

Simple analogue frequency meter features linear scale

This simple project is easy to build, inexpensive and should find many uses in the hobby workshop.

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THERE ARE MANY applications in the home workshop where simple audio frequency measurements are required. When experimenting with oscillators, building or repairing function generators etc, it is often handy to have some means of measuring frequency — accuracy to the last Hertz is not always required and thus a full-blown digital counter is not warranted.

This project will enable you to measure frequency from around 100 Hz right up to 100 kHz with an accuracy of a few percent. It is inexpensive to build but performance is quite adequate to meet a large number of needs in any hobbyist's workshop. Accuracy is unaffected by the waveshape of the signal being measured and the unit will accept signal levels as low as 200 mV. The input is fully protected against high signal levels and against dc voltages up to the rating of the input capacitor, C1. The input is also fully floating above earth — a useful feature.

The frequency meter may be powered from an internal No. 216, 9 V battery or from a Plugpack battery eliminator. A suitable dc socket may be installed on the rear of the cabinet.

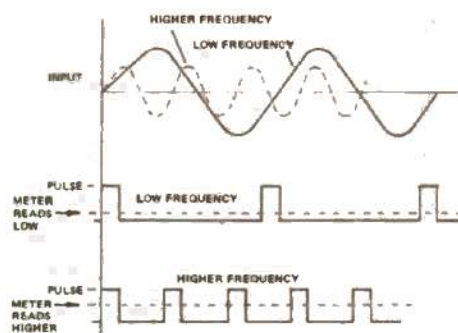
All components are readily obtainable, the moulded plastic case in which we housed the prototype is an item supplied by A & R Soanar and is available from many suppliers.

Circuit features

The circuit generates a series of short pulses at the same frequency as the input. These pulses drive a moving-coil meter the current through which will be the average amplitude of the pulse waveform; that is, it will integrate the pulses. This average will be proportional to the ratio of time the pulse is on to the time it is off. The time the pulse is on, that is — the pulse width, is fixed. At low frequencies, the time the pulse is off will be much, much longer than



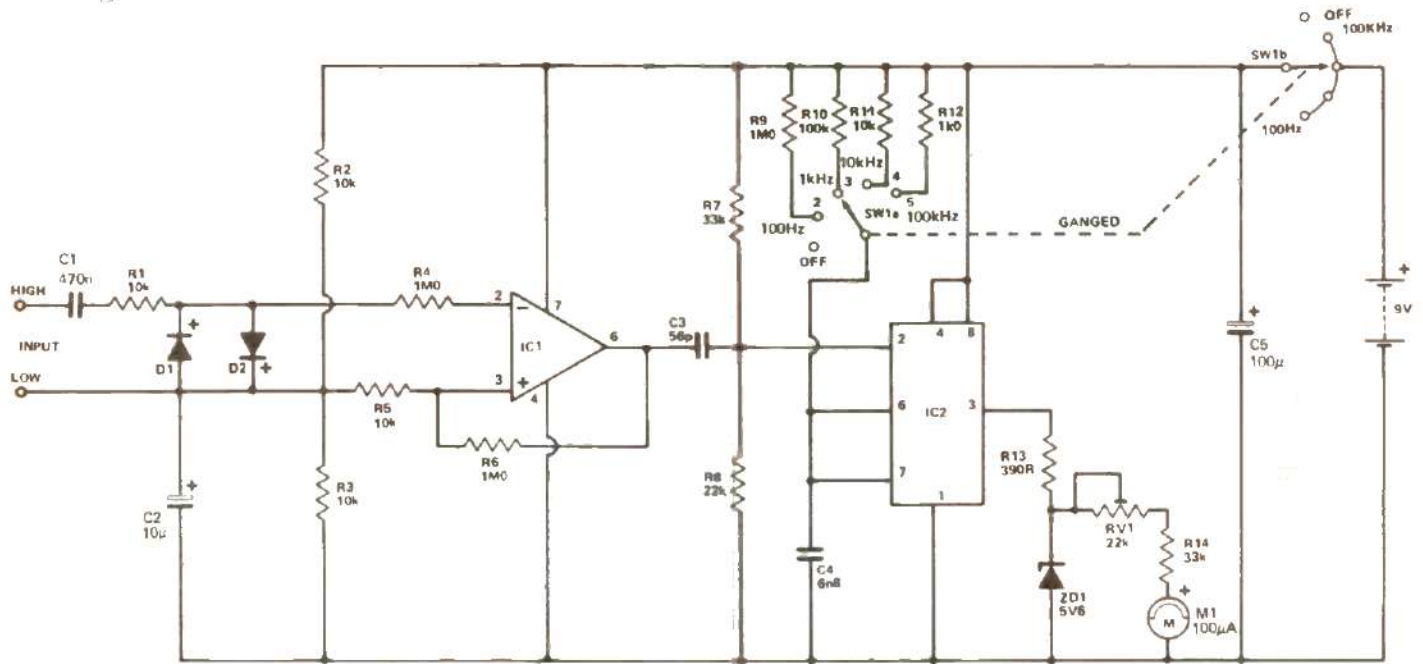
the time the pulse is on. Thus, the average current through the meter will be quite low. At higher frequencies, the time between pulses will be quite short and the average current through the meter will be quite a bit higher (As shown in the diagram). Thus, as the frequency of the pulses is proportional to the input frequency, the pulse on/off ratio, and therefore the meter current, will be proportional to the input frequency. The meter can be calibrated directly in frequency as the relationship is a linear one. We have used a 100



