

FET-controlled op amp permits wide dynamic range

by Henry E. Santana
Hewlett-Packard, Loveland Instrument Division, Loveland, Colo.

When a field-effect transistor is operated as a voltage-controlled resistor, it is usually limited to a relatively small dynamic signal-voltage range. This is due to the nonlinearity of its drain-source resistance over a wide range of drain-source voltage.

But a wide-range voltage-controlled amplifier can be realized if a pair of FETs is connected in the bridge configuration shown in the diagram. The inverting terminal of the operational amplifier is kept at virtual ground, permitting the range of each FET's drain-source voltage to remain small, regardless of how broad the actual signal-voltage range is. This also assures that the excursions of V_{DS} will remain well within the FET's pinch-off region.

Wide-ranging. Voltage-variable amplifier can operate over a broad range of input-signal voltages. The FETs, which function as voltage-controlled resistors, are wired in a bridge configuration. Their inherent resistance nonlinearity is avoided by limiting each FET's drain-source voltage range, no matter how large the signal voltage becomes. The op amp's inverting input is held at virtual ground.

The circuit's voltage-transfer function can be written as:

$$A_v = -(R_2/R_1) + N(R_1 + R_2)/R_1 + NR_2r_{on}[1 - (V_{GS}/V_P)]$$

where r_{on} is the on-resistance of the right-hand FET, V_{GS} is the gate-source voltage, and V_P is the pinch-off voltage. Variable N represents a resistance ratio:

$$N = r_{on}/(r_{on} + R_1)$$

If N is very small, and r_{on} is much less than R_1 , then:

$$AV = -(R_2/R_1)(V_{GS}/V_P)$$

Although N must be small, it must, nevertheless, be greater than zero for the circuit to work. The control voltage for the circuit can range from 0 to V_P , and the peak ac input-signal voltage is determined by $I_{DS}R_1$.

Applications for this voltage-controlled amplifier include automatic gain control, true rms conversion, amplitude compression, and signal modulation. □

