CIRCLE 520

AC VOLTMETER HAS UNIQUE FEATURES

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Though it's built with standard components, this ac voltmeter contains many features not typically found in commercial meters; the most unusual is a selection of rectification modes. The meter responses available include true RMS (TRMS), average, RMS-calibrated average responding, positive peak, negative peak, positive-peak hold, and negative-peak hold.

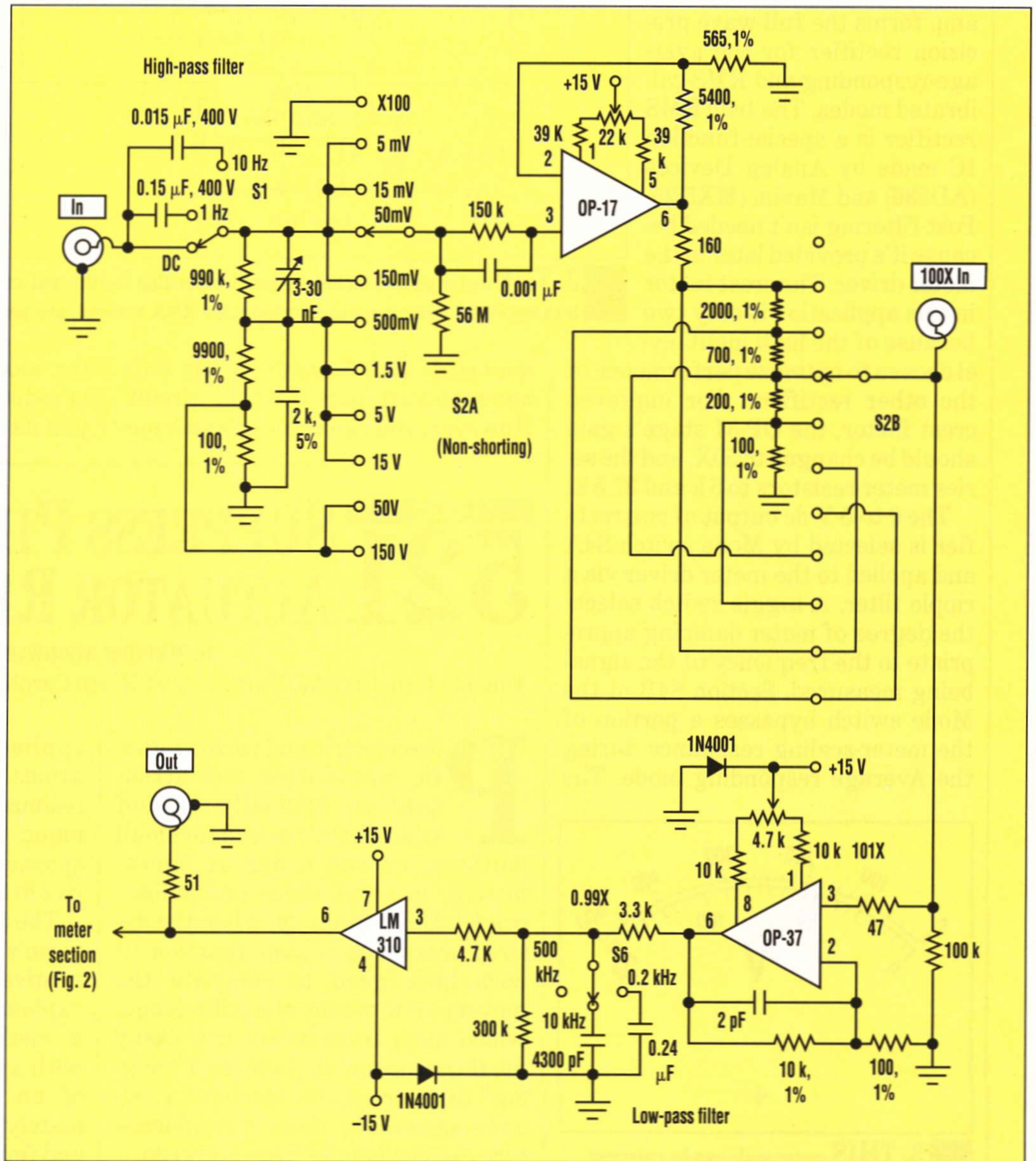
Being able to select meter response has several key advantages, such as increased accuracy with unusual waveforms (in the TRMS and peak modes), and reproducibility of published readings (made with a specific meter type). The worst-case bandwidth for 0.5-dB error is 120 kHz (in the average-responding mode; in the TRMS mode, bandwidth is about 200 kHz).

