Si3480MS8-KIT

EVALUATION KIT USER'S GUIDE FOR THE Si3480 POWER MANAGEMENT CONTROLLER

1. Introduction

In Power over Ethernet (PoE) Power Sourcing Equipment (PSE), typically, not all PoE ports are connected to loads, and the ports that are connected to loads draw substantially less than the maximum power defined in the IEEE standard (30 W). For this reason, it is normal to use a power supply that is not capable of supplying full power to all ports and to add a system-level power management function to deal with the rare situations in which the system power supply becomes overloaded by selectively not granting power or by turning off ports in priority order. In these situations, the system user can redistribute loads, add a larger power supply, or add more PSE systems as needed.

The Si3480 works with the Si3452 PoE controllers and implements power management to enable the use of smaller, lower-cost, and more efficiently-utilized power supplies in unmanaged PSE systems with up to eight ports. The Si3480 also supports LED indication of port status and power supply consumption.

The Si3480MS8 evaluation board contains the Si3480 power manager, two Si3452 PoE controllers, a –50 V to +3.3 V dc-to-dc converter based on an Si3500, status LEDs, and Ethernet coupling circuitry.

For demonstration purposes, Class 3 and Class 4 Powered Device (PD) loads are supplied with the evaluation system. Various load resistors (also supplied) can be used to simulate normal and overload conditions.

2. Evaluation Board Overview

Figure 1 shows a photo of the evaluation board with highlights of the major functional blocks.

The PoE coupling circuit and Ethernet connectors are arranged as a "mid-span" power injector. Ethernet without power is connected to the top row of connectors, and Ethernet with power injected is connected to the bottom row of connectors. J300 is for the four ports connected to U1, and J301 is for the four ports connected to U2. If only the PSE function is being evaluated, only the bottom row of connectors needs to be used. Table 1 lists the contents of the Si3480MS8 evaluation kit.

Table 1. Si3480MS8 Evaluation Kit Contents

Part Number	Quantity	Description
Si3480-EVB	1	The Si3480 evaluation board shown in Figure 1.
Si3402ISO-EVB	2	A powered device with Class 3 signature (15.4 W maximum).
Si3402ISO-C4-EVB	1	A powered device with Class 4 signature (30 W maximum).
	3	Ethernet cables for connecting the powered devices.
	3	Load board with three 5 Ω loads. Each resistor that is connected will draw about 6.5 W of input power from the PSE.

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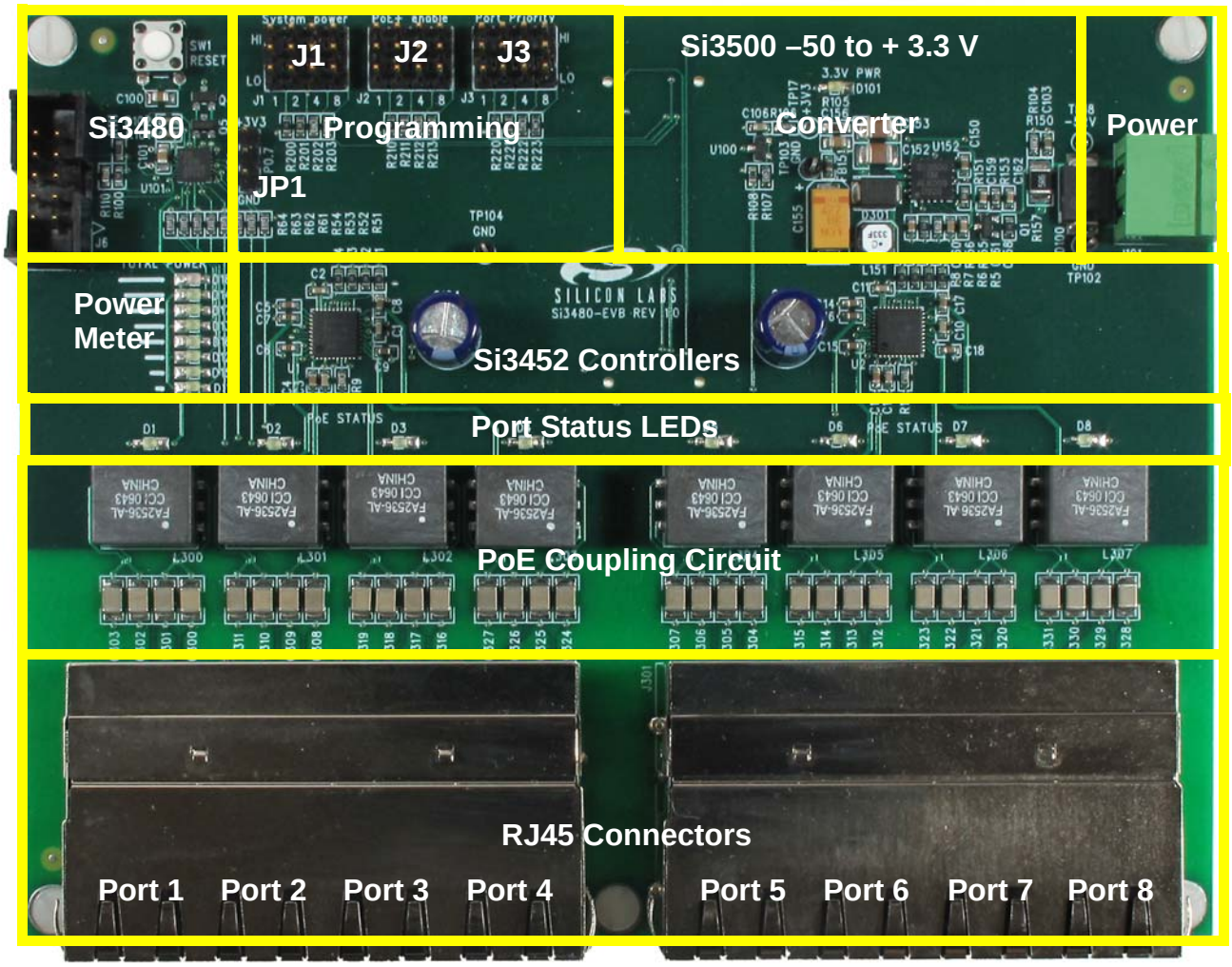


Figure 1. Si3480 Evaluation Board Functional Blocks

3. Using the Si3480 Evaluation Board

3.1. Board Power

A nominal 50 V power supply is connected to J101. For high-power (PoE+) support according to the IEEE standard, the supply voltage should be between 51 and 57 V. For normal power levels, the power supply can be 45 to 57 V. The total power supply wattage is normally in the range of 30 to 150 W. The large diode, D100, will be forward-biased in case of accidental wrong input polarity. It is recommended that the power supply be connected to the board and then turned on so as to prevent large inrush current from charging the two 33 µF filter capacitors on the board.

3.2. Jumper Settings

Jumper JP1 sets the timing configuration. Since the board implements Alterative B wiring, the normal setting of JP1 is tied high (+3.3 V side). The Si3482 can support Alternative A timing by setting JPI low.

Jumpers J1, J2, and J3 set the voltage on the Si3480 programming pins. The voltage is set by a resistor ladder as shown in Figure 2.

