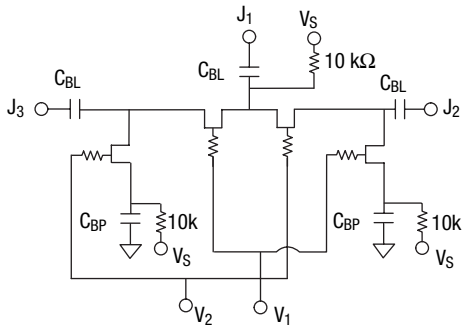
APPLICATION NOTE

# APN2017: Positive Voltage Operation of GaAs Control ICs

Depletion mode GaAs IC control products that are not internally bypassed can be "floated" or "level shifted" to operate using 0/+3 to +5 V control voltages. This is a great advantage since the majority of high volume wireless designs have only a positive voltage supply available.

## Switches

GaAs IC switches can easily be made to operate from a positive voltage supply ($V_S$) by "floating" the source/drain to the $V_S$ voltage and controlling the gates with 0 and $V_S$ voltages. This satisfies the requirement that the gate must be negative with respect to source/drain. Typical schematics implementing this technique are shown in Figures 1 and 2 for a series/shunt FET switch design. It is essential that the PCB ground plane be a minimal distance from the switch ground pins. The $C_{BP}$ capacitor can then be soldered directly to ground minimizing the inductive path and maximizing the switch performance. (See Figure 2.)




$C_{BL}$ = 100 pF @ 900 MHz.
$C_{BP}$ = .001 to 0.1 µF depending on lowest operating frequency.

## Truth Table

### Negative Operation ($V_S$ = Open)

| $V_1$ | $V_2$ | $J_1$–$J_2$ | $J_1$–$J_3$ |
|---|---|---|---|
| 0 | -5 | Isolation | Insertion loss |
| -5 | 0 | Insertion loss | Isolation |

### Positive Operation ($V_S$ = 5 V)

| $V_1$ | $V_2$ | $J_1$–$J_2$ | $J_1$–$J_3$ |
|---|---|---|---|
| +5 | 0 | Isolation | Insertion loss |
| 0 | +5 | Insertion loss | Isolation |

**Figure 1. Schematic Diagram and Truth Table for SPDT Series/Shunt Switch (AS239-12)**

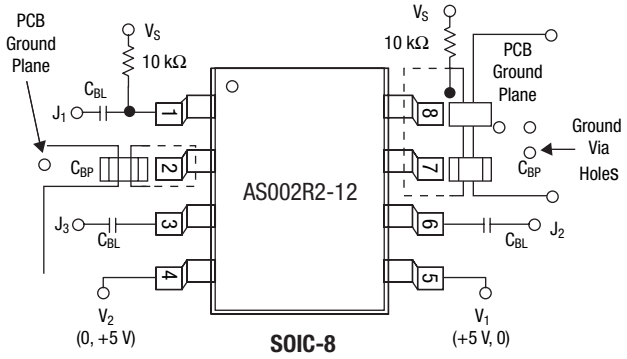
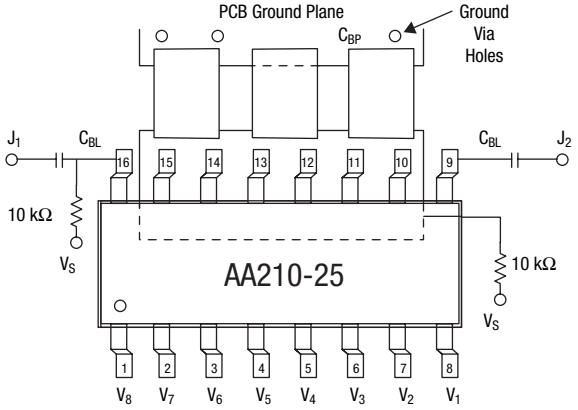



**Figure 2. Positive Voltage Control Configuration**

## Digital Attenuators (DA) and Voltage Variable Attenuators (VVA)

The floating technique discussed for switches can be applied to other GaAs IC control devices. DAs utilize the same floating scheme to achieve positive voltage operation. The AA210-25 is shown as an example of a digital attenuator that is floated. (See Figure 3.) All ground pins are AC coupled to the PCB ground through a single bypass capacitor. Inductance to ground must be minimized to achieve the best possible RF performance of the device.




$C_{BL}$ = 100 pF.
$C_{BP}$ = 1000 pF.

## Truth Table

### Positive Operation ($V_S$ = 5 V)

| $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_5$ | $V_6$ | $V_7$ | $V_8$ | Attenuation (dB) |
|---|---|---|---|---|---|---|---|---|
| 0 | 5 | 0 | 5 | 0 | 5 | 0 | 5 | Reference |
| 5 | 0 | 0 | 5 | 0 | 5 | 0 | 5 | 1 dB |
| 0 | 5 | 5 | 0 | 0 | 5 | 0 | 5 | 2 dB |
| 0 | 5 | 0 | 5 | 5 | 0 | 0 | 5 | 4 dB |
| 0 | 5 | 0 | 5 | 0 | 5 | 5 | 0 | 8 dB |
| 5 | 0 | 5 | 0 | 5 | 0 | 5 | 0 | 15 dB |

**Figure 3. Positive Voltage Configuration of AA210-25 and Truth Table**