

TPD3S044EVM

This user's guide describes the characteristics, operation, and use of the TPD3S044EVM evaluation module (EVM). This EVM includes five TPD3S044's in various configurations for testing. One TPD3S044 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.

1 Introduction

Texas Instrument's TPD3S044 evaluation module helps designers evaluate the operation and performance of the TPD3S044 device. The TPD3S044 is a current limiting switch intended for applications such as USB where heavy capacitive loads and short-circuits are likely to be encountered; TPD3S044 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 TPD3S044s. TPD3S044 (U1) is configured with two USB2.0 Type A connectors (USB1 & USB2) for capturing Eye Diagrams and evaluating current limiting with a system. TPD3S044 (U2) is configured with 4 SMA (J1 – J4) connectors to allow 4-port analysis with a vector network analyzer. TPD3S044 (U4) is configured with test points for striking ESD to the protection pins. TPD3S044 (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 below 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 8kV, testing can continue in 2 kV increments until failure.

Table 1. IEC61000-4-2 Test Levels

| Contact Discharge | | Air Discharge | |
|-------------------|--------------------------|---------------|--------------------------|
| Class | Test Voltage [\pm kV] | Class | Test Voltage [\pm 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] | I _{peak} ±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 |

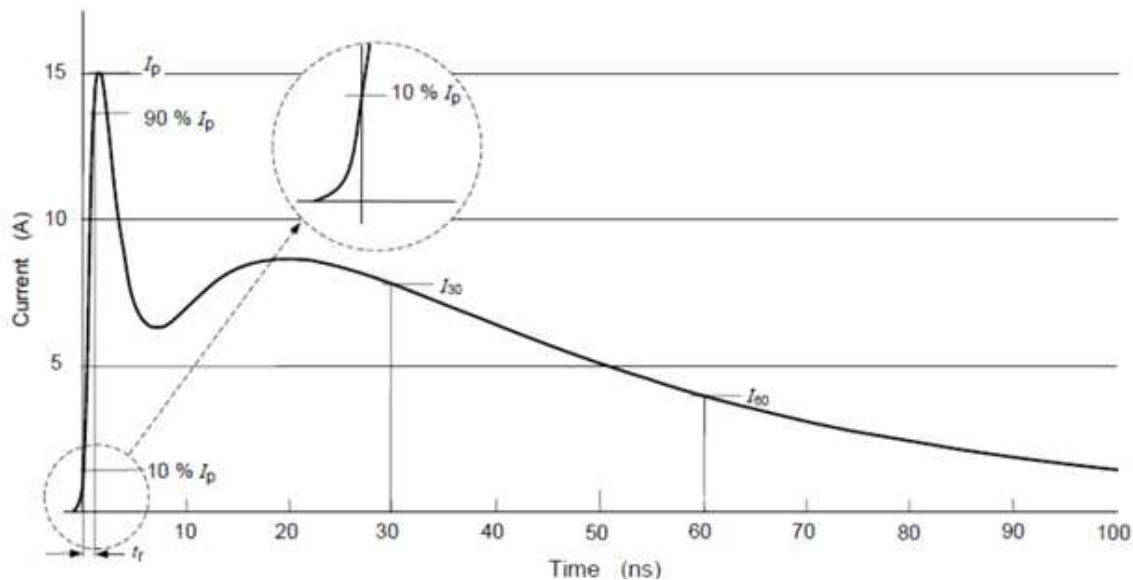


Figure 1. Ideal Contact Discharge Waveform of the Output Current of the ESD Simulator at 4 kV

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 5V to the +5V test point and ground to GND. Tests can be performed with device enable pins set HI or LO. For TPD3S044 the device is active-low, so set EN to LO to enable the devices on the board.

3.1 U1

A single TPD3S044 (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 USB2.0 compliant Eye Diagram tester setup for the intended application, either transmitter or receiver.

3.2 U2

A TPD3S044 (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:

- S₁₁: Return loss
- S₂₁: Insertion loss
- S₃₁: Near end cross talk
- S₄₁: Far end cross talk

3.3 U4

A TPD3S044 (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.

