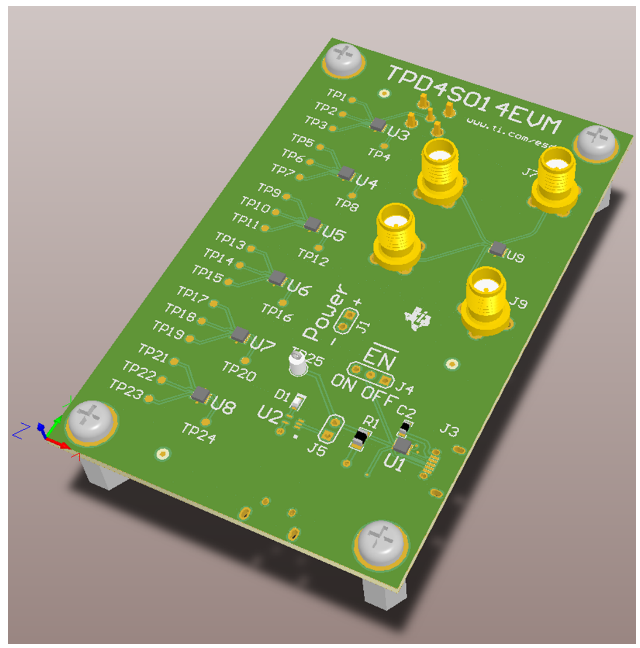
TPD4S014 EVM

Introduction

The TPD4S014 is a single-chip solution for USB charger port protection. This device offers low capacitance TVS type ESD clamps for the D+, D– and standard Capacitance for the ID pin. On the VBUS pin, this device can handle over-voltage protection up to 28 V. The over voltage lock-out feature ensures that, if there is a fault condition at the VBUS line, the TPD4S014 is able to isolate the VBUS line and protect the internal circuitry from damage.

Similarly, the under voltage lock out feature ensures that there is no power drain from the internal VCC plane to external VBUS side in case there is short to GND. There is a 16 ms turn-on delay after VBUS crosses the under voltage lockout threshold, in order to let the voltage stabilize before closing the switch. This function acts as a deglitch filter and prevents unnecessary switching if there is any ringing on the line during connection.



Highlighted Features

- Over-voltage protection functionality
- Under voltage lockout functionality
- USB connectors used for ease of use
- LED indicating fault condition
- Test point for EN and ACK signals
- D+, D– lines are routed as differential pair

1 EVM Description and Configuration

The TPD4S014EVM consists of four separate sections. One section is a USB2.0 pass through protected port, one section allows 4-port analysis, one section allows ESD testing of 6 devices, and another allows capturing a clamping waveform during an ESD event. All sections are powered up by a 1.8 V – 3.3 V supply. This supply is used for three purposes:

1. To provide the HI and LO logic levels for the EN signal
2. To provide a pullup voltage for the open drain ACK signal
3. To power the fault indicator LED

2 Definitions

Contact Discharge — a method of testing in which the electrode of the ESD simulator is held in contact with the device-under-test (DUT).

Air Discharge — a method of testing in which the charged electrode of the ESD simulator approaches the DUT, and a spark to the DUT actuates the discharge.

ESD Simulator — a device that outputs IEC61000-4-2 compliance ESD waveforms shown in Figure 1 with adjustable ranges shown in Table 1 and Table 2.

IEC61000-4-2 has 4 classes of protection levels. Classes 1 – 4 are shown in Table 1. Stress tests should be incrementally tested to level 4 as shown in Table 2 until the point of failure. If the DUT does not fail at 8 kV, testing can continue in 2 kV increments until failure.

Table 1. IEC61000-4-2 Test Levels

Contact Discharge		Air Discharge	
Class	**Test Voltage [± kV]**	**Class**	**Test Voltage [± kV]**
1	2	1	2
2	4	2	4
3	6	3	8
4	8	4	15

Table 2. Waveform Parameters in Contact Discharge Mode

Stress Level Step	Simulator Voltage [kV]	Ipeak ±15% [A]	Rise Time ±25% [nS]	Current at 30ns ±30% [A]	Current at 60ns ±30% [A]
1	2	7.5	0.8	4	2
2	4	15	0.8	8	4
3	6	22.5	0.8	12	6
4	8	30	0.8	16	8

