TPD3S014-Q1 Evaluation Module

This user's guide describes the characteristics, operation, and use of the TPD3S014-Q1 EVM evaluation module (EVM). This EVM includes five TPD3S014-Q1s in various configurations for testing. One TPD3S014-Q1 is configured for IEC61000-4-2 compliance testing, one is configured for 4-port s-parameter analysis, one is pinned out for evaluating the current limiting switch, one is configured for throughput on USB 2.0 Type A connectors for throughput analysis, and one is configured for the capture of clamping waveforms during an ESD event. This user's guide includes setup instructions, schematic diagrams, a bill of materials, and printed-circuit board layout drawings for the evaluation module.

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1 Introduction

Texas Instrument's TPD3S014-Q1 evaluation module helps designers evaluate the operation and performance of the TPD3S014-Q1 device. The TPD3S014-Q1 is a current limiting switch intended for applications such as USB where heavy capacitive loads and short-circuits are likely to be encountered; TPD3S014-Q1 provides short-circuit and over-current protection. This device has a fixed current-limit threshold of 0.5 A. ESD protection for D+ and D– is also provided.

The EVM contains five TPD3S014-Q1s. TPD3S014-Q1 (U1) is configured with two USB2.0 Type A connectors (USB1 and USB2) for capturing Eye Diagrams and evaluating current limiting with a system. TPD3S014-Q1 (U2) is configured with 4 SMA (J1 – J4) connectors to allow 4-port analysis with a vector network analyzer. TPD3S014-Q1 (U4) is configured with test points for striking ESD to the protection pins. TPD3S014-Q1 (U3) is configured for capturing clamping waveforms with an oscilloscope during an ESD test. Caution must be taken when capturing clamping waveforms during an ESD event so as not to damage the oscilloscope. A proper procedure is outlined in *Section 3.4.1*.

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

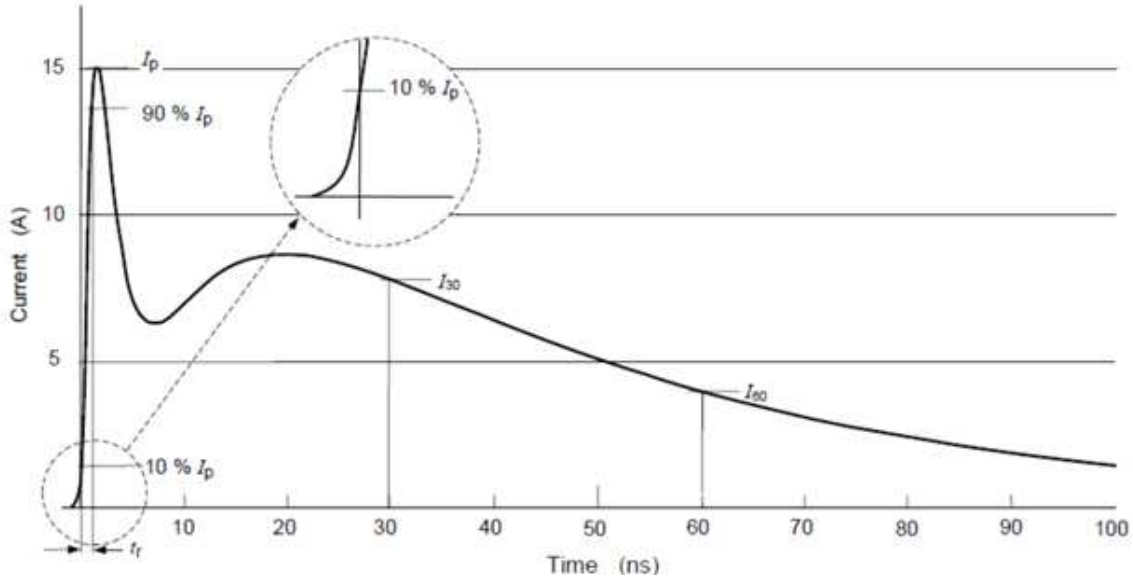

Figure 1. Ideal Contact Discharge Waveform of the Output Current of the ESD Simulator at 4 kV

