Audio prescaler for frequency meters

Multiplies frequencies from 25-100Hz by 100

Here is a neat solution to improving the resolution of a frequency meter when measuring low frequencies. The signal is multiplied one hundred times by the prescaler, without loss of accuracy, before passing on to the frequency meter. This enables the frequency meter to deliver three or four-digit resolution on low frequency readings.

by JOHN CLARKE

Well, why "prescale"? After all, digital frequency counters have no trouble measuring low frequencies. Well, there are really two problems in the measurement of low frequencies using run-of the mill digital frequency counters. The first of these has to do with "resolution", which refers to the smallest resolvable (ie, readable) unit of measurement. For a conventional digital counter, resolution is one Hertz. Now while a resolution of one Hertz is fine when you are measuring frequencies of 1MHz or more, it is poor when measuring frequencies below 100Hz.

The more expensive frequency counters overcome this problem by providing a facility for period measurement, so that high resolution (in terms of microseconds, usually) is then possible.

The second problem to do with low frequency measurement is that of accuracy. While, for high frequency measurement, the measurement accuracy is dependent mainly on the accuracy of the crystal derived timebase, for low frequencies it depends mainly on the "gating" time. For typical counters, the gating time is usually one second (maximum).

Depending on how the signal frequency being counted actually synchronises (or not) with the counter's gating periods, there may be a counting error. This usually amounts to plus one digit. For example, a one-second gating time and a 10Hz input signal may result in a reading of 10Hz or 11Hz.

Again, for high frequencies, a counting error of plus one digit is not important but it introduces appreciable error when measuring low frequencies. In the example, a count error of plus one digit is equal to an error of 10%.

Our prescaler neatly solves these problems of resolution and counting error by multiplying the signal frequency by one hundred. In so doing, it improves the resolution by one hundredfold.

The term "prescaler" is normally applied to frequency division, so that high frequencies are divided down to a frequency suitable for measurement by the frequency counter. Our prescaler actually multiplies the input signal by 100 to suit the capabilities of the frequency counter and therefore still deserves the title of "prescaler".

The audio prescaler will multiply frequencies from 2.5Hz to 100Hz by 100. The input sensitivity is 30mV p-p with a maximum allowable input of 8V. The input impedance is 1 megohm. The output from the prescaler is 7 to 10V

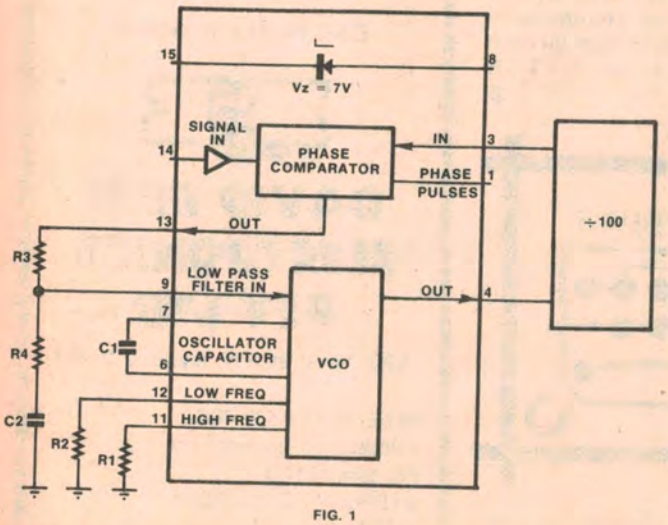
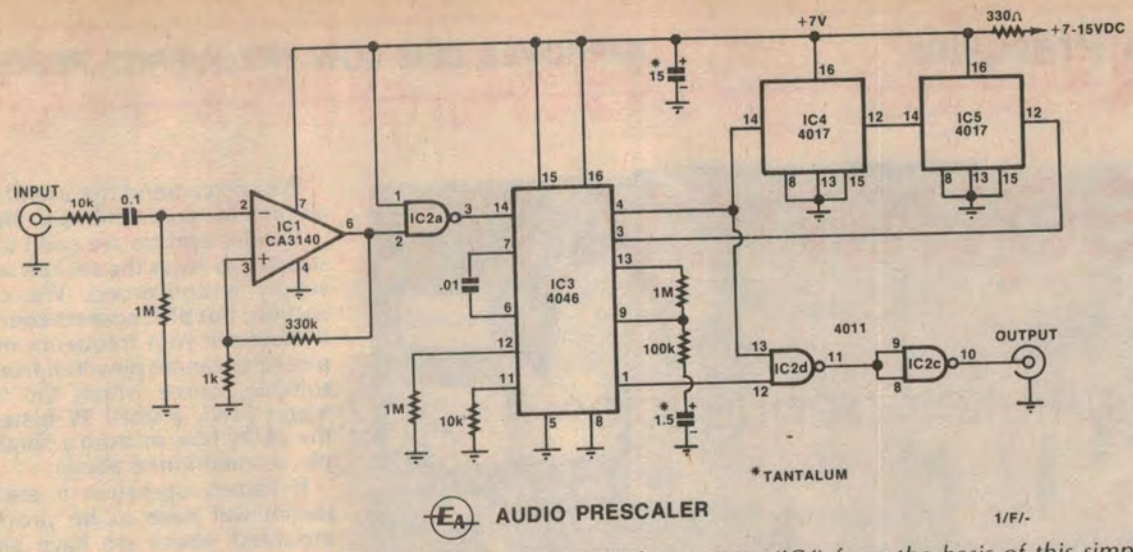


