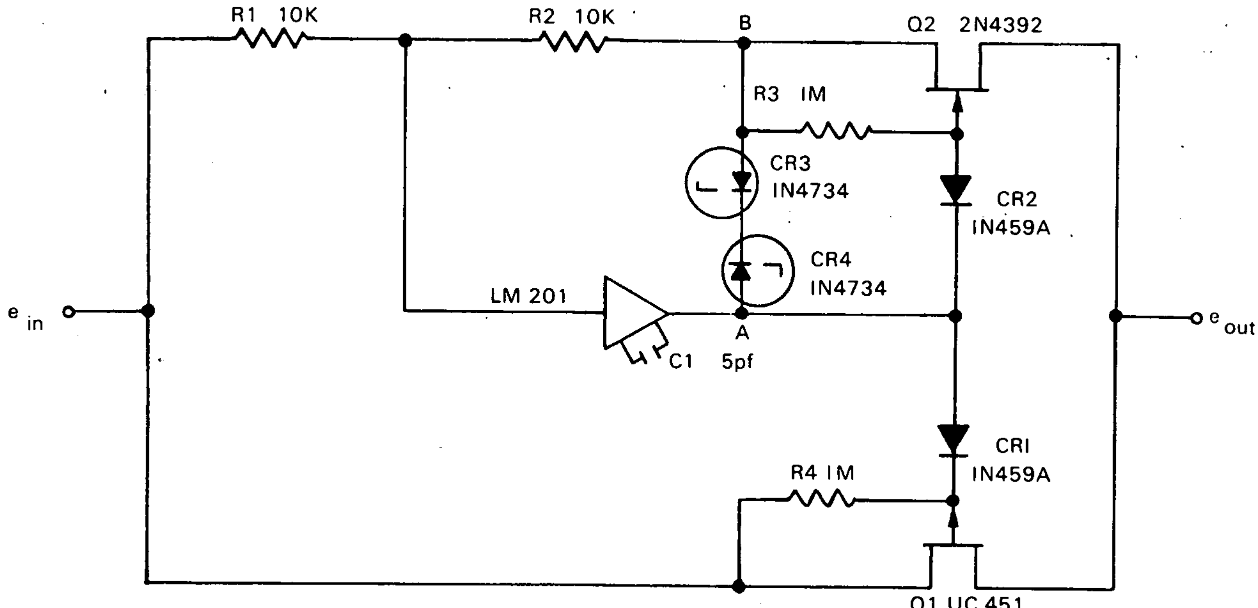
April 1970 Brief 70-10161

NASA TECH BRIEF

Precision Full-Wave Rectifier



Full-Wave Rectifier Circuit

The problem:

To simplify the circuits of precision full-wave rectifiers which use operational amplifiers. Conventional circuits require at least two operational amplifiers and six precision resistors.

The solution:

A circuit using only one operational amplifier (acting as a linear amplifier and a switch driver) and two precision resistors. The operational amplifier is operated open loop for switching and closed loop for linear gain, both simultaneously.

How it's done:

In the figure, precision resistors R1 and R2 are of equal value, and function as the conventional input-feedback loop for the operational amplifier; the other resistors can be of the ordinary ±20% carbon types. When the input voltage is positive, the voltage at point B will be equal in magnitude but 180° out of phase with the input. This requires the output of the operational amplifier at point A to be more negative by an amount equal to the sum of the forward and reverse potentials of the zener diodes CR3 and CR4; this value will be of the order of 6 volts for diodes which have zener breakdown potentials of about 5.5 volts. Thus, even though the input voltage may be a very small positive value, the amplifier generates at least −5.5 volts at point A, and this potential is more than sufficient to turn off the field effect transistor (FET) switch Q2 via a forward biased diode CR2.

(continued overleaf)

Diode CR1 prevents transfer of the voltage at point A to the gate of the FET switch Q1, and since the gate and source of Q1 are at the same potential (the condition for minimum source-to-drain channel resistance), Q1 is on and the input is coupled directly to the output.

When the input voltage is negative, it is evident that the FET switch Q2 is turned on and Q1 is turned off. Hence, full-wave rectification is effected (positive output voltage) by coupling the input to the output terminal in one mode of operation (via Q1), and the output of the amplifier appearing at point B through Q2 in the other mode. Since the FET switches in the signal paths have no offsets and very low values of resistance, the circuit provides linear full-wave rectification. Frequencies up to a few kHz can be handled by the components; higher frequency operation is possible by replacing the FET switches with MOSFET devices of superior high-speed switching characteristics and using high-bandwidth operational amplifiers.

If Q1 and Q2 are interchanged, and CR1 and CR2 are each reversed, the polarity of the output terminal will be negative. FET switches minimize temperature-sensitive offsets.

Notes:

1. Additional information is contained in the following paper: Deboo, G. J. and Hedlund, R. C.: Precision Full-Wave Rectifier Uses Only One Operational Amplifier, EEE Magazine, June 1968, p. 120.
2. Requests for further documentation may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, Calif. 94035
   Reference: B70-10161

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to National Aeronautics and Space Administration, Code GP, Washington, D.C. 20546.

Source: Gordon J. Deboo
and Roger C. Hedlund
Ames Research Center
(ARC-10101)