DFM adaptor for the Function Generator

Improves linearity and measures to 300kHz

Did you build the Function Generator described in April 1982? Now you can add this enhancement which lets it operate as a frequency meter and improves the linearity of the coarse frequency control.

by JEFF SKEEN & LEO SIMPSON

The Function Generator was and still is a very popular project. Now, in response to a number of requests, we have produced a small printed circuit board which enhances the capabilities of the project.

For those not familiar with the Function Generator and who do not have access to the original April 1982 article, the circuit itself was republished in last month's issue in an article entitled, "What to do if your project doesn't work". Reference to that circuit will show that there are two major sections: the oscillator, involving the XR2206, and the frequency meter, involving the 74C926.

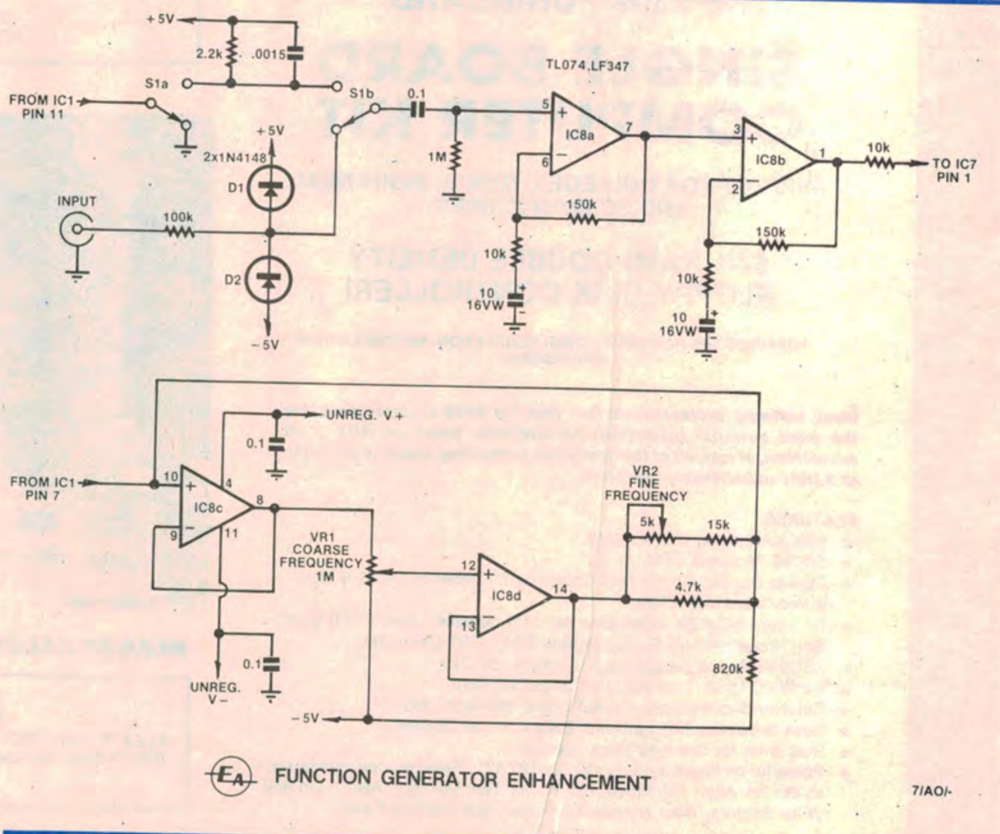
In the original design the frequency meter section of the circuit was permanently connected to the output of the XR2206 oscillator; it could not measure the frequency of external signals. The rationale for this approach was that we did not want to unduly complicate the design. That the project has proved so popular indicates that this was a good decision. Now we are providing an option to those who wish to make use of that frequency meter.

The modification gives the Function Generator the ability to measure frequencies up to 300kHz and above, depending on the signal level. The accompanying graph shows a plot of input sensitivity versus frequency. For most of the range the sensitivity is around 20 millivolts peak-to-peak or better which is more than adequate for most applications.

