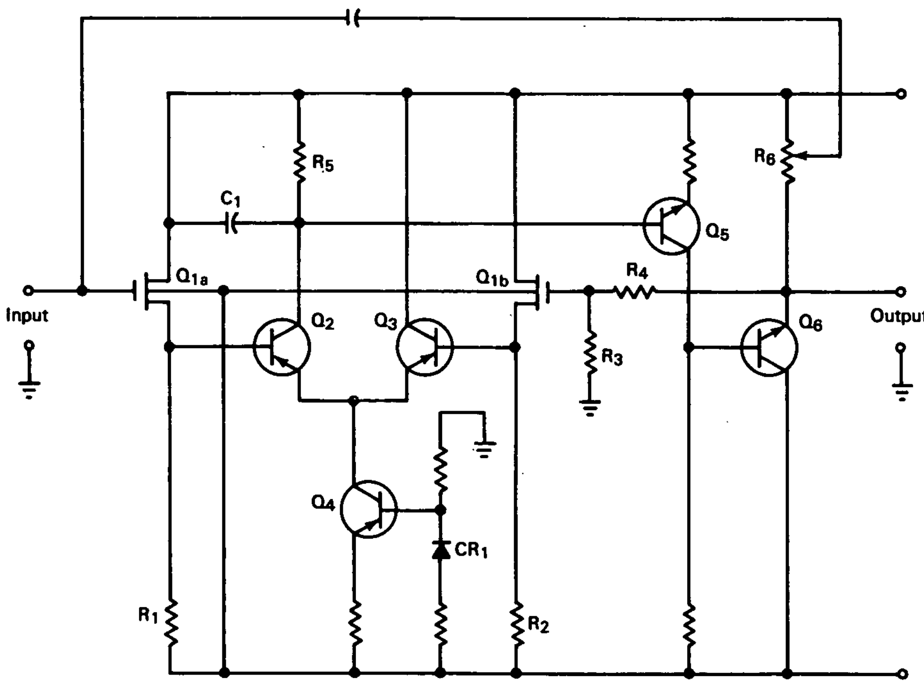
NASA TECH BRIEF

Miniature Electrometer Preamplifier Effectively Compensates for Input Capacitance



The problem:

To design an electrometer preamplifier that can be used with intracellular microelectrodes in recording bioelectric potentials. The requirements of such a device are low input current, high input impedance, low noise, low output impedance, and small size.

The solution:

A negative capacitance preamplifier using a dual MOS (Metal Oxide Silicon) transistor in conjunction with bipolar transistors.

How it's done:

The input signal is coupled to the gate of Q_{1a}, which is one half of a dual MOS transistor used in a differential amplifier configuration. Temperature compensation is achieved automatically by differential action and because both halves of the MOS transistor, Q_{1a} and Q_{1b}, are diffused on a single substrate. The required open loop gain is provided by Q_2, Q_3, and Q_5, and a low output impedance by Q_6. The temperature drift of Q_4, a constant current generator, is

(continued overleaf)

compensated by CR_1. Resistors R_1 and R_2 are important for two reasons. First, they cannot be omitted because the source currents then will be limited to the base currents of Q_2 and Q_3. Such low currents will result in a voltage gain of considerably less than unity for Q_{1a} and Q_{1b} because of the low transconductance achieved with MOS devices at low current levels. Second, they can be adjusted to regulate the drain current so that the temperature coefficient of the gate-to-source voltage is approximately zero. Resistors R_3 and R_4 form a 2:1 negative-feedback potential divider, which sets the closed loop gain at 2. Resistor R_5 is shunted by C_1 to assure stability. If the negative capacitance control potentiometer, R_6, is overadjusted, the circuit will oscillate, but if the circuit is adjusted for critical damping, then it is stable.

A common technique often used to reduce the effects of input capacitance is bootstrapping; unfortunately, this technique cannot compensate for source capacitance when it is not accessible. Using the amplifier in a particular application, it was determined that an inaccessible input capacitance of approximately 5 picofarads existed. After adjustment of the negative capacitance control, an effective input capacitance of 0.4 picofarad was measured. This is an effective reduction of input capacitance by more than an order of magnitude.

Notes:

1. Although MOS field effect transistors exhibit 10–20 db greater noise levels than junction field effect transistors, other considerations, such as the acceptance of extremely low current, noncritical adjustment, ease of temperature compensation, and small size favor the use of the MOS transistor.
2. Although the preamplifier was designed for use with intracellular microelectrodes, it should be applicable to a wide variety of measurements, especially where stable wideband dc amplification from high impedance sources is required. Such applications would include their use as a pickup plate video amplifier in storage tube tests and for pH and ionization chamber measurements.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B66-10549

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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