Decimal point switching for the 500MHz DFM

simple circuit lets you read directly in MHz or μs

Using just two low-cost CMOS ICs and a handful of other components, this circuit will add the convenience of decimal point indication to the 500MHz Digital Frequency Meter described in the December, 1981 issue. Now you can read frequency and period directly in "MHz" and "μs".

by COLIN DAWSON

As we expected, the 500MHz Digital Frequency Meter is proving to be a popular project. Many hundreds of kits have now been sold and demand continues. That's hardly surprising considering you can build a full 500MHz DFM with switchable gating and period measurement capability for around $145.

But the project does have one drawback: it does not have decimal point indication, making it necessary to refer to a table (on page 49 of the February, 1982 issue) in order to decipher readings. While this may be satisfactory for occasional readings, it can become tedious when taking multiple readings on different ranges.

The design featured here was contributed by Mr A. Maurer (VK3YWV) of Mitcham North, Victoria, who developed it for use in his own 500MHz DFM. Rather than simply present his idea in Circuit and Design Ideas, we decided to design a suitable PCB and described the circuit as a full project. The resulting circuit is inexpensive, simple to install, and will automatically drive the appropriate decimal point for various settings of the DFM.

In addition to the PCB, we have also prepared a new front panel artwork for use with new kits equipped with the decimal point option, which can be retrofitted to older kits if you so wish. The new artwork is compatible with the existing front panel of the DFM, and simply indicates that the display can now be read directly in MHz and μs.

For example, a reading of 4.99498 in the frequency mode will be 4.99498MHz, while a reading of .14573 in the period mode is .14573μs.

How it works

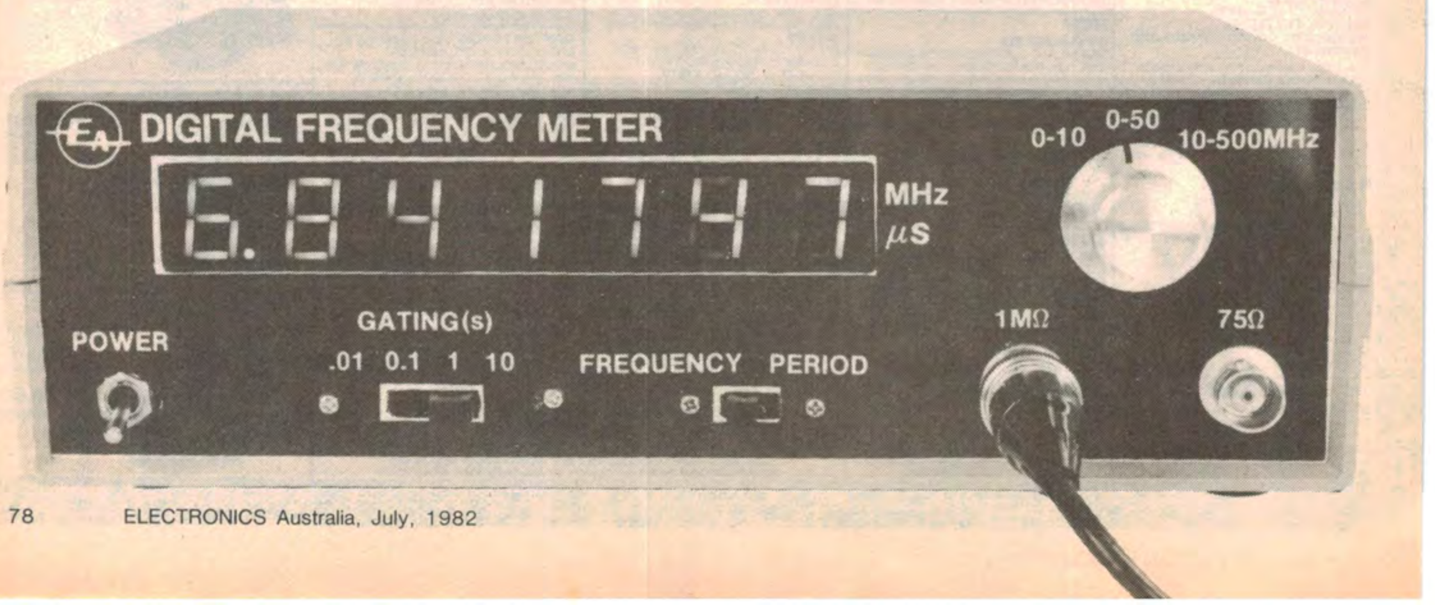
The circuit makes use of unused poles on the range switch (S1), while double pole switches are now required for the gating switch (S3) and the function switch S4. In many kits, however, double pole switches have been supplied instead of the single pole units specified, so replacements may not be necessary. No other component substitutions are required.

