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Analogue Frequency Meter

Directly indicates on a linear scale from 100 Hz to 100 kHz full scale in four decade ranges.

The Linear Scale Analogue Frequency Meter described in this article enables measurement of frequencies from less than 10 Hz to 100 kHz in four decade ranges. The instrument is easy to construct, low in cost and yet good in performance.

Input impedance of the meter is fairly high ($>$ 200k for inputs less than 500mV peak), and the instrument is sensitive enough to respond to input signals as low as 50mV peak. The input circuitry is diode protected against input voltages as high as 100 volts.

The frequency meter operates on a single 9-volt battery. Since battery drain is fairly low, even a small Eveready type 216, 9-volt battery offers a reasonably long service life.

Principle of operation

A block diagram of the instrument is shown in Fig. 1. Sketches of the waveforms available at different stages of the instrument are shown in Fig. 2, and the circuit diagram is given in Fig. 3.

The input signal is coupled via capacitor C1. Resistor R1 along with diodes D1 and D2 limits the input voltage to IC1, thus protecting the input circuitry against high level inputs.

IC1 is a CA3140 op-amp. This op-amp has been chosen for its high input impedance, low bias current requirement and good slew rate. It is wired as a non-inverting amplifier with an AC gain of 100 and functions as a preamplifier for low level input signals. The output of this IC is directly coupled to IC2.

IC2 is an NE556 dual timer integrated circuit. The first timer in this IC is connected as a schmitt trigger by tying together the trigger and threshold terminals. The output of IC1 is given to the junction of these terminals. When the amplified input voltage exceeds 2/3 V_{CC}, the schmitt trigger output (pin 5) goes low, and it goes high when IC1 output falls below 1/3 V_{CC}. Hence, the output of the schmitt trigger is a train of square waves at the same frequency as the input signal. With a 9-volt battery, the hysteresis of this schmitt trigger is 3 volts, and transferred to the input this represents a hysteresis of 30 mV.

The second timer in IC2 is connected as a monostable multivibrator. The schmitt trigger output is coupled via C4 and is used to trigger the monostable. At each trigger, the monostable outputs a pulse whose duration is determined by the timing capacitor C7 and the range resistance selected via range selector switch S1. Specifically, the monostable duration is given by $t = 1.1 \times R_{range} \times C7$.

Thus the monostable output is a series of pulses at the same frequency as the input signal but the monostable duration for any given range is fixed. Thus changes in the input signal frequency mean a change in the duty cycle. Now duty cycle $D = t/T$, and since $f_{in} = 1/T$, so $D = t \times f_{in}$. Hence the duty cycle is proportional to the frequency of the input

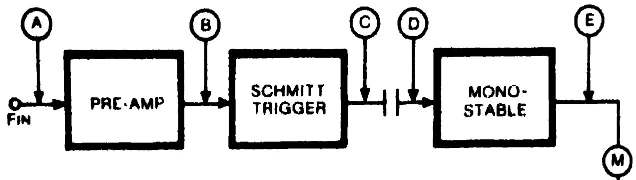

Fig. 1: Block diagram of analogue frequency meter.

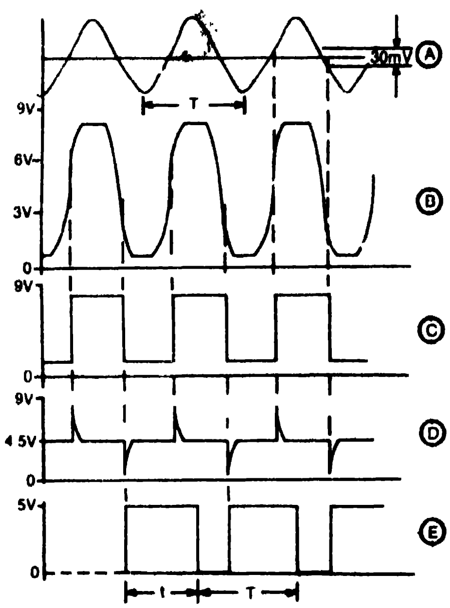

Fig. 2: Waveforms diagram.