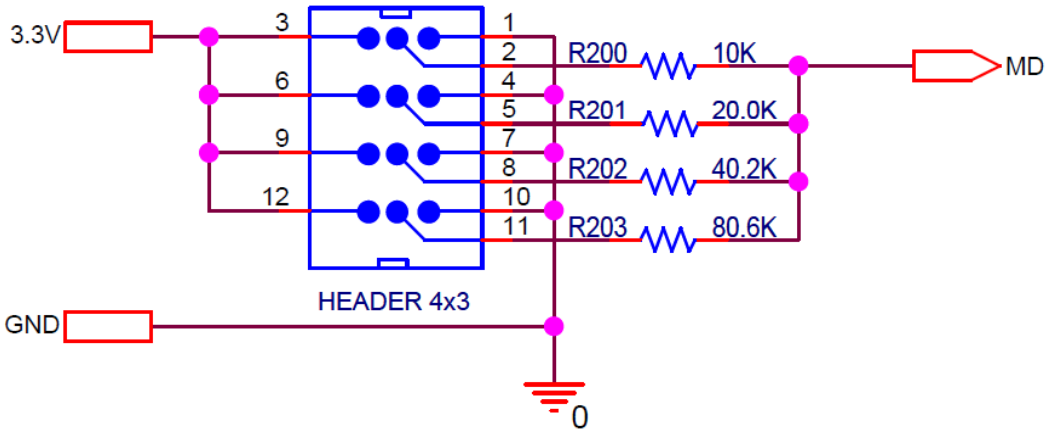


Figure 2. Si3480 Programming Jumpers

The silk-screen numbers 1, 2, 4, 8 refer to the resistor weighting; so, the jumper near the “1” is the MSB, and the jumper near the “8” is the LSB. The voltage on the output pin (MD in Figure 2) as well as the way in which this is interpreted by the Si3480 is shown in Table 2.

Table 2. Possible Jumper Settings

Jumper				Pin Voltage (V_{DD} = 3.3 V)	J1 System Power	J2 PoE+ Enable	J3 Port Priority
1	2	4	8				
0	0	0	0	0.00 V	0	No ports PoE+	All same
0	0	0	1	0.22 V	13.3 W	Port 1	Port 1 high priority
0	0	1	0	0.44 V	26.7 W		
0	0	1	1	0.66 V	40 W	Ports 1,2	Ports 1,2 high priority
0	1	0	0	0.88 V	53.3 W		
0	1	0	1	1.10 V	66.7 W	Ports 1–3	Ports 1–3 high priority
0	1	1	0	1.32 V	80 W		

Table 2. Possible Jumper Settings (Continued)

Jumper				Pin Voltage (V_{DD} = 3.3 V)	J1 System Power	J2 PoE+ Enable	J3 Port Priority
1	2	4	8				
0	1	1	1	1.54 V	93.3 W	Ports 1–4	Ports 1–4 high priority
1	0	0	0	1.76 V	106.7 W		
1	0	0	1	1.98 V	120 W	Ports 1–5	Ports 1–5 high priority
1	0	1	0	2.20 V	133.3 W		
1	0	1	1	2.42 V	146.7 W	Ports 1–6	Ports 1–6 high priority
1	1	0	0	2.64 V	160 W		
1	1	0	1	2.86 V	173.3 W	Ports 1–7	Ports 1–7 high priority
1	1	1	0	3.08 V	186.7 W		
1	1	1	1	3.30 V	200 W	All ports PoE+	All same

In a system where the voltage at the pin will be fixed, the jumper arrangement can be replaced with a simple resistor divider. The A/D reference voltage for the Si3480 is V_{DD}; so, as V_{DD} varies, the Si3480 is only sensitive to the ratio of resistors.

3.3. LEDs

Upon power application or reset (by SW1 in the upper left corner), the Si3480 probes to see whether there are one or two Si3452 ICs connected (4 or 8 ports). The Si3480 then controls the LED display in the startup sequence described and automatically starts managing the power among the ports as determined by the jumper settings. After startup, the power meter and port status LEDs give a visual indication of the Si3480 operation.

3.3.1. Start-Up LED Sequence

During startup, the LEDs are lit in the sequence listed in Table 3 (1 second for each step).

Table 3. Startup Sequence

Step	Action
1	All LEDs on.
2	Port 1 LED and either four or eight power meter LEDs to indicate the number of 4-port controllers found by the Si3480 (no LEDs if no controllers are found).
3	Port 2 LED and zero to eight power meter LEDs to indicate the provided power as determined by reading the voltage at the PWRCFG pin in 25 W steps (For example, two LEDs is 50 W).
4	Port 3 LED and zero to eight power meter LEDs to indicate the number of PoE+ ports as determined by reading the voltage at the POECFG pin.
5	Port 4 LED and zero to eight power meter LEDs to indicate the number of high-priority ports as determined by reading the voltage at the PRIOCFG pin.

3.3.2. Port Status LEDs

After the startup sequence, the port status LEDs display the patterns listed in Table 4 to indicate port status.

Table 4. Port LED Pattern Definitions

Port LED Pattern	Meaning
Flashing once every two seconds	Detection and Classification in process.
Continuously lit	PoE port is on.
Blinks off once every two seconds	PoE+ port is on with a class 4 PD load (30 W granted).
Flashing five times per second	Port overloaded.
Flashing twice every two seconds	Power denied due to lack of power.

For a port overload, an open circuit must be seen before the port is re-enabled; that is, the PD must be unplugged, and the overload must be cleared.

Ports are turned off in priority order if more than the available power is being consumed. If the amount of power consumed is >10% more than the available power, all low priority ports are shut off immediately.

Ports are not granted power unless there is enough power available to grant the requested power (based on classification) with 15% margin. The 15% margin generally avoids situations where a port is granted power and then later turned off due to lack of power.

If a port is turned off or denied power due to a lack of available power, the LED continues flashing twice every two seconds until enough power is available to turn the port on or the PD is unplugged.

3.3.3. Power Meter LEDs

The power meter LEDs light consecutively, indicating the amount of power that is being consumed. There are eight LEDs in the power meter. The LEDs will light in bar graph fashion:

Number_LEDs_Lit = 8 x Total_Power_Consumed / (0.85 x Provided_Power – 4 W) (rounded down)

The eighth power meter LED is generally a red LED. If this LED is lit, it means that there is not enough power available to grant even a Class 1 load power and maintain a 15% margin. The eighth LED is flashed five times per second if the Si3452 controllers report a power supply undervoltage.

3.4. Demonstration Using the Supplied Loads

The Si3480MS8-KIT ships with three powered devices based on the Si3402 with loads for up to approximately 18 W of input power. The loads are arranged as one to three 5 Ω resistors, which draw 5 W each at the PD output voltage of 5 V. Due to the PD input diode bridge and the dc-to-dc conversion efficiency, each resistor causes approximately 6.5 W of power to be drawn from the PSE. This means that the PD will draw 6.5, 13, or 19.5 W from the PSE, depending on the number of load resistors connected.

The Si3402 loads and resistors can be used to demonstrate most of the operation of the Si3480. In the following example, it is assumed that the Si3480 board is connected to a 50 V power supply with a capacity of at least 40 W.

Step 1: Set the Jumpers.

Table 5. Jumper Settings

J1	System Power	0011	40 W of power provided.
J2	PoE+ enable	0001	Only port 1 is PoE+.
J3	Port priority	0001	Only port 1 is high priority.

Because the system power is set to 40 W, the power meter display during normal operation is:

Number_LEDs_Lit = 8 x Total_Power_Consumed / (0.85 x 40 W – 4 W) (rounded down)
= Total_Power_Consumed/3.75 W (rounded down)

Thus:

Number of LEDs	Power Consumed (W)	Total Number of Load Resistors
0	0–3.75	
1	3.75–7.5	1 load (6.5 W)
2	7.5–11.25	
3	11.25–15	2 loads (13 W)
4	15–18.75	
5	18.75–22.5	3 loads (19.5 W)
6	22.5–26.25	4 loads (26 W)
7	26.25–30	
8	>30	5 loads (32.5 W)
		6 loads (39 W)
System Overload		7 loads (45.5 W)

Step 2: Apply the –50 V Power.

Observe the power up LED sequence of one second at each step:

1. All LEDs
2. Port 1 LED and eight power meter LEDs to indicate two Si3452 port controllers found by the Si3480
3. Port 2 LED and two power meter LEDs to indicate the provided power is between 25 and 50 W
4. Port 3 LED and one power meter LEDs to indicate one PoE+ port
5. Port 4 LED and one power meter LEDs to indicate one high priority port

After the power up sequence, the port LEDs flash once every two seconds to indicate detection in process.

Step 3: Connect a Class 3 PD with one load resistor into Port 1 and a Class 4 PD with one load resistor into Port 2.

