Author: Tamara I. Ahrens

Diodes have long served as adequate rectifiers despite necessarily large input voltages and poor accuracy. The most common configuration for a simple diode peak detector (Figure 1) provides a mediocre 10% error for very large input voltages (Figure 2). If the diode is linearized, the necessary input voltage is only reduced to 1V peak for the same 10% error (Figure 2). However, development of high frequency op amps allows feedback circuitry to provide better accuracy and more sensitivity at the input. With feedback (Figure 3), peak detection is feasible at input voltages as small as 50mVrms.

Function of Feedback Diode Circuitry

The input stage consists of a high frequency op amp whose output is fed into both a diode (D1), which functions similar to the diode of a simple peak detector, and a clamping network, which limits the negative output swing of the forward op amp. The output of the diode (D1) is connected to the storage capacitor and is also fed back to the input through a buffer. A storage capacitor of 0.1µF is recommended for peak detection at audio frequencies. A small resistance is shown in series with the storage capacitor to isolate it from the feedback loop. The smallest functional value is recommended for minimal peaking and maximum bandwidth; 10Ω is suggested. A bleed current is necessary to allow the output to relax for a smaller input or in the absence of an input. 20µA, small enough to avoid deteriorating the output value substantially, but large enough to dominate the bias current of the feedback buffer, was chosen. The output of the buffer is fed back to the negative input of the forward op amp through a resistor. This resistor buffers the emitter of the pnp transistor of the clamping network from the low impedance at the output of the buffer. Please note: a compensation capacitor on the forward op amp may be a necessary addition to ensure stability and the output of the entire peak detection circuit must be buffered to prevent a disturbance in performance.

Clamping Network

The diode (D2) of the clamping network is always held on by the current source. For voltage signals greater than the peak held at the output, the forward, rectifying diode (D1) is conducting, the output voltage is raised to match the input voltage, the buffer feeds that voltage back around to the negative input of the forward op amp, and the emitter of the pnp transistor is held at the same voltage as its base, keeping it off and eliminating the second feedback loop.

For voltage signals less than the peak held at the output, the rectifying diode (D1) is off. The emitter of the pnp transistor is set as high as the output voltage by the buffer through the

1kΩ resistor while the base is pulled down by the output of the forward op amp through the feedback diode (D2). The 270Ω resistor adds a 0.3V bias to the base of the transistor producing a charge-discharge current ratio of 10,000:1. When the transistor turns on, a crude unity gain feedback loop is completed through the clamping network (from the output voltage, down a diode drop and up the base-emitter diode of the transistor, to the input voltage) and a voltage drop builds across the 1kΩ resistor. This clamping action minimizes the recovery time of the circuit. Since the clamping network works like a unity gain buffer for inputs less than the peak voltage, the output needs to slew less than one diode drop to turn on the rectifying diode (D1) for inputs greater than the peak voltage. In this manner, the clamping network prevents the forward op amp from exhibiting open loop behavior and railing negative for inputs less than the peak voltage. This greatly reduces the slew rate necessary to achieve a desired bandwidth.

Amplitude Considerations

This circuit has the ability to function with amplitudes 30 times smaller than a simple diode peak detector. The EL2244 has an open loop gain of 60dB, raising smaller input signals enough to be detectable by the diode. The smallest amplitudes recoverable will be determined by the noise amplified within the circuit. For the given circuit, this limit is approximately 30mVrms input voltage. The largest amplitudes allowable will be determined by the input constraints of the op amp. For the EL2244 at ±5V supplies, the maximum input range is approximately ±3.5V.

Frequency Considerations

If 5% errors can be tolerated, this circuit has a bandwidth of 100kHz (Figure 4), making it ideal for audio applications. A great deal of small signal bandwidth and large slew rates are necessary to swing quickly through the dead zone at the output of the first op amp and these quantities limit circuit performance.

Thus, for a handful of inexpensive parts, a drastic improvement can be made in the performance of a peak detector over that of a simple diode. With the utilization of modern, high-speed op amps, the feedback diode peak detector offers almost two decades of input voltage range improvement while maintaining functionality into the megahertz range.

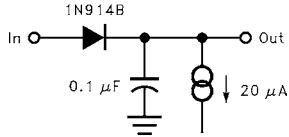Note: Reprinted from Electronic Design, June 26, 1995.
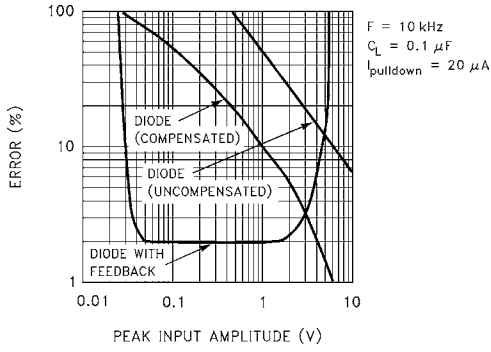
FIGURE 1. SIMPLE DIODE PEAK DETECTOR
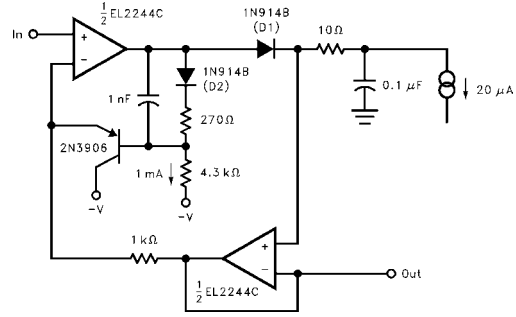

FIGURE 2. ERROR vs AMPLITUDE

FIGURE 3. DIODE WITH FEEDBACK
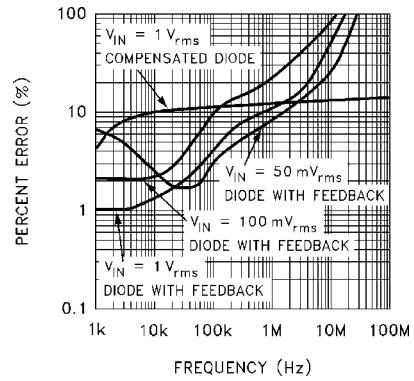
FIGURE 4. ERROR vs FREQUENCY

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