The other feature of this option is an improvement to the coarse frequency control, making it more linear and much easier to use to select a given output frequency. In the original design, the frequency control is essentially a potentiometer wired as a variable resistor; the lower the resistance, the higher the output frequency. Hence, the control has a very non-linear 1/x or hyperbolic law.

Again, we were aware of this drawback when we produced the original design but it does have the virtue of simplicity. The add-on circuit is a big improvement though and makes it very easy to set the frequency output.

Mechanically, the modifications entail the addition of a BNC socket and a toggle switch on the rear panel plus a small printed circuit board. Quite a lot of rewiring is involved too, which is the hardest part of the whole job. The cost is quite minor though, so it is quite a worthwhile addition to an already useful piece of test equipment.



FUNCTION GENERATOR ENHANCEMENT

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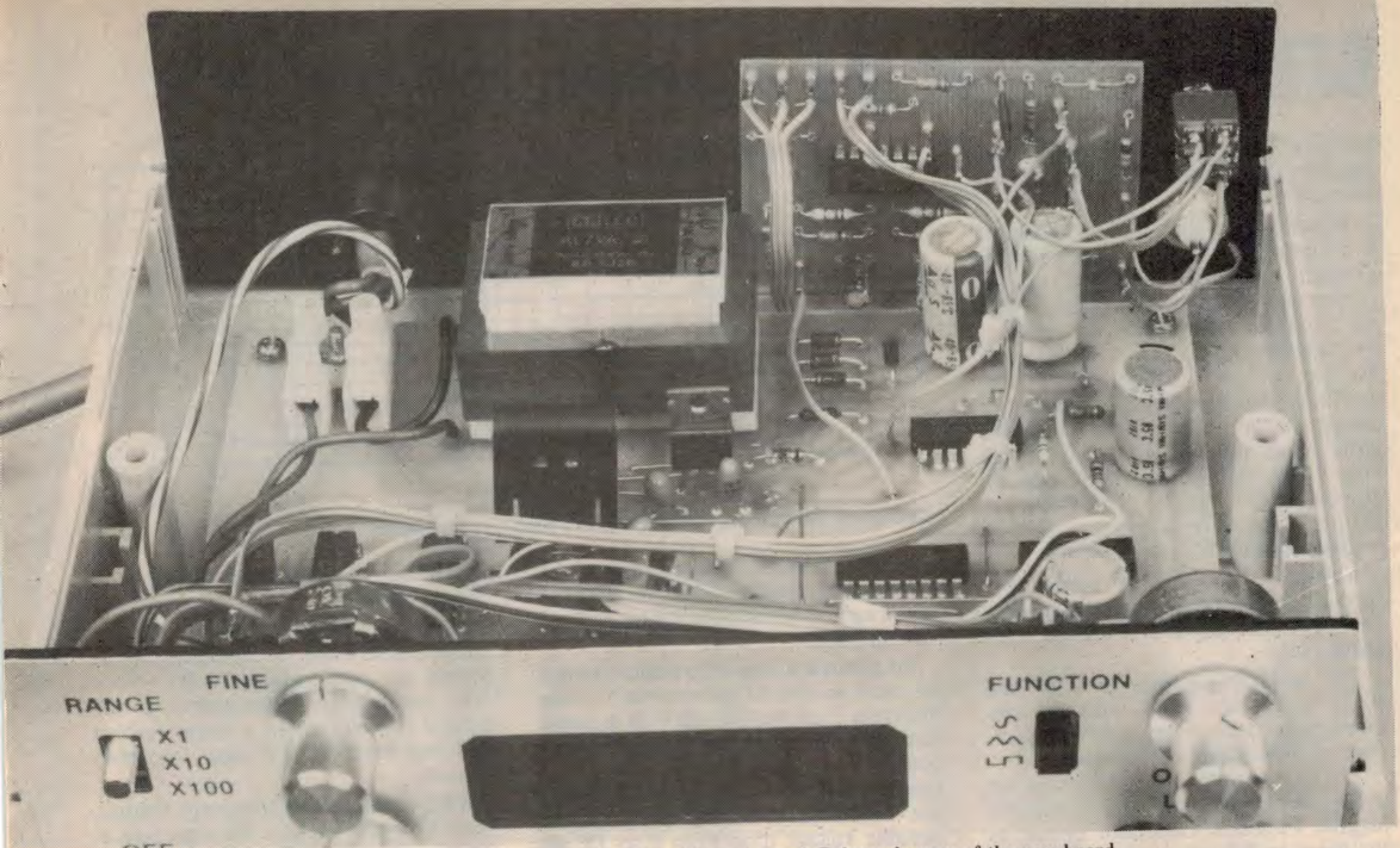
