menlomicro

Application Note

ESD Protection for MEMS Relays

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ESD Safeguards for MEMS Relays

ESD (electro-static discharge) events are transient spikes of high voltage that can happen when charge is stored on a floating capacitor – such as a human body or test equipment – that suddenly discharges to a nearby object – such as an antenna or connector. Ohmic MEMS devices can be damaged by these voltage spikes, and care must be taken to prevent or mitigate ESD events in systems using MEMS.

Ohmic MEMS devices are composed of a beam, contact, and gate that have a small gap between them. Voltage spikes above the rated voltage of a MEMS device can cause charge to arc between these structures and damage them. This can result in the switch having a reduced lifetime, a reduced leakage current in off-state, a failure to close (stuck open), or a short to the output/gate (stuck closed).

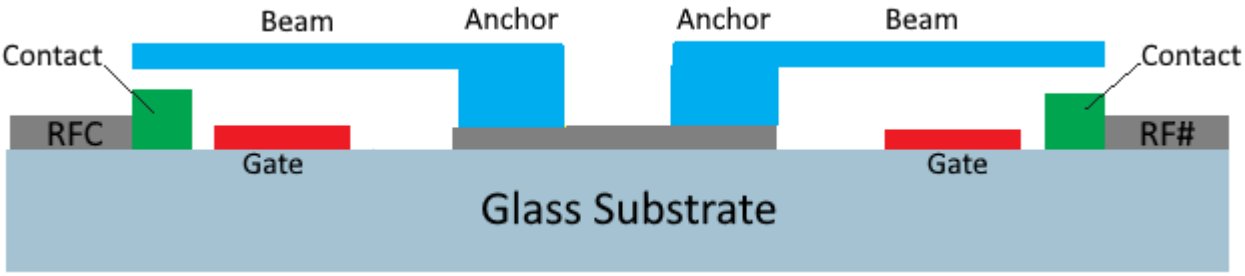

Figure 1: Cross-Section Diagram of MEMS Switch

MM5130 ESD Test Results

At outgoing test, the MM5130-03NDB device is subjected to a 150 V standoff voltage on each RF port; this test is used to define the specified limits in the datasheet of the part in ESD events.[1] In addition to production testing, performance of the devices and visual inspections were performed on parts after simulated ESD shocks above the voltage limits set in the MM5130 datasheet.

35 devices were tested up to 350 V in compliance with the CDM (charged device model) JS-002-2018, and 15 devices were tested up to 350 V in compliance with the HBM (human body model) JS-001-2017. In both cases device performance was measured after the simulated ESD shock to meet the same standards as outgoing production devices. See the MM5130 ESD Test Summary in our customer portal for details.

Handling

Ohmic MEMS switches have comparable ESD sensitivity as GaN and other high-power RF relays. For example, the MM5130-03NDB device is ESD rated Class 0 and the same precautions should be taken as with any other ESD-sensitive device. In applications where ESD events are likely, ESD protection circuits should be used.

[1] See MM5130 Datasheet Rev 2.7

ESD Protection Circuits

For system applications that use Ohmic MEMS switches and require higher than Class 0 ESD survivability, ESD protection circuits are required. When choosing an ESD protection circuit, key parameters are peak voltage at rated ESD level, insertion loss, and the rated voltage.

- Peak voltage at rated ESD level should be below the maximum rated voltage of the MEMS switch. For example, if the system requirement is Class 1 (2 kV) and the MEMS device maximum rated voltage is 150 V, the peak voltage after a 2 kV ESD shock should be 150 V.
- The insertion loss of the protection circuit will directly affect the insertion loss of the RF switch.
- The rated voltage defines the maximum DC voltage the ESD protection circuit can reliably withstand without turning on. This impacts the maximum RF power handling of the switch because voltage peaks above this value caused by high-power RF signals will be clamped when the protection circuit turns on.

For RF systems up to 12 GHz and 8 W, Menlo Microsystems recommends the Panasonic EZAEG1N50AC ESD suppressor. This ESD suppressor has been tested on our MM5130 evaluation kit to protect from 2 kV HBM ESD events between RF ports and ground.