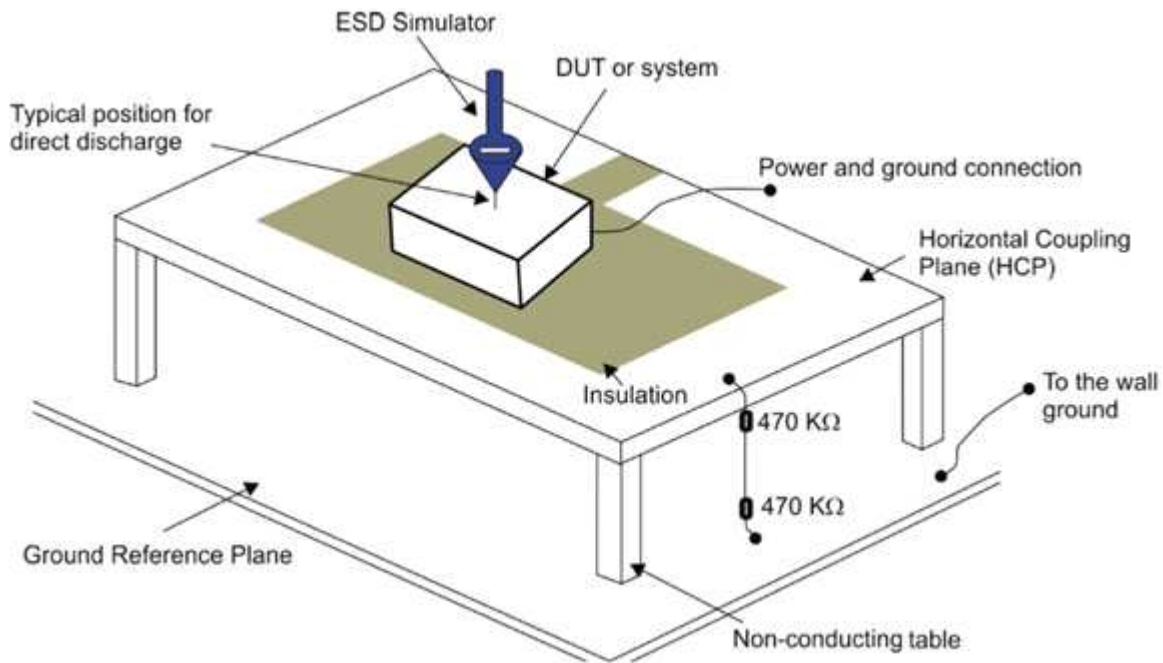


Figure 2. System Level ESD Test Setup

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 TPD3S044 (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 ± 8 kV while capturing clamping waveforms.

4 Board Layout

This section provides the TPD3S044EVM board layout. TPD3S044EVM 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.

