FLOATING GROUND SPNT MMIC SWITCH DRIVER TECHNIQUES

Positive Voltage Control of MMIC Multi-Throw Switches with Floating Ground Technique

Hittite Microwave Corporation developed multi-throw switches with on-board-decoders in the mid-1990's. The Hittite Microwave SPNT switch product line includes non-reflective and reflective switches in standard configuratoins of HMC165S14 SP4T, HMC182S14 SP4T, HMC172QS24 SP6T, and HMC183QS24 SP8T. All are plastic encapsulated devices in industry standard SOIC and QSOP packages, readily used in automated assembly environments.

The decoder-on-board technology developed by Hittite Microwave provides the user with the advantage of a simplified control interface. Decoder topologies for each switch style are as follows: 2:4 decoder for the SP4T, 3:6 decoder for the SP6T, and 3:8 decoder for the SP8T switch. This directly simplifies board layout by reducing the number of driver lines required to control the switch. The reduction of control lines on the PCB serves directly to reduce pathways for RF crosstalkon the bias & control lines and ingress of signal from one channel to another thus enhancing isolation performance of the multi-throw switch. There is a −Vee bias requirement (-5.0 to -6.5 Vdc +/-10%) for each SPNT switch and the control lines accept negative logic voltages of; Low = 0.0 to -1.0 Vdc & High = Vee +/-0.25 Vdc.

The RF performance using Hittite Microwave proprietary driver & RF circuitry has inherently low loss & linear performance. The active elements of the circuit are depletion mode MESFET's (Metal Semiconductor Field Effect Transistor) or "FETs", a voltage controlled device. In standard operation, the drain & source of each FET is held at DC ground with the potential at the gate of the FET held at 0 volts placing the FET in the low loss or "on" state, and the potential of the gate held at -5 volts for the high

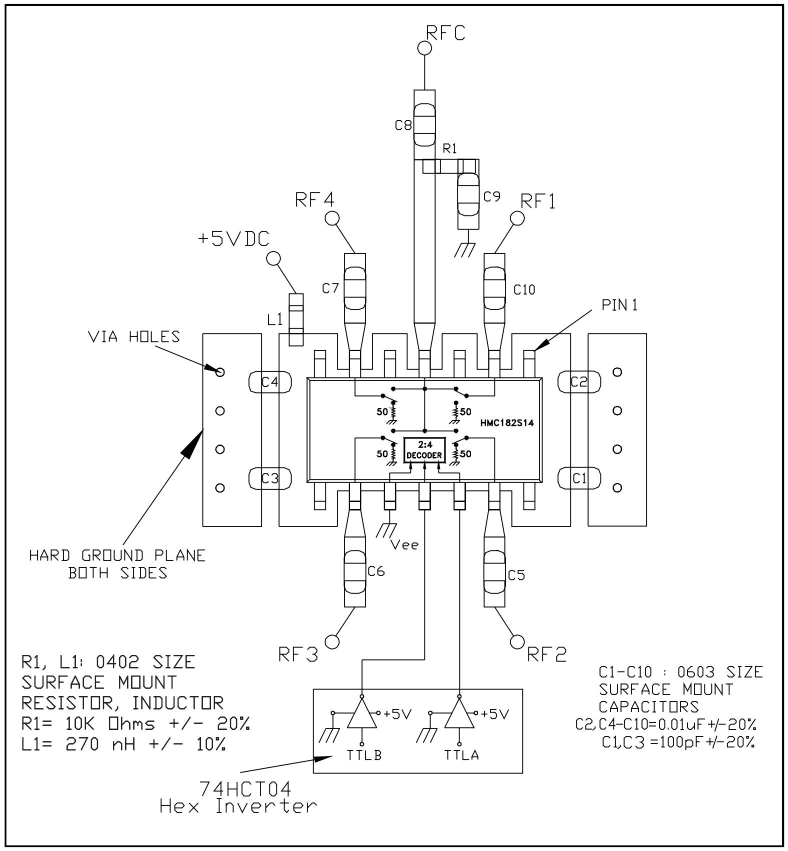

***Figure 1**: Floating Ground Driver for the HMC182S14 SP4T Switch.*

impedance or "off" state.

