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Extend RMS-to-DC Converter's Range

by Mark Murphy and Jeff Smith

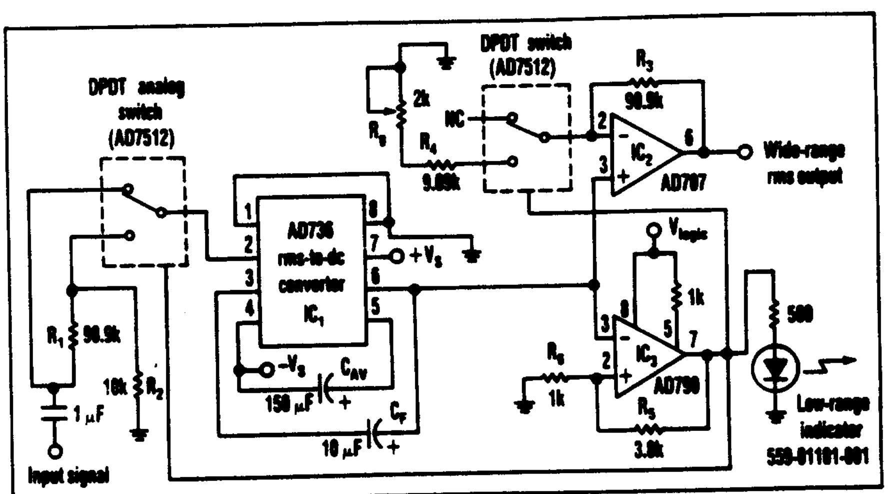
Comparator hysteresis can extend the dynamic range of ac signal measurement by autoranging an rms-to-dc con verter. A circuit can be built with a dynamic range of 80 dB or more, and can resolve input signals from 1 mV to 10 V with less than 1% total error *(Fig. 1)*. The circuit also maintains high accuracy while measuring various input waveforms with different crest factors, including variable duty-cycle pulses. The autoranging method can be utilized in other signal-processing applications as well.

The AD736 rms-to-dc converter is a 1-V, full-scale device. Voltage comparator IC_3 can increase the full-scale input range to 10 V automatically. When the rms-to-dc operating range is exceeded, the comparator's hysteresis switches in an attenuator at the rms-to-dc converter's input. Concurrently, it adds a gain stage to the circuit's output-buffer amplifier, maintaining a steady output voltage.

The comparator has two stable overlapping output states. The lower hysteresis-transition point is set at 90 mV, while the upper point occurs at 1 V. This minimizes the situations in which a varying input waveform produces a confusing or unstable output state. The comparator's logic-high output is typically 4.8 V. Resistor-divider network R_5 and R_6 attenuate the output by a factor of 4.8, setting the noninverting input to 1 V. Similarly, the comparator's logic-low output is typically 0.44 V, setting the noninverting input to about 90 mV.

For input signals within the 100-μV to 1-V-rms operating range of IC_1, the state of the switches is such that the rms-to-dc converteris driven directly from the input signal and IC_2 operates as a unity-gain follower buffering the output of IC_1. When the inverting input to the comparator exceeds 1 V rms, its output goes low. The analog switches are active low, attenuator network R_1 and R_2, and the gain stage consisting of R_3, R_4, and R_9, are switched on.

R_1 and R_2 attenuate the input signal by a factor of 10. This means that inputs between 1 and 10 V now fall within the normal operating range of the rms-to-dc converter. The AD736's output is then amplified by 10 and the true rms value of the input signal is retained. When the output signal drops below 900 mV rms, the output of IC_1 falls below 90 mV, coming within the typical range of the



1. THE DYNAMIC RANGE of ac signal measurement can be extended by autoranging an AD736 rms-to-dc converter through comparator hysteresis.

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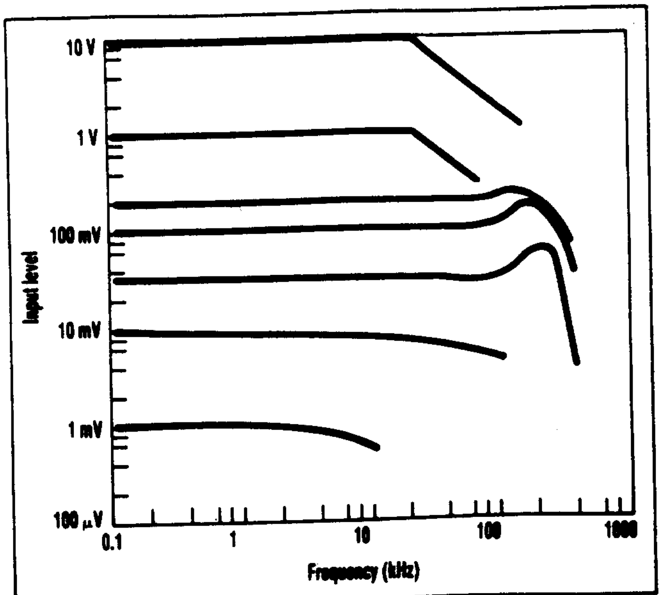
rms-to-dc converter again. Then, the comparator's output goes high, the input attenuator is bypassed, and the output-buffer amp functions as a voltage follower.

Due to the circuit's attenuation, the frequency response for 2 V acts similar to that of 200 mV, and 10 V acts like 1 V *(Fig. 2)*. This helps to improve the frequency response of large input signals. The low frequency cutoff (–3 dB) is 20 Hz. With the capacitor values shown, the rms converter's settling time is 360 ms for a 1-V symmetrical sine-wave input; the settling time is greater for input signals of decreasing amplitude. Settling time improves to 36 ms when $C_{av} = 15\ \mu F$ and $C_f = 1\ \mu F$. The low-frequency cutoff rises 200 Hz.



2. THE FREQUENCY RESPONSE of large input signals improves because the signals are attenuated by a factor of 10. For example, the frequency response for 10-V inputs is the same as for 1-V signals.

All measurements shown in the figure are for sine-wave inputs, and all voltage specifications are peak values. The circuit is calibrated using a sine-wave input greater than 1 V rms. The relationship between peak and rms value is given by:

The rms value of an untrimmed sine wave = $V_{PEAK}/\sqrt{2}$.