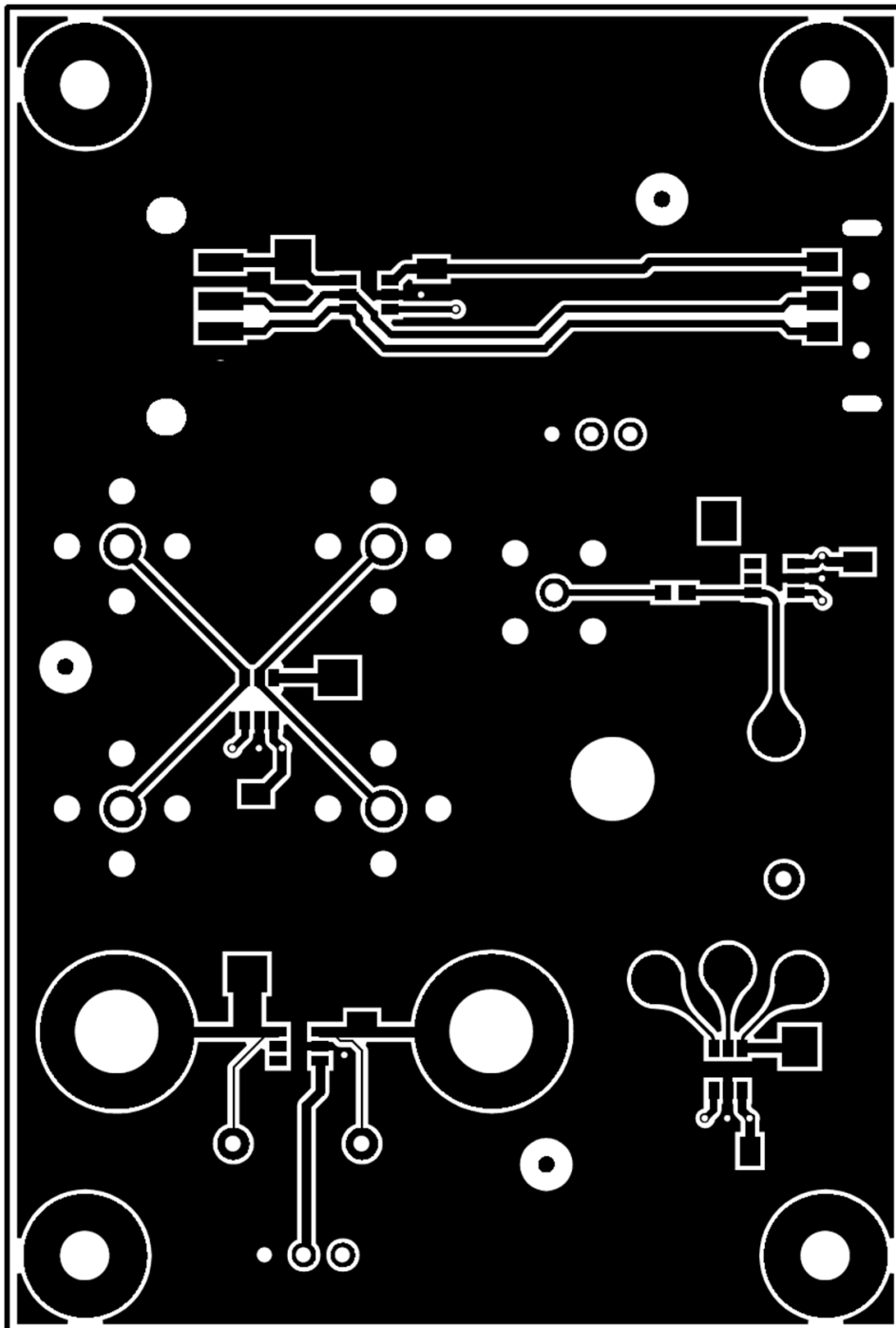


Figure 3. TPD3S044EVM Top Layer

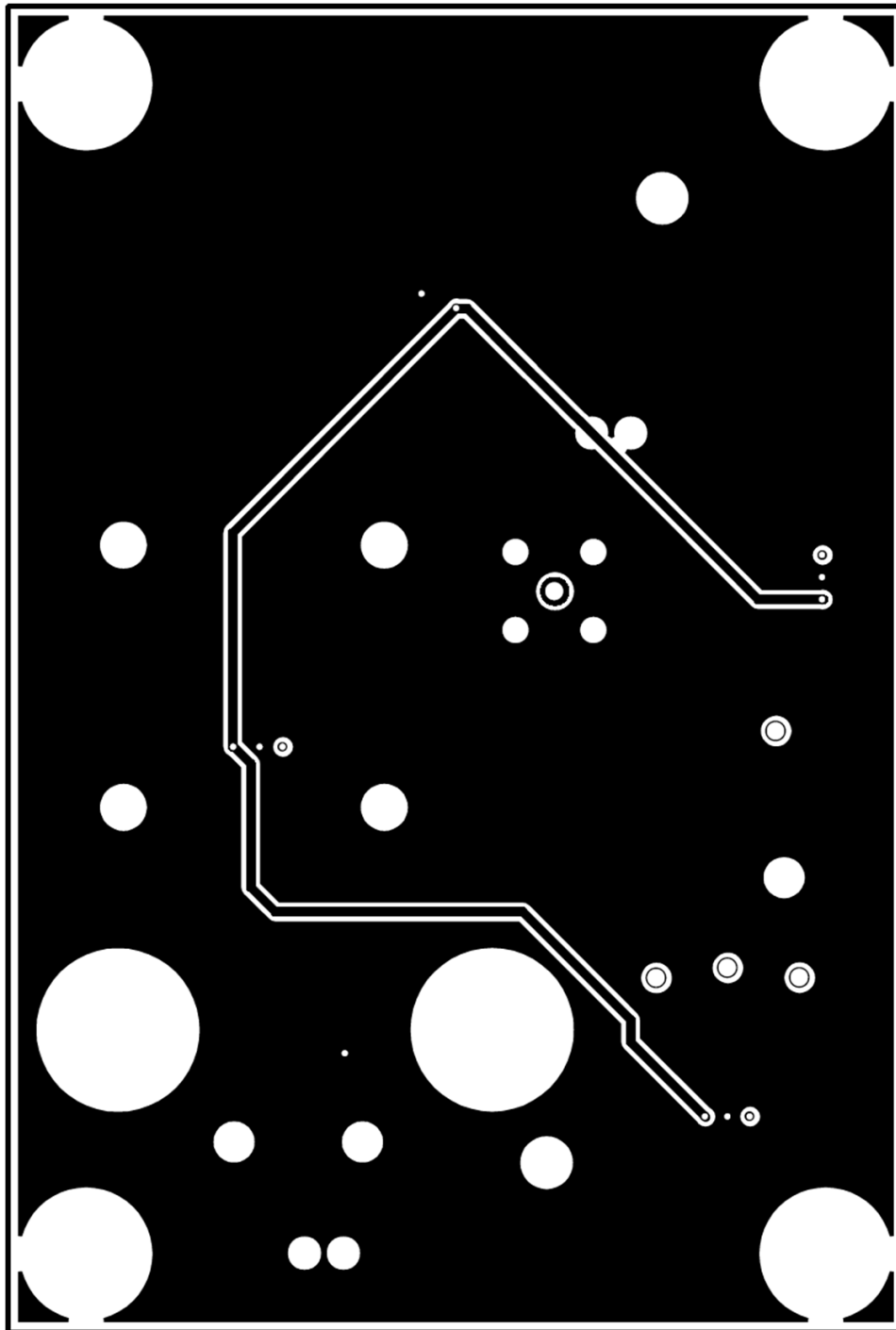


Figure 4. TPD3S044EVM Bottom Layer

5 Schematics and Bill Of Materials

5.1 Schematics

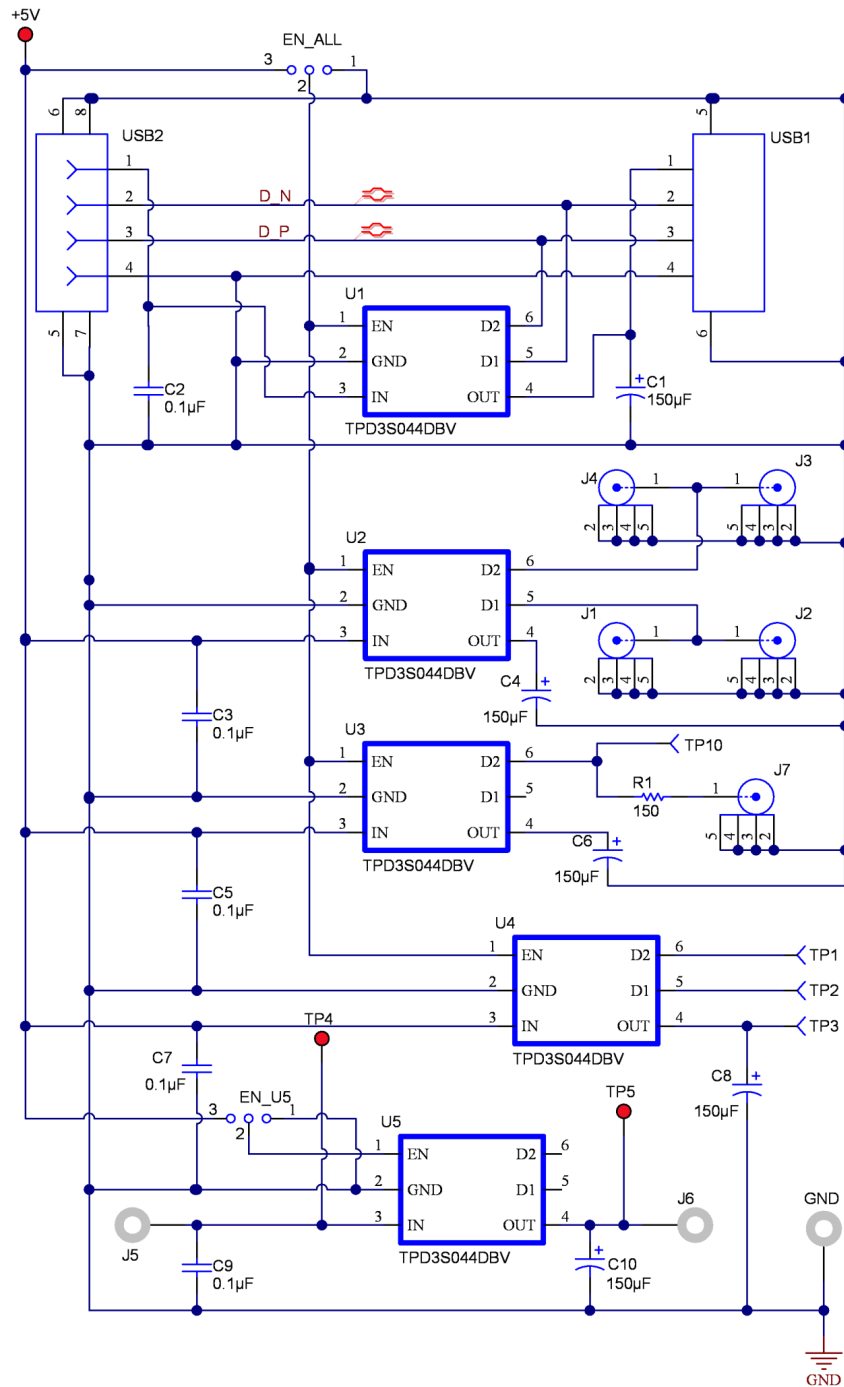


Figure 5. TPD3S044EVM Schematic

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 | CRCW0603150RFK EA | Vishay-Dale |
| 5 | U1, U2, U3, U4, U5 | IC, Low-Capacitance 4-Chan ±15-kV ESD-Protection Array For High-Speed Data Interfaces | SOT-23 | TPD3S044DBV | 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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- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
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