High- and low-pass filters (S1 and S6, respectively) allow the –3-dB passband to be varied from as little as 10 Hz to 200 Hz, to as wide as dc to 500 kHz *(Fig. 1)*. The low-pass filter also is effective in the 100X amplifier mode, where the input equivalent noise level is only 0.3 μV, with 10-kHz roll-off.

Range selection is accomplished by a split attenuator. The first attenuator section (S2A) divides by 1, 100, or 10 k. Only the ÷100 position requires a compensation trimmer; the 100-Ω output impedance of the ÷10-k divider is too low to require capacitive compensation. The OP-17 input amplifier's gain is an unconventional 10.55X for two reasons: It permits gain setting by standard 1% value resistors, and allows a series resistor (160 Ω) to protect the op amp in case the 100X input jack is shorted while the range switch is set to the 5 mV, 500 mV, or 50 V position. The 160-Ω resistor and 3-k output attenuator (S2B) produce a gain of 0.95 that restores the combined op-amp/attenuator gain to 10.00X.

A similar technique is used for the OP-37 main amplifier: The 3.3-k resistor at its output serves as both the resistive element of the lowpass filter, and as part of a 0.99X gain divider to reduce the op amp's 101X gain to an even 100.00X. This stage and the entire circuit are dc-coupled for maximum low-frequency response; thus offset-adjustment potentiometers are provided for each op amp.

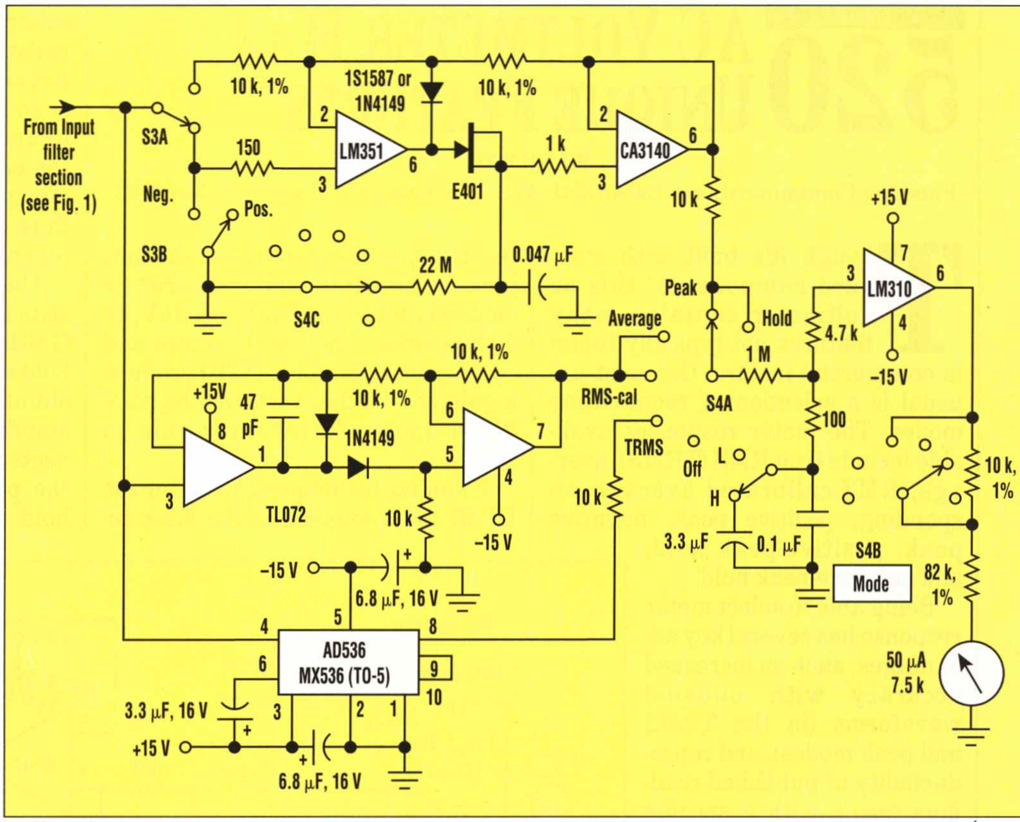
The peak-responding rectifier consists of an LM351 input driver and a CA3140 MOSFET op amp for the hold stage *(Fig. 2)*. A 22-MΩ resistor shunts the hold capacitor for the standard peak modes, but is disconnected by the Mode switch (S4C) for the peak-hold modes. To maximize hold time, a Siliconix E401 FET is



