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Application Note

Avoiding Floating Nodes in Ohmic MEMS Circuits

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Controlling DC Potential in Ohmic MEMS Circuits

Ohmic MEMS circuits are generally sensitive to *hot-switching* a voltage across the switch contacts when transitioning between open and closed states. When designing switching circuits with MEMS, it is important to avoid hot-switching which can degrade operational lifetime. This implies that the differential DC voltage across the switch INPUT-OUTPUT terminals should be near zero volts when the switch opens or closes. Though the terminal DC voltage when switching is recommended to be 0 V, the requirement is that the voltage level is equal on both sides of the switch when it opens or closes. To maximize the lifetime of MEMS devices, hot-switching should be avoided. This application note describes how to avoid hot-switching arising from a build-up of charge in DC-isolated floating nodes.

Methods to Avoid Floating Nodes

There are several ways to avoid the floating node issue. In order of preference, they are:

1. Design the circuit to have a DC-path to ground through the system so that there are no DC-isolated floating nodes. This is the preferred way as it does not impact Q-value of the circuit nor the DC-isolation properties. Isolate system input and output so that no DC voltage is entering the MEMS network.
2. In RF applications, if one or several floating nodes are necessary to achieve desired circuit topology, use of large value inductors to GND to connect otherwise DC-isolated nodes should be considered. The Inductor will provide a DC path to ground while blocking the path for RF signal. This may be an option for higher frequency applications (in the GHz range) where a large value (large reactance) inductor is reasonable small.
3. For lower frequency applications where inductors are impractical due to physical size, it is recommended to use a large value resistor between the floating node and ground. This ensures that any charge that accumulates over time has a way to discharge. If the system cannot be designed without floating nodes, and the frequency is too low to use inductors, then this method using “pull-down” resistors is recommended. Recommended values are 100 kΩ to 10 MΩ.

Node Impedance and Loading on High-Q Circuits and Resonators

In systems with many MEMS switches, resistive losses can add up and it may be desirable to use the method that provides the least amount of loading on the node, especially if the floating node is a high impedance point such as a filter resonator. Note that only one method for DC-grounding per network node is required.

For RF circuits with high Q values such as resonators, resistor values at the upper end of the range are recommended. Likewise, for circuits where DC-leakage is critical, again resistor values at the upper end of the range are recommended.

A Design Example

Figure 1**Error! Reference source not found.** below shows an RF application using MM31xx with an L-C network and two floating nodes (with the switches open). Apart from possible overvoltage due to stored charge on the isolated nodes, the switch on the left has an output that is DC isolated. Since the Output is also the reference for the Gate voltage, this will lead to problems with actuation and de-actuation of the switch. The switch on the right side has its Output DC-grounded so no action is required there, but the Input is DC-isolated.

To remedy the situation and fix these DC-isolated floating nodes, Figure 2 shows how 10 MΩ resistors have been added to connect the floating nodes to ground. With the Output of the switch on the right side now at ground potential, the switch will actuate and de-actuate as intended. Any charges that accumulate will discharge safely to ground and the switches are safe to operate.

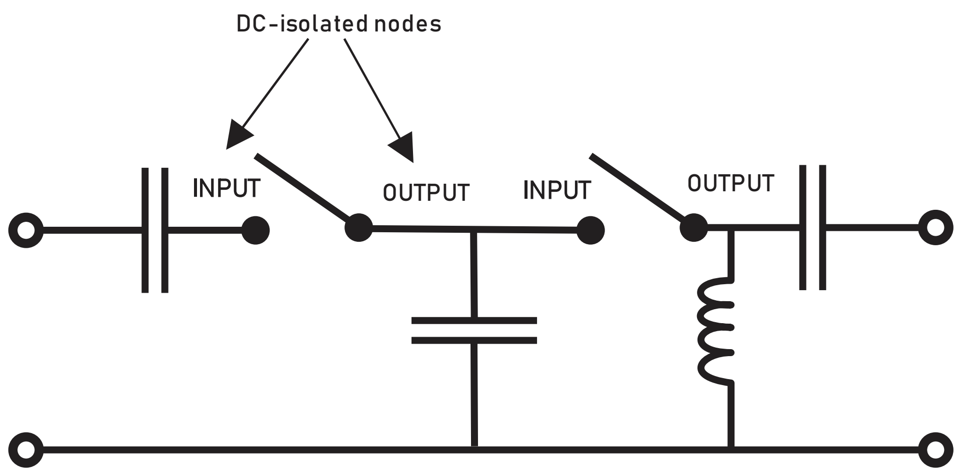

Figure 1: Switch L-C Network with Two DC-Isolated Floating Nodes

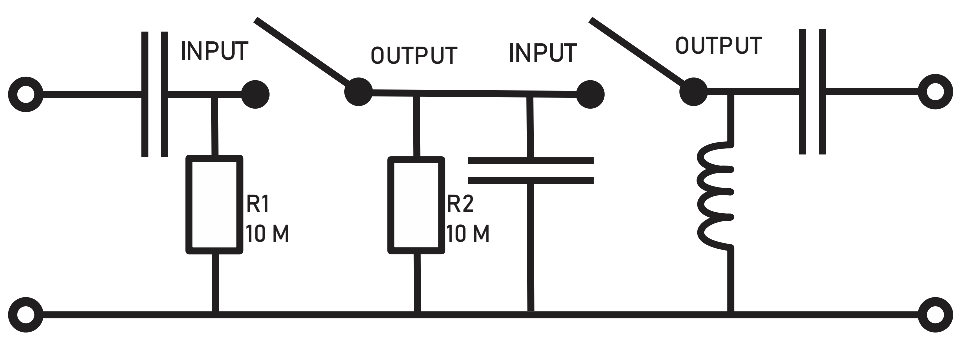

Figure 2: L-C Network from Figure 1 with Added Resistors Eliminates the Isolated Nodes

Super-Port Considerations

Super-Port connection method can provide enhanced performance in RF isolation and return loss. The floating node arising from the series connection of switches together in Super-Port can be avoided by using a shunt with DC path to ground and sequenced switching. Figure 3 below shows a Super-Port connection example using a MM5130 with R switched ON creating a DC path to ground when the Super-Port switch is Off. The R is removed when the Super-Port switch is On.

