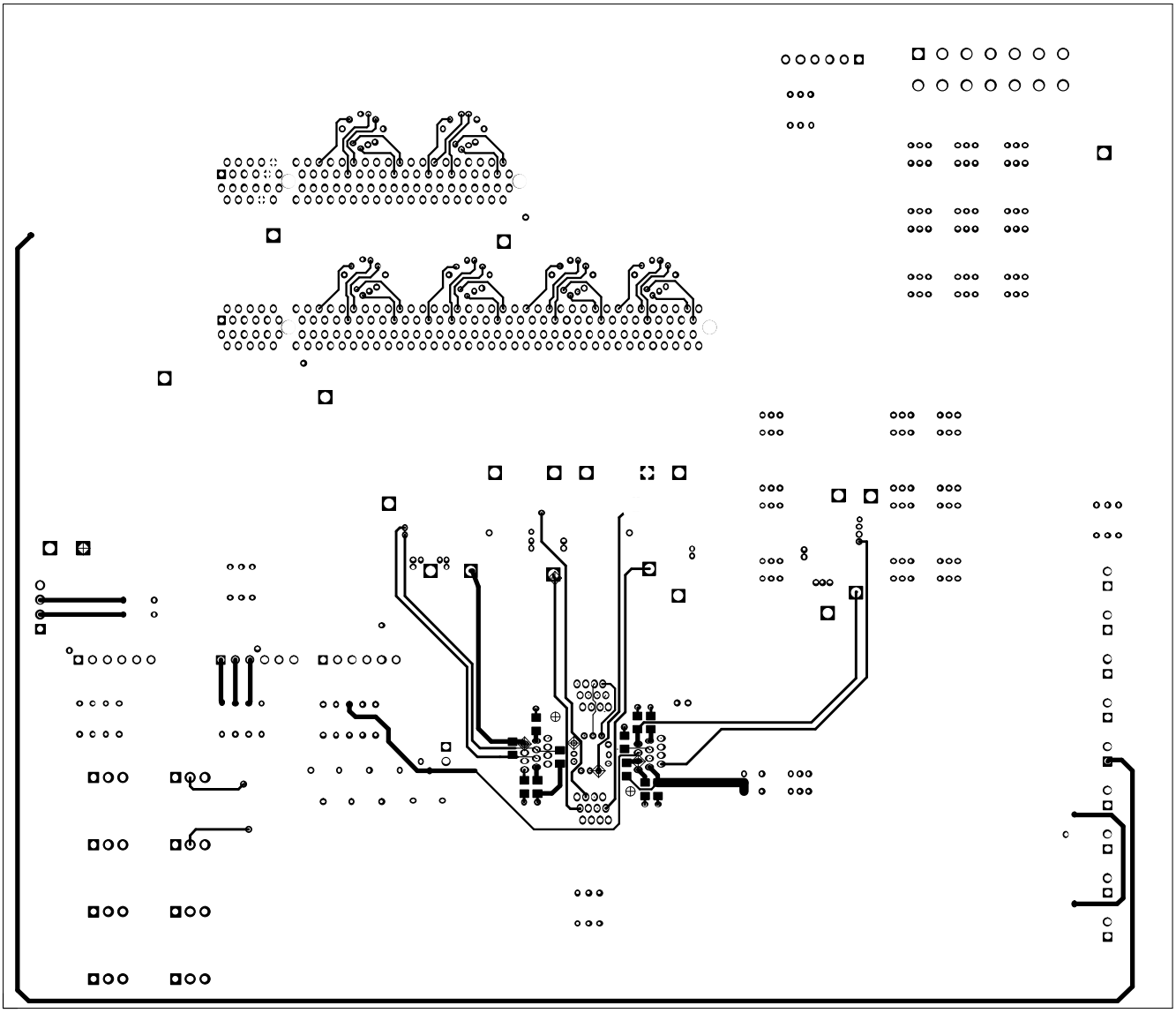

Figure A-8. Layout System Demo Board, Bottom Layer

A.3 Demo Load Boards