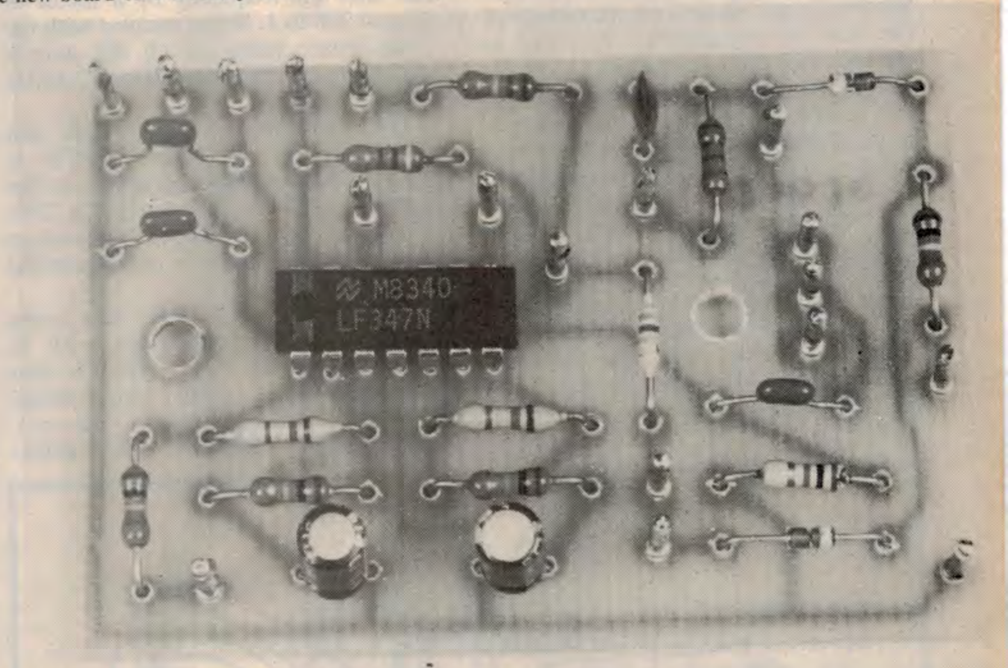


Above: interior of the function generator with the new board on the rear panel. Below: close-up of the new board.



Circuit description

Relatively few components are needed for this modification. There is just one quad op amp IC package and a few other passive components.

Let's have a look at the frequency meter side of the circuit first. Incidentally, the quad op amp on the add-on PCB is referred to as IC8, which continues the numbering used in the Function Generator to avoid confusion.

At first sight, adding the external frequency meter facility to the Function Generator is quite straightforward. All that is necessary is to break into the signal measuring chain involving the hex Schmitt trigger IC7 and install an amplifier with sufficient gain to give an adequate sensitivity.

In practice, it is not so easy. What you need is an amplifier which can provide gain and sufficient output signal to exceed the positive and negative thresholds of the Schmitt trigger.