3 Setup

This section describes the intended use of the EVM. A generalized outline of the procedure given in IEC-61000-4-2 is described here. IEC-61000-4-2 should be referred to for a more specific testing outline. Basic configurations for collecting S-parameters, Eye Diagrams, and ESD clamping waveforms are outlined as well. Attach 5 V to the +5-V test point and ground to GND. Tests can be performed will device enable pins set HI or LO. For TPD3S014-Q1 the device is active-low, so set EN to LO to enable the devices on the board.

3.1 U1

A single TPD3S014-Q1 (U1) is configured with two USB2.0 Type A connectors (USB1 & USB2) for capturing Eye Diagrams. Using USB2 as input and USB1 as output, attach to a USB 2.0 compliant Eye Diagram tester setup for the intended application, either transmitter or receiver.

3.2 U2

A TPD3S014-Q1 (U2) is configured with 4 SMA (J1 – J4) connectors to allow 4-port analysis with a vector network analyzer. Connect Port 1 to J1, Port 2 to J2, Port 3 to J3, and Port 4 to J4. 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

3.3 U4

A TPD3S014-Q1 (U3) has an SMB connector (J7) for capturing clamping waveforms with an oscilloscope during an ESD strike. Caution must be taken when capturing clamping waveforms during an ESD event so as not to damage the oscilloscope.

3.3.1 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.