- The Port 1 LED is continuously lit to indicate the port is powered and is not PoE+ (because a Class 3 load was connected).
- The Port 2 LED is continuously lit to indicate the port is powered and is not PoE+ (because the port has not been enabled for POE+). Three power meter LEDs are lit due to the 13 W of power consumption.

Step 4: Disconnect the PDs from Step 1, and connect the Class 4 PD to Port 1 and Class 3 PDs to each of Ports 2 and 3. Initially, use one load resistor on each PD.

- The port status LED on port 1 is on but blinks off every two seconds to indicate Port 1 is powered as PoE+.
- The Port 2 and Port 3 LEDs are continuously lit to indicate those ports are powered and not PoE+.
- The power meter LED has five LEDs lit due to the 19.5 W of power consumption.

Step 5: Increase the Load on the Ports to create a port overload by switching in more load resistors.

- For Port 2 or Port 3 (with Class 3 PDs), the port overload condition occurs with the three resistors, which corresponds to about 19.5 W of input power.
- When the overload occurs, the port status LEDs flash five times per second to indicate that the overload has occurred and the port is turned off.
- To reset the port, decrease the load back to one resistor; unplug the PD, and plug it back in.

- For Port 1 (PoE+ port with Class 4 PD), the overload does not happen even with 19.5 W being drawn by the PD. Note that, in this case, the load resistors and PD will get hot, so use care.

Step 6: Demonstrate the port priority and system overload protection features.

- Disconnect all PDs and then connect the Class 3 PDs to Ports 2 and 3 with two load resistors so they are drawing 13 W each (26 W total power).
- Connect the Class 4 PD with three resistors (19.5 W) to Port 1.
- Port 1 is granted power, and a system level overload is created with approximately 45.5 W.
- Either Port 3 or Ports 2 and 3 will be turned off depending on whether the Si3480 reported a severe overload (>44 W).
- Because the PDs have a soft start circuit, it is possible that only Port 3 is turned off when the power exceeds 40 W.
- The ports that are turned off will not turn back on until the load on port 1 is reduced.

3.5. Higher Power Applications

The 40 W power supply used in “3.4. Demonstration Using the Supplied Loads” is typical of a PSE system that supports PoE+ on one port and is not expected to have PDs on all ports. By using a higher power supply and setting the jumpers appropriately, the evaluation system can be used for higher power applications. As the available power is increased, it becomes increasingly difficult to create a system-level overload.

4. Detailed Schematics, BOM, and Layout

The following figures show the detailed schematics, bill of materials, and layout for the Si3480 evaluation board.