FIG. 1

Fig. 1: Basic scheme of the audio prescaler circuit.

The prototype was built into a low-cost plastic utility box.



A Schmitt trigger (IC1), a phase-locked loop (IC3) and two decade counters (IC4) form the basis of this simple circuit.

p-p depending on the power supply. This can be reduced with a resistive divider if necessary. The input waveform should be a sinusuoid or square wave.

The basis of our prescaler is a phase-locked loop IC combined with a pair of decade counter IC's which give a total division of one hundred. The basic format is shown in Fig. 1.

A phase-locked loop (PLL) is comprised of two parts, a voltage-controlled oscillator and a phase comparator. In our circuit, the VCO "free-runs" at about 250Hz when no input signal is present (at pin 14 of the PLL). The VCO output at pin 4 is fed to the "divide-by 100" counter stages mentioned previously to emerge as a low frequency (2.5Hz or higher) at one of the comparator inputs, pin 3.

When an input signal is applied to the other comparator input, pin 14, the comparator detects whether the two inputs are in phase. If not, the comparator develops an error voltage which is fed to the VCO to shift its output frequency.

Through this process, the comparator is able to bring the signal at pin 3 into phase with the signal at pin 14, while the VCO then runs at an exact 100-times the input frequency. This VCO output is then fed to the external frequency counter.

The VCO can be programmed to run within a certain specified range by selecting the resistors at pins 11 and 12 and the capacitor at pins 6 and 7. With the components as specified the VCO will oscillate between 2.5kHz and 100kHz.

Five integrated circuits make up the complete circuit. Besides the PLL and two decade counters, there is a CA3140 fet-input op amp and a 4011 quad 2-input NAND gate. The op amp is connected as a Schmitt trigger to provide the necessary square wave input for the PLL.

As well, the op amp provides a high input impedance (one megohm) and high input sensitivity.

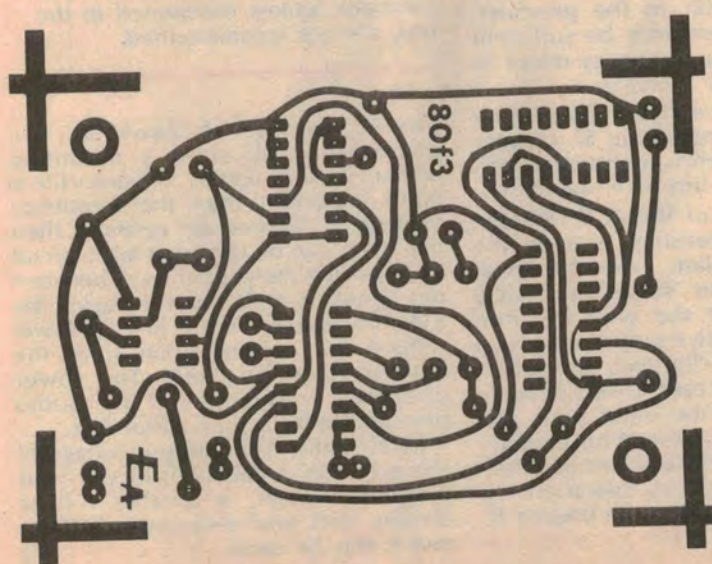
As explained previously, when no signal is applied to the input of the PLL, the VCO will oscillate in the "free run" mode at about 2.5kHz and this signal would normally be read by an external frequency meter as a valid signal. This problem is overcome by the 4011 which gates through valid VCO output signals when the PLL is "locked" to an input signal.