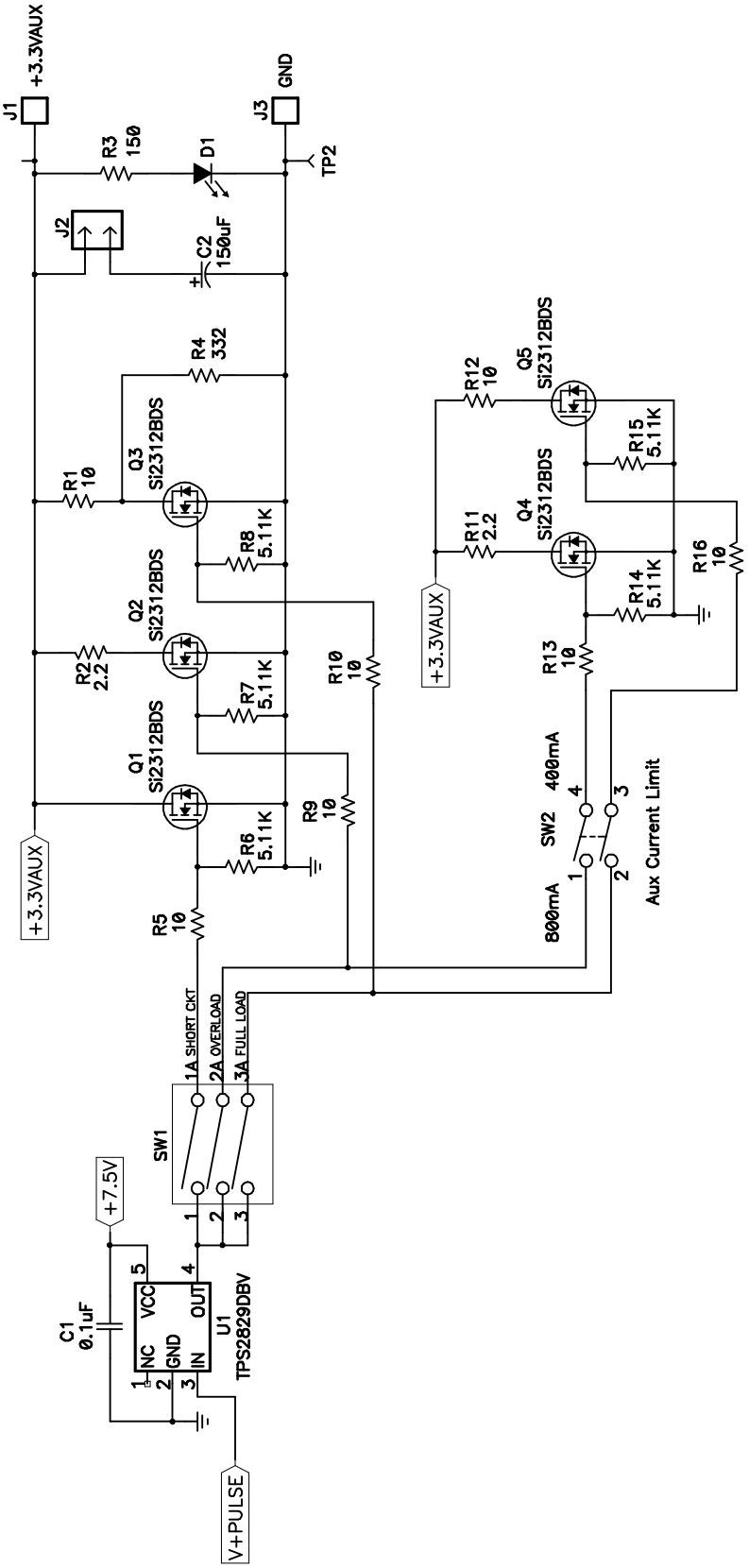

Figure A-9. Schematic Load Board Sheet 1 of 5

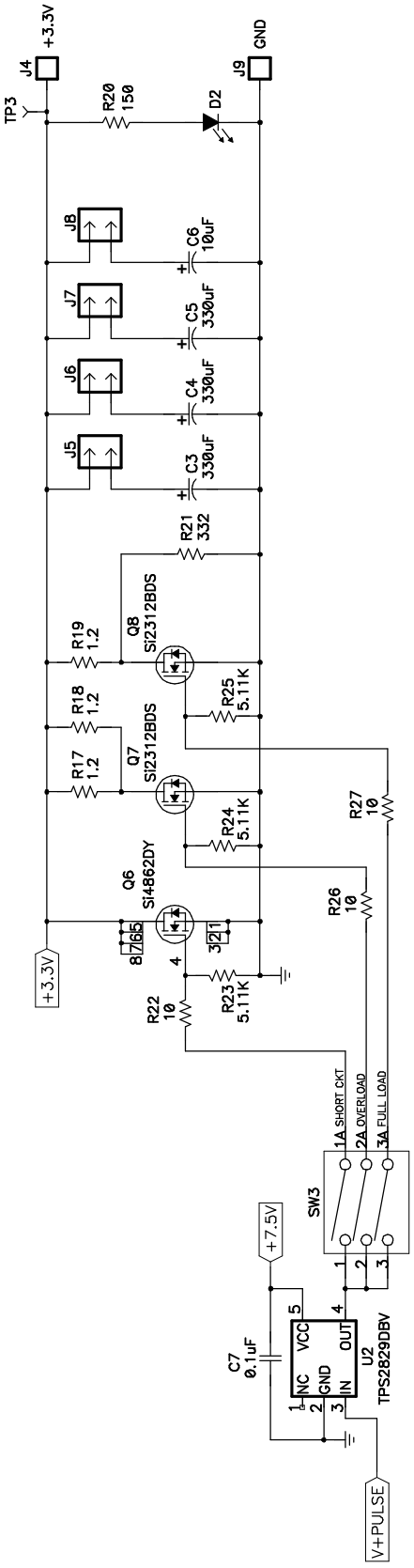