4.1. Schematics

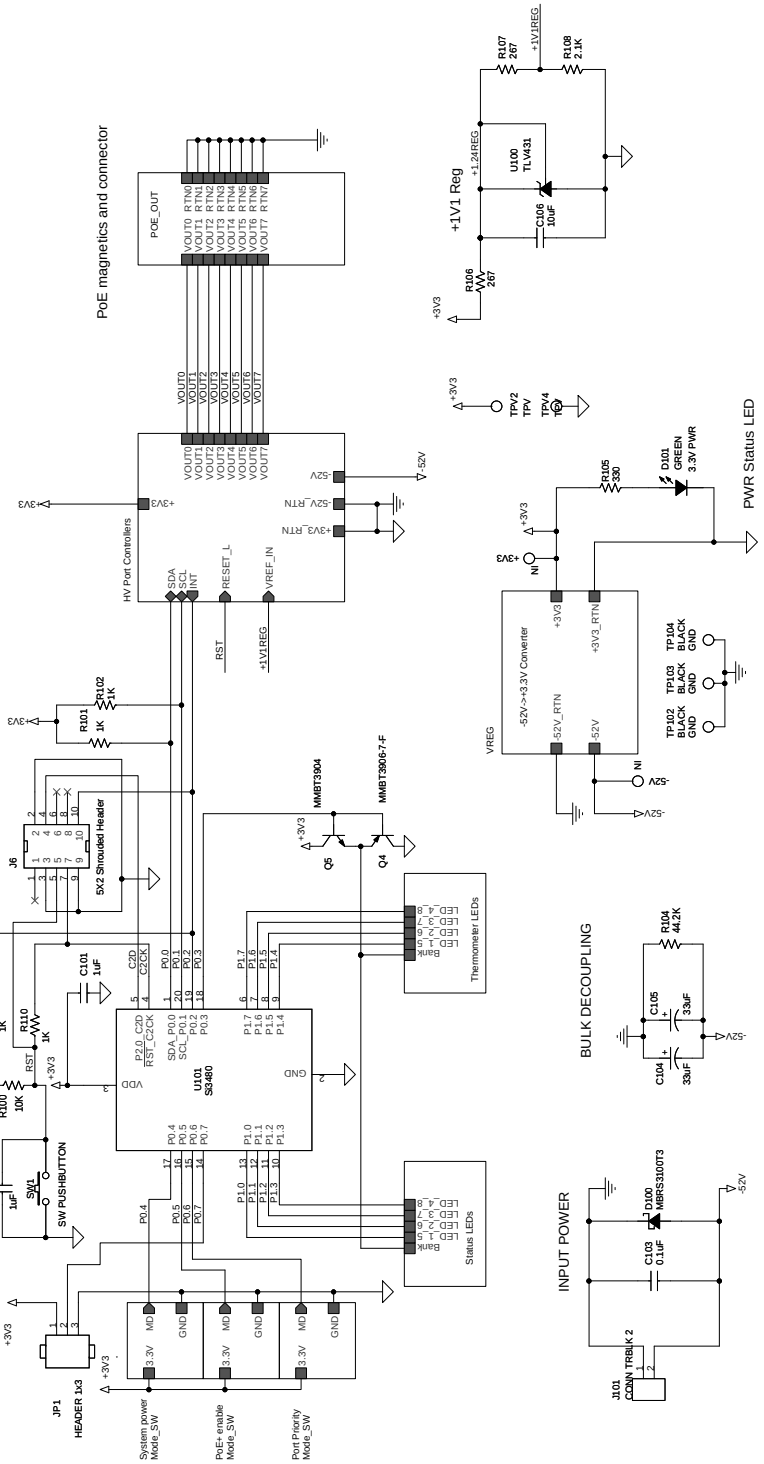


Figure 3. Si3480 and Top Level

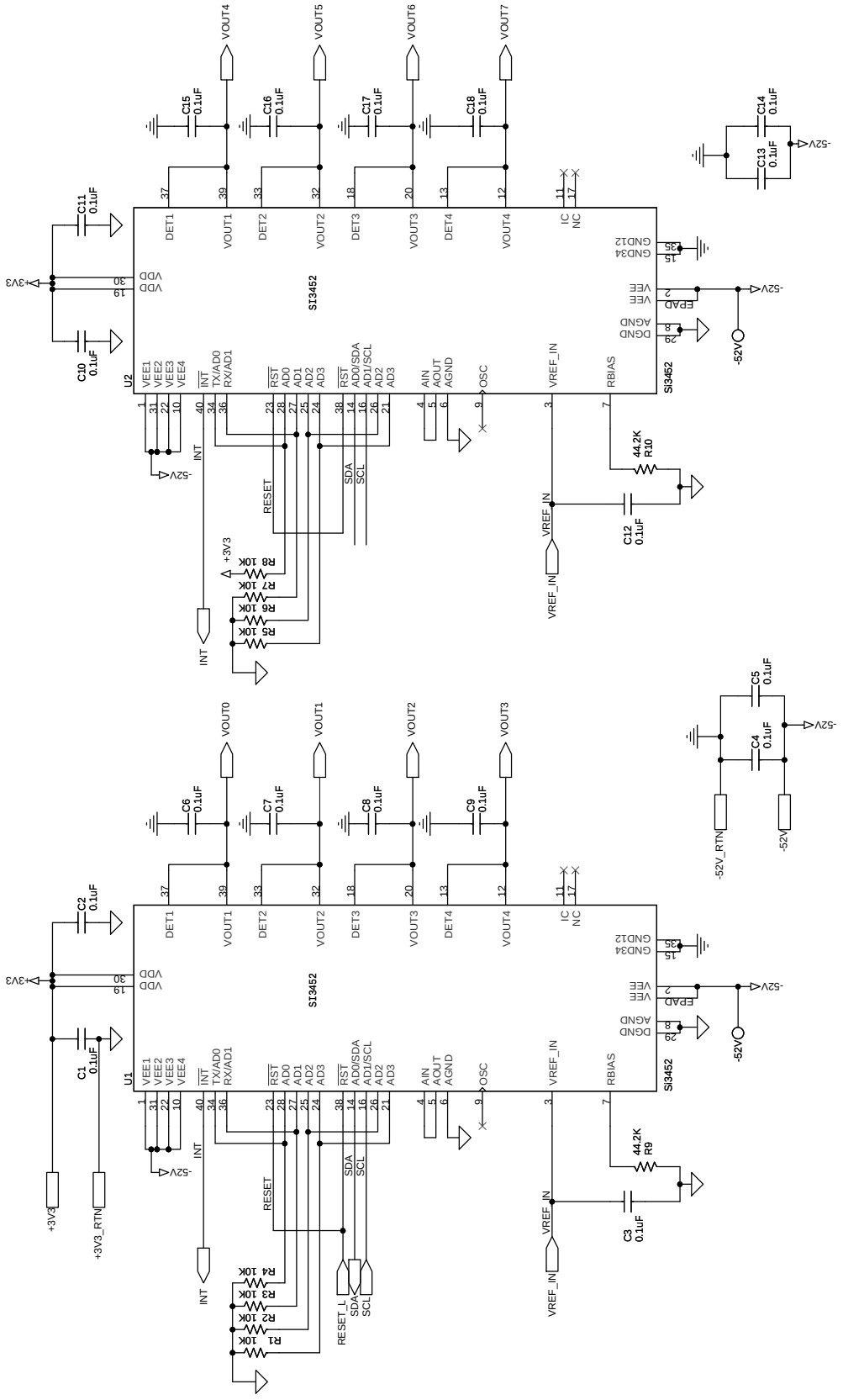


Figure 4. Si3452 Controllers

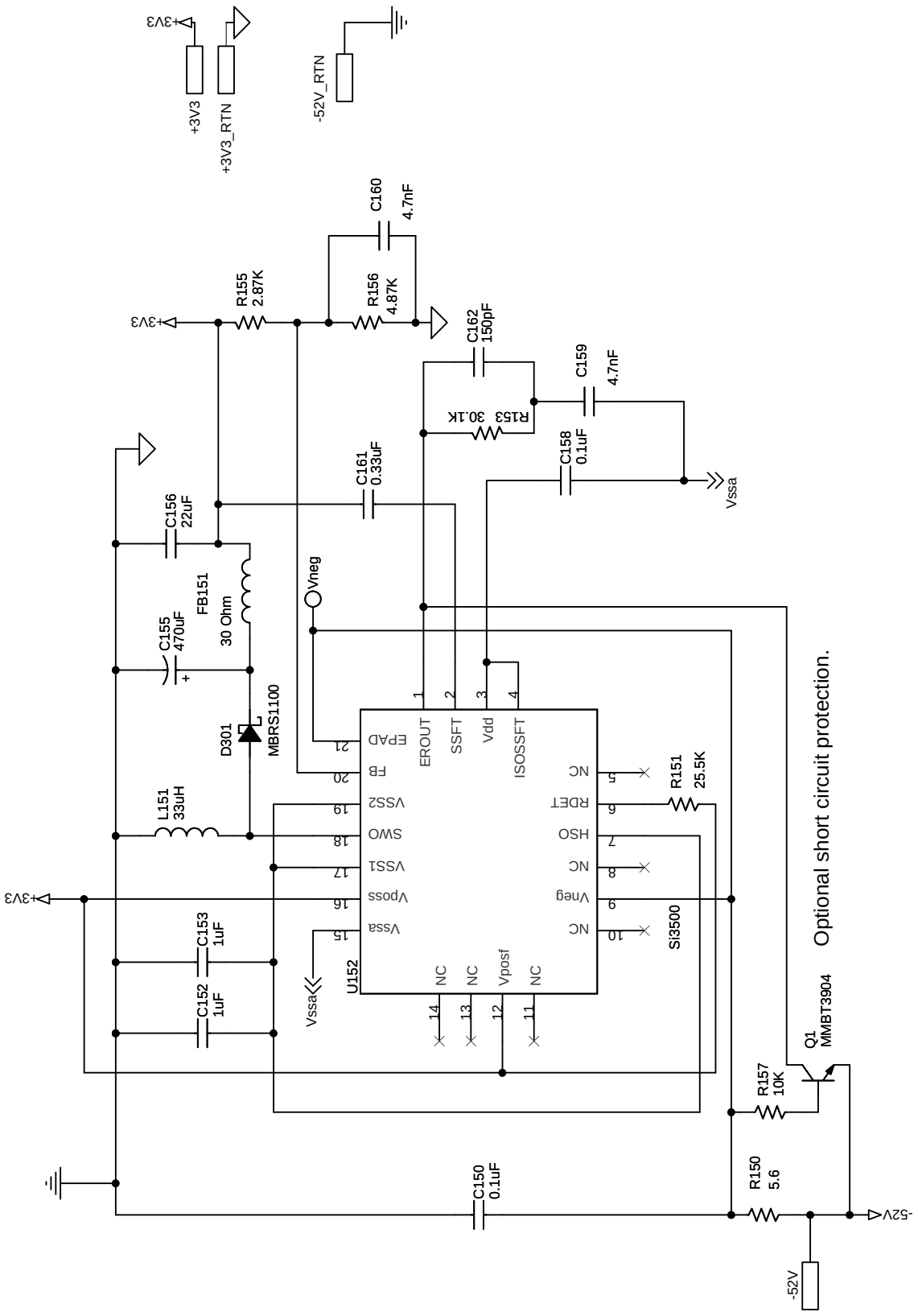


Figure 5. –52 V to +3.3 V Converter

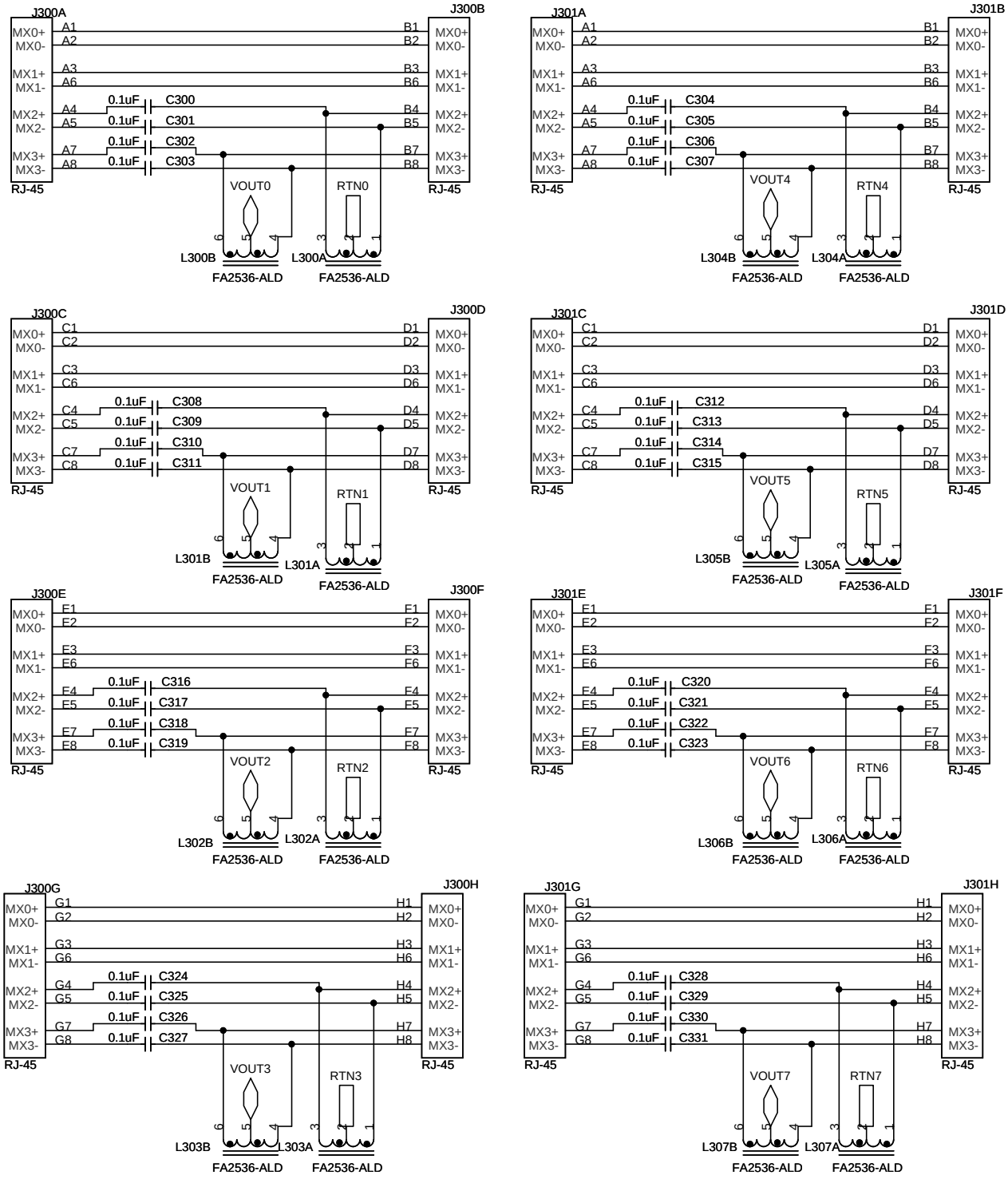


Figure 6. Midspan Coupling Circuit

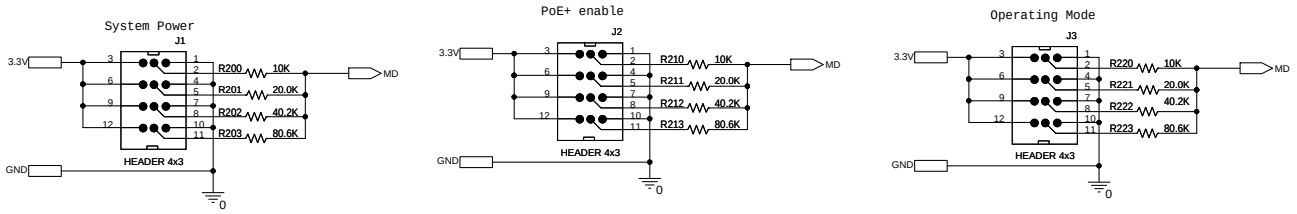


Figure 7. Mode Selection

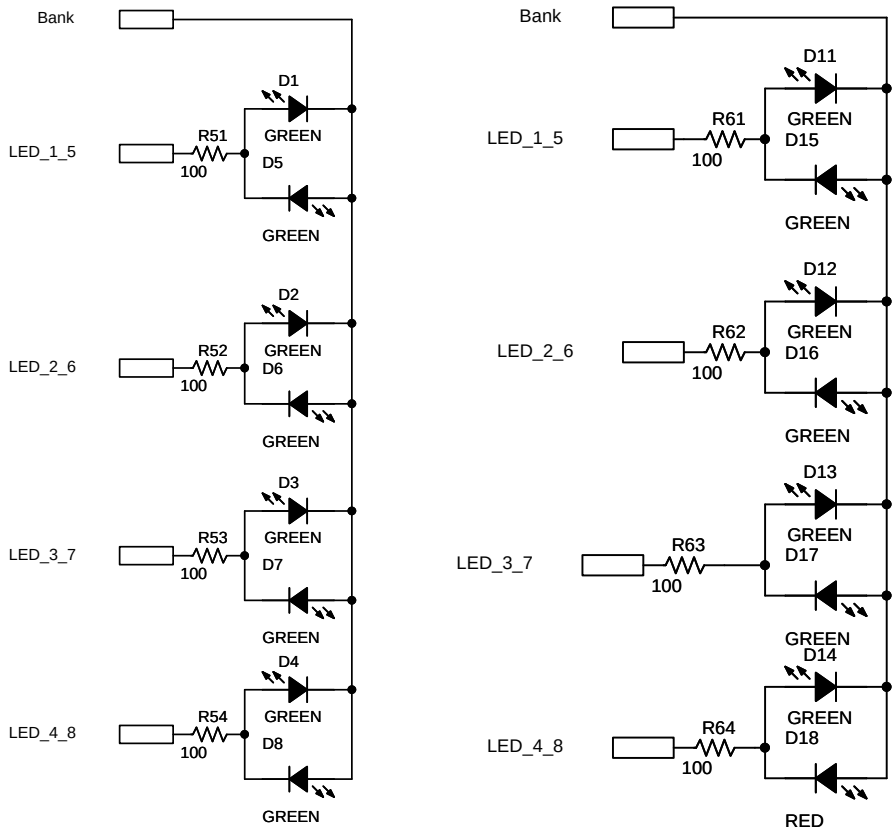


Figure 8. LEDs

4.2. Bill of Materials

Table 6. Si3480-EVB Bill of Materials

Item	NI	Qty	Ref	Value	Rating	Tol	PCB Footprint	Mfr Part Number	Mfr
50	NI	1	TP17	Red			TESTPOINT	151-207-RC	Kobiconn
51	NI	1	TP18	White			TESTPOINT	151-201-RC	Kobiconn
1		6	C1, C2, C3, C10, C11, C12	0.1 µF		±20%	C0603	C0603X7R160-104M	Venkel
2		14	C4, C5, C6, C7, C8, C9, C13, C14, C15, C16, C17, C18, C103, C150	0.1 µF		±20%	C0603	C0603X7R101-104M	Venkel
3		2	C100, C101	1 µF		±20%	C0805	C0805X7R160-105M	Venkel