The system designer may not have negative voltage bias & control signals readily available. The floating ground switch dri8ver method described below can be used to enable positive bias & control operation of the GaAs multi-throw switch. By the use of blocking capacitors, pull-up resistors, and careful attention to layout details of the PCB, the floating ground switch driver approach can be used with good results and a minimum of additional circuitry.

Because the FET is a voltage controlled deivce there must be a potential difference of >-3.5 Vdc to <- 7 Vdc between the gate and drain-source channel to establish the certain pinch-off of the channel, therefor acheiving the high loss or "off" state in the FET. This can be accomplished by holding the source and drain at +5 Vdc +/-10% and toggling the gate between 0 and +5 Vdc +/- 10% to change the state of the FET. All DC bias points and control signals are therefore raised +5Vdc from their normal potentials.

An example of this floating ground technique using microstrip transmission lines is shown in Figure 1 for the HMC182S14 SP4T non-re-

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flective switch. Please note that the use of coplanar waveguide (CPW) ciruit techniques will save space and enhance RF performance, lower loss and higher isolation. See Hittite Microwave catalog application note, “Design Techniques Enhance Isolation in Switch Assemblies” page 8-24, for further deiscussion of the use of CPW transmission lines and printed circuit board design techniques.

In Figure 1, the internal switch shunt FET sources are pulled to +5 volts through the 270 nH inductor (L1) applying bias to the floating ground plane. The internal switch FET drains are held at +5 volts potential via the 10 Kohm resistor (R1) and capacitor (C9) arrangement shown at the RF Common Node. The 10 Kohm resistor is critical for reducing RF crosstalk, with capacitor C9 providing a path to ground for stray RF signals. It is critical in all cases for capacitors to be placed as closely as possible to the body of the switch for best RF performance. The 10 Kohm resistor should be placed on the RF trace without use of a “stub” landing solder pad for the resistor on the trace. If a resistor landing pad is required for PCB manufacturing yield issues then it’ssize should be minimized to reduce RF signal loss. The connections to hard RF/DC ground must have many via holes to ensure a low impedance path to ground at the highest RF frequency of operation.

High Q capacitors should be used for best performance in all cases, C1-C10. DC block, decoupling & bypass applications shoulduse 100 pF to 0.01 uF capacitors. For a typical operating range of 10 - 1500 MHz, the 0.01 uF capacitor provides for a low resistance path to ground for RF in the decoupling & bypass functions and a low insertion loss element in the DC block function. Switch users at predomnantly higher frequencies (through 2 GHz) may wish to substitute lower value capacitors as 100 to 330 pF for Dc block, decoupling and bypass functions. In Figure 1, the bypass capacitors C1-C4 should be placed as clost to the floating ground plane as possilbe to minimize ground inductance and maximize isolation. For broadband operation of this circuit, 10-2000 MHz, it is recommended that a combination of 0.01 uF capacitors (C2 & C4) and 100 pF capacitors (C1 & C3) be used bor the bypass function on the RF circuit ground.

The bias pin, Vee, of the HMC182S14 must now be held to Vdc (DC ground) versus it’s normal non-floating bias of -5 to -6.5 Vdc. Direct connection to the HMC182S14 switch A & B control lines by the +5 Vdc biased 74HCT04 hex inverter (or any positive logic HCT TTL logic driver device) is now possible.

Table I shows the truth table of the HMC182S14 in positve bias operation for the floating ground circuit topology of Figure 1.

TABLE 1

TTL A Control Input	TTL B Control Input	RF Path "ON" State
HI	HI	RF to RF1
HI	LO	RF to RF2
LO	HI	RF to RF3
LO	LO	RF to RF4