The problem is that typical CMOS Schmitt trigger ICs have positive and negative thresholds which are within a volt or so of the supply rails. For example, if the supply rails are ±5V, as in this case, the input signal to the Schmitt trigger will need to be in excess of 8V peak-to-peak for reliable operation.

Typical op amps running from the same ±5V rails cannot satisfy this requirement. They just don't have enough output voltage swing. To overcome this problem, the quad op amp package is powered from the unregulated supply rails of the Function Generator, which are around ±13 volts DC.

The unregulated supply rails do not present any problems to the op amps in this circuit since they have a very high supply voltage rejection ratio of 80dB or more. This is another way of saying that fluctuations of the supply voltage rails do not affect the output of the op amps.

The input source to the amplifier is controlled by S1. When this switch is in the "generator" position, the squarewave output from pin 11 of the XR2206 IC passes via S1a and S1b to the input of the amplifier. The 2.2kΩ resistor is a pull-up resistor necessary for correct operation of the XR2206 output while the .0015μF capacitor was a circuit modification

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(published in June, 1982) to prevent false triggering of the counter circuit at low frequencies.

When S1 is in the "counter" position, S1a shorts the output of the XR2206 to ground to prevent stray circuit capacitance from coupling spikes into the amplifier input while S1b connects the amplifier input to the BNC socket. To prevent gross overloading of the amplifier, voltage limiting diodes are placed between the input and the positive and negative 5V power supply rails. These limit the maximum voltage at the amplifier input to ±5.6V and are in turn protected from excess current by a 100kΩ limiting resistor.

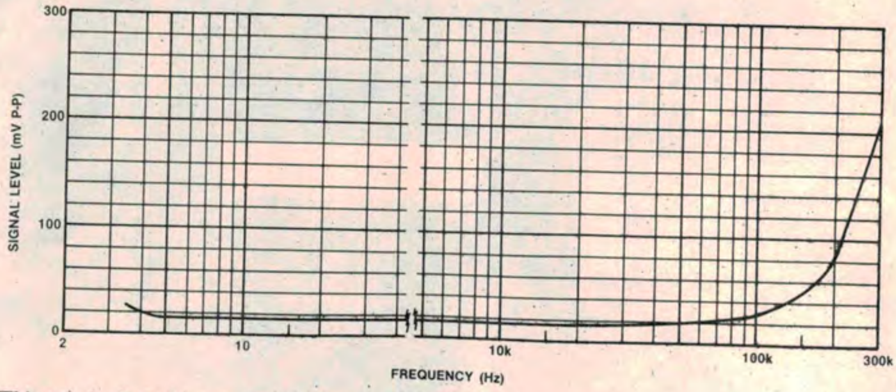
Following S1b, a 0.1μF capacitor is used to couple the input signals while a 1MΩ resistor sets the amplifier input impedance.

The amplifier consists of IC8a and IC8b which are both used in non-inverting mode to give a gain of 16 each, thus an overall gain of 256 times.

The output of the amplifier passes via a 10kΩ limiting resistor and rejoins the original Function Generator circuit as the input to Schmitt trigger IC7a. This Schmitt trigger squares up the output of the amplifier and provides the drive to the following counter section.

Because the amplifier output voltage can swing higher than the Schmitt trigger supply voltage, voltage protection is required on the Schmitt trigger input. This is achieved by the internal protection diodes in the Schmitt trigger in conjunction with the 10kΩ limiting resistor just mentioned.

Now let's have a look at the second part of the circuit which involves the frequency control on the XR2206 oscillator chip. As previously mentioned, this originally used a pot wired as a variable resistor. The actual frequency produced is directly proportional to the current drain from pin 7 of the XR2206 which can be varied over the range from 1μA to 3mA.



This graph plots the input sensitivity as a function of frequency.