SPECIFICATIONS ETI 150

| | |
|----------------|--|
| Frequency | 10 Hz to 100 kHz in four decade ranges |
| Minimum input | 200 mV RMS |
| Maximum input | 250 V peak AC or DC (dependent on voltage rating of C1) |
| Supply voltage | 9 Vdc battery or Plugpack battery eliminator |

Project 150



microamp movement for convenience as it does not have to be re-scaled. The lowest range is 100 Hz full-scale deflection, the highest, 100 kHz.

Only two cheap IC's are used in the whole design a 3140 op-amp and a

555 timer. The 3140 amplifies and squares the input signal and was selected for its high slew rate, wide frequency response and high input impedance. The output of this stage will be a square wave of the same level for all

input signal levels and waveforms.

The pulses are generated by a 555 timer connected as a one-shot monostable giving a single pulse output for each input cycle. The monostable has four ranges giving decade scales on the meter. A fifth position on the switch is used as a power switch.

Regulation of the output pulses by a zener diode preserves the accuracy of the unit with falling battery voltage.

HOW IT WORKS - ETI 150

The circuit consists of an op-amp operated as a Schmitt trigger to amplify and square the input signal, followed by a 555 timer wired as a monostable, giving a short output pulse of fixed width for each cycle of input signal. This pulse drives a moving-coil meter, the reading being an average of the pulse amplitude, which is proportional to the pulse frequency. As the pulse frequency is directly related to the input frequency, the meter reading is directly proportional to the input frequency.

The input signal is coupled into IC1 via C1, which provides dc blocking. Protection from overload caused by high amplitude input signals is provided by a diode clipper consisting of D1, D2 and R1. The diodes are connected in an inverse-parallel arrangement so that both positive and negative peaks, above the diode forward conduction voltage, are clipped.

IC1 is a fast op-amp connected as a Schmitt trigger with amplification, as mentioned above. Resistors R5 and R6 provide hysteresis, a 'dead band' in the action of the Schmitt, centred on zero input level. This dead band ensures that the Schmitt ignores noise pulses.

As the unit is required to operate from a single supply, for convenience, R2 and R3 bias the input of IC1 at half the supply

voltage.

The output of IC1 is a train of square waves at the same frequency as the input. The output of IC1 is differentiated to provide short trigger pulses for the 555 timer, IC2. The differentiating network consists of C3, R7 and R8. This network is arranged to provide a trigger pulse that is always shorter than the output pulse of the 555. Capacitor C3 is selected to give the shortest possible pulse to the 555 consistent with reliable triggering.

The output of the 555 monostable will be a pulse of fixed width, determined by the range resistors, R9 to R12, and capacitor C4. The ranges are arranged to give a 75% output duty cycle at frequencies of 100 Hz, 1 kHz, 10 kHz and 100 kHz on the input.

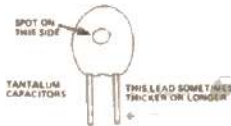
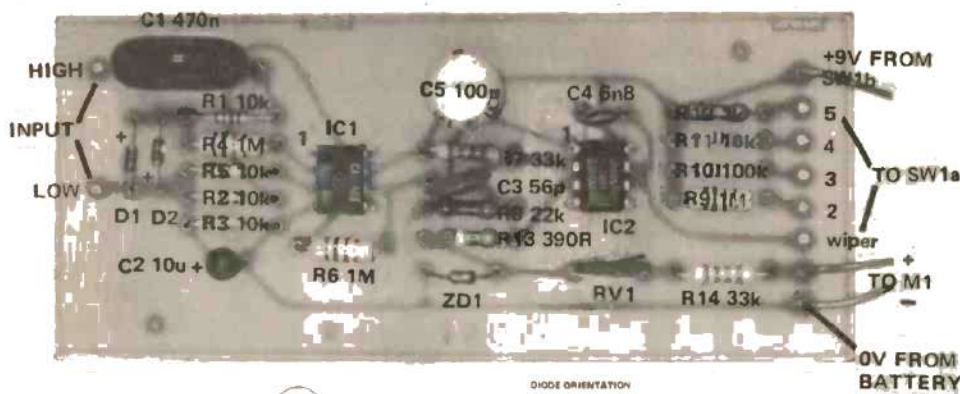
The output pulse from the 555 is clipped at 5.6 V by a zener diode, ZD1, to avoid inaccuracies caused by falling battery voltage (as the battery ages). The meter responds to the average value of the clipped pulses. As the frequency increases, the duty cycle (on/off ratio) of the pulse train increases, increasing the average voltage and thus the meter current in direct proportion. Thus the reading on the meter will be linearly related to frequency.

Construction

Even though this project is relatively simple, we strongly recommend you use the pc board - saves possible hassles!