1. THE input section of the ac voltmeter comprises a high- and low-pass filter, and an attenuator to set the scale (switch S2). The output of this section feeds the meter section, shown in Fig. 2.

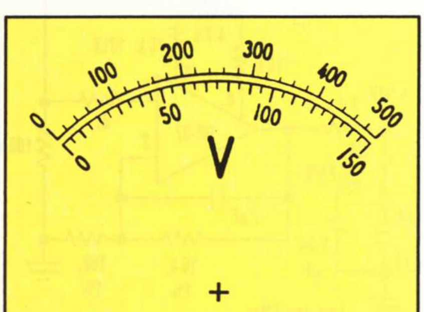
used as an inexpensive way to secure an ultra-low leakage diode. Similarly, the 0.047-µF hold capacitor must have a low-leakage, low-soakage dielectric, such as polystyrene or polypropylene. The construction technique at this point is important. Both ends of the 1-kΩ resistor and its attached components should be "air supported" to eliminate the effects of board leakage. Peak polarity is determined by whether the DPDT switch S3 sets up the input driver as an inverter (negative peak) or a non-inverter (positive peak).

The TL072 dual-FET op amp forms the full-wave precision rectifier for the average-responding and RMS-calibrated modes. The true RMS rectifier is a special-function IC made by Analog Devices (AD536) and Maxim (MX536). Post-filtering isn't needed because it's provided later in the meter driver. The crest factor in this application is only two because of the high input level chosen to optimize performance of the other rectifiers. For improved crest factor, the OP-37 stage's gain should be changed to 50X, and the series meter resistors to 5 k and 37.5 k.



2. THE **meter section includes a peak-responding rectifer and an E401 FET used as an ultra-low leakage diode. Meter responses include true RMS, average, and positive/negative peak.**

The 0-to-5-V dc output of one rectifier is selected by Mode switch S4A and applied to the meter driver via a ripple filter. A toggle switch selects the degree of meter damping appropriate to the frequency of the signal being measured. Section S4B of the Mode switch bypasses a portion of the meter-scaling resistance during the Average responding mode. The dual-scale (1.5/5) meter is the only non-standard part in this circuit. However, you can use any 50-µA meter, along with the scale in Figure 3 (a reducing/enlarging copier can adjust its size to fit your meter).□



3. THIS **meter scale can be enlarged on a copier and attached to a meter face for the dual-scale ac voltmeter.**

CIRCLE 521

Suppress Piezo-Actuator Resonance

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Piezoelectric and piezomagnetic transducers and actuators are typically applied when there's a need for small motions, on the order of micrometers, in short times (submilliseconds). Unfortunately, when the desired motion is a step function, it does little good to complete the movement in tenths of a millisecond, which such transducers can easily do, if the movement induces a "ringing" that persists for tenths of a second—something these transducers *also* can easily (and frequently) do.

Of course, a low-pass filter can be used to "soften" the driving signals applied to the actuators, which avoids exciting those troublesome resonance modes. But, that technique compromises the speedy response that makes piezos so attractive in the first place.

The circuit avoids squandering the piezo's speed while evading the disruptive ringing *(see the figure)*. It exploits the physical principle that if a mechanical resonator is driven with a stair-step function consisting of an intermediate level approximately halfway between the initial and final drive values with a duration equal to half the period of the resonator, overshoot and ringing will be