Figure A-10. Schematic Load Board Sheet 2 of 5

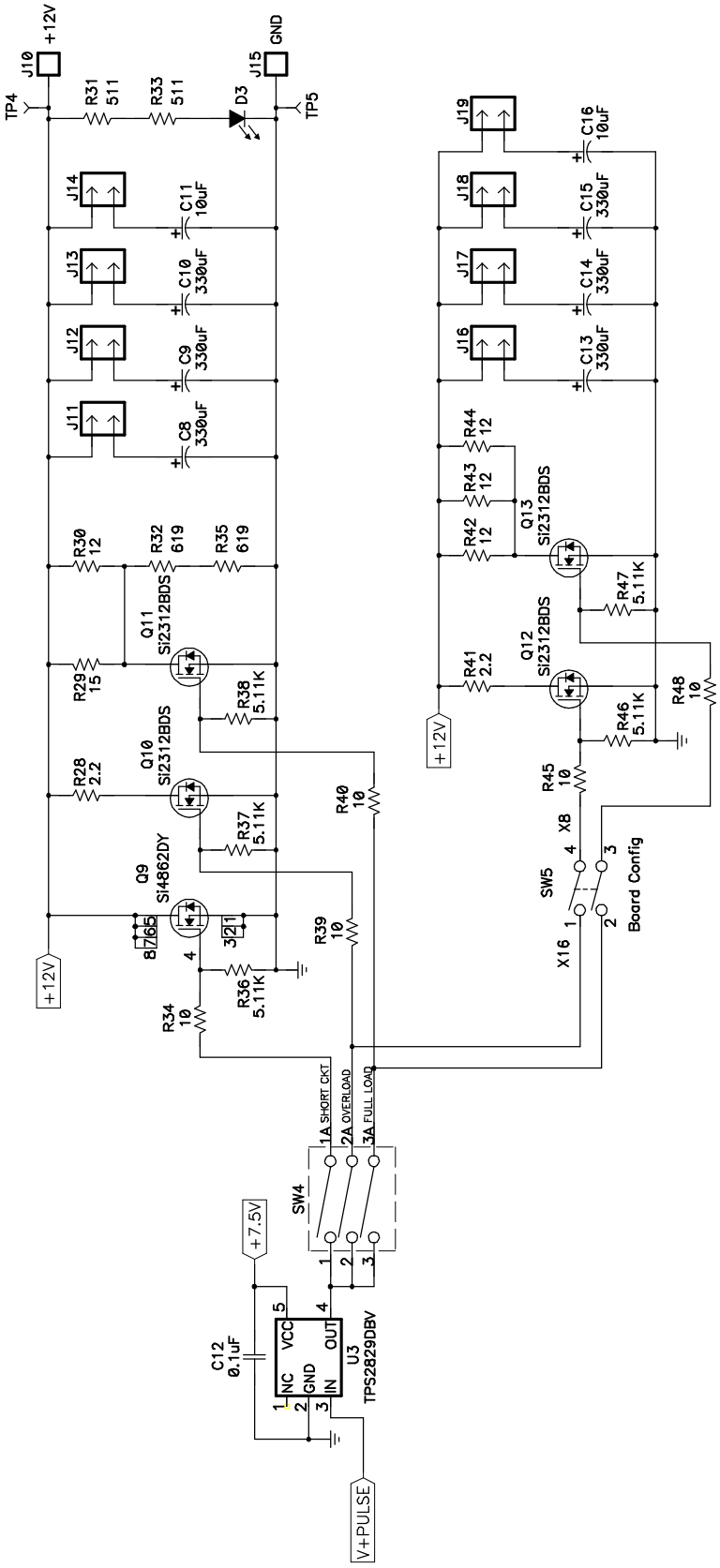

Figure A-11. Schematic Load Board Sheet 3 of 5