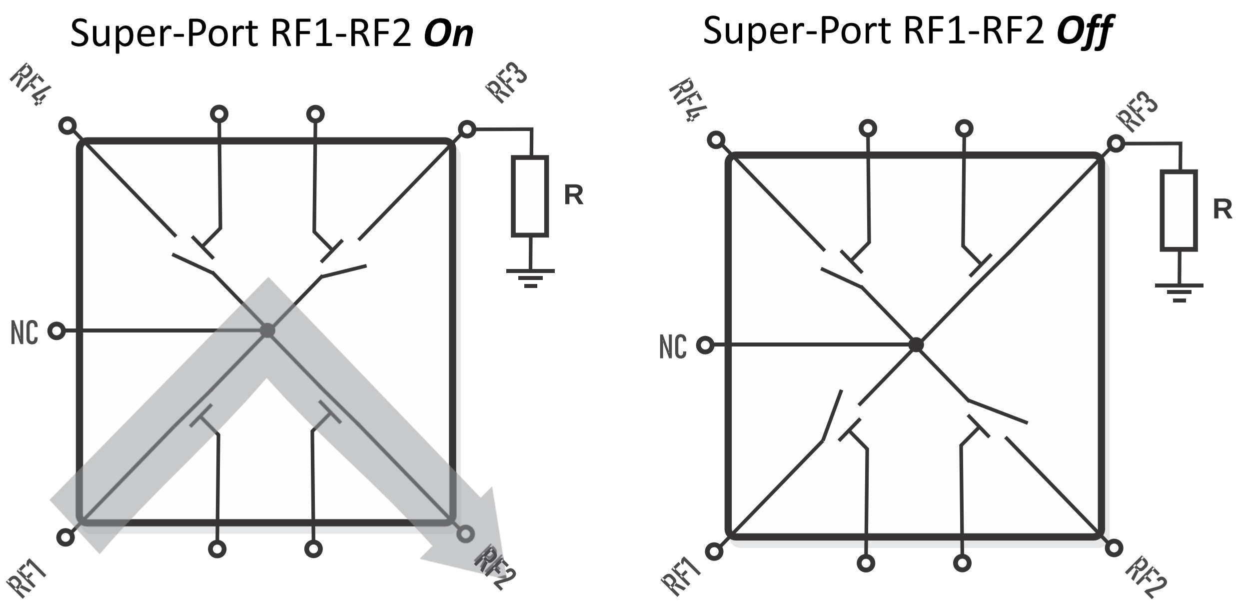

Figure 3:Super-Port Connection with Sequenced Switching of DC path to Avoid Floating Node

Sequencing the gates as shown in Figure 4 below provides a solution to removing the DC path when the Super-Port is ON. The DC path through RF3 is ON when the Super-Port switch path is OFF thereby avoiding the floating node arising at the series connection of RF1 and RF2.

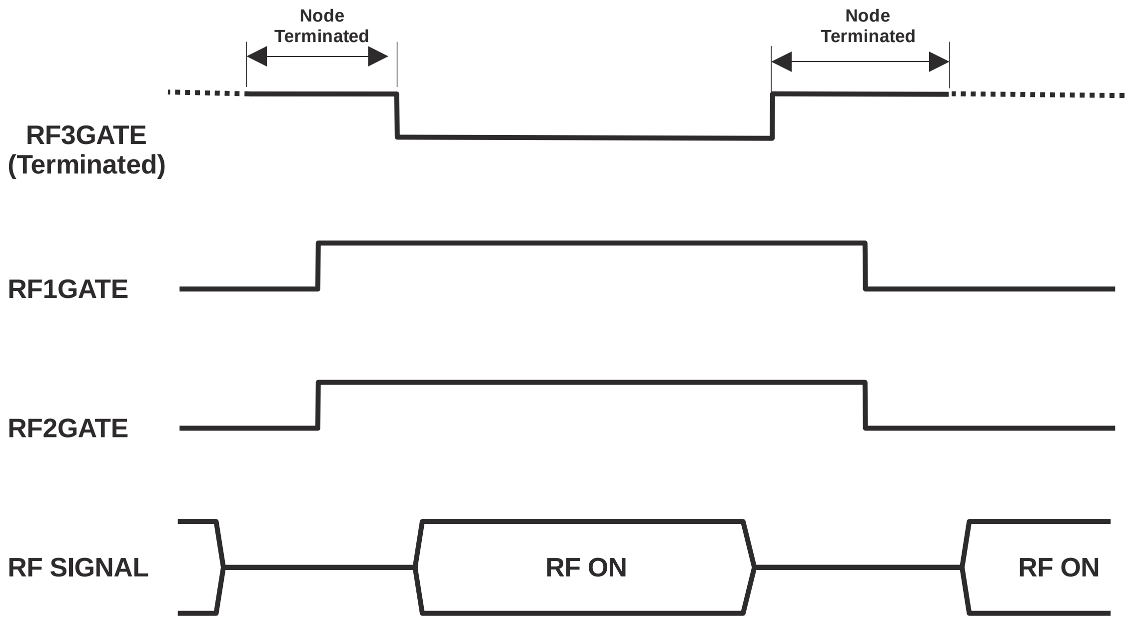

Figure 4:Super-Port gate sequencing disconnects DC path when switch is ON

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