GaAs FETs as Control Devices

SKYWORKS

APN2015

Gallium arsenide MESFETs are being used in RF control device applications as switches and attenuators. They are very easily adapted to monolithic circuit form, dissipate essentially no power and can easily be designed into broadband circuits.

The RF signal flows from source to drain, while the RF isolated gate is the voltage control. The high impedance "off state" is attained by applying a DC voltage on the gate more negative than the "pinch-off" voltage (V_P). In this condition the source-drain channel is "pinched off." The capacitance is typically 0.25 pF per mm of gate periphery (see Figure 1A). The "on" state occurs when zero DC bias is applied to the gate (see Figure 1B). The channel from source to drain is "open" and represents a 2.5–3.5 Ω resistance per mm of gate periphery.

A configuration of FETs used in series and shunt normally produce the optimum switch or attenuator performance in monolithic circuits (see Figure 2). The only DC current that flows is the leakage of the gate-source and gate-drain reverse biased junctions (when negative voltage is applied to gate). Typical current drain is < 25 µA @ -5 V. This leakage is a function of the wafer fabrication process, the device periphery, and magnitude of applied voltage. For isolation of gate voltage control, 2.5–5 kΩ resistor is incorporated monolithically in the gate. Since no further external bias circuitry is required, the switch is inherently broadband.

The power handling of the switches is primarily limited by the current handling capability, which is related to the IDSS of the FET. The IDSS is a function of the gate periphery which then determines the source-drain capacitance. The input series FET in switches have a nominal 1 dB compression of 1 W/mm.

Digital attenuators use FETs configured as "T" or "PI" pads to achieve a given attenuation value (Figure 3). For the low loss state V_2 is set to 0 V and V_1 is set to -5 V. For the attenuation state V_2 is set to -5 V and V_1 is set to 0 V.

Typically digital attenuators are composed of multiple bit values (e.g. 2, 4, 8, 16 dB AD220-25).

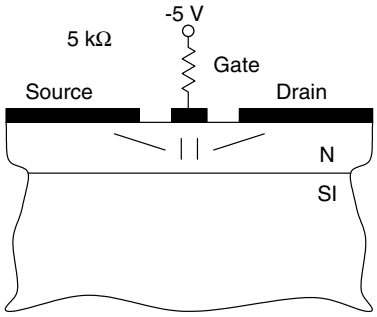


Figure 1A. MESFET Control Device in High Impedance State ("Off" State)

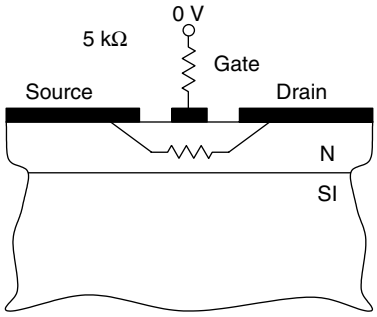
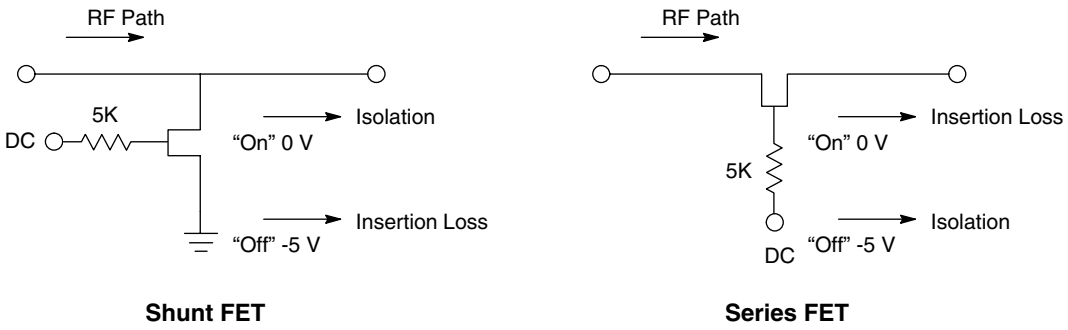


Figure 1B. MESFET Control Device in Low Impedance State ("On" State)

Voltage variable attenuators (VVAs) use the channel resistance of the FET as the actual resistance of the circuit components. The resistance is a nonlinear relationship with control voltage as shown in Figure 4 (FET with a "pinch-off" voltage of 1.5 V). Figure 5 shows a TEE VVA that uses two series FETs and one shunt FET.



Shunt FET **Series FET**

Figure 2. Shunt/Series FET

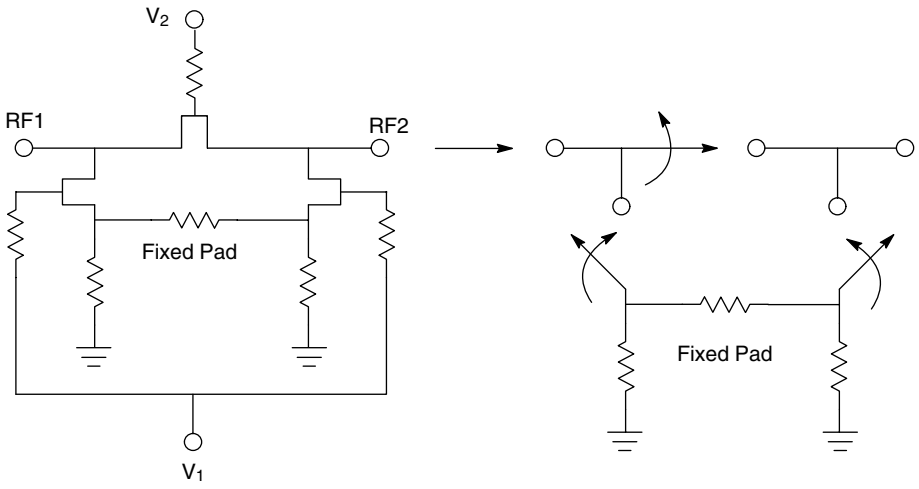


Figure 3. Single Bit Configuration for Digital Attenuator

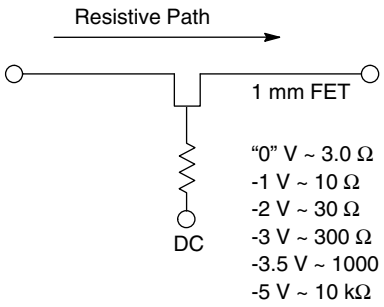


Figure 4. FET as a Variable Resistor

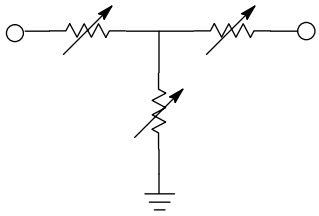


Figure 5. Voltage Variable Attenuator (VVA) in Tee Configuration