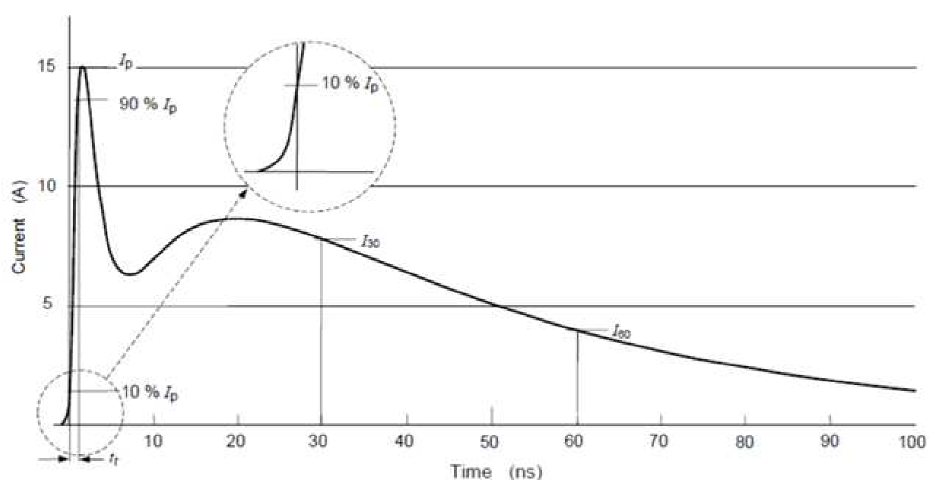


Figure 1. Ideal Contact Discharge Waveform of the Output Current of the ESD Simulator at 4 kV

3 Setup

3.1 U1

TPD4S014DSQ (U1) section has a switch to toggle the polarity of the EN signal. There are labels indicating the ON and OFF positions of the switch. There are also test points that can be used to determine the logic level ACK signal. This section also has an LED which indicates a fault condition. Please note that the LED lights up when the ACK signal is at logic HI. This section is intended to illustrate the functionality of the device without any additional test equipment. Two USB2.0 Type AB female connectors (J2 & J3) can be used for capturing Eye Diagrams. Using either J2 as input and J3 as output, attach to a USB2.0 compliant Eye Diagram tester setup for the intended application. For all test procedures apply 1.8V – 3.3V to "+" of J1 and GND to "–" of J1.

Setup Procedure

1. The fault indication LED should light up when board power is applied.
2. Connect a USB cable to the Input connector (J3). Connect a variable power supply to the VBUS line on the other end of the cable. Set the Voltage on the power supply to < 2V.
3. Connect another USB cable to the output connector (J2) of the board. Connect a variable load to the VBUS line on the other end of the cable. Set the load to > 25 Ω
4. Slowly increase the Voltage on the input. The LED should turn OFF when the Voltage crosses 3V.
5. Continue to increase the voltage past 6V. When the voltage crosses 6V the LED should turn ON again indicating a fault (condition).

3.2 U3 – U8

Six TPD4S014DSQ's (U3 – U8) can be used for destructive electrostatic discharge (ESD) pass/fail ESD strikes. Specifically, they can be used for both IEC-61000-4-2 air and contact discharge tests. The following procedure ensures proper testing setup and method for both discharge tests. Each IO has a Test Pad (TP1 – TP24) directly connected to it.

3.2.1 Test Method and Set-Up

An example test setup is shown in Figure 2. Details of the testing table and ground planes can be found in the IEC 61000-4-2 test procedure. Ground the EVM using the banana connector labeled GND (J9). Discharge the ESD simulator on any of the Test Points TP1 – TP10. Contact and air-gap discharge are tested using the same simulator with the same discharge waveform. While the simulator is in direct contact with the test point during contact, it is not during air-gap.

