GENERAL DESCRIPTION

RMI's RMSWXXX™ RF-MEMS switches are electrostatically actuated cantilever beams connected in a three terminal configuration. Functionality is analogous to a field effect transistor (FET), the terminals being labeled Source, Gate, and Drain. Operation of the device can be understood referring to Figures 2 and 3.

When a DC bias voltage, V_{GS}, is applied between the gate and source, an electrostatic force results that deflects the beam toward the substrate. When the bias between the gate and source exceeds the threshold voltage, V_{TH}, the contacts on the beam touch the drain and complete the circuit between source and drain. When the bias voltage is removed, the beam acts as a spring, generating sufficient restoring force to open the connection between source and drain, thus breaking the circuit.

SWITCH ACTUATION

The gate to source bias voltage is insensitive to polarity, i.e. the gate may be driven either positive or negative with respect to the source. The recommended bias voltage is +/-100 V.

Since these are three terminal devices, note that the bias applied to the gate, V_{GS}, to actuate the switch must be made relative to the source. In the event that voltage of the signal being switched (i.e., conducted between the source and the drain) is not small compared with V_{GS}, (i.e., if V_S exceeds 5V) the gate voltage V_G will have to be varied to keep V_{GS} constant.

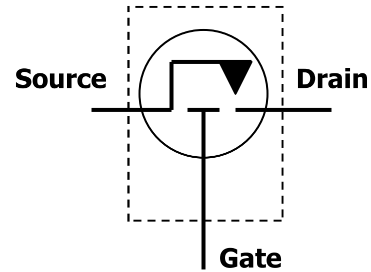

Figure 1 – Functional block diagram of SPST switch

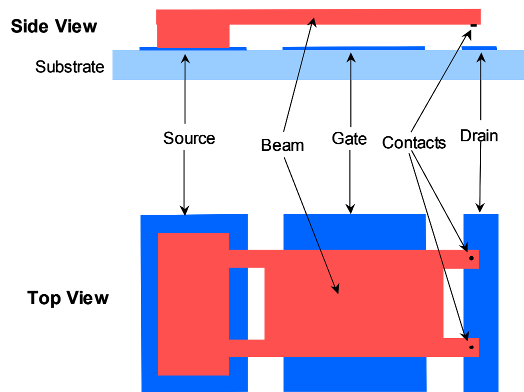

Figure 2 – Simplified representation of a switch

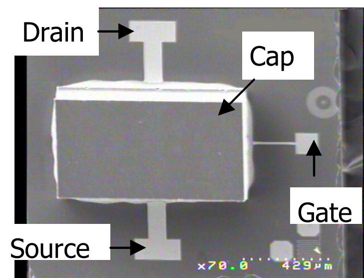

Figure 3 – SEM image of a RMSW100™ SPST Switch

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COLD SWITCHING

The longest lifetime of the switches and best contact resistance stability will be achieved when they are cold-switched, that is, there is no difference between the drain and source potentials when the switch opens or closes. This assures that no additional energy is dissipated at the contacts during switching events. Here, a few measures are strongly recommended to assure cold-switching.

Parasitic capacitances in the test system will cause capacitive coupling of transitions in the gate bias signal to the drain and source terminals. In order to minimize hot-switching caused by the coupled signals:

- **the test system must provide a path (resistance 100 KΩ or less) from the drain and source terminals to ground;**
- **the bias applied to turn the switch on should have a minimum rise time (from 0 to the final value, V_{GS}) of 10 μs.**

Contact bounce will occur immediately after the switch closes (the duration of the bounce depends on the rise time of the gate bias signal). In order to avoid hot switching during contact bounce, **the switch signal (voltage between drain and source) should be applied a minimum of 5 μs after the final bias voltage, V_{GS}, is reached.**

Finally, the switch signal should be removed a minimum of 1 μs before the gate bias signal is removed.

The above timing recommendations are summarized in Figure 4.

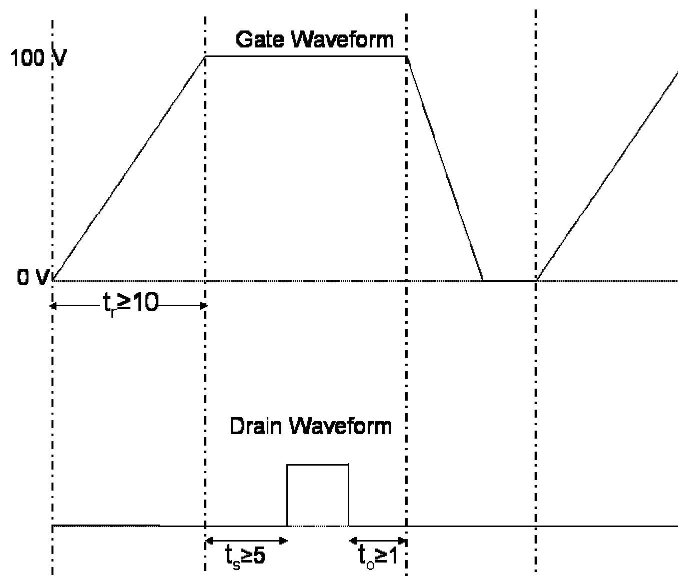

Figure 4 — Timing recommendations to assure cold switching

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A suggested set-up for evaluating a switch with a cold-switched DC load is shown below, in Figure 5. A suggested set-up for evaluating a switch with a cold-switched RF load is shown on the next page, in Figure 6.

