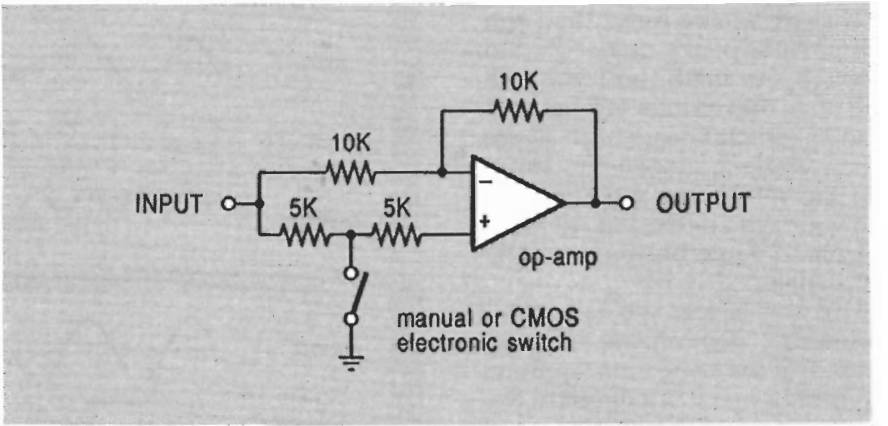

FIG. 1—A PROGRAMMABLE GAIN AMPLIFIER. When the switch is closed, the gain is −1. When the switch is opened, the gain is +1. One important circuit use is for synchronous demodulation.

FET programs op amp for invertible gain

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With only a few inexpensive components, an amplifier can be built with a gain of either +N or -N, depending on whether a field-effect transistor is turned off or on. Such a circuit is useful for programable inversion of analog signals or for programable phase-shifting of 180° for signals that are symmetrical with respect to ground. When a comparator is added to program the inverter, the circuit becomes a precision rectifier, the output of which is:

$$V_{out} = |V_{in} - V_{ref}|$$

When the FET is off, the input signal goes only to the inverting input terminal of the operational amplifier; the gain is:

$$V_{out}/V_{in} = -R_f/R$$

But when the FET is on, the gain is:

$$V_{out}/V_{in} = \eta A/[1+(ARR_1)/(R_1R_f+RR_f+RR_1)]\theta \times [f-)R_1R_f)/(R_1R_f+RR_f+RR_1)]$$

where A is the open-loop gain of the op amp, and

$$f = R_3/(R_2+R_3)$$

Since A is large, this reduces to:

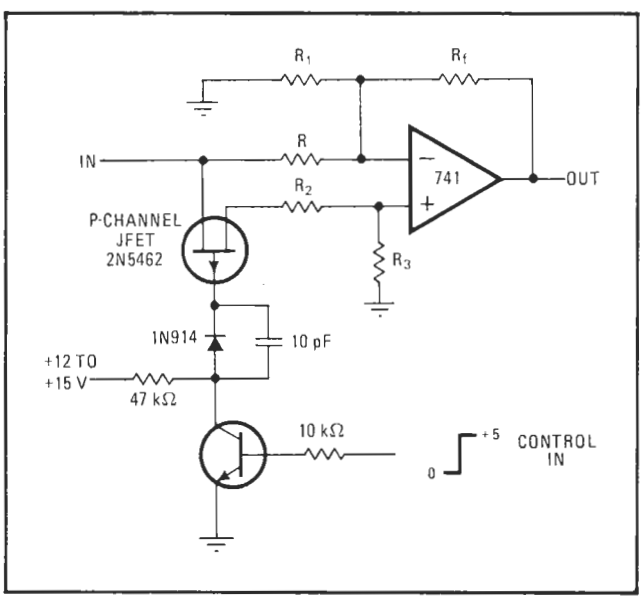
$$V_{out}/V_{in} = (f-1)(R_f/R) + f[(R_f/R_1)+1]$$

To make +N and -N numerically equal, choose the resistance values so that $R_f/R = N$. From that, it follows algebraically that:

$$N = (f-1)(N) + f[(NR/R_1)+1]$$
$$2N = fN + (fNR/R_1) + f$$
$$2NR_1 = fNR_1 + fNR + fR_1$$
$$2NR_1 - fNR_1 - fR_1 = fNR$$
$$R_1 = NRf/[2N-(N+1)f]$$

For the simplest case—a gain of ±1—all amplifier input and feedback resistors have the same value, except R_1, which is half that value.

The gate of the FET is controlled by a standard analog switch configuration, which allows the inputs to be 0 or +5 volts, compatible with TTL. □



FET inverts op amp. Amplifier gain can be programmed either positive or negative, depending on whether the field-effect transistor is conducting or not conducting. Gain is the ratio of R_f to R; for gains of ±1, R_f, R_2, and R_3 are all equal value, and R_1 is half the value.