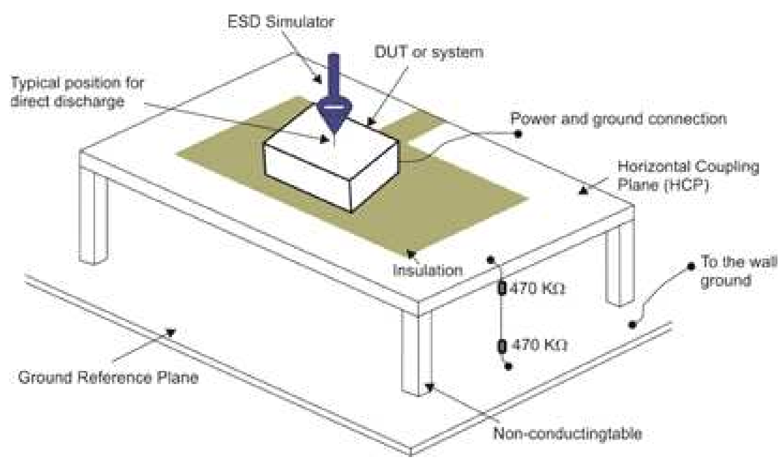


Figure 2. System Level ESD Test Setup

Evaluation of Test Results

Connect the tested device on the EVM to a curve tracer both before and after ESD testing. After each incremental level, if the IV curve of the ESD protection diode shifts ±0.1V, or leakage current increases by a factor of ten, then the device is permanently damaged by ESD.

3.3 U3

U3 has a test point (J10) for capturing clamping waveforms during an ESD event. The following section describes capturing an ESD clamping waveforms.

Oscilloscope Setup

Without a proper procedure, capturing ESD clamping waveforms exposes the oscilloscope to potential voltages higher than the rating of the equipment. Proper methodology can mitigate any risk in this operation.

Recommended Equipment

- Minimum of 1 GHz bandwidth oscilloscope (recommended 2 GHz)
- Either of the following:
  - One 10X 50Ω attenuator and 0 Ω 0603 resistor (to be installed at R2).
  - Two 10X 50Ω attenuators and 150 Ω 0603 resistor (already installed at R2).
- 50 Ω shielded SMB cable.

Procedure

In order to protect the oscilloscope, attenuation of the measured signal is required. Here are two possible procedures for testing U3:

1. Using two 10X attenuators:
   - Install a 0 Ω resistor in R2.
   - Attach two 10X attenuators to the oscilloscope channel being used.
   - Attach the 50 Ω shielded SMB cable between J10 and the attenuator.
   - Set the scope attenuation factor to 100X.
   - Set the oscilloscope to trigger on a positive edge for (+) ESD or a negative edge for (–) ESD strikes. Set the trigger point to 20V.
   - Following *Section 3.2.1*, strike contact ESD to TP1.
2. Using one 10X attenuator:
   - Attach one 10X attenuator to the oscilloscope.
   - Attach the 50 Ω shielded SMB cable between J10 and the attenuator.
   - Set the scope attenuation factor to 40X.
   - Set the oscilloscope to trigger on a positive edge for (+) ESD or a negative edge for (–) ESD strikes. Set the trigger point to 20V.
   - Following *Section 3.2.1*, strike contact ESD to TP1.

Recommended settings for the time axis is 20 ns/div and for the voltage axis is 10 V division. The voltage level of the ESD applied to TP1 should not exceed ± 8 kV while capturing clamping waveforms.

3.4 U9

TPD4S014 (U9) is configured with 4 SMA (J6 – J9) connectors to allow 4-port analysis with a vector network analyzer. Connect Port 1 to J6, Port 2 to J7, Port 3 to J8, and Port 4 to J9. This configuration allows for the following terminology in 4 port analysis:

- S_{11}: Return loss
- S_{21}: Insertion loss
- S_{31}: Near end cross talk
- S_{41}: Far end cross talk