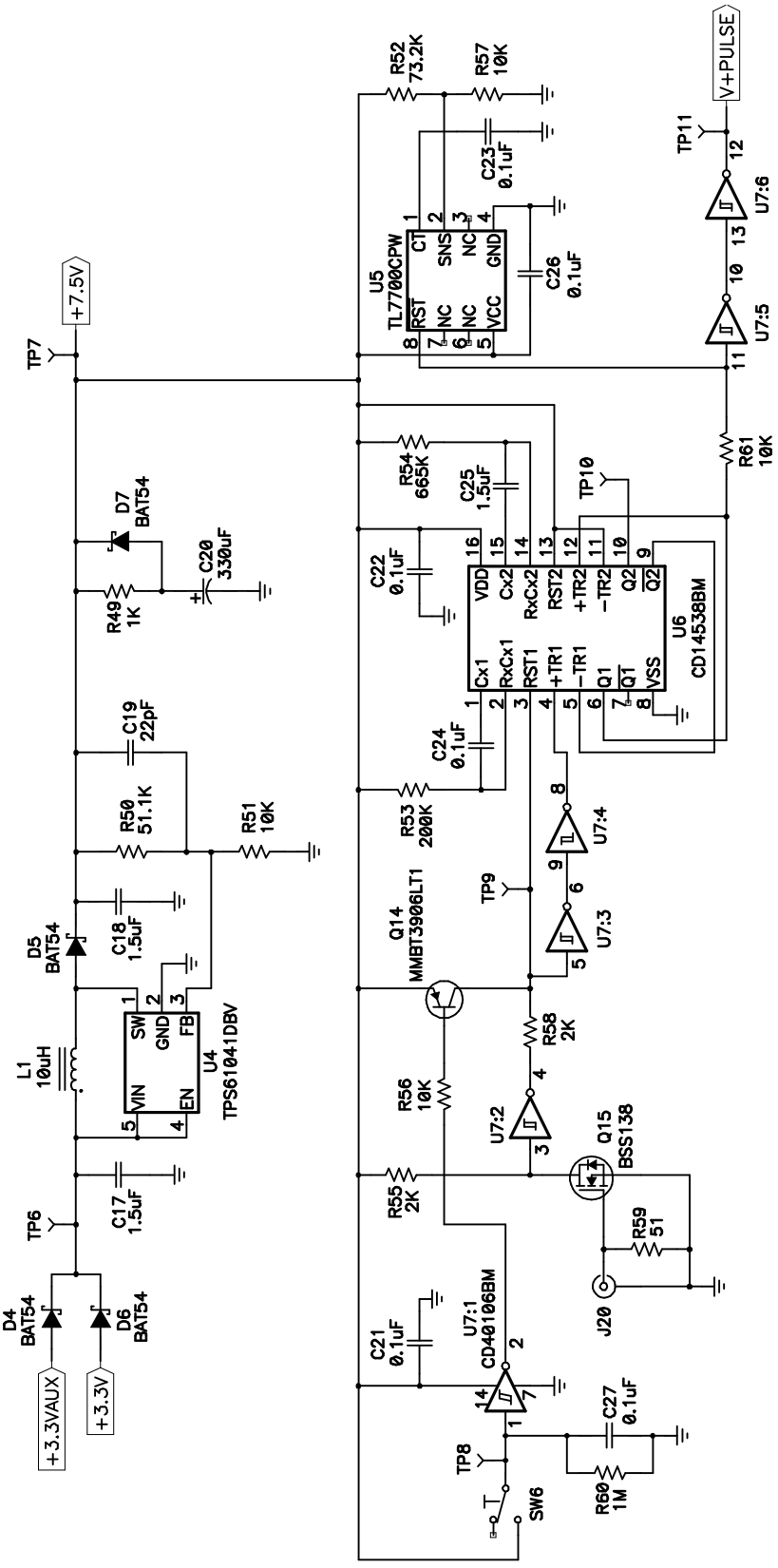

Figure A-12. Schematic Load Board Sheet 4 of 5

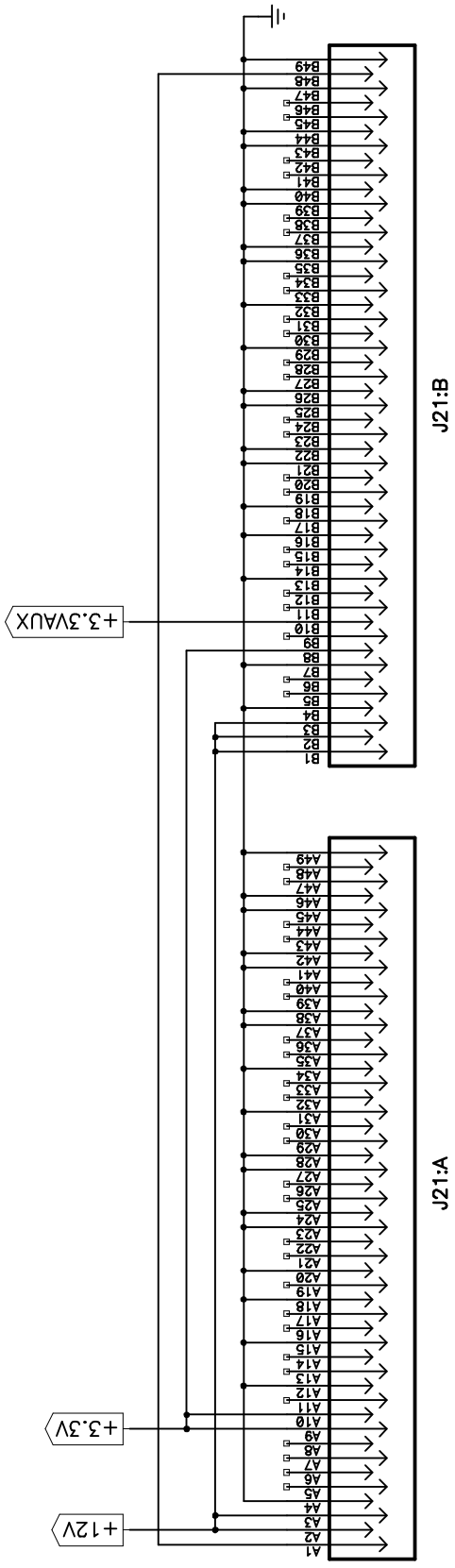