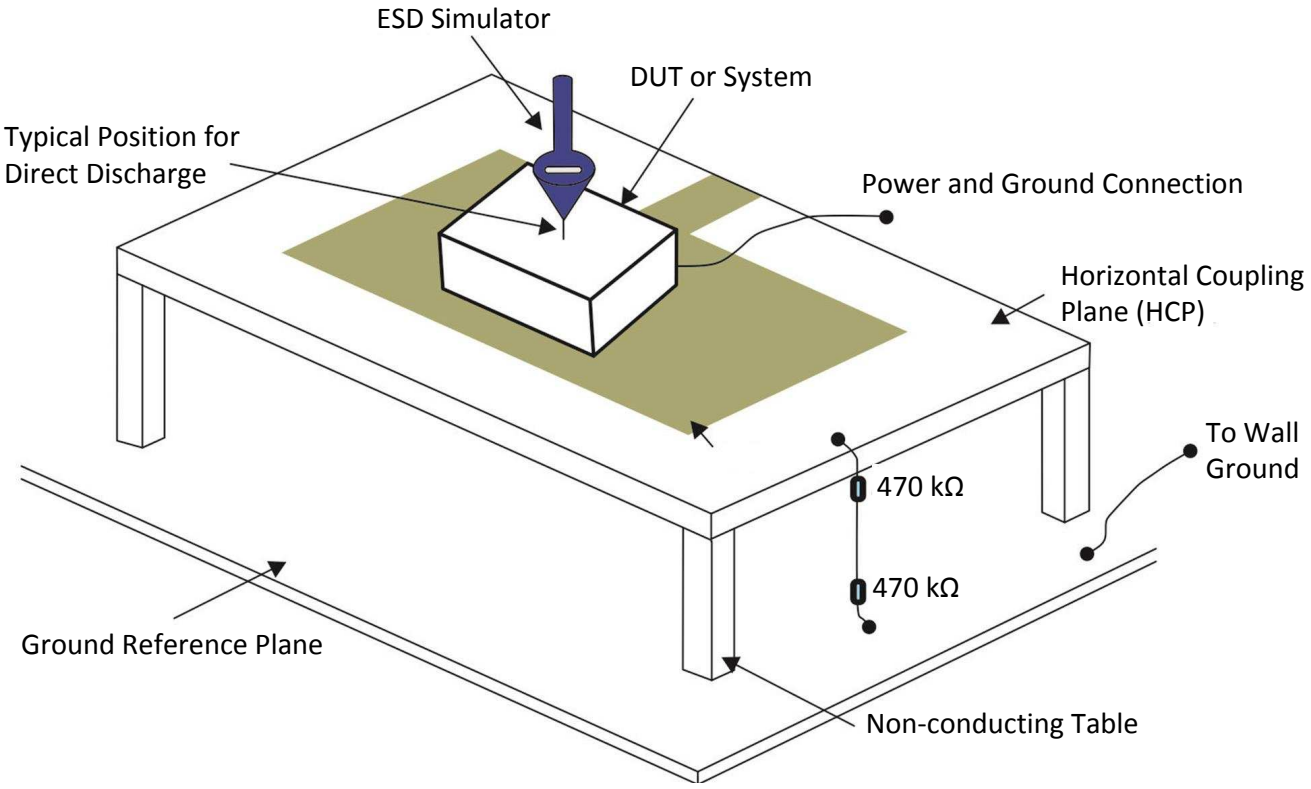

Figure 2. System Level ESD Test Setup

3.3.2 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 ±0.1 V, or leakage current increases by a factor of ten, then the device is permanently damaged by ESD.

3.4 U3

A TPD3S014-Q1 (U3) has an SMB connector (J7) for capturing clamping waveforms with an oscilloscope during an ESD strike. Caution must be taken when capturing clamping waveforms during an ESD event so as not to damage the oscilloscope.

3.4.1 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.
- Either of the following:
  - 2 10X 50 Ω attenuators and a 0 Ω resistor (to be installed at R1).
  - 1 10X 50 Ω attenuator and a 150 Ω resistor (already installed at R1).
- 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 R1
   - Attach two 10X attenuators to the oscilloscope channel being used.
   - Attach the 50 Ω shielded SMB cable between J7 and the attenuator.
   - Set the scope attenuation factor to 100X.
   - Set the oscilloscope to trigger on a positive edge for (+) ESD and a negative edge for (–) ESD strikes. The magnitude should be set to 20 V.
   - Following Section 3.3.1, strike contact ESD to TP10.
2. Using one 10X attenuator:
   - Attach one 10X attenuator to the oscilloscope.
   - Attach the 50 Ω shielded SMB cable between J7 and the attenuator.
   - Set the scope attenuation factor to 40X.
   - Set the oscilloscope to trigger on a positive edge for (+) ESD and a negative edge for (–) ESD strikes. The magnitude should be set to 20 V.
   - Following Section 3.3.1, strike contact ESD to TP10.

Recommended settings for the time axis is 20 ns/div and for the voltage axis is 10 V division.

The voltage levels of the ESD applied to TP10 should not exceed ±8kV while capturing clamping waveforms.

4 Board Layout

This section provides the TPD3S014-Q1EVM board layout. TPD3S014-Q1EVM is a 4-layer board of FR-4 at 0.062 inch thickness. Layers 2 and 3 are ground and power planes, respectively, and not shown.

