# BUILD DIRECT READOUT IC FREQ METER

LOW-COST DIGITAL LOGIC IC'S ALLOW EASY CONSTRUCTION OF 5-RANGE METER COVERING THE SPECTRUM FROM 5 HZ TO 1.0 MHZ

**By DON LANCASTER**


EVER DREAM of owning a good frequency counter? The $500-and-up instruments are tops for all sorts of experimental and industrial work, but the accurate clock and complex decoding circuitry they use puts them well out of reach of most experimenters. But how about a frequency *meter*? About $12 worth of semiconductors, integrated circuits, and other parts can put you in command of a five-range, linear scale meter, good from 5 Hz to 1 MHz. It has an input sensitivity of 30 millivolts r.m.s., accepts any waveshape with no loss of accuracy, and automatically calibrates itself simply by borrowing the 60-Hz reference belonging to the local power company. The integrated circuits and a printed board make it a snap to put together.

This frequency meter is perfect for checking the performance of experimental audio oscillators, tone generators, and square-wave signal sources, and is particularly handy if you're working with RTTY, FM multiplex decoders, tone-signaling circuits, or electronic musical instruments. It's a "must have" instrument for working with transistor or SCR power inverters when it comes time to set—and keep—the operating frequency right on 60 Hz, and it's useful for checking out the performance of engine-driven emergency power units.

Add an external oscillator, and the unit becomes an accurate LC bridge for determining the value of an inductance or capacitance. And, finally, you can make the meter count anything you can convert into repetitive electrical pulses by adding a small generator and a photoelectric pickup, or something similar; then the meter is an accurate, wide-range linear-scale tachometer.

**How It Works.** The input signals are amplified and inverted by transistor *Q1*, as shown in Fig. 1. This transistor drives a Schmitt trigger circuit (*IC1*) whose output snaps from ground to +3.9 volts the instant the input signal goes positive above a certain threshold level. The rise time of *IC1*'s output (from pin 6) is independent of the *shape* of the input signal, so a rectangular waveform of identical frequency to the input results.

Capacitor *C8* and resistor *R14* differentiate the square wave to produce a positive trigger pulse every time *IC1* snaps *on*. These pulses trigger *IC2* (a monostable multivibrator), which also snaps *on*, and stays *on* for a precise time interval determined by *R8*, *R15*, and a selected range capacitor (from *C9*

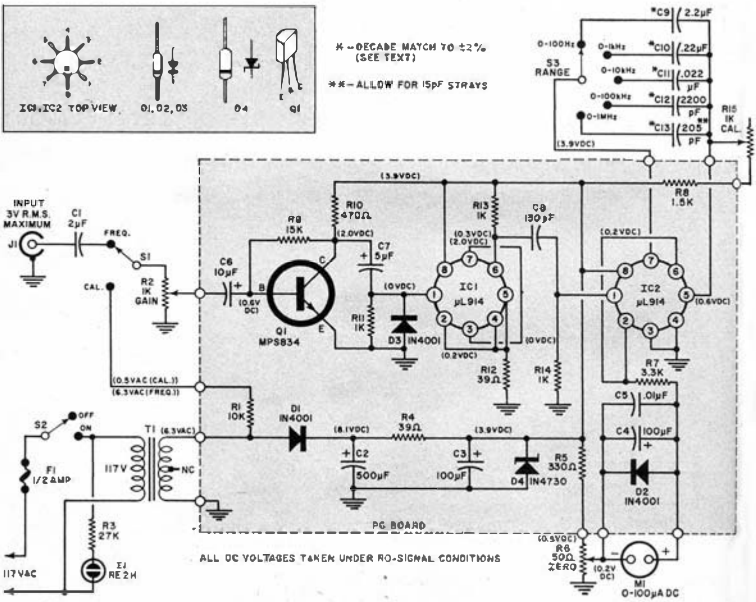



Fig. 1. Although only one transistor is shown, the two IC's contain five transistors and nine resistors. The circuit is self-checking from commercial power line through S1 (calibrate position) and resistor R1.