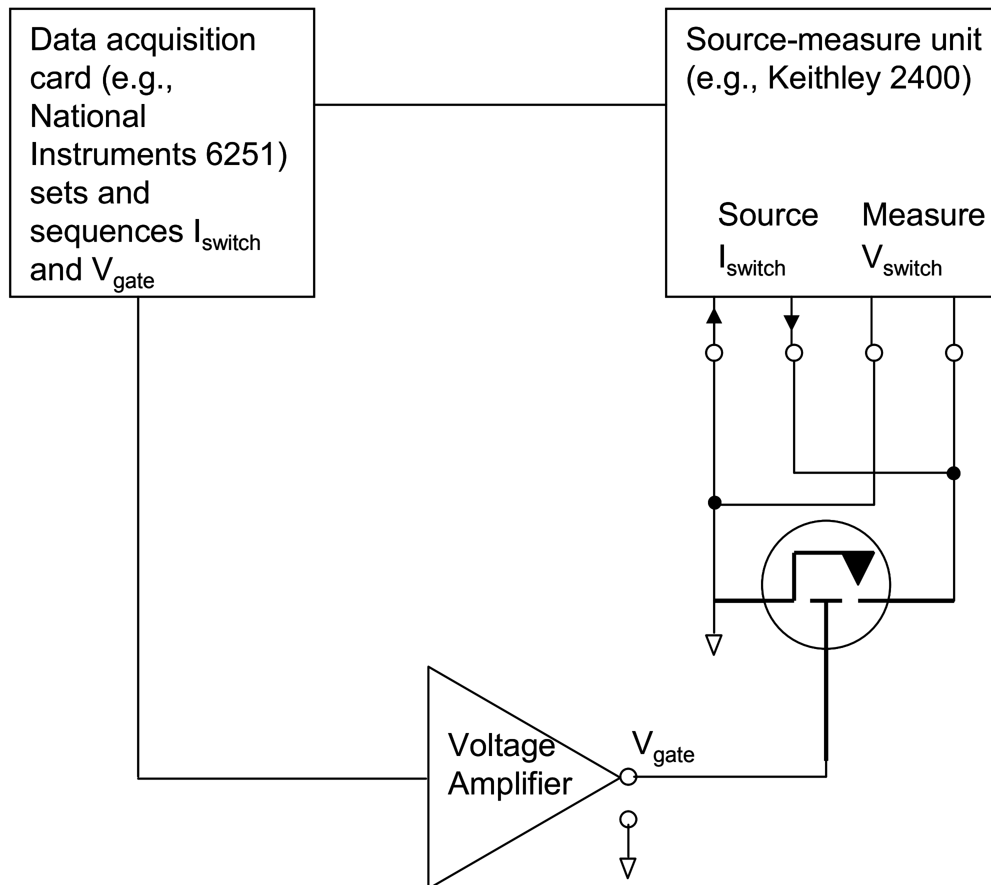

Figure 5— Suggested system for evaluating switch with cold-switched DC load

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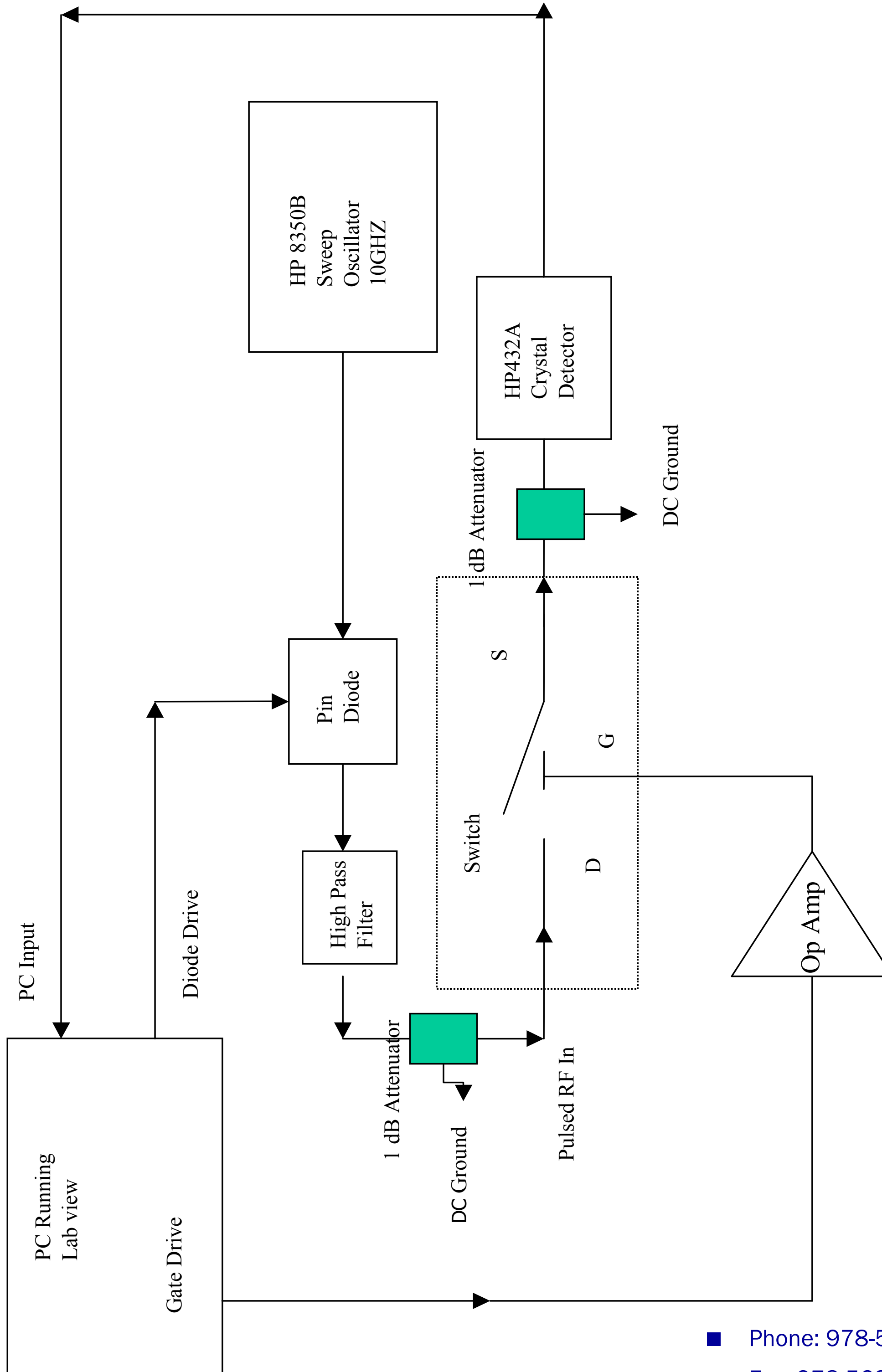

Figure 5— Suggested system for evaluating switch with cold-switched RF load

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TESTING PRECAUTIONS

ESD Precautions

RMI's RF-MEMS switches have been fabricated without any ESD protection. This combined with the extremely small size, low on-resistance, and minimal parasitic capacitance, makes the switches sensitive to transients which may arise from handling and test system cabling. Stored charge inadvertently conducted through the switches can result in immediate permanent damage to the devices. As a result, the following precautions should be observed.

1. Normal handling precautions applicable to ESD-sensitive devices should be observed including working only on static dissipative surfaces, wearing wrist-straps or other ESD control devices, storing unused devices in conductive foam, etc.

2. Care should be taken connecting signals to these units under test.

    a. Avoid connecting "live" signal sources. Assure that outputs are switched off (preferably grounded) before connecting to devices under test. Assure that all instrumentation shares a common chassis ground.
    b. Avoid running measurement instruments (e.g. DMM's, etc.) in auto range modes. Some instruments can generate large transient compliance voltages when switching ranges.
    c. Use the highest practical range (i.e. lowest resolution) setting for resistance measurements. This will minimize compliance voltages.
    d. Where practical, avoid using coaxial cable for DC connections. Energy stored in the cable capacitance can be inadvertently discharged through a device under test.

Ground Return Resistors