Figure A-13. Schematic Load Board Sheet 5 of 5

A.4 Demo Boards

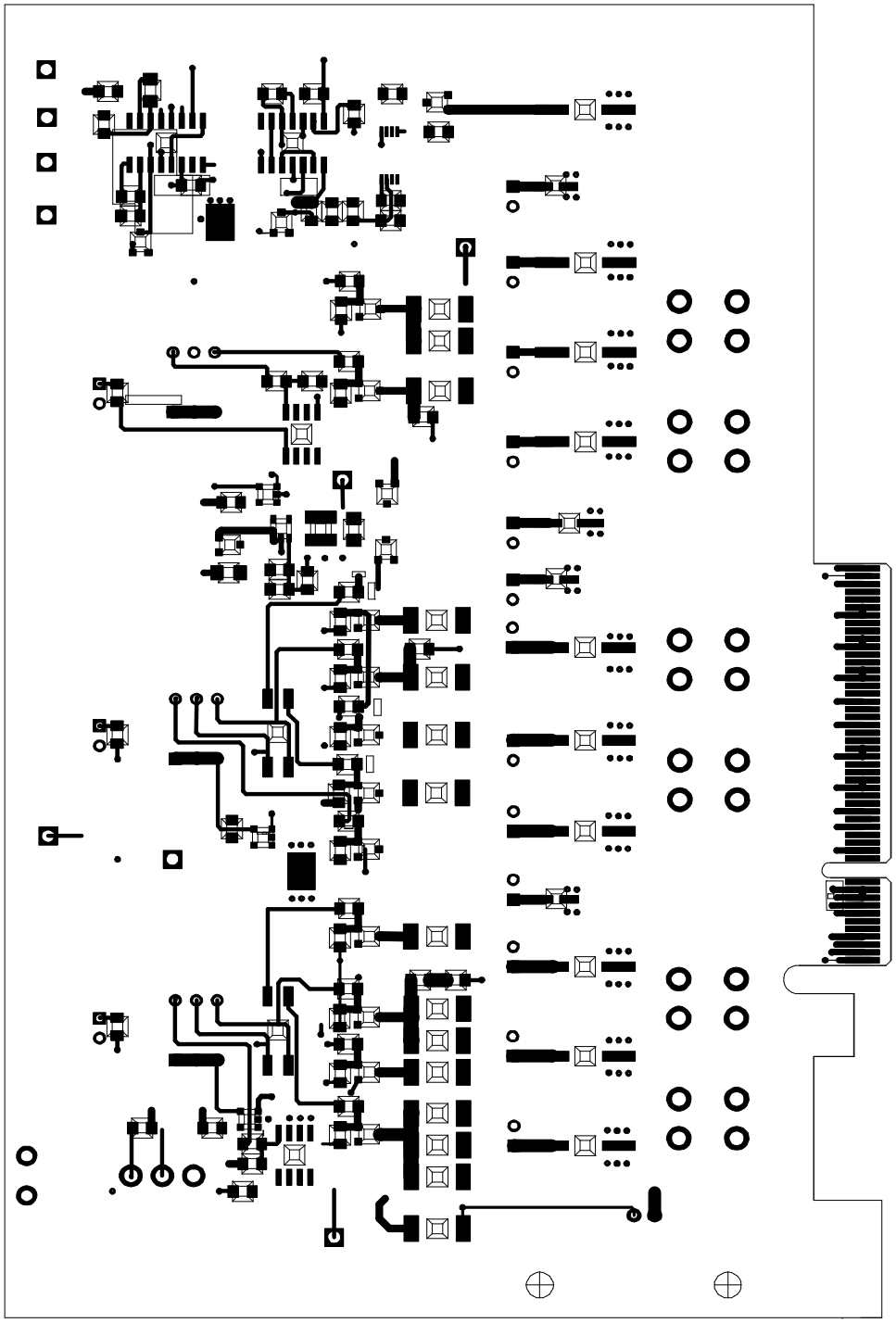

Figure A-14.