4 Bill of Materials (BOM)

Quantity	Designator	Value	Description	Package Reference	Part Number	Manufacturer
1	C1	10 uF	CAP, CERM, 10uF, 6.3V, ±20%, X5R, 0603	603	C0603C106M 9PACTU	Kemet
1	C2	10 uF	CAP, CERM, 10uF, 35V, -20%/+80%, Y5V 1206	1206	GMK316F106 ZL-T	Taiyo Yuden
1	D1	Green	LED, Green, SMD	1.6x0.8x0.8m m	LTST-C190GKT	Lite-On
4	H1, H2, H3, H4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
4	H5, H6, H7, H8		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
2	J1, J5		Header, Male 2-pin, 100mil spacing,	0.100 inch x 2	PEC02SAAN	Sullins
2	J2, J3		Connector, USB Micro, Type AB	5.3x7.5 mm	SD-47590-001	Molex
1	J4		Header, Male 3-pin, 100mil spacing,	0.100 inch x 3	PEC03SAAN	Sullins
4	J6, J7, J8, J9		Connector, TH, SMA	SMA	142-0701-201	Emerson Network power
1	J10		Connector, SMB,Vertical RCP 0-4GHz, 50 ohm, TH	236x293x236 mil	131-3701-261	Emerson Network power
1	R1	10 k	RES, 10k ohm, 5%, 0.125W, 0805	805	CRCW080510 K0JNEA	Vishay-Dale
1	R2	453 k	RES, 453k ohm, 1%, 0.1W, 0603	603	CRCW060345 3KFKEA	Vishay-Dale
1	TP25		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
8	U1, U3, U4, U5, U6, U7, U8, U9		Complete USB Port Protection Device, 4 Channels, -40 to +85 degC, 10-pin SON (DSQ), Green (RoHS & no Sb/Br)	DSQ0010A	TPD4S014DS QR	Texas Instruments
1	U2		IC, Single Bus Buffer Gate With 3-States Outputs, OE Active Low	DCK	SN74LVC1G1 25DCK	TI