4		2	C104, C105	33 µF		±20%	C3.5X8MM-RAD	ECA2AM330	Panasonic
5		1	C106	10 µF		±20%	C0603	C0603X5R6R3-106M	Venkel
6		2	C152, C153	1 µF		±10%	C1210	C1210X7R101-105K	Venkel
7		1	C155	470 µF	45 mohm ESR	±20%	C7343D	T495D477M006ATE045728 0	Kemet
8		1	C156	22 µF		±20%	C0805	C0805X5R6R3-226M	Venkel
9		1	C158	0.1 µF		±10%	C0603	C0603X7R250-104K	Venkel
10		2	C159, C160	4.7 nF		±10%	C0603	C0603X7R160-472K	Venkel
11		1	C161	0.33 µF		±10%	C0603	C0603X7R100-334K	Venkel
12		1	C162	150 pF		±10%	C0603	C0603X7R160-151K	Venkel
13		32	C300, C301, C302, C303, C304, C305, C306,C307, C308, C309, C310, C311, C312, C313, C314, C315, C316, C317, C318, C319, C320, C321, C322, C323, C324, C325, C326, C327, C328, C329, C330, C331	0.1 µF		±20%	C1210	C1210X7R251-104M	Venkel
14		16	D1, D2, D3, D4, D5, D6, D7, D8, D11, D12, D13, D14, D15, D16, D17, D101	GREEN	20 mA		LED-S-GW-AK	LN1371G	Panasonic
15		1	D18	RED	20 mA		LED-S-GW-KA	LN1271RAL	Panasonic

Table 6. Si3480-EVB Bill of Materials (Continued)