To produce a linear frequency control we need to control the current flowing from pin 7 of the XR-2206 in a linear fashion. Our method for doing this is to control the voltage drop across the resistance in series with pin 7. By fixing the resistance at 4.7kΩ and using a variable voltage drop from 0 to 3V we can alter the frequency by a factor of around 200 to 1. When coupled with the three decade range switch this gave a total frequency range of 12Hz to 220kHz on the prototype.

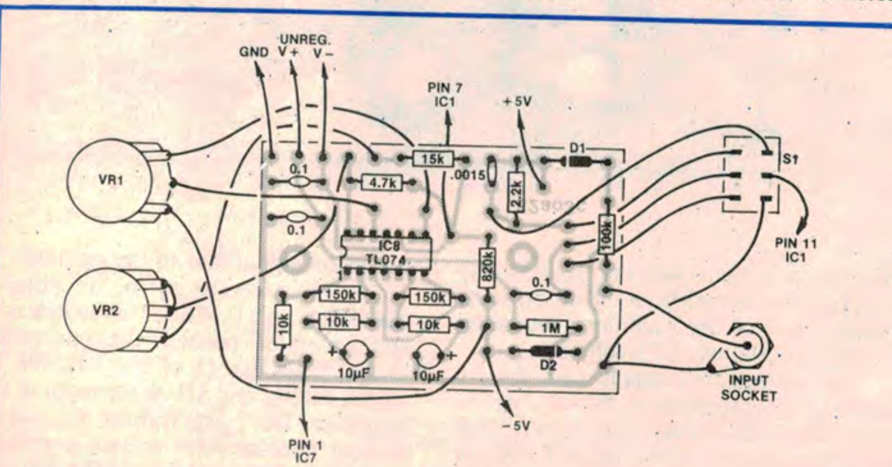
The remaining op amps, IC8c and IC8d, provide this function. IC8c is connected as a voltage follower to buffer the fixed −2V at pin 7 of the XR2206, IC1. The output of IC8c is connected to VR1 which has its other end connected to −5V.

Thus the wiper of VR1 can swing linearly over the range from −2V to −5V and drives IC8c which is also connected as a unity gain voltage follower. IC8d drives a network consisting of VR2 and two resistors which are also connected to the −2V output of IC1.

So IC8d functions as a variable current sink which is controlled by the setting of potentiometer VR1. Since VR1 has a linear characteristic it will control the current in a linear fashion and thus function as a linear frequency control.

VR2 acts as a fine frequency control. Both VR1 and VR2 are the same pots as used in the original Function Generator design. In fact, in a simplified design, the coarse frequency control is so effective that VR2 could be dispensed with.

The 820kΩ resistor at the output of IC8d is used to set the minimum frequency of oscillation of the XR2206. The 820kΩ resistor is permanently connected between pin 7 of the XR2206



Take care with the orientation of polarised components.

PARTS LIST

1 PCB, code 82ao3c, 70 x 48mm
18 PC stakes
1 DPDT toggle switch
1 panel-mounting BNC socket
2 6mm PCB spacers
2 sets 12mm x ⅛-inch nuts and bolts
½ metre 10-way ribbon cable

Semiconductors

1 LF347 or TL047 quad op amp IC
2 1N4148 diodes

Capacitors

2 10μF 16VW PC mount electrolytics
3 0.1μF metallised polyester

Resistors (¼W, 5%)

1 x 1MΩ, 1 x 820kΩ, 2 x 150kΩ, 1 x 100kΩ, 1 x 15kΩ, 3 x 10kΩ

NOTE: As discussed in the text, the two potentiometers, two resistors and one capacitor on the PCB are from the Function Generator and do not need to be purchased.

and the negative supply rail. This means that there will always be a 3V drop across it and so it will always draw about 3.7μA from pin 7 regardless of the settings of the fine and coarse frequency controls. This minimum current corresponds to a frequency of around 12Hz.