5 Schematics

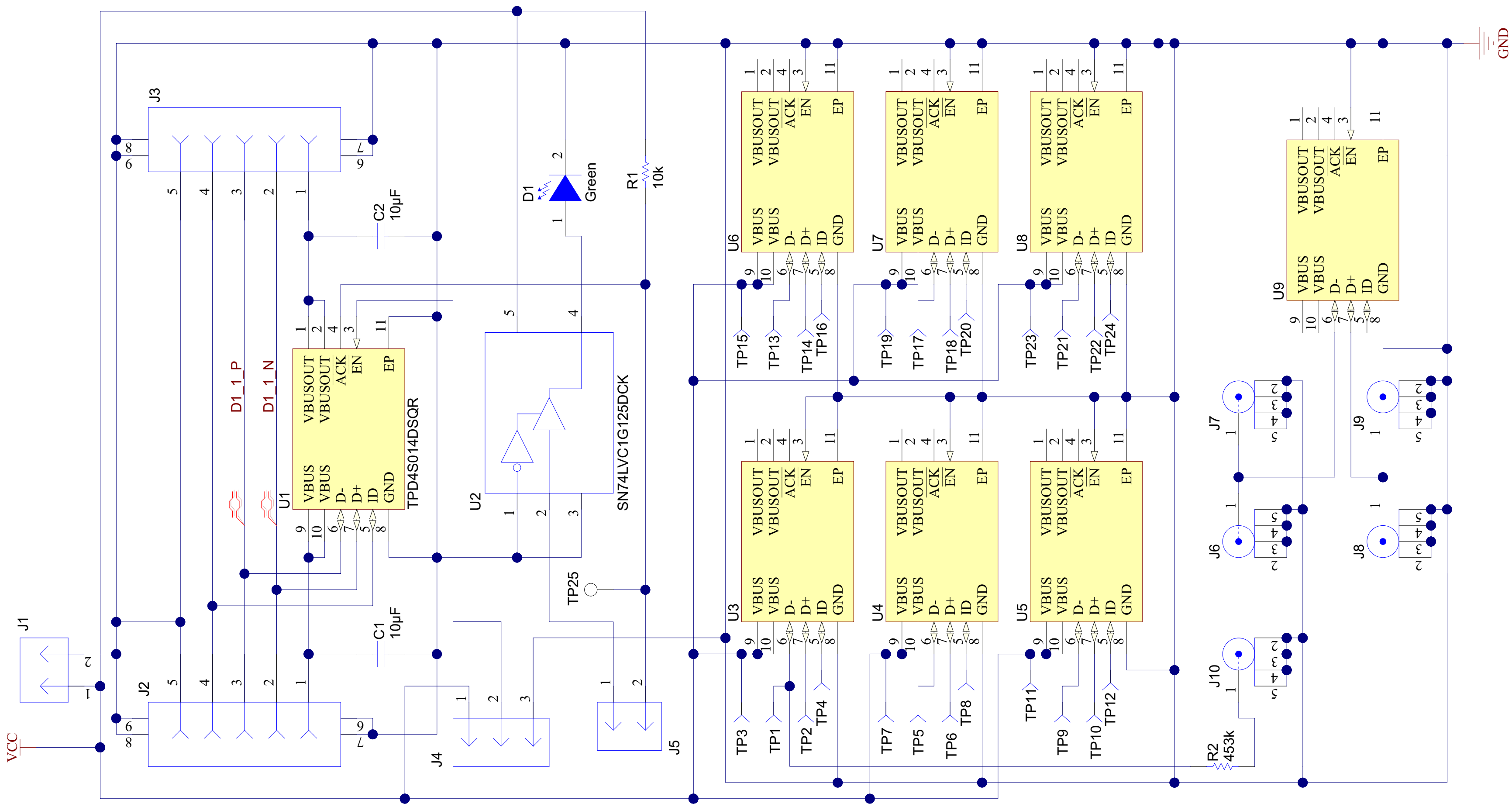


Figure 3. Schematics for TPD4S014EVM

6 Layout

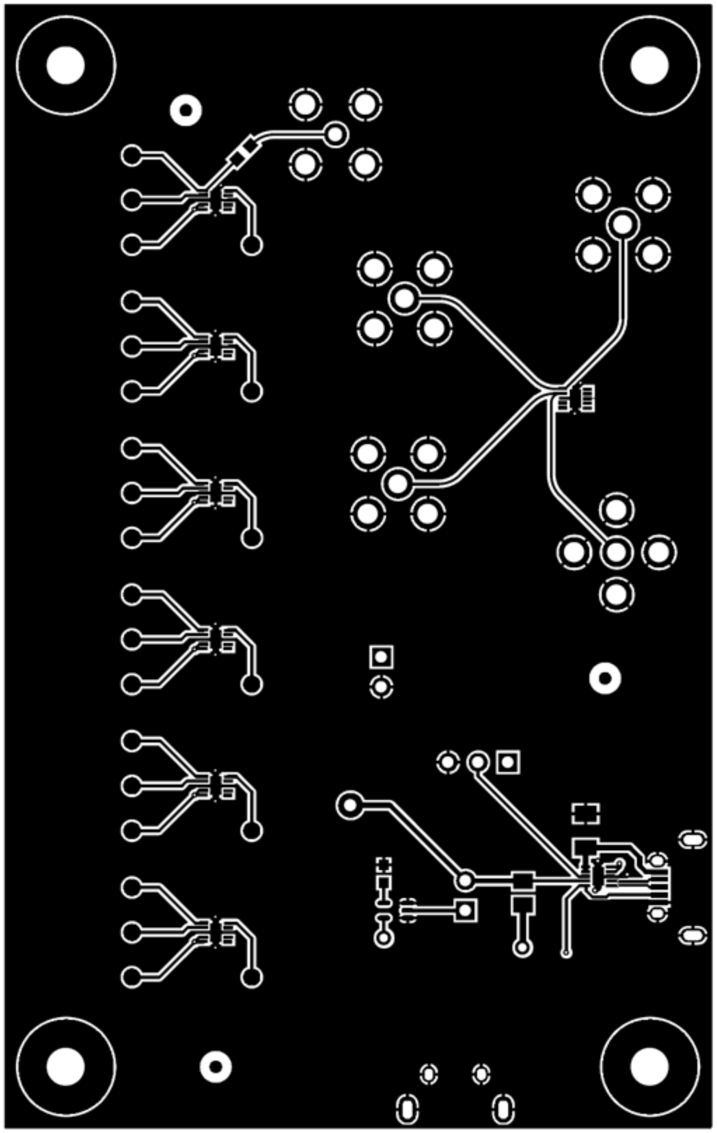


Figure 4. Top Layer