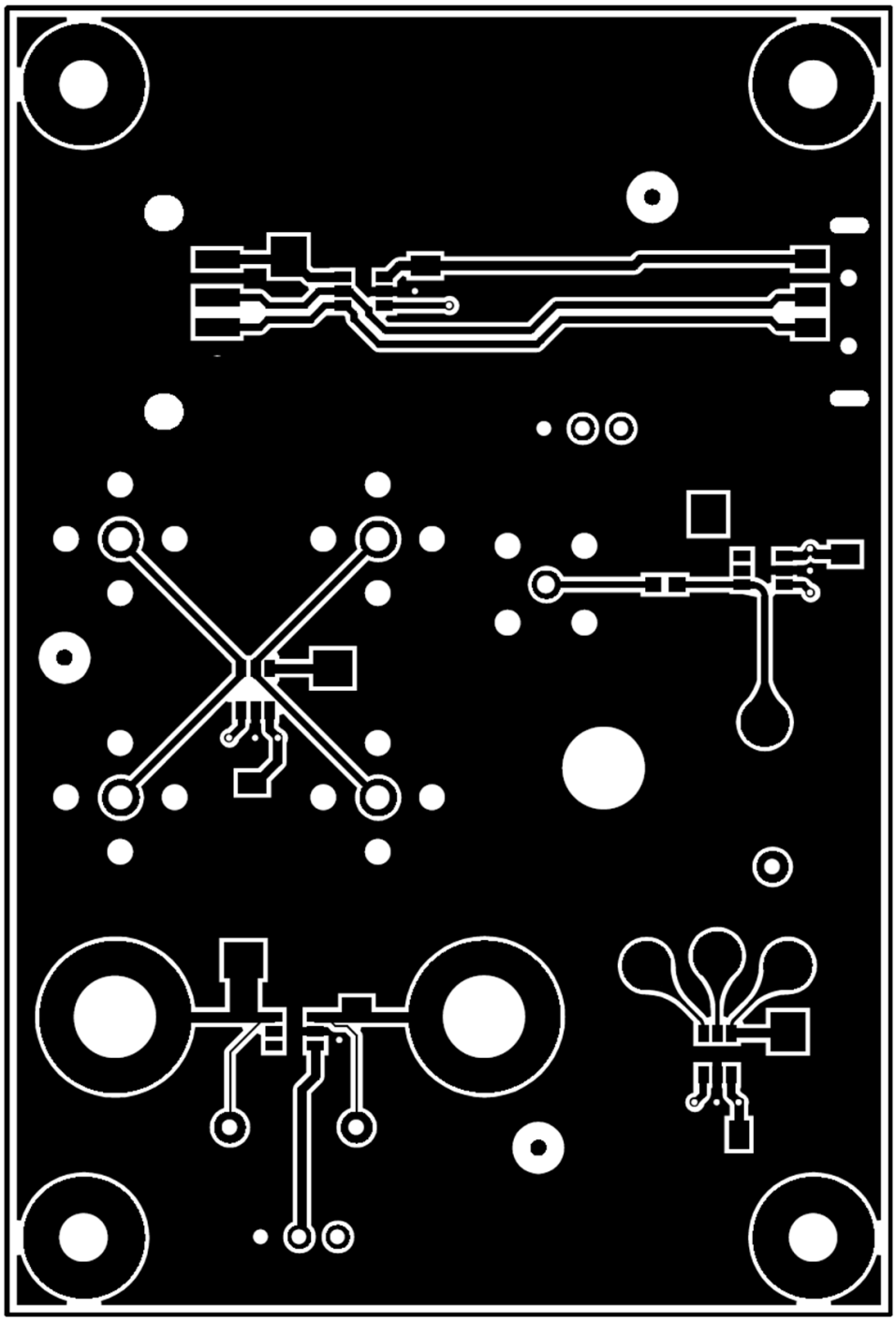

Figure 3. TPD3S014-Q1EVM Top Layer

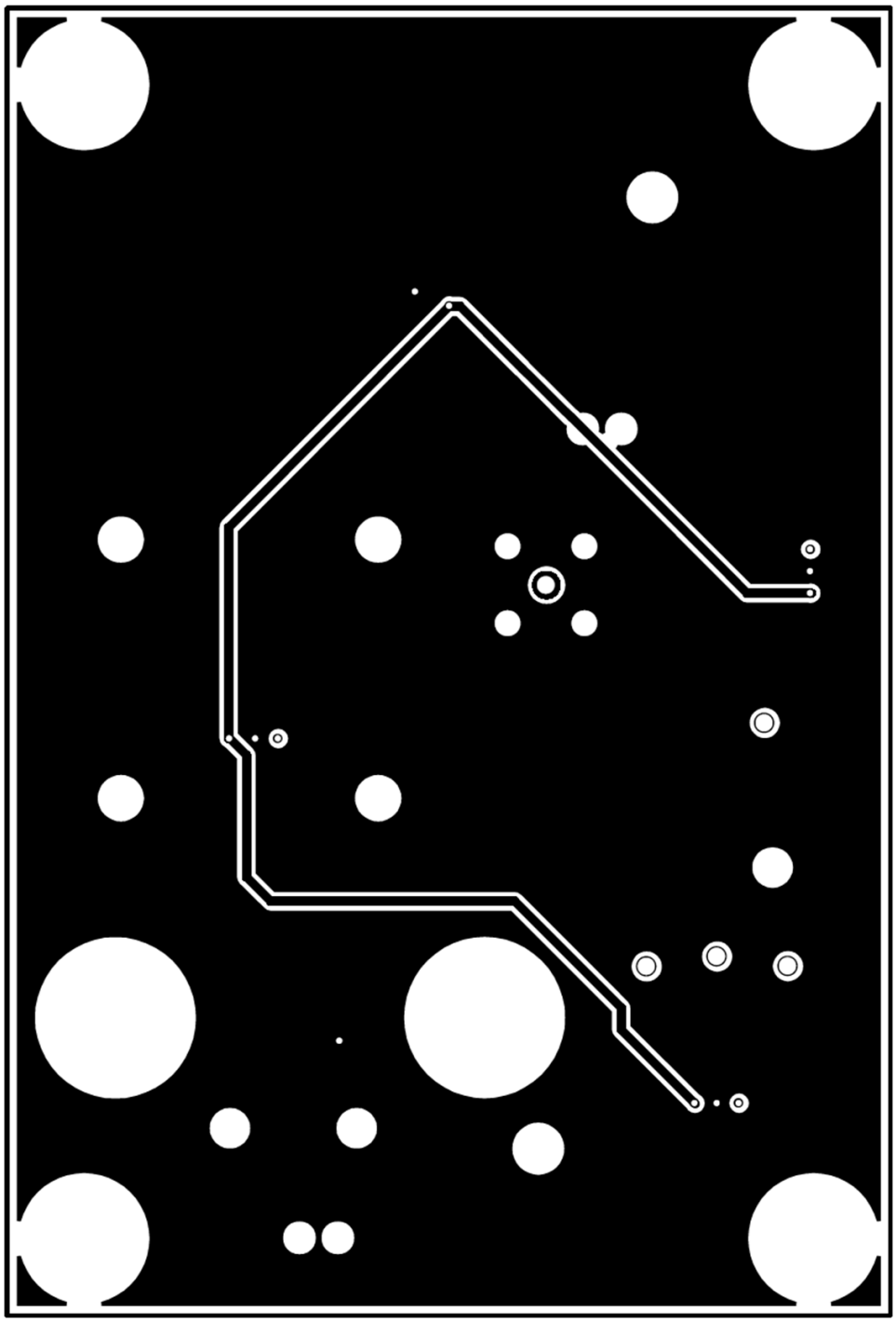

Figure 4. TPD3S014-Q1EVM Bottom Layer

5 Schematics

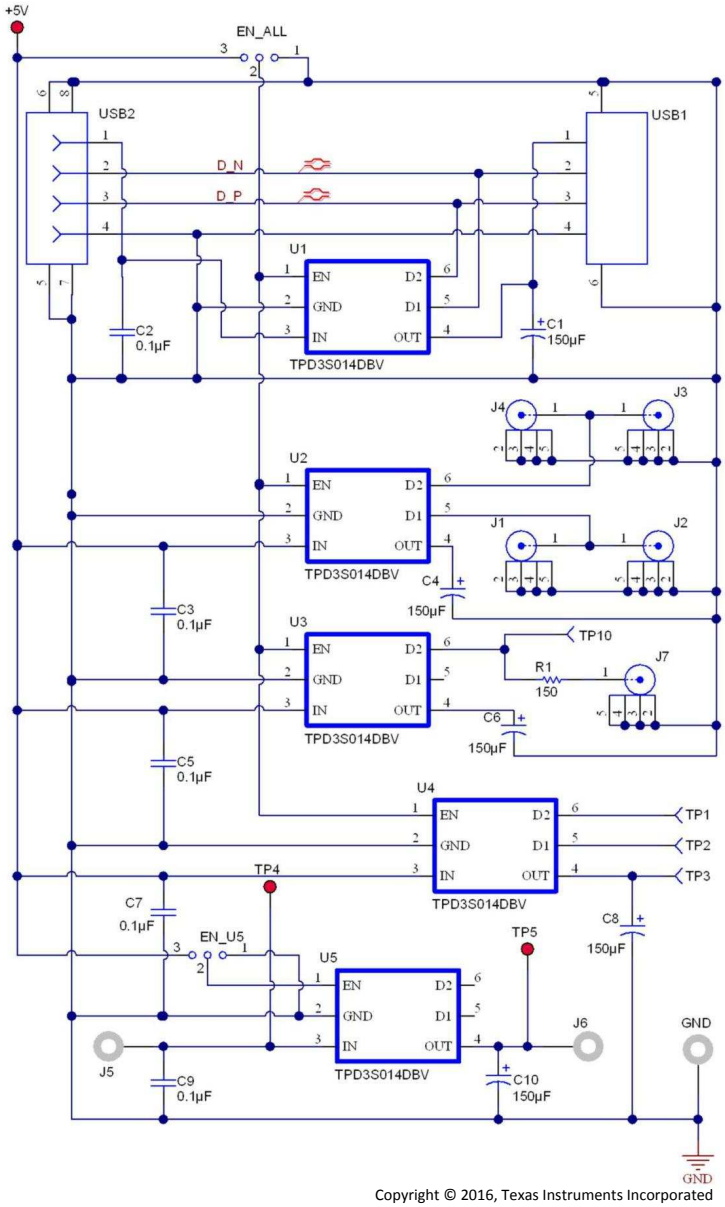

Figure 5. TPD3S014-Q1EVM Schematic

6 Bill of Materials

Table 3. Bill of Materials

Count	RefDes	Description	Package Reference	Part Number	MFR
1	+5V	Test Point, Miniature, Red, TH	Red Miniature Test point	5000	Keystone
5	C1, C4, C6, C8, C10	CAP, TA, 150uF, 6.3V, +/- 10%, 0.15 ohm, SMD	6032-28	TPSC157K006R0150	AVX