Item	NI	Qty	Ref	Value	Rating	Tol	PCB Footprint	Mfr Part Number	Mfr
16		1	D100	MBRS3100T3	3 A		DO-214AB	MBRS3100T3	On Semi
17		1	D301	MBRS1100	1 A		DO-214AA	MBRS1100T3	On Semi
18		1	FB151	30 Ω	1000 mA		L0603	BLM18PG300SN1	MuRata
19		1	JP1	HEADER 1x3			CONN-1X3	TSW-103-07-T-S	Samtec
20		3	J1, J2, J3	HEADER 4x3			CONN3X4	TSW-104-07-G-T	Samtec
21	NI	2	J4, J5	DF9-17S-1V	0.1 A		CONN-DF9-17S-1V	DF9-17S-1V	Hirose
22		1	J6	5X2 Shrouded Header			CONN2X5-4W	5103309-1	Tyco
23		1	J101	CONN TRBLK 2			CONN-TB-1757242	1757242	Phoenix Contact
24		2	J300, J301	RJ-45			RJ45-8PORT	44170-0001	MOLEX
25		1	L151	33 µH	0.4 A	±20%	IND-LPS4018	LPS4018-333ML	Coilcraft
26		8	L300, L301, L302, L303, L304, L305, L306, L307,	FA2536-ALD	675 µH		IND-FA2536	FA2536-ALD	Coilcraft
27		2	Q1, Q5	MMBT3904	200 mA		SOT23-BEC	MMBT3904	Fairchild
28		1	Q4	MMBT3906-7-F	200 mA		SOT23-BEC	MMBT3906-7-F	Diodes Inc.
29		9	R1, R2, R3, R4, R5, R6, R7, R8, R157	10 kΩ	1/10 W	±5%	R0603	CR0603-10W-103J	Venkel
30		3	R9, R10, R104	44.2 kΩ	1/10 W	±1%	R0603	CR0603-10W-4422F	Venkel
31		8	R51, R52, R53, R54, R61, R62, R63, R64	100 Ω	1/10 W	±1%	R0603	CR0603-10W-1000F	Venkel
32		1	R100	10 kΩ	1/10 W	±1%	R0603	CR0603-10W-1002F	Venkel
33		2	R101, R102	1 kΩ	1/10 W	±1%	R0603	CR0603-10W-1001F	Venkel
34		1	R105	330 Ω	1/10 W	±1%	R0805	CR0805-10W-3300F	Venkel
35		2	R106, R107	267 Ω	1/10 W	±1%	R0603	CR0603-10W-2670F	Venkel
36		1	R108	2.1 kΩ	1/16 W	±1%	R0603	CR0603-16W-2101F	Venkel
37		2	R110, R111	1 kΩ	1/10 W	±5%	R0603	CR0603-10W-1001J	Venkel
38		1	R150	5.6 Ω	1/4 W	±5%	R1210	CR1210-4W-5R6J	Venkel
39		1	R151	25.5 kΩ	1/16 W	±1%	R0603	CR0603-16W-2552F	Venkel
40		1	R153	30.1 kΩ	1/16 W	±1%	R0603	CR0603-16W-3012F	Venkel
41		1	R155	2.87 kΩ	1/16 W	±1%	R0603	CR0603-16W-2871F	Venkel
42		1	R156	4.87 kΩ	1/16 W	±1%	R0603	CR0603-16W-4871F	Venkel

Table 6. Si3480-EVB Bill of Materials (Continued)

Item	NI	Qty	Ref	Value	Rating	Tol	PCB Footprint	Mfr Part Number	Mfr
43		3	R200, R210, R220	10 kΩ	1/16 W	±1%	R0603	CR0603-16W-1002F	Venkel
44		3	R201, R211, R221	20.0 kΩ	1/16 W	±1%	R0603	CR0603-16W-2002F	Venkel
45		3	R202, R212, R222	40.2 kΩ	1/10 W	±1%	R0603	CR0603-10W-4022F	Venkel
46		3	R203, R213, R223	80.6 kΩ	1/16 W	±1%	R0603	CR0603-16W-8062F	Venkel
47		1	SW1	SW Pushbutton	50 mA		SW-PB-MOM	101-0161-EV	Mountain Switch
48		2	TPV2, TPV4	TPV			VIA-TP	N/A	N/A
49		3	TPV50x, TPV50x1, TPV50x5	EPAD			VIA-EPAD	N/A	N/A
52		3	TP102, TP103, TP104	Black			TESTPOINT	151-203-RC	Kobiconn
53		2	U1, U2	Si3452			QFN40N6X6P0.5	Si3452-A00-GM	SiLabs
54		1	U100	TLV431			TLV431-DBZ	TLV431BCDBZR	TI
55		1	U101	Si3480			QFN20N4X4P0.5	Si3480	Silicon Labs
56		1	U152	Si3500			QFN20N5X5P0.8	Si3500	Silicon Labs