PARTS LIST

Semiconductors:		
IC1		CA3140 operational-amplifier
IC2		NE556 dual timer IC
D1, D2		1N4148 silicon switching diode
D3		5.1V, 400mW zener diode
Resistors: (all ¼watt, ±5% carbon)		
R1	—	22-kilohm
R2, R3, R4	—	220-kilohm
R5	—	330-kilohm
R6	—	3.3-kilohm
R7a, R7b	—	33-kilohm
R8	—	560-ohm
R9	—	36-kilohm
R10	—	1-megohm, ±1% metal-film
R11	—	100-kilohm, ±1% metal-film
R12	—	10-kilohm, ±1% metal-film
R13	—	1-kilohm, ±1% metal-film
VR1	—	10k horizontal preset
Capacitors:		
C1	—	0.22µF, 250V ceramic
C2		4.7µF, 12V electrolytic
C3	—	22µF, 12V electrolytic
C4	—	33pF, 12V ceramic
C5, C6	—	0.01µF, 12V ceramic
C7	—	7.2kpF, 12V ceramic
C8	—	1000µF, 12V electrolytic
Miscellaneous:		
S1		2-pole, 5-way switch
M1	—	100µA, moving coil ammeter
Batt	—	9-volt, PP3 battery
	—	PCB, enclosure, battery clamps, test probe with socket, IC socket etc.

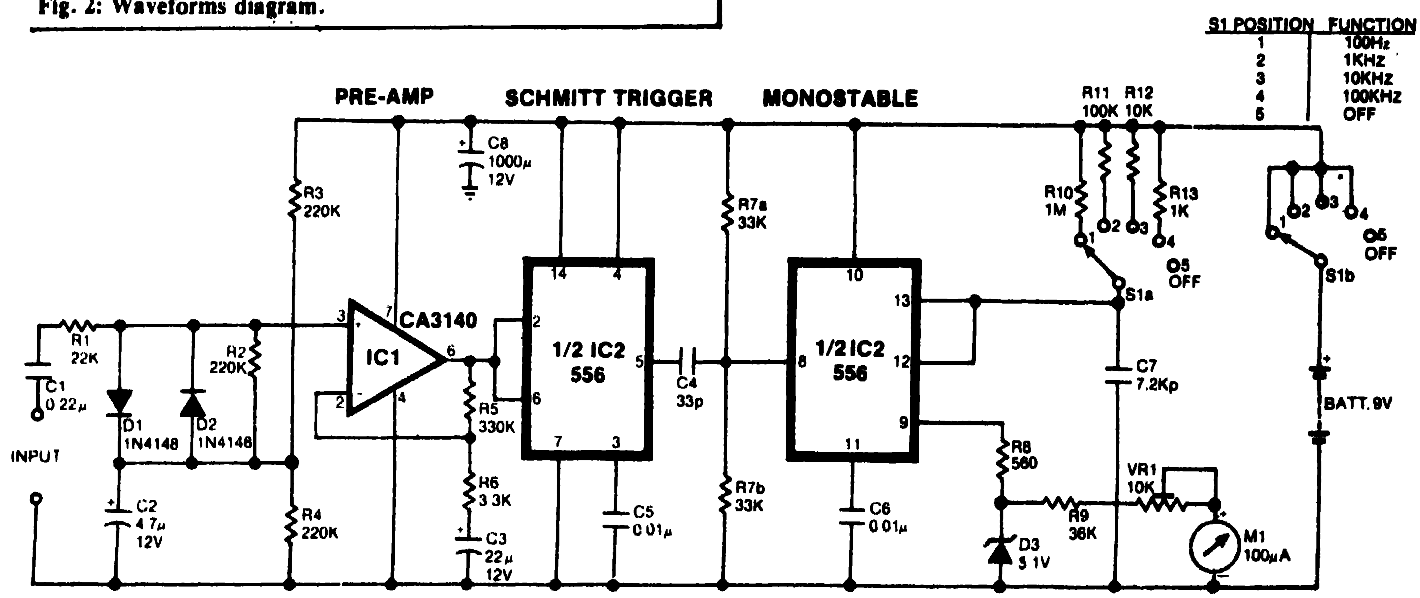

Fig. 3: Circuit diagram of the analogue frequency meter.

signal. Since the average DC level is also proportional to the duty cycle, it follows that the average DC level is proportional to the frequency of the input signal.

For proper operation of the monostable, the monostable triggering pulse should be of shorter duration than the monostable width. To accomplish this, the schmitt trigger output is differentiated by the C4-R7a-R7b network to provide a series of negative going triggering spikes at the same frequency as the input signal.

To avoid inaccuracies which may arise due to falling battery voltage, the monostable output is clamped at 5.1 volts by zener diode D3. 5.1-volt zener diodes have a low temperature coefficient and hence their breakdown voltage remains practically unaffected by temperature changes.

