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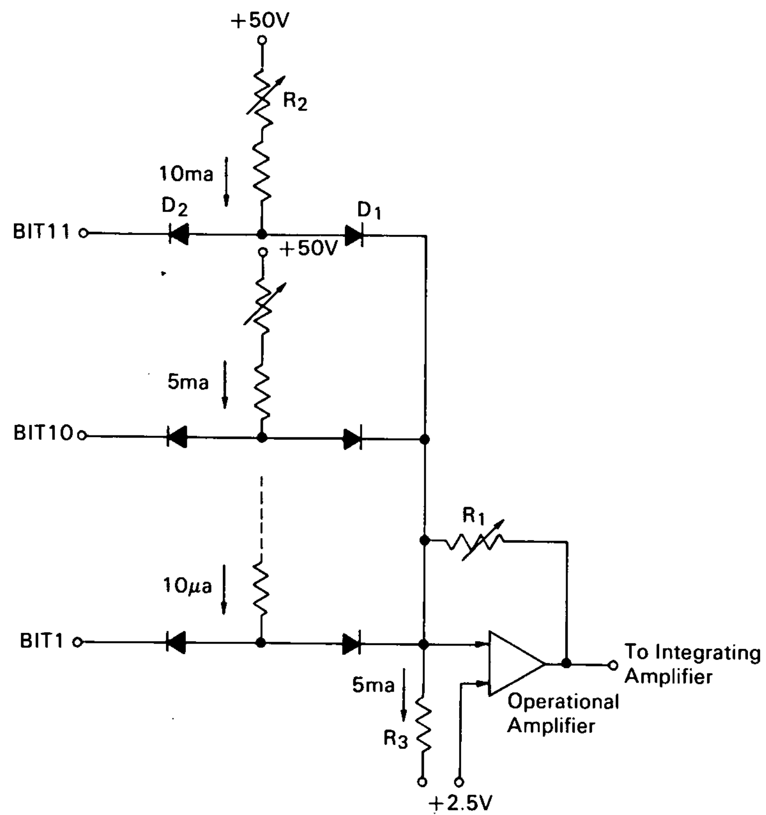
NASA TECH BRIEF

Digital-to-Analog Converter Operates from Low Level Inputs



The problem:

To control a voltage controlled oscillator from computer output binary data representing a rate at which the oscillator is to change. The computer derived rate number is held in a buffer that is periodically read out into a digital-to-analog (D/A) converter. The buffer register uses integrated circuits not capable of driving conventional D/A converter circuits without prior amplification.

The solution:

A circuit that operates with low level output devices such as integrated circuit registers and devices with somewhat variable output levels. Normal transition level is +2.5v so that if the flip-flop register output voltage at any binary order position is less positive than +2.5v, the "zero" state exists at the input to the D/A converter; if the register output voltage is more positive than +2.5v, the "one" state exists.

(continued overleaf)

How it's done:

A standard reference power supply of 50v is used for the reference source. By means of selected resistors in the input branches, the current in each succeeding branch from bit 1 to bit 11 is doubled as an initial calibration of the current input to the operational amplifier.

As the illustration shows, the converter contains multiple binary scaled current sources (bits 1 through 11) that are summed by the operational amplifier. Each of these sources has two steering diodes, D_1 and D_2. Diode D_1 directs current flow to the operational amplifier and D_2 directs current flow to the driving circuit. If the input voltage is less positive than +2.5v, current is steered by D_2 away from the operational amplifier and into the driving circuit. If the input voltage is more positive than +2.5v, D_2 is back biased and D_1 steers the current into the operational amplifier where its binary value contributes to the output dc voltage. Amplifier gain is adjusted by R_1 from +5v to −5v over the complete range of code inputs. Bias is set for a constant +2.5v at the amplifier input by external means. The D/A converter is calibrated by adjusting R_2 in each branch for monotonic operation.

A major portion of drift and voltage uncertainty versus temperature variation is due to the variable voltage drop across the steering diodes leading to the operational amplifier. For example, in the most significant bit position, a 50 mv change is equivalent to one whole code increment change. This effect diminishes by a factor of two for each successive lower order bit position. To minimize this condition, the operational amplifier steering diodes in the four most significant bit positions (bits 8, 9, 10, and 11) are metal silicon hot carrier diodes with low barrier potential to minimize drift due to temperature variation. The voltage drop temperature coefficient of these diodes approaches zero for currents in the vicinity of 10 ma. At low currents the temperature coefficient is much less than that of the silicon junction diodes used in the other steering positions.

Notes:

1. The low level operational capability of this D/A converter makes it suitable for commercial computer and control applications involving integrated circuitry.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B67-10357

Patent status:

No patent action is contemplated by NASA.

Source: Robin A. Winkelstein
(JPL-907)