Parasitic capacitances in the test system will cause capacitive coupling of the actuation signal to the drain and source terminals. In order to minimize hot-switching caused by the coupled signals, the test system must provide a path (resistance 100 KΩ or less) from the drain and source terminals to DC Ground.

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ASSEMBLY CONSIDERATIONS

The following precautions and guidelines should be observed in handling and assembling the switch die.

CLEANLINESS
The die should be handled in a clean environment.

GENERAL HANDLING
The die should primarily be handled with vacuum pickups, or alternatively with plastic tweezers.

ESD PRECAUTIONS
Normal handling precautions applicable to ESD-sensitive devices should be observed, including working only on static dissipative surfaces, wearing wrist-straps or other ESD control devices, storing unused devices in conductive foam, etc.

MOUNTING TECHNIQUES
The gold backside-metallization on the die is designed to be mounted with electrically conductive silver epoxy or with a lower temperature solder pre-form, which is not rich in Sn content. All die attach and bonding methods should be compatible with gold metal.

ELECTRICALLY CONDUCTIVE EPOXY DIE-ATTACHMENT
The assembly can be preheated to approximately 125°C. Use a controlled thickness of approximately 50 Micrometers for best electrical and thermal conductivity. Cure epoxy as per manufacturer's recommendation.

SOLDER DIE-ATTACHMENT
Solders which do not consume gold are required. Do not expose die to a temperature greater than 290°C for more than 10 seconds.

WIRE BONDING
Bond pads on the die are made of gold. Ball-bonds should be utilized to attach 1 mil wires (as many as three 1 mil wires may be used side by side) to the bond pads.

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