## PARTS LIST

*C1*—2-µF, 200-volt paper or Mylar capacitor (NOT an electrolytic)
*C2*—500-µF, 25-volt electrolytic capacitor
*C3*—100-µF, 15-volt electrolytic capacitor
*C4*—100-µF, 6-volt electrolytic capacitor
*C5*—0.01-µF, 50-volt Mylar or paper capacitor
*C6*—10-µF, 10-volt electrolytic capacitor
*C7*—5-µF, 10-volt electrolytic capacitor
*C8*—150-pF mica or disc ceramic capacitor
*C9*—2.2-µF, 50-volt Mylar or paper capacitor (NOT an electrolytic)*
*C10*—0.22-µF, 50-volt Mylar or paper capacitor*
*C11*—0.022-µF, 50-volt Mylar or paper capacitor*
*C12*—2200-pF Mylar, paper, mica, or disc ceramic capacitor*
*C13*—205-pF mica or disc ceramic capacitor (allows for 15 pF of stray and circuit capacitance)*
*D1, D2, D3*—Silicon diode, 200 mA, 50 PIV (1N4001 or similar)**
*D4*—Zener diode, 3.9 volts, 1 watt (1N4730A or similar)**
*F1*—½-ampere fuse (and fuse holder)
*I1*—Neon lamp
*IC1, IC2*—µL914 epoxy integrated circuit (Fairchild)**
*J1*—Phono jack
*M1*—0-100 d.c. microammeter, 4½" rectangular (Knight 52 A 7206, or similar)
*Q1*—Silicon transistor (Motorola MPS2923 or MPS834)**
*R1*—10,000-ohm, ½-watt carbon resistor
*R2, R15*—1000-ohm, linear-taper carbon potentiometer
*R3*—27,000-ohm, ½-watt resistor (may be a part of I1)
*R4*—39-ohm, 1-watt carbon resistor
*R5*—330-ohm, ½-watt carbon resistor
*R6*—30-ohm, linear-taper carbon potentiometer
*R7*—3300-ohm, ½-watt carbon resistor
*R8*—1300-ohm, ½-watt carbon resistor
*R9*—15,000-ohm, ½-watt carbon resistor
*R10*—470-ohm, ½-watt carbon resistor
*R11, R13, R14*—1000-ohm, ½-watt carbon resistor
*R12*—39-ohm, ½-watt carbon resistor
*S1*—S.p.s.t. slide switch (Wirt G323, or similar)
*S2*—S.p.d.t. slide switch (Wirt G324, or similar)
*S3*—Single-pole, five-position, non-shorting selector switch (Mallory 31151, or similar)
*T1*—Filament transformer, 6.3 volts, 0.6 ampere (Knight 54 A 1416, Stancor P6465, Thordarson 21F21, or similar)
1—1/16" x 2¾" x 3½" single-sided copper printed circuit board***
1—3-½" x 6" x 8" aluminum box (Bud CU-2109A, or similar)
*Misc.*—Line cord and strain relief, handle, knobs (3), rubber feet (4), PC terminals (11), mounting hardware for M1 and I1, wire, solder, etc.

* Accuracy of instrument depends directly upon accuracy with which C10 through C13 are exact decade submultiples of C9.
** A kit of all semiconductors is available from Hamilton Electro of Arizona, 1741 N. 28 St., Phoenix, Ariz. 85009, for $4.50, postpaid in USA. Stock #ZX-53.
*** The printed board in 1/16" etched and drilled G-10 fiberglass is available for $2.50 from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, Texas 78216. Most of the other parts as well as complete kits are also available—write to Southwest Technical for complete list and prices.

through *C13*). Each capacitor provides a time delay ten times that of its neighbor, resulting in five decade frequency ranges. *Calibrate* control *R15* sets the time delay to a value that causes a 60-Hz input signal to read exactly 60 on the 100-Hz range.

How *often IC2* snaps *on* is determined by the input frequency, while how *long* it stays *on* is determined by the range switch-selected capacitor. The ratio of *on* time to *off* time linearly increases with increasing frequency. Resistor *R7* charges up *C4* and *C5* (an integrator) to a voltage whose *average* value equals the ratio of *on* to *off* time. Meter *M1* then indicates this average voltage as frequency.

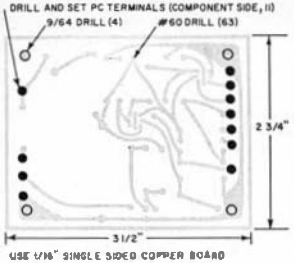
Zero control *R6* provides a small d.c. voltage to buck out the saturation effect of *IC2*, while *D2* protects the meter from overload if an input frequency higher than full scale is encountered. A conventional zener-regulated +3.9-volt d.c. supply is used. Switch *S1* and resistor *R1* route the 60-Hz power to the input for calibration.