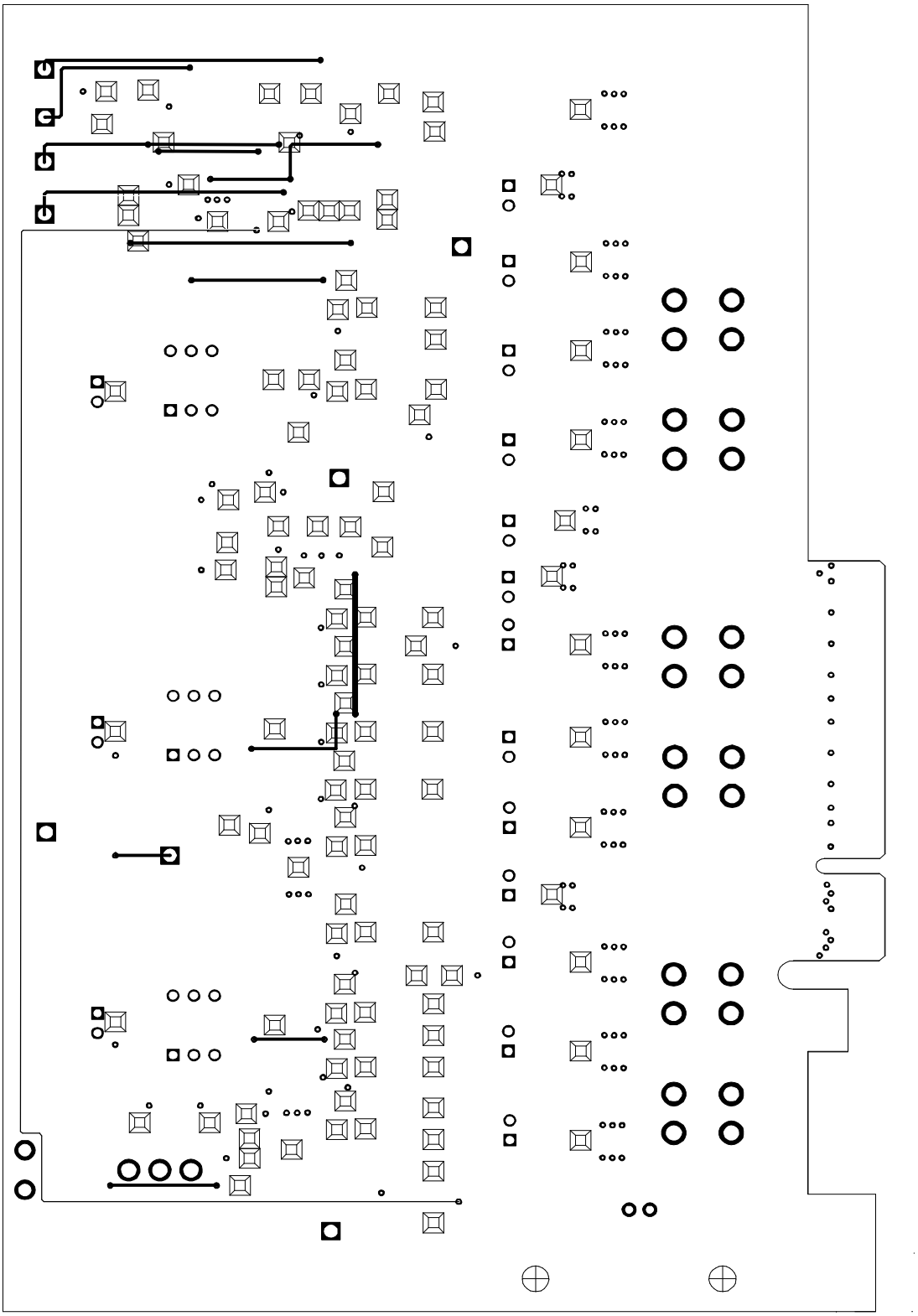

Figure A-15.