5	C2, C3, C5, C7, C9	CAP, CERM, 10 uF, 50V, +/- 10%, X7R, 1206	1206	GMK316F106ZL-T	Taiyo Yuden
2	EN_ALL, EN_U5	Header, Male 3-pin, 100mil spacing,	0.100 inch x 3	PEC03SAAN	Sullins
3	GND, J5, J6	Standard Banana Jack, Uninsulated, 5.5mm	Keystone 575-4	575-4	Keystone
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
4	J1, J2, J3, J4	Connector, TH, SMA	SMA	142-0701-231	Emerson Network Power
1	J7	Connector, SMB, Vertical RCP 0-4GHz, 50 ohm, TH	SMB	131-3701-261	Emerson Network Power
1	R1	RES, 150 ohm, 1%, 0.1W, 0603	603	CRCW0603150RFKEA	Vishay-Dale
5	U1, U2, U3, U4, U5	IC, Low-Capacitance 4-Chan ±15-kV ESD-Protection Array For High-Seed Data Interfaces	SOT-23	TPD3S014-Q1DBV	TI
1	USB1	Connector, Receptacle, USB TYPE A, 4POS SMD	USB Type A connector, receptacle, 4 POS SMD	896-43-004-00-000000	Mill-Max
1	USB2	Connector, USB Type A, 4POS R/A, SMD	USB Type A right angle	48037-1000	Molex

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