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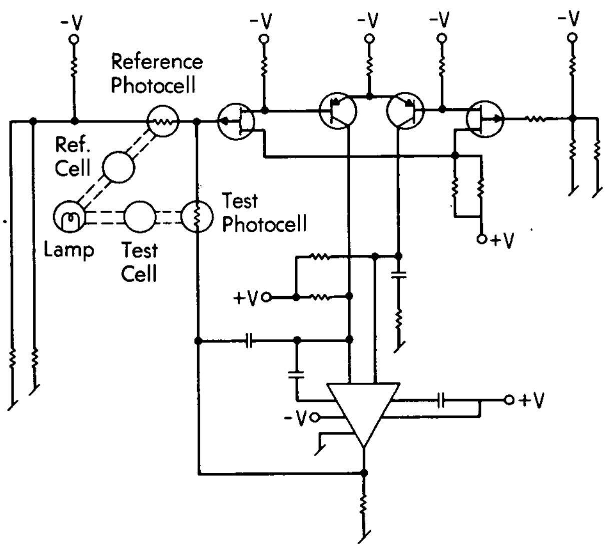
Stable Photosensor Amplifiers

The problem:

To minimize common mode effects in a differential amplifier arrangement which processes signals from two high-impedance photosensors.



The solution:

Connect one photosensor in the feedback loop of the amplifier and use field-effect transistors in the input circuit.

How it's done:

The operational amplifier arrangement was developed for use in the JPL "Biosatellite Urinalysis Instrument;" it is part of the system designed for the remote determination of creatinine in the urine of small animals. The amplifier processes data generated by cadmium sulfide photocells as they view light transmitted by solutions; appropriate filters are used to enhance the sensitivity of analysis as is commonly done in analytical procedures based on photometry. As reference, a cuvette containing only the reagent solution used for the analysis is illuminated by the common light source (a lamp); light transmitted by the cuvette is sensed by the reference photocell. The reference photocell serves as one input source to the positive terminal of the operational amplifier that is set up to operate in a differential mode. The test photocell, which receives light through a cuvette containing a colored solution formed by reaction of creatinine with the reagent, is connected in the feedback loop of the amplifier.

The overall arrangement is thus seen to be the familiar filter photometer in wide use in chemical laboratories. However, since the impedance of the resistive photosensors used in the flight instrument is fairly high (from 100 to over 300 megohms), two field-effect transistors (FET) operating as a high impedance differential input stage are used to couple the photosensors to the relatively low input impedance of the operational amplifier. The input FET's are of primary concern since they can be major contributors to output voltage drift caused by local and ambient temperature changes. Because the input stages are not preceded by any voltage gain, bias changes due to temperature fluctuation will appear at the output just as though there had been a change in reference voltages. The matched FET's operating in differential mode minimize initial offset of the gate-source voltage, and the effects of changes in drain current values are also held at a minimum by biasing each FET at its zero-temperature-coefficient voltage; since the devices are matched, the bias point is very

(continued overleaf)

nearly the same for both transistors (about +1.5 V at 150 microamperes). The two FET's are biased in a manner which places their drains close to ground and provides optimum coupling to the integrated-circuit operational amplifier. Dual NPN transistors are used to shift the drain voltage to zero, that is, the optimum value for the operational amplifier.

Stability of the light source is of great importance; hence, a power supply with a regulation of better than 0.01% was used. The photocells are screened for matched characteristics with respect to temperature and resistance excursions; matching was effected to better than 1% for both parameters. Moreover, the entire circuit was operated at the Q-point in the voltage-transfer curve, that is, the point where changes in test cell resistance cause no change in output voltage.

Notes:

1. A variation of this basic circuit has been developed for the fluorometric determination of calcium in spacecraft operations.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B72-10100

Patent status:

No patent action is contemplated by NASA.

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