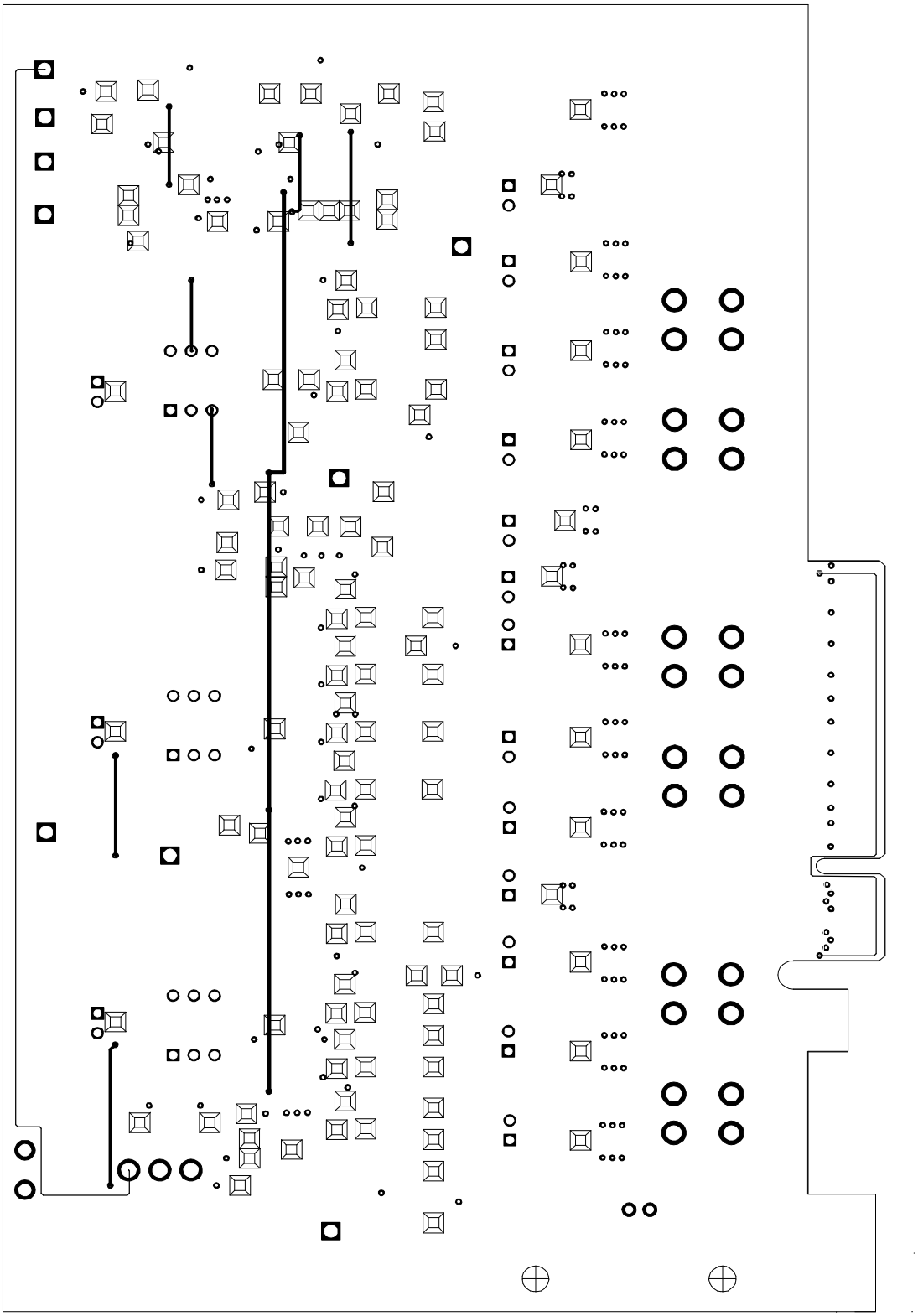

Figure A-16.