One of the NAND gate inputs of the 4011 is used to monitor the "phase pulses" output of the VCO. This output is "high" whenever the PLL is locked onto an incoming signal and is "low" when the VCO is free-running. Thus, IC2d gates the free-running VCO output off and so avoids a spurious reading

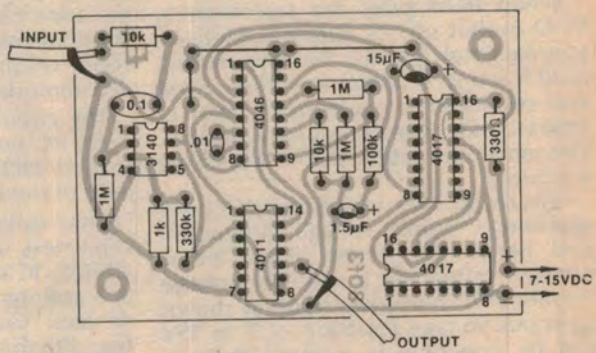
We estimate that the current cost of parts for this project is approximately

$16

including sales tax. This does not include the plugpack power supply.



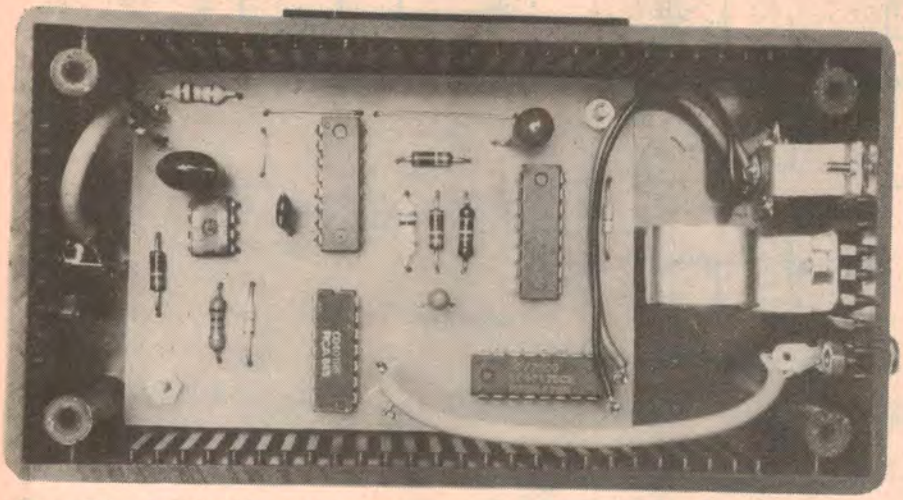
At left is an actual size artwork for the printed circuit board. The board measures 57 x 83mm.



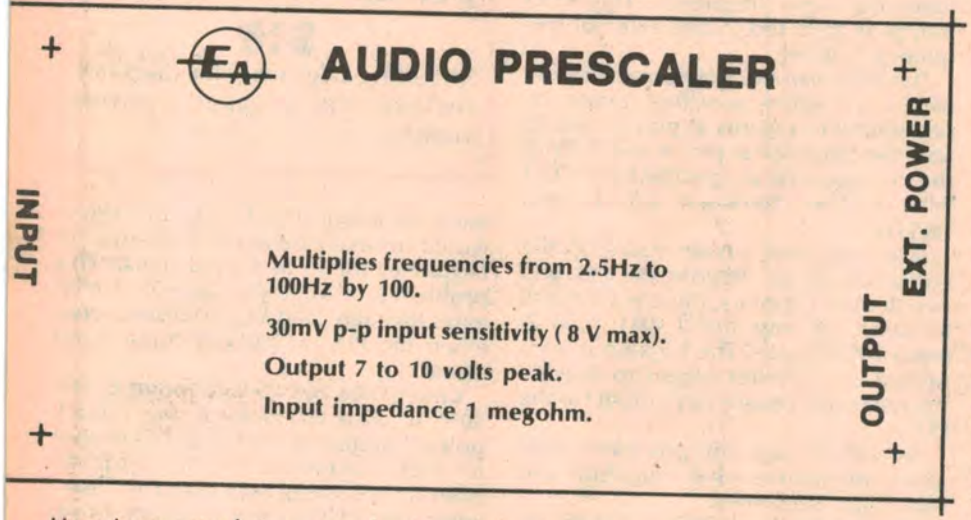
This wiring diagram shows the PC board as viewed from the component side. Note the use of shielded cable for the input and output connections.