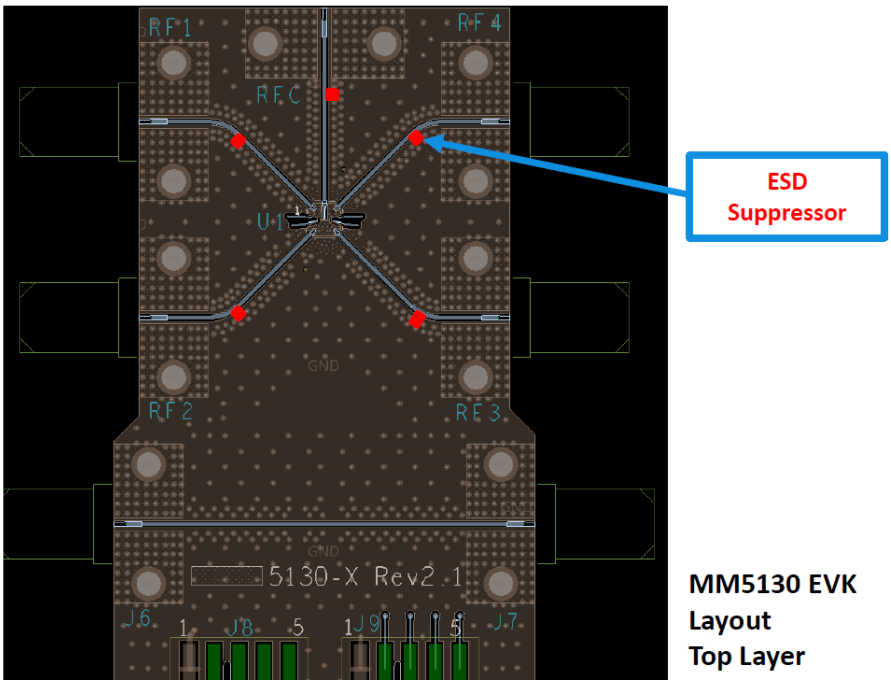

Figure 2: MEMS Switch Evaluation Kit with ESD Suppressors

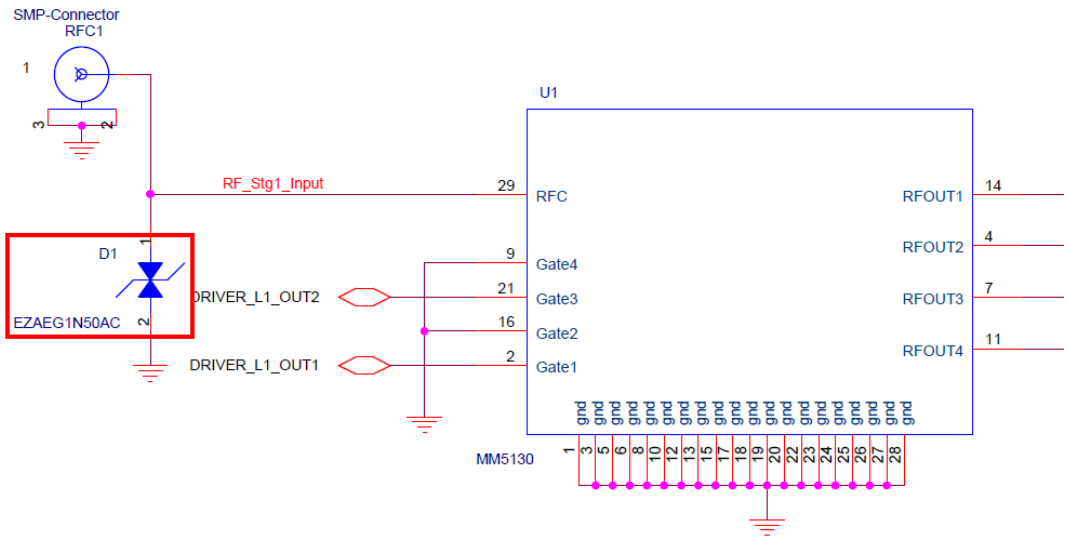

Figure 3: Schematic of MEMS Switch with ESD Suppressor

Figure 4 below shows the IL performance of the Panasonic EZAEG1N50AC ESD suppressor alone, while Figure 5 shows the IL performance of the MM5130 RF switch in Superport mode, with ESD suppressors on both ports.