Construction

The circuit is constructed on a small printed circuit board (PCB) coded 82ao3c and measuring 70 x 48mm. Use the overlay diagram as a guide to the component locations and double check the orientation of the polarised components — the two diodes, the op amp and the two electrolytics.

PC stakes are used to terminate all wires leading to and from the PCB. This allows connections to be made easily to the PCB when it is mounted in position. There are 18 PC stakes to be placed on the board in all.

Separate the two halves of the Function Generator case from the PCB and front and rear panels. Several components must be removed from the function generator PCB and installed on the new PCB. These components are: the 2.2kΩ resistor adjacent (and connected to) pin 1 of IC7, the .0015μF capacitor in parallel with the 2.2kΩ resistor, and the 4.7kΩ resistor in series with the fine and coarse frequency controls.

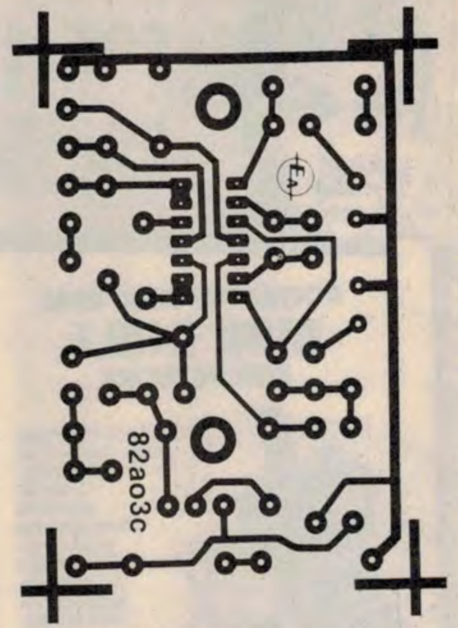
In addition, the connection between pin 11 of the XR2206 and pin 1 of IC7 must be broken. This is most easily done by removing the wire link by which the connection is made.

Once all components are mounted on the PCB, the rear panel should be removed from the Function Generator and the mounting hole positions for the PCB, BNC socket and toggle switch laid out. The positions shown in our photograph give the best clearance between the existing PCB and the new components. Drill the mounting holes, fit standoffs to the PCB mounting screws, then attach the PCB, BNC socket and toggle switch to the rear panel.

The existing wiring leading to the frequency controls should be removed now and the wiring leading to the new PCB commenced. Follow our wiring diagram carefully and use colour coded ribbon cable so that identification of the individual wires is made easier. Most connections to the original PCB can be made from the component side via vacant component mounting holes. The exceptions are the connections to the unregulated power supply rails and ground which are made to the underside of the PCB.

When the wiring is completed, reassemble the Function Generator into its case and switch on. Set the rear panel toggle switch to the frequency generator position and check that the display changes frequency as the coarse frequency control is rotated. Rotating the fine frequency control will give only a slight change at the lowest frequencies but should have more effect at higher frequencies where it is most likely to be used. There should be a big difference apparent in the operation of the coarse frequency control now, with the frequency range not being bunched towards one end of the potentiometer.

With the Frequency Generator position tested, the toggle switch is set to the counter position and a test signal with an amplitude greater than 20mV and a frequency between 20Hz and 100kHz applied to the BNC input. The digital display should indicate the frequency of the applied signal. When acting as a frequency counter, the Function Generator will still deliver sine



Full size PCB artwork.

We estimate the cost of parts for this project to be approximately

$12

This includes sales tax.

and triangular waves but the square wave output will be a squared up version of the frequency counter input. This signal may be used as an external trigger signal for oscilloscopes if required.

If you wish to still have the Function Generator square wave output available when in the counter mode it will be necessary to isolate pin 3 of IC7 from pins 2 and 5 by cutting tracks. The amplifier output should then be connected to pin 3 of IC7 rather than pin 1. The 2.2kΩ resistor, .0015μF capacitor and wire link should be left in position if this is done.