Enclosing diode in op-amp feedback loop zeroes distortion in transmission gate

A transmission gate, built around an ordinary junction diode connected in the feedback loop of a voltage-follower, virtually eliminates distortion and the need for adjustments. Moreover, the gate, which requires only low-cost components, has extremely high off-state isolation, a frequency range that stretches from dc to the limits of the op amps used, and no pedestal.

Diode D_1, the key element in the circuit (see fig.), gates the signal, passing it when forward-biased, blocking it when back-biased. Amplifier A_1, which includes D_1 in its feedback loop, serves as a voltage-follower, while amplifiers A_2 and A_3 serve as comparators, simply controlling the bias that switches D_1. Including the gating diode in A_1's feedback loop compensates for the diode's nonlinear forward-conduction characteristic, so distortion is very low.

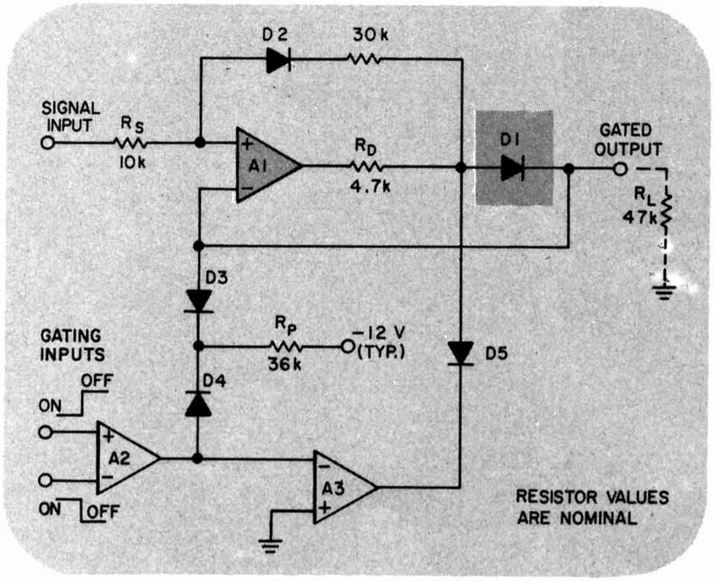
The circuit gates on when comparators A_2 and A_3 reverse-bias diodes D_4 and D_5. As soon as D_4 becomes reverse-biased, resistor R_P pulls down the inverting input of A_1 through diode D_3, causing a positive output from A_1 to forward-bias gating diode D_1. While the circuit is gating on, a transient may appear at the output. Its size depends on how quickly A_1 gains control of the feedback loop and settles.

When the circuit gates off, A_3 and D_5 pull down the anode of D_1, back-biasing it. Diode D_4 removes the pull-down bias from the cathode of D_1, so there is no pedestal. Diode D_2 and the 30-kΩ resistor keep A_1's output low, so A_1 will not load down A_3 through D_5. During the circuit's transition from on to off, the diode capacitances of D_1 and D_3 combine to cancel any switching spikes. Cancellation improves when A_3's propagation delay is short—D_1 and D_3 are driven almost simultaneously.

For positive swings of the input signal, A_1 pulls up the output through D_1. For negative swings, R_P pulls the output down through D_3.

If the load impedance is low and the gate is handling large signals, the circuit clips negative peaks first, since the load is driven by resistor R_P. When the circuit is to gate large signals, then, the load should have a fairly high impedance.

Off-state isolation can be extremely good. In fact, it is limited by the stray impedance of the board on which the circuit is built, instead of by leakage through the components. Since both the signal input and the circuit's output appear at the inputs of A_1, this amplifier's differential input impedance has a major effect on off-state isolation. Op amps (like the 741) that have inputs whose differential impedance increases as differential input voltage increases give extremely good off-state isolation.



A diode (D_1) connected in the feedback loop of a voltage-follower (A_1) passes signals with very little distortion. The circuit provides very high off-state isolation, and there is no switching pedestal.

Other op amps, however, including some video types and especially those with back-to-back protective diodes across the inputs, have a differential impedance that decreases substantially as differential voltage increases. Getting good isolation with such op amps may require putting Schottky diodes in series with the op-amp inputs. Moreover, with MOS op amps, high-value bleeders (on the order of 100 MΩ) may be needed to keep the Schottkys in conduction during signal swings.

The off-state feedback through diode D_2 could latch up A_1 if it is a video op amp. Input series diodes lessen the likelihood of latchup, but some care should be taken with the amount of positive feedback used.

Applications are numerous, including muting, signal selection, turn-on thump suppression in high-quality audio systems, and even video switching.

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