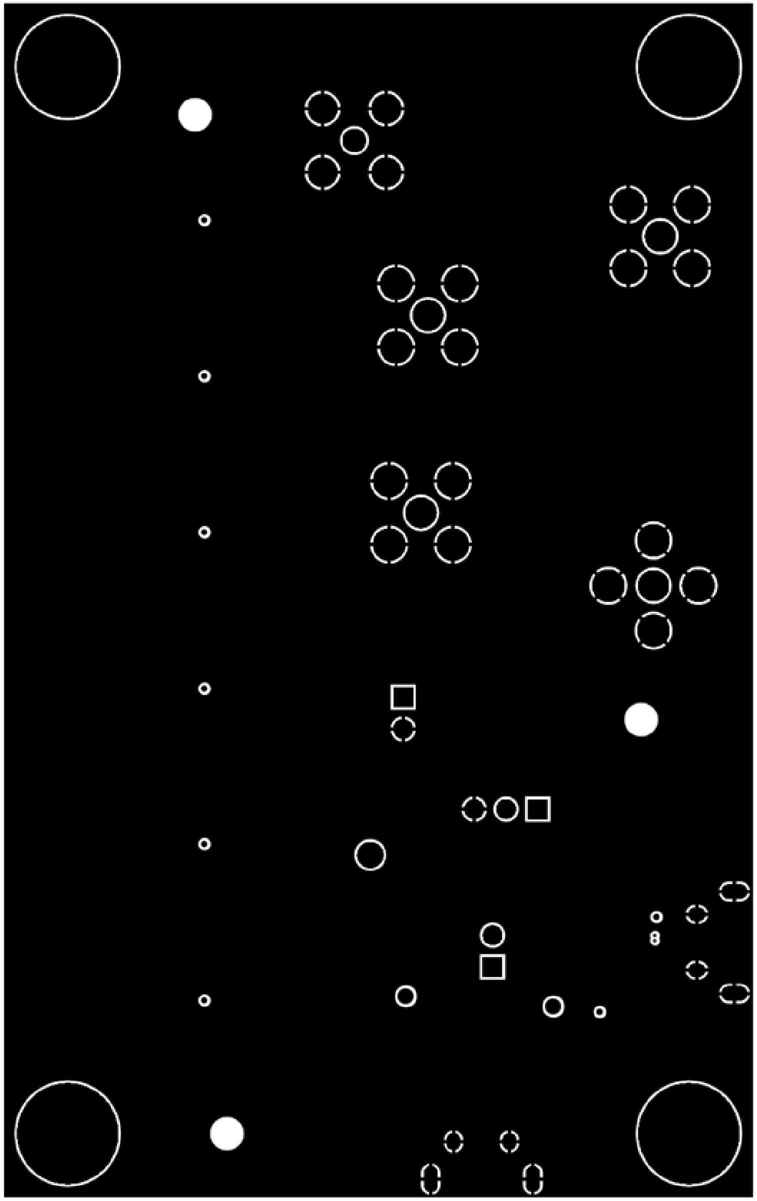


Figure 5. Layer 2

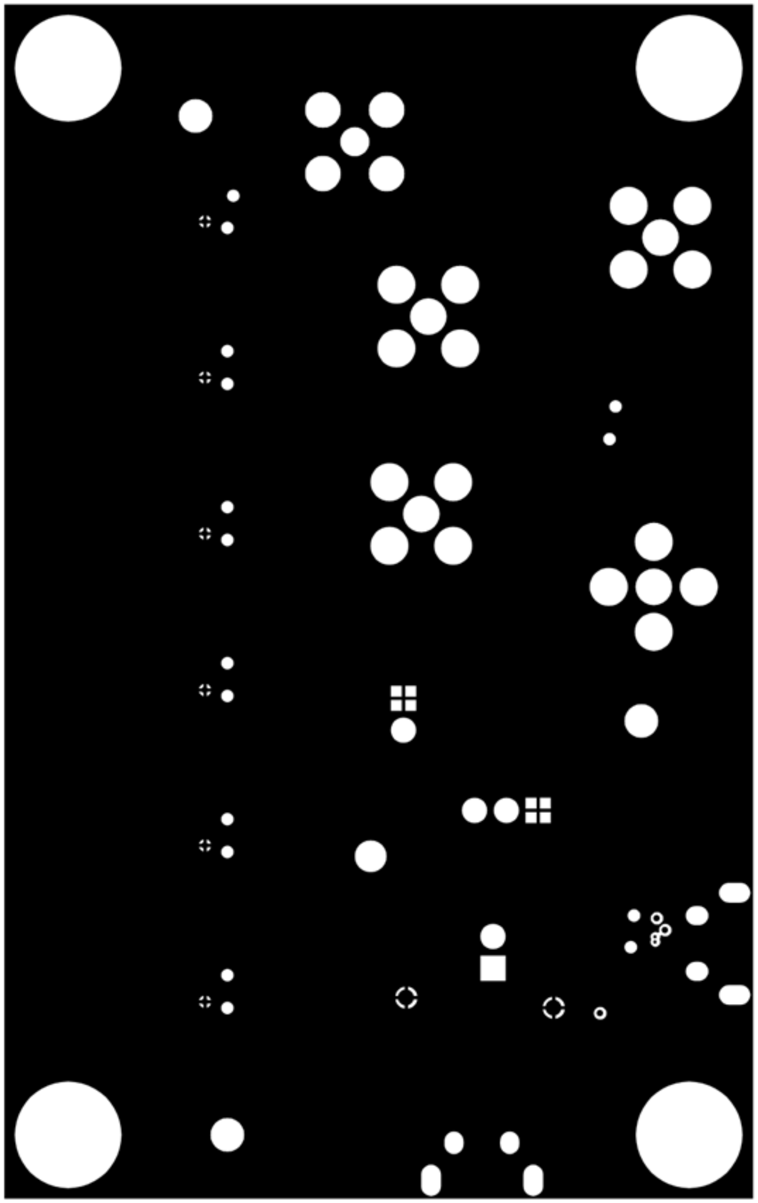


Figure 6. Layer 3

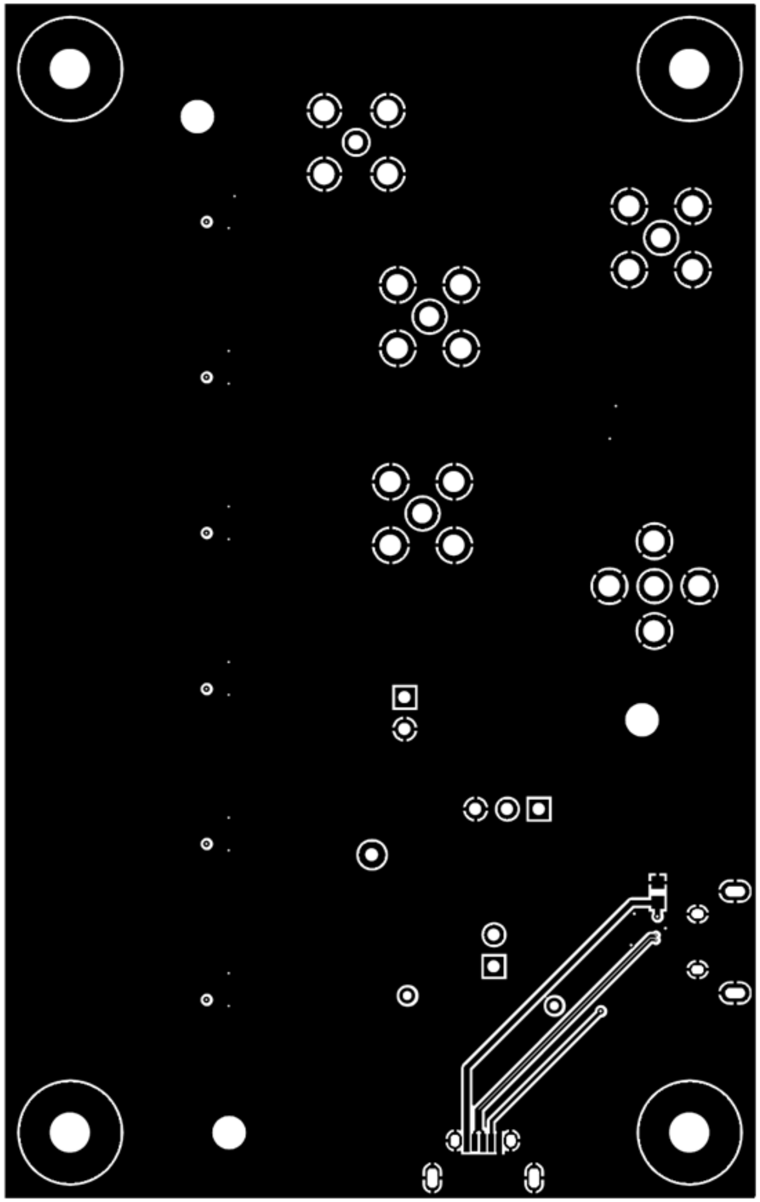


Figure 7. Bottom Layer

Revision History

Changes from Original (June 2011) to A Revision	Page
• Updated entire EVM with new content	1

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