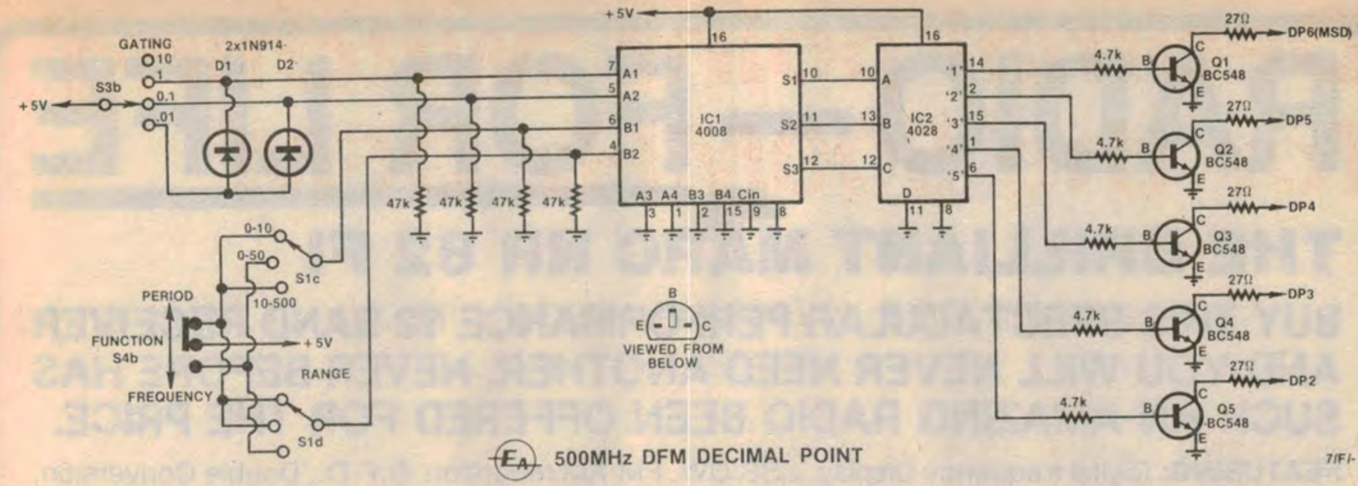
Refer now to the circuit diagram. Each position of the gating switch is assigned a 2-bit binary code equivalent to a decimal value of 0, 1, 2 or 3 (10s, 1s, 0.1s and .01s gating respectively), irrespective of whether the DFM is in the frequency mode or the period mode. This binary number is fed to the A1 and A2 inputs of IC1, a 4008 4-bit binary adder.

The values assigned to the range switch (S1) positions depend upon the mode selected by the function switch (S4b) – for frequency they are 0, 1 and 2; and for period they are 3, 2 and 1 (0-10, 10-50 and 10-500MHz range respectively). These values, in binary form, are fed to the B1 and B2 inputs of IC1.

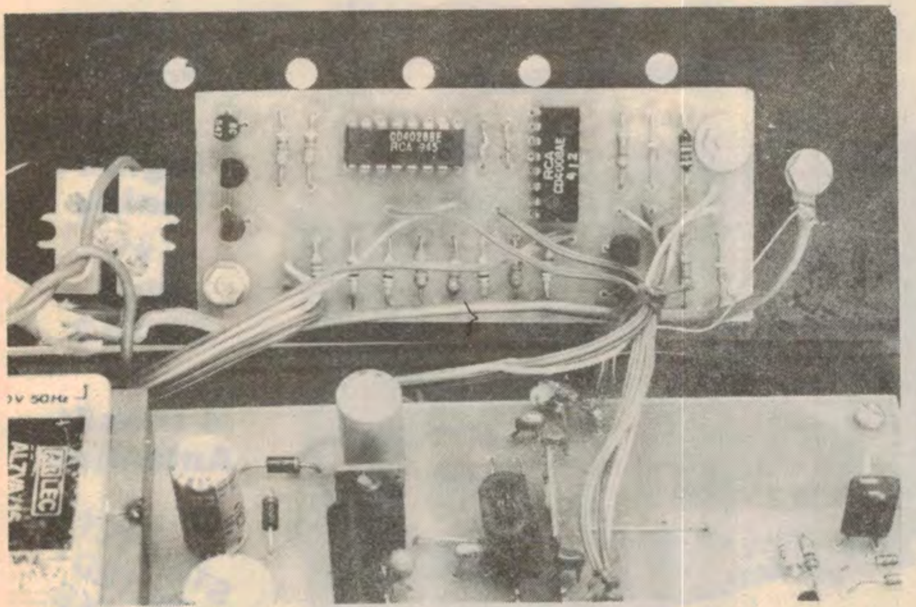
IC1 adds the two binary numbers produced by the gating switch and the range