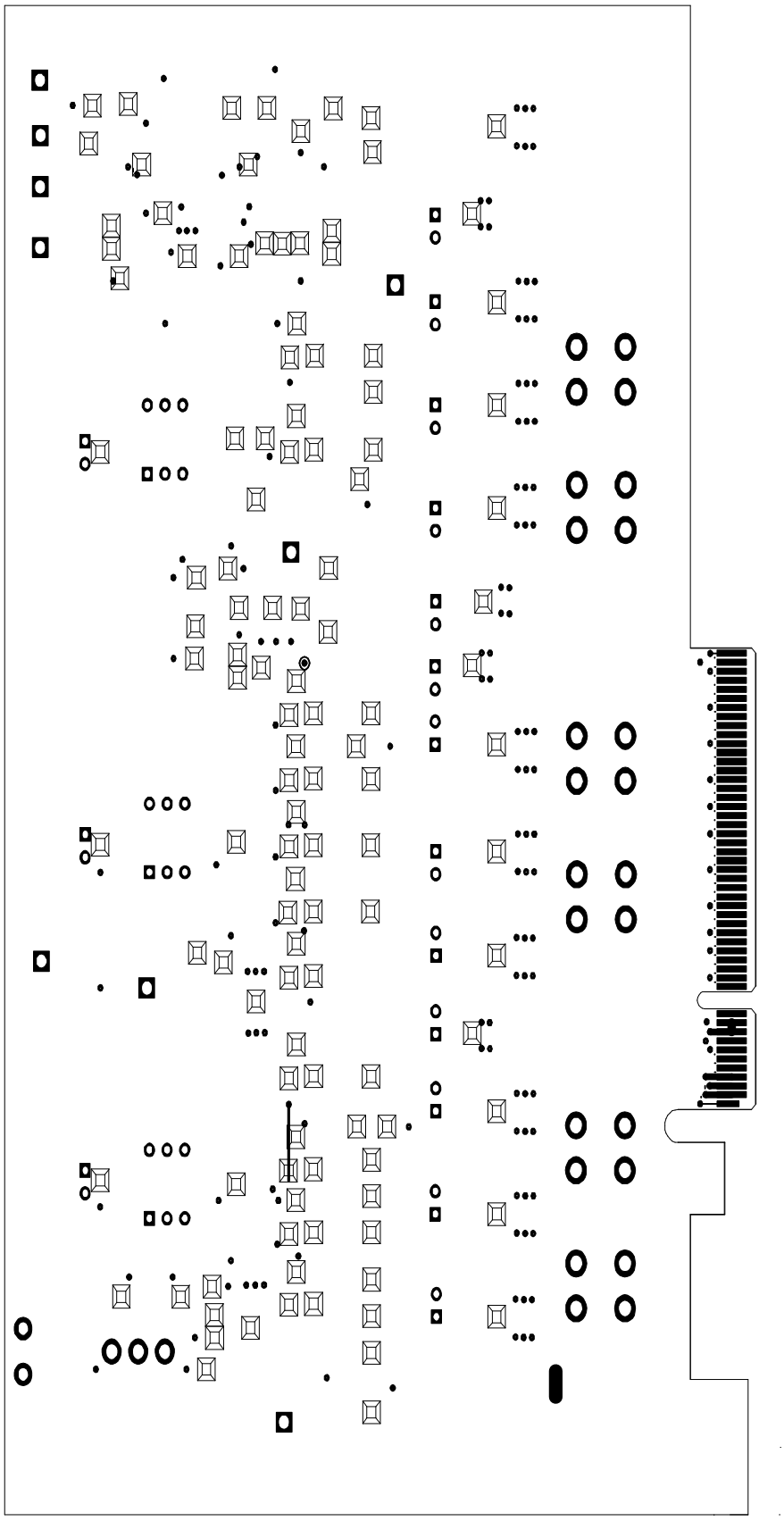

Figure A-17.

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