Single-MOSFET circuits gate & modulate


Discrete small-signal MOSFETs still find uses today, and this Design Idea presents two simple examples: an AND gate, and an amplitude modulator.

**Figure 1** shows a standard two-input AND gate along with its MOSFET (and one- or two-resistor) implementation.

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**Figure 1** Two-input AND gate (a), and MOSFET realization (b)
Input-A and Input-B are here connected to single pole switches that are energized from a 15V battery. Input-A is connected to the drain terminal of MOSFET; Input-B to its gate terminal. The source terminal, labeled as Output-C, is the output of the AND gate. The MOSFET in the circuit is either in cut-off or saturated mode.

When a logic-low (0V) is applied at the gate terminal, the MOSFET operates in the cut-off mode, and a high impedance is present between the drain and source terminals of the MOSFET. Similarly, when a high voltage (15V) is applied at the gate terminal, the MOSFET operates in the saturated mode, and a low impedance is present between the drain and source terminals of the MOSFET.

Figure 2  Example simulation with both inputs = 1

A NAND gate can of course be realized by adding M2 and R3 to form an output inverter.
For a more analog MOSFET application, consider this simple AM modulator.

**Figure 3** Two-input NAND gate (a), and MOSFET realization (b)

**Figure 4** MOSFET amplitude modulator
The circuit consists of an N-channel MOSFET, two resistors, and a Schottky diode. The modulation signal, $v_{\text{sig}}(t)$, is connected to the drain terminal of the MOSFET. The carrier signal, $v_{\text{carr}}(t)$, is connected to the gate terminal. The amplitude-modulated output signal, $v_{\text{out}}(t)$, is obtained from the source terminal.

The carrier signal is a square wave, and since the gate of the MOSFET is connected to the carrier, the MOSFET will switch on and off at that frequency. When on, any voltage at the drain will pass through the MOSFET and appear at the source terminal. When the MOSFET is off, R2 will pull the output to ground.

For proper operation, the peak-to-peak voltage of the carrier signal should be twice the peak-to-peak voltage of the modulating signal. The Schottky diode prevents the amplitude-modulated output signal from being a bipolar signal.

Figure 5 Simulation results with a 25kHz 12V\text{p-p} carrier and 1kHz 6V\text{p-p} sine modulation
Figure 6 As above, with squarewave modulation

Also see:

- MOSFET-based, analog circuit calculates square root
- MOSFET pair makes simple SPDT switch