4.3. Layout

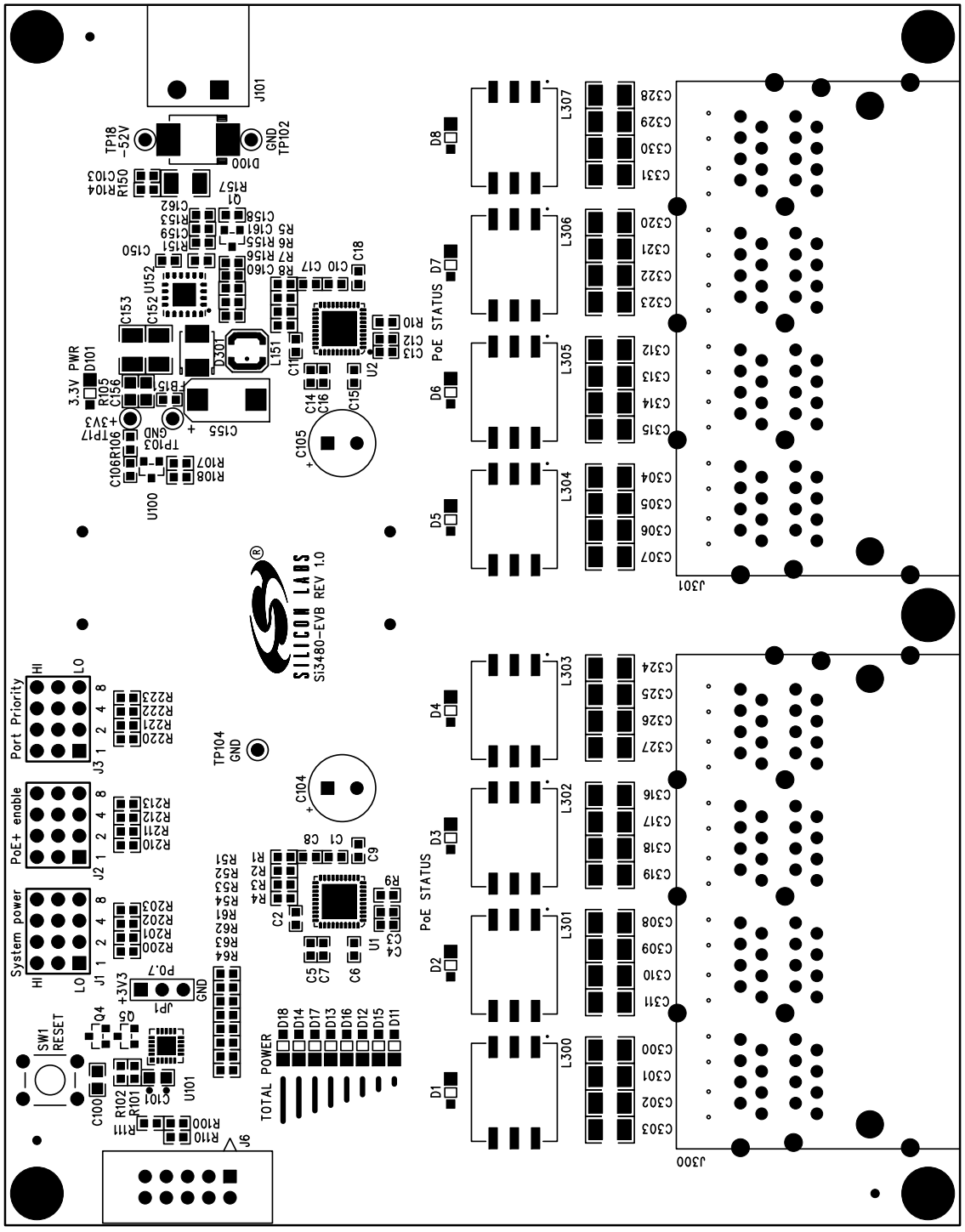


Figure 9. Component and Silk Screen

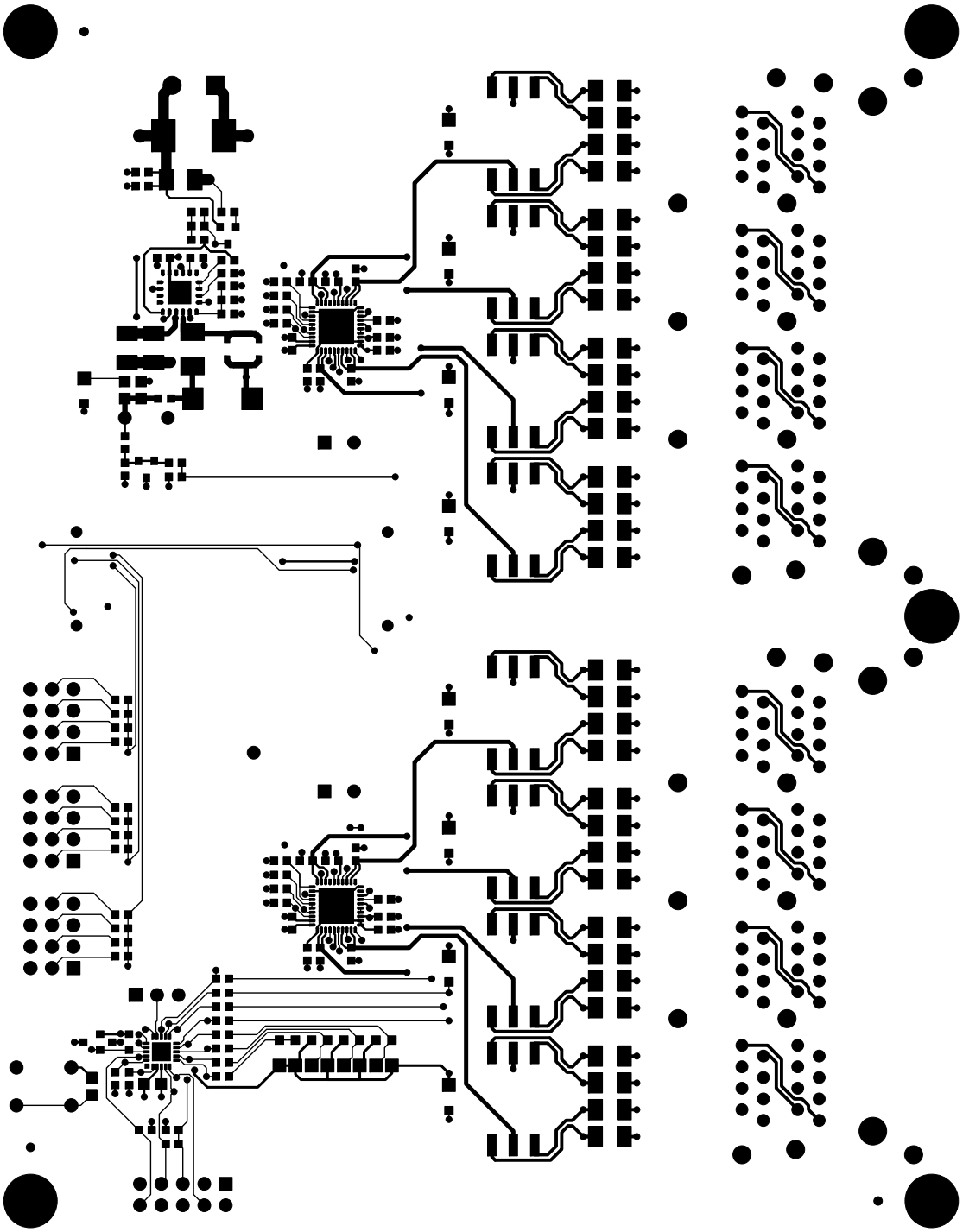


Figure 10. Top Layer

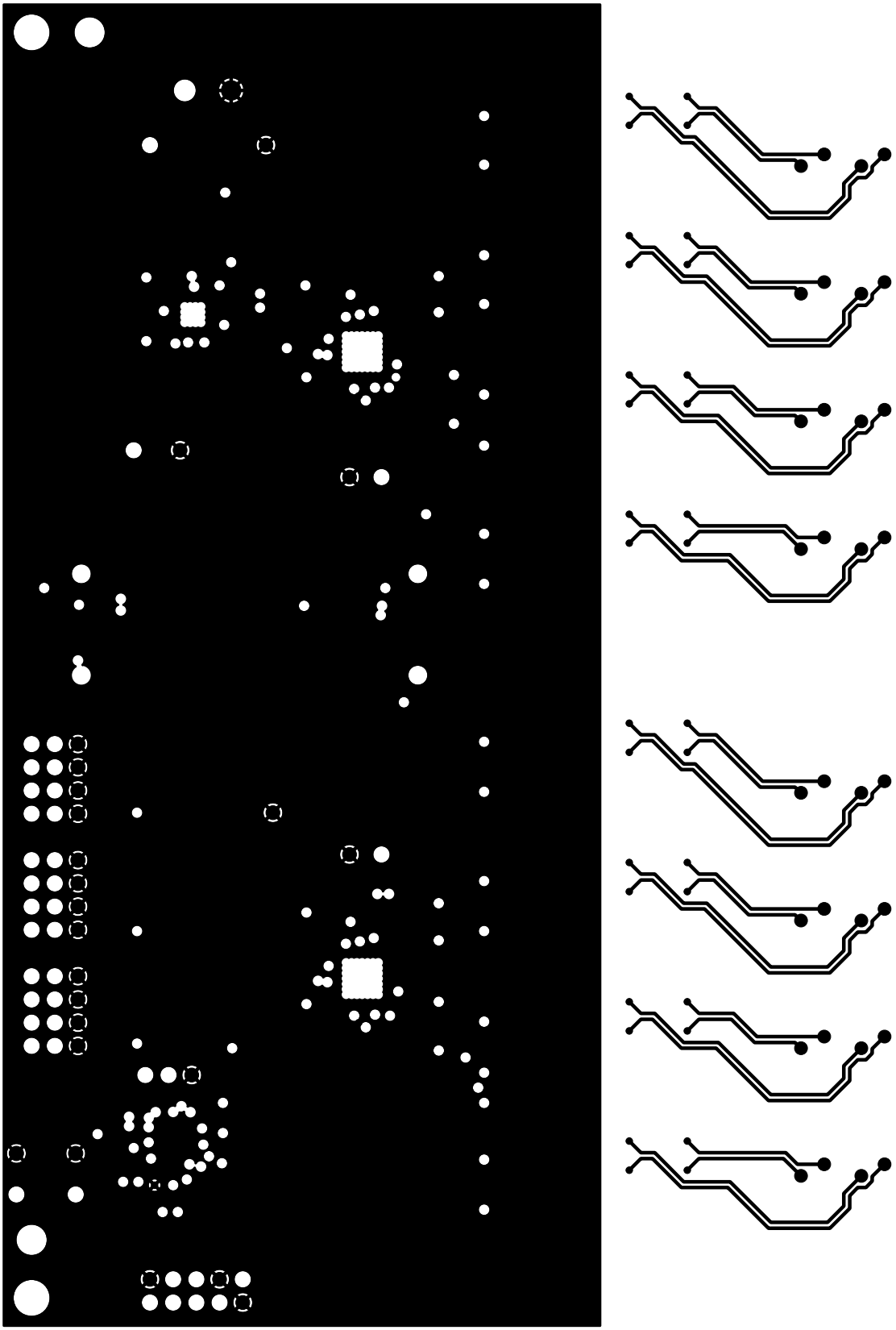


Figure 11. Second Layer

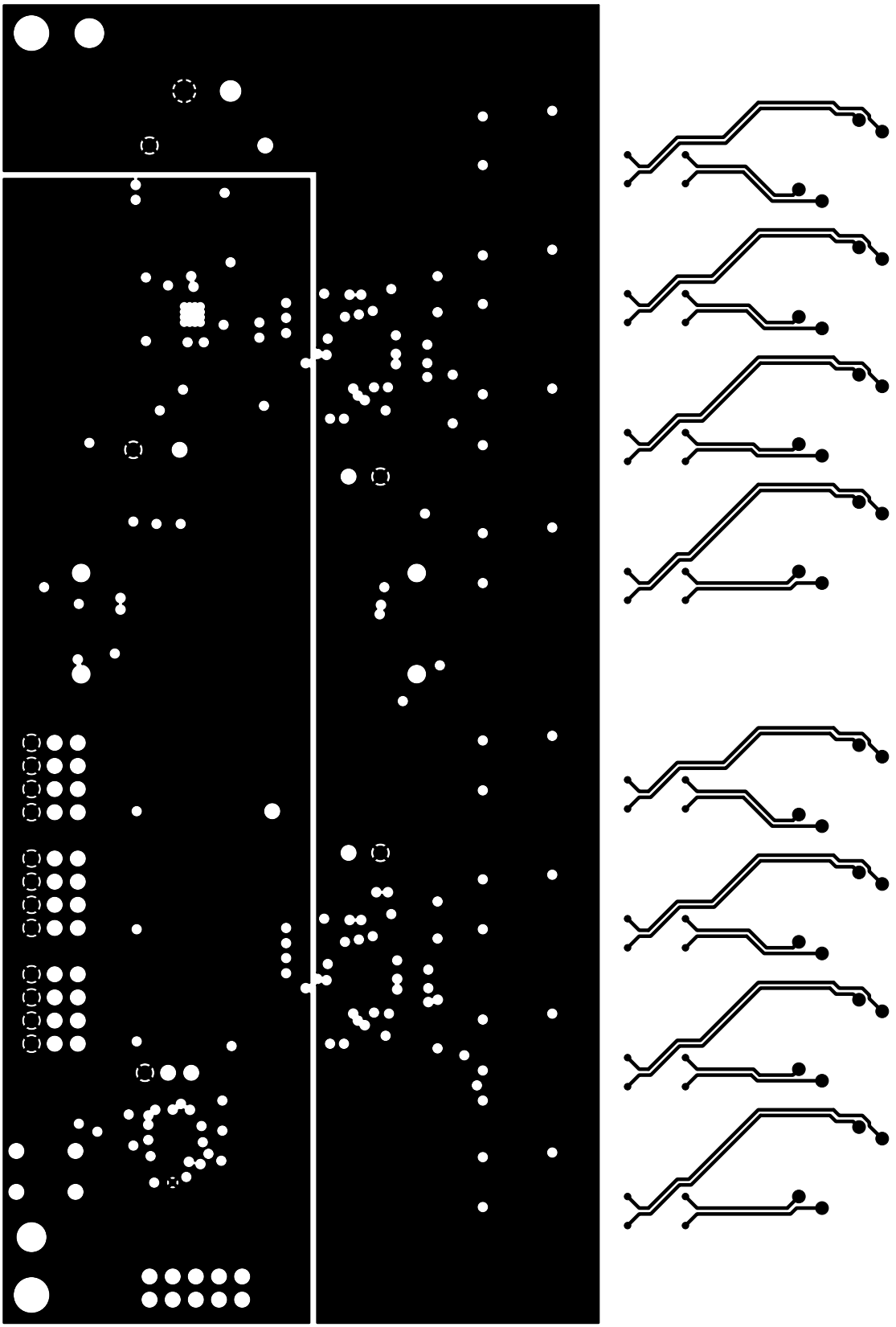


Figure 12. Third Layer