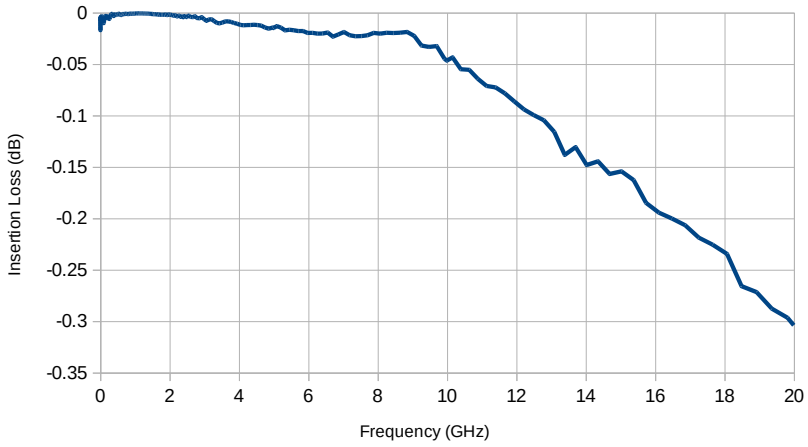

Figure 4: Through Line with ESD Suppressor

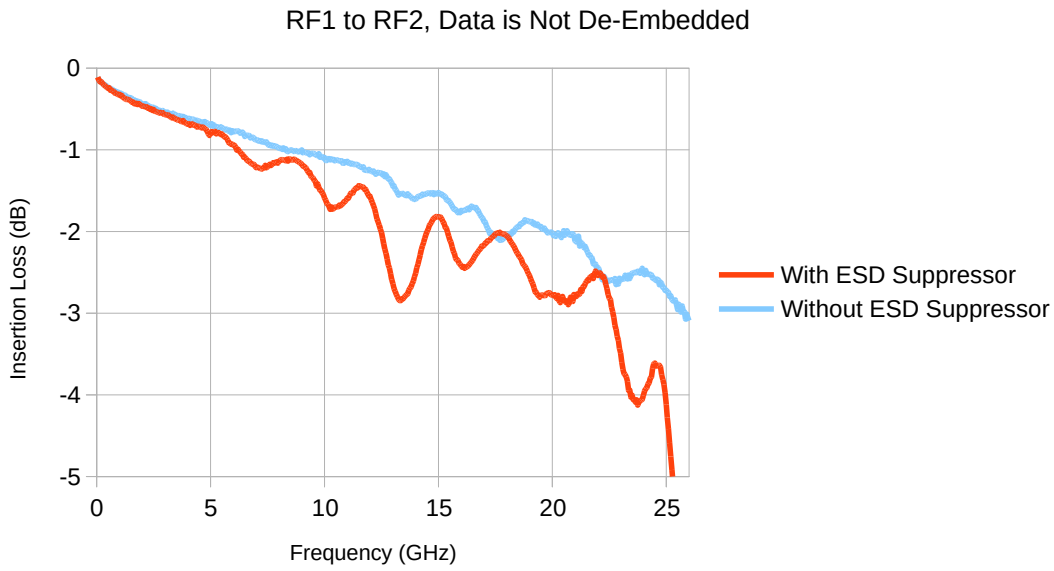

Figure 5: MM5130 Superport EVK Insertion Loss with ESD Suppressors

Note that Figure 5 shows performance without de-embedding to demonstrate impact to system performance. Measurement includes a 34mm long, 0.36mm wide trace on 0.2mm thick RO4003C substrate.

For an example of this ESD protection circuit in an application, see the MM4008 reference design in our customer portal.

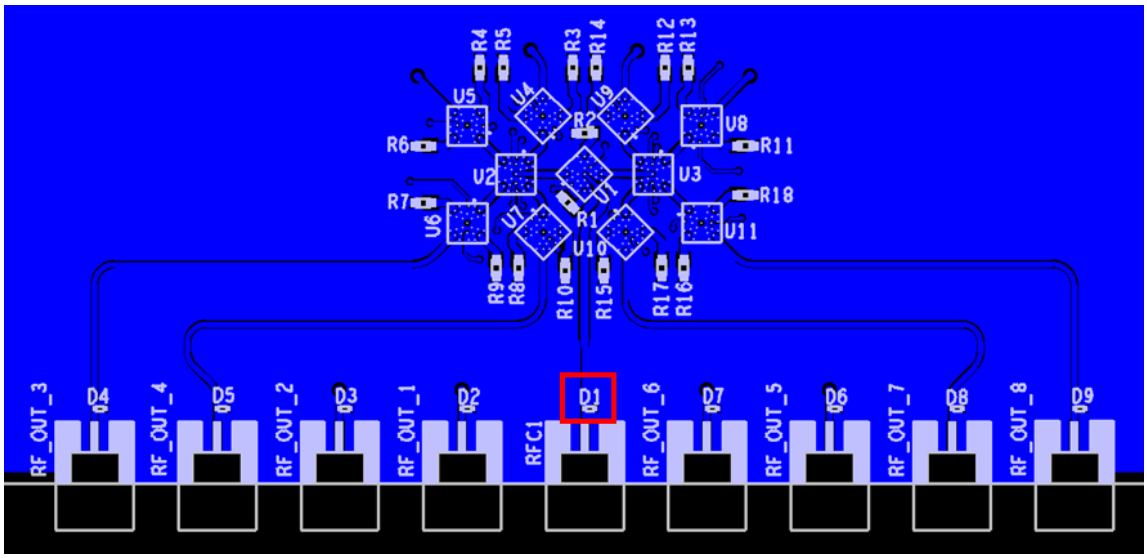

Figure 6: SP8T Reference Design Layout with ESD Protection

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