Audio Prescaler

IMPROVES DFM LOW-FREQUENCY RESOLUTION



Above: View inside the prototype. The unit can be powered from either a battery, a plugback supply, or a source within the frequency meter itself.



Here is an actual-size reproduction of the front panel artwork.

on the external frequency counter.

When IC2d gates the free-running VCO output off, its output is high, ie, approximately 7V DC. For this reason, IC2d is fed to IC2c to invert the output and results in a "quiescent" level of zero volts DC when no signal is present. The remaining gate in the 4011 package is unused.

The range over which the VCO will oscillate is supply voltage dependent and hence the zener diode incorporated within IC3 is used for voltage stabilisation. With the circuit as shown an input voltage variation of 7 to 15V can be coped with. Current drain is about 10 milliamps. The unit can be powered from a nine-volt battery or a mains plugpack supply.

CONSTRUCTION

Our version was made up in a plastic utility box measuring 130 x 68 x 41mm. A Scotchcal panel for the lid provides an attractive finish to the prescaler. Alternatively, there may be sufficient room within your frequency meter to accommodate the prescaler.

The circuitry is accommodated on a small PC board measuring 57 x 83mm (coded 80f3) which is mounted to the base of the utility box with two screws.

Start assembly of the PCB with the capacitors and resistors, leaving the CMOS IC's till last. Take the usual precautions when soldering CMOS devices. Connect the soldering iron barrel to the negative supply pattern on the PCB, using a clip lead, and solder the supply pins of each CMOS package before soldering the other pins. This enables the static protection circuitry within each CMOS device to be effective during the soldering operation. It is not necessary to solder the unused IC pins.

We recommend the use of PC stakes or pins for connections to the PCB.

Various options are open to the constructor as far as the sockets and power supply is concerned. We used RCA sockets, but BNC sockets could be used if these suit your frequency meter. The prescaler can be powered from either a suitable source within the frequency meter itself, a small 9V battery within the utility box, or from a plugback supply, as mentioned above.

If battery operation is envisaged, a switch will have to be provided and mounted where we have placed the power socket. A look at the photograph will show a mounting bracket for a 9V battery. If battery life is more important than the frequency over which the prescaler operates, then the zener can be removed from circuit by removing the copper track between pin 15 and 16 on IC3 and replacing the 330 ohm resistor with a link. This will reduce the current drain from the battery to about 3mA. The lower operating frequency of the audio prescaler at 9V is then about 4Hz.

Incidentally, if the output voltage of the prescaler is too high to suit your frequency meter, a suitable voltage divider, with total resistance of 10k or more, may be used.

PARTS LIST

1 PCB, 80f3, 57 x 83mm
1 plastic utility box 130 x 68 x 41mm or similar
1 Scotchcal front panel 125 x 62mm
2 RCA sockets
1 2.1mm DC input socket to suit plugpack
1 CA3140 op amp
1 4011 quad two-input NAND gate
2 4017 decade counters
1 4046 phase-locked loop

RESISTORS
(¼ or ½W, 10% tolerance)
3 x 1M, 1 x 330k, 1 x 100k, 2 x 10k, 1 x 1k, 1 x 330 ohms.

CAPACITORS
1 x .01uF metallised polyester
1 x 0.1uF metallised polyester
1 x 1.5uF/15VW tantalum electrolytic
1 x 15uF/15VW tantalum electrolytic

Miscellaneous: screws, nuts, scrap aluminium, hook up wire, shielded cable, etc.

Note: Capacitors and resistors with higher ratings may be used if physically compatible. Other substitutions, unless mentioned in the text, are not recommended.