The 100-Hz scale accuracy depends solely upon how closely you can read the meter, while the scale-to-scale accuracy depends upon how closely the range capacitors (*C9* through *C13*) are exact decade multiples. An accuracy of better than ±3% should be easily obtained with a quality meter and careful capacitor selection.

**Construction.** The two IC's together replace five transistors and nine resistors, which, if bought separately, would cost eight dollars, or well over twice that of the IC's, not counting the extra assembly time and trouble.

Buy (see Parts List), or etch, cut, and drill the printed circuit board and mount the components as shown in Figs. 2, 3, and 5. Watch the polarity on all semiconductors and electrolytic capacitors. On *IC1* and *IC2*, *make certain lead 8* (center lead of flat side, having a red dot) *goes to the +3.9-volt supply.*

Mount the meter, pilot lamp, *Range* switch *S3*, *Gain* control *R2*, input jack *J1*, *Zero* control *R6*, on/off switch *S2*, calibration switch *S1*, and calibration potentiometer *R15* on a suitable front panel as shown in the photo on page 53. Mount the PC board and the remainder of the components within the selected



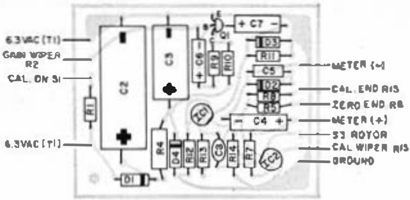




Fig. 2 (above). Drilling details for the printed board. Actual-size board is shown on page 98.

Fig. 3. (above, right). Component location on board, and connections to remainder of circuit.

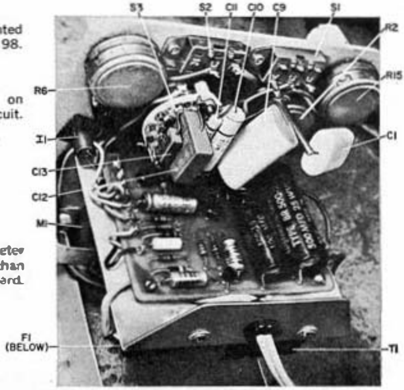



Fig. 4 (right). Interior of the frequency meter showing general location of parts other than those already mounted on the printed board.

metal enclosure. Use Fig. 3 as a guide for interconnecting the PC board with the remainder of the system.

The accuracy of the instrument on the four upper scales depends entirely upon how closely range capacitors *C10* through *C13* are exact decade submultiples of *C9*. One source of matched capacitors is given in the Parts List. Otherwise, by using an LC bridge, a quality oscilloscope, or a good audio oscillator, you can trim the capacitance (and therefore, the *on* time of *IC2*) so that the frequency indication on *M1* has exact scale-to-scale calibration.

When the capacitors are accurate, you'll have a correct frequency reading on *any* scale without having to retouch the *Calibrate* control, and with a power-line calibration, you can rest assured that all scales will be accurate.

**Operating Hints.** *Always turn the gain control fully counterclockwise before you make any measurement or connect the instrument to a live circuit*, or you might risk damage to *Q1*. Calibrate the instrument each time you use it by zeroing the meter (with front-panel *Zero* control *R6*), selecting the 100-Hz range, and setting the *Freq/60 Hz* switch (*S1*) to 60 Hz. Bring the *Gain* control up a quarter turn and adjust the meter to a steady "60" reading using the *Calibrate* potentiometer. Set the *Freq/60 Hz* switch to *Freq*, and you're all set to measure.

Keep the input amplitude under 3 volts r.m.s. maximum. If you're working with higher signal levels, add a resistive divider to cut the level down. You may safely connect the input to any d.c. level within the breakdown rating of *C1*.

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## IC FREQ METER

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Avoid pegging the meter by always starting one range *above* the frequency you want to measure. Best operation occurs when the *Gain* control is advanced ⅛th of a turn beyond the point where the meter first produces a steady indication.

For power inverter work, there's a different way to use the frequency meter. Calibrate the instrument against the 60-Hz power line and then plug the frequency meter's power line cord into the inverter, leaving the *Freq/60 Hz* switch in the *60 Hz* position. Now, read the frequency directly. The zener-regulated supply automatically takes care of any inverter voltage from 70 to 160 volts, at any frequency from 30 to 1200 Hz.

Fig. 5. Actual-size layout of PC board. Drill as shown in Fig. 2; mount components as per Fig. 3.

In cases where you're measuring pulses or other low duty cycle signals, you'll get best results with a narrow, *negative-going* input waveform.