As mentioned previously, we constructed our prototype in a commonly available plastic box. This has the advantage that the unit can be operated fully floating from earth - handy in some situations. Check placement of components on the front panel and the positioning of the pc board inside before commencing major assembly. It's probably best to assemble the components on the pc board first. Take care with the orientation of the ICs, diodes and tantalum capacitor.

The input capacitor, C1, can be obtained in several voltage ratings. Greencaps are available in ratings of 100 V, 250 V and 630 V. If all your work is with solid-state circuitry, a 100 V type will be more than adequate. If you anticipate using your unit with say, valve equipment, the highest rating type for C1 is recommended. The rating applies to the combined



The pc board pattern is on page 145.

capacitor (C3) may have to be increased in value to say 100p or 150p. This component has been selected to give a very short trigger pulse into the 555 and has been found to work correctly, using the value shown in the circuit, with several different ICs.

Using your meter

Selecting the 100 kHz range will connect power to the unit and the unknown signal can then be applied to the input. The reading and switch to a lower range if required. This procedure avoids the possibility of spurious readings that may be obtained on lower ranges due to re-triggering of the 555 by high frequency signals. There are no other adjustments, so all you need is something to measure.

This is the sort of instrument that, once you have it, seems to find a great many uses for itself!

dc voltage that may be present on the input, plus the possible peak value of the input signal.

A 630 V rated capacitor will be physically larger than a 100 V type and the leads may have to be shaped to fit the capacitor on the board.

Once the board is assembled, the major components can be assembled onto the front panel of the case. We made up a Scotchcal overlay for the front panel, to dress it up and give it a bit of a 'professional' look. Kit suppliers will probably have these available shortly after this issue goes on sale. Radio Despatch Service in Broadway, Sydney offer a special Scotchcal front panel service for projects so, if you are using a similar case you may have on hand, then they will be able to supply a front panel.

The meter, we used a University TD66 - but many other types are suitable, was mounted in a circular cutout on the left hand side of the panel. The range switch should be mounted next, followed by the input socket. After much discussion around the office ("A jack socket!", "No, screw terminals", "Rubbish! RCA socket" . . .), we settled on an RCA socket. It's a common item on audio equipment, inexpensive and coax cables terminated in RCA plugs, for input leads, are cheap and readily available.

However, any type of socket to suit your individual requirement will do equally well. If you use a metal box, the input connector earth must be the only connection from the circuitry to the case, as the negative rail from the battery is not at earth potential.

The pc board may be mounted anywhere convenient in the case and wires run to the front panel for the input and switch connections. Make sure the

board does not get in the way of the meter when the front panel is in place.

The unit may be powered from an internal battery, which makes it a handy portable unit. If you wish to operate the unit from a plugpack battery eliminator, then we recommend you purchase a unit giving a nominal 6 Vdc output. The current requirement for the project is quite modest and the output of these small battery eliminators is dependent on the load. A 6 V unit will typically deliver 9 V or so under a light load.

If you do decide to use one of these units, a socket matching the unit's plug will have to be mounted on the rear panel and leads run to the supply rail pads on the pc board. If you wish to have the option of both battery and mains operation, then a small SPDT toggle switch should be mounted on the rear panel also and wired into the circuit.

Calibrating it

Calibration of the frequency meter is very easy, aided by the fact that it has a very high input impedance.

With the unit switched to the 100 Hz range, touch your finger to the input. There will usually be enough 50 Hz field from the electrical wiring in a building to drive the input. This will cause a deflection on the meter and RV1 should then be adjusted to give a meter reading of 50 (half scale). Move the unit near house wiring to increase the amount of signal to the input if a reading cannot be obtained.

If a signal generator of known accuracy is available the instrument can be calibrated on any range. Only one range need be calibrated as the others will automatically fall into line.

If it is impossible to obtain any reading on the meter, the coupling

PARTS LIST - ETI 150

| | | |
|--|--|--------------|
| Resistors | | all 1/4W, 5% |
| R1-R3 | 10k | |
| R4 | 1M | |
| R5 | 10k | |
| R6 | 1M | |
| R7 | 33k | |
| R8 | 22k | |
| R9 | 1M | |
| R10 | 100k | |
| R11 | 10k | |
| R12 | 1k | |
| R13 | 390R | |
| R14 | 33k | |
| Capacitors | | |
| C1 | 470n greencap | |
| C2 | 10µ tantalum | |
| C3 | 56p ceramic | |
| C4 | 6n8 greencap | |
| C5 | 100µ 25V electrolytic | |
| Semiconductors | | |
| D1, D2 | 1N914 or similar | |
| ZD1 | 5V6, 400mW Zener diode | |
| IC1 | 3140 op amp | |
| IC2 | 555 timer | |
| Miscellaneous | | |
| M1 | 100µA meter, University TD-66 or similar | |
| RV1 | 22k min vert mounting trim pot | |
| SW1 | two pole five pos wafer switch | |
| Plastic box to suit (approx. 75 mm x 135 mm x 130 mm); input connector chassis mounting RCA socket or similar; knob, ETI 150 pc board. | | |