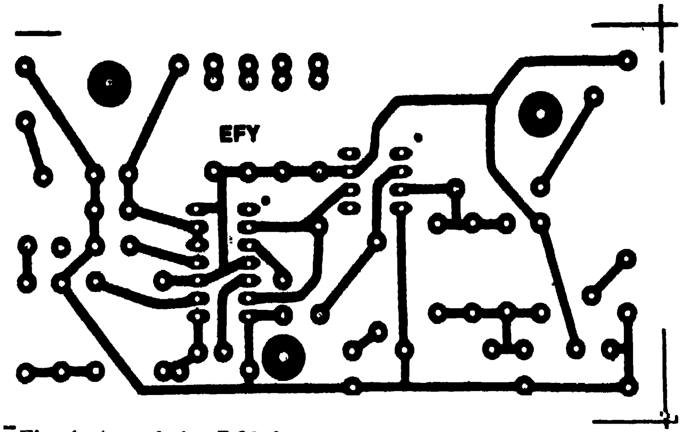

Fig. 4: Actual-size PCB layout.

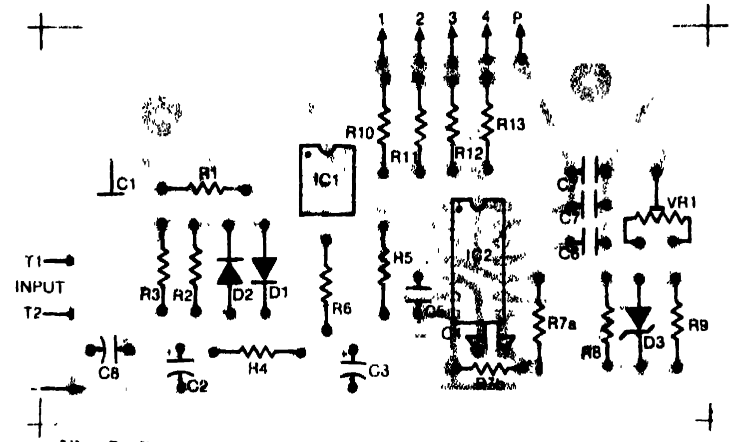

Fig. 5: Component overlay.

The output thus obtained is given to the 100μA moving coil type meter through the current limiting resistors R9 and VR1. In the meter, the current pulses from the monostable are averaged and the meter deflection, which is proportional to the average DC level, indicates the frequency of the input signal.

Construction

The circuit may be assembled on an IC type (2.55 mm) strip board. If available, the use of glass epoxy strip board is recommended.

For those who would prefer to etch their own printed circuit board, the printed circuit pattern (foil side) used in preparing the PCB of the prototype is shown in Fig. 4 and the corresponding component overlay is shown in Fig. 5. As before, the use of glass epoxy material for the PCB is recommended.

It is better to solder the integrated circuits directly onto the printed circuit/strip board rather than make use of IC sockets. No special precautions need be taken with IC2, this being an ordinary bipolar device. However the CA3140 is an MOS device and the precautions usual to the handling of these devices ought to be observed.

To facilitate easy and accurate measurements, a 100μA meter movement with a large mirror backed scale is recommended. Either screw type terminal binding posts or a BNC socket may be used for the input terminals. Range resistors R10 to R13 are metal-film, +1% tolerance types.

Calibration

If an accurate signal/function generator is available, it may be used to calibrate the instrument. Adjust for a level of about 1-volt peak and connect the generator output to the input terminals of the instrument. Switch to the appropriate range and adjust VR1 so that the meter indicates the correct frequency.

If an accurate generator is not available, the following calibration procedure may be adopted: Switch the instrument to the 100Hz range and connect to its input terminals the 6-volt or 9-volt secondary winding of a mains step-down transformer. Energise the transformer from the 230V, 50Hz mains and adjust VR1 for a 50μA meter reading.

Use

In use, it is always advisable to start with the highest range (i.e. 100 kHz) and work downwards until a reading is obtained beyond the lower 10 per cent of the scale. The instrument is automatically switched on via range selector switch S1(b) which is ganged to S1(a) when switched to any of the ranges 1 to 4, and switched off when the range switch is in the 'off' position.

S1 must be switched to the off position when the instrument is not in use to avoid unnecessary drain on the battery. When measurements are being made, the input terminals must not be touched as this could affect the accuracy of the measurement. Also, it is not advisable to power the instrument off the mains with an adaptor.

The approximate cost of the instrument, exclusive of a case and an indicating meter, works out to Rs 150. A suitable 100μA meter movement may be obtained for between Rs 150 and Rs 250, depending on its size and accuracy. □