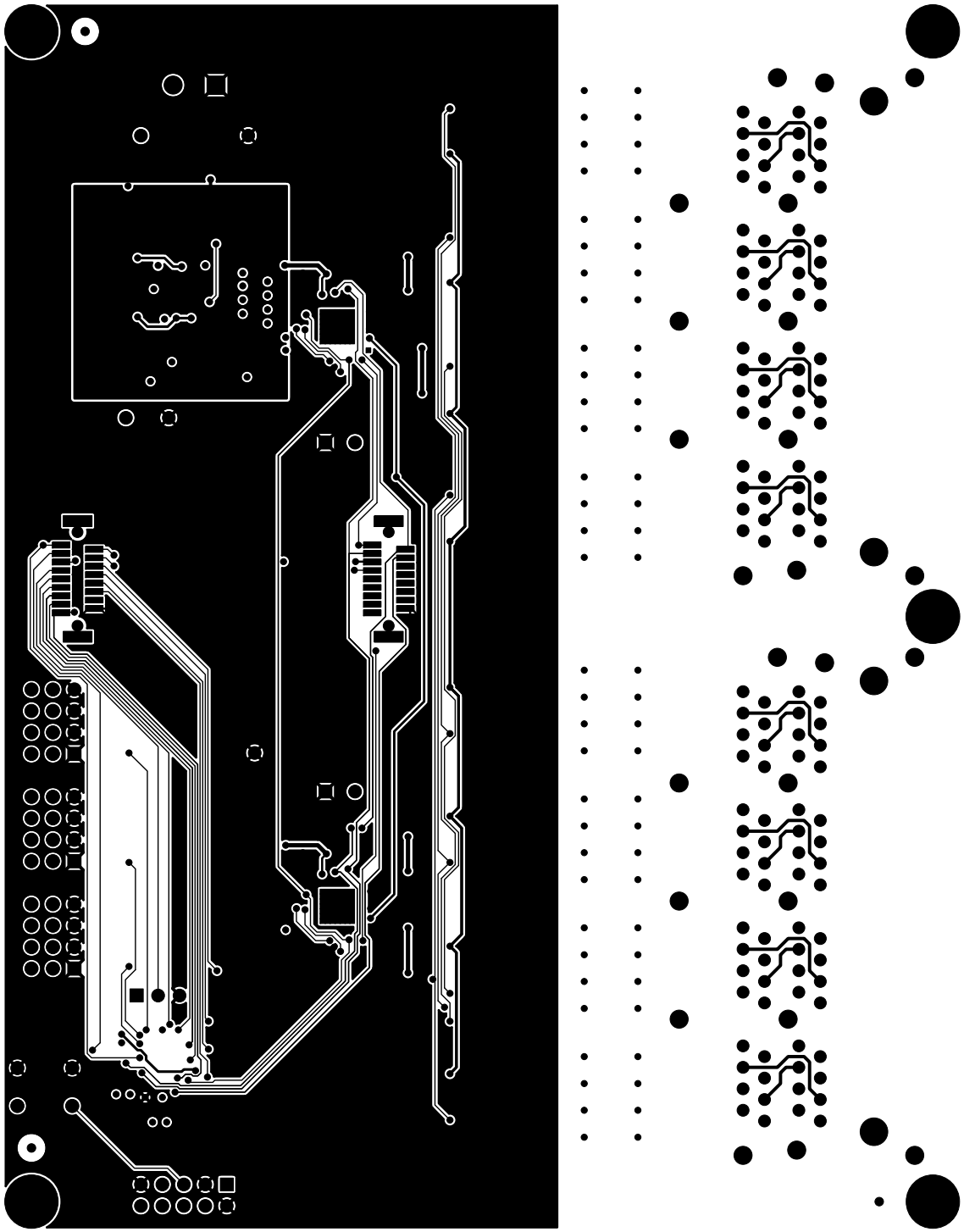


Figure 13. Bottom Layer

DOCUMENT CHANGE LIST

Revision 0.1 to Revision 0.2

- Changed document name from Si3480MS8-EVB to Si3480MS8-KIT to reflect the evaluation kit name change.

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