Below is the prototype fitted with decimal point switching and the new Scotchcal front panel.





The circuit consists of a binary adder (IC1), a BCD to decimal decoder (IC2), and five driver transistors.



The PCB is mounted on the rear panel of the DFM case using machine screws and nuts. External wiring connections can be run in rainbow cable.

PARTS LIST

1 printed circuit board, code 82dp6, 90 x 41mm
1 Scotchcal front panel, 197 x 59mm (see text)
1 panel mounting 2-pole 4-position slide switch (see text)
1 panel mounting 2-pole 2-position slide switch (see text)

SEMICONDUCTORS
1 4008 4-bit full adder IC
1 4028 BCD to decimal decoder IC
5 BC548 NPN transistors
2 1N914 silicon diodes

RESISTORS
4 × 47kΩ, 5 × 4.7kΩ, 5 × 27Ω

MISCELLANEOUS
Rainbow cable, machine screws and nuts, solder etc.

switch together. The resultant number is the decimal point position in binary coded decimal (BCD). This is decoded by IC2, a 4028 BCD to decimal decoder, which turns on one of five decimal point driving stages (transistors Q1 to Q5).

Let's take a closer look at IC1 and see how it works.

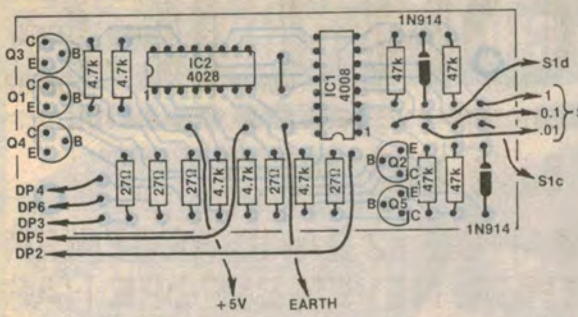
Being a 4-bit adder, IC1 has eight inputs labelled A1-A4 and B1-B4. The device operates by first adding A1 to B1 and presenting their sum at output 1 – or S1 (pin 10). If there is a carry (ie. their total is more than 1), then the carry is presented to S2 and added to the number produced by adding A2 to B2. If this total is greater than 1), a carry is presented to S3.

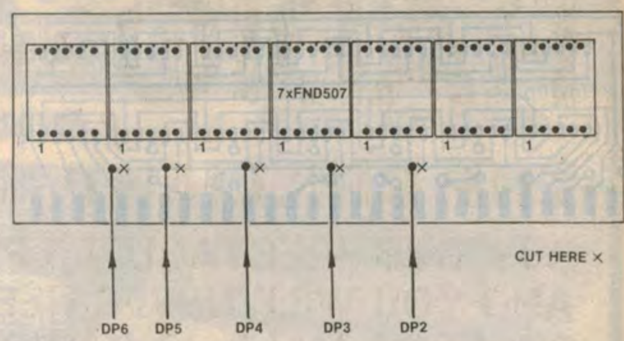
The third and fourth adders (A3 plus B3, A4 plus B4) work in exactly the same fashion. In this circuit, however, the third and fourth adders are not needed, and are tied to ground. The reason for this is that only two inputs are required to provide codes for the four possible positions of the gating switch, and similarly for the three possible positions of the range switch.

In summary, IC1 simply adds together two binary numbers representing the positions of the gating and function switches, and presents the result at outputs S1, S2 and S3 (S4 not used here). This is illustrated by Table 1, which is the truth table for IC1 when the DFM is in the frequency mode. Outputs S1, S2 and S3 are decoded by IC2, which turns on the appropriate driver transistor.

The range switch connections to B1 and B2 are similar to the gating switch connections but, since the range switch has only three positions, no additional diode logic is required. There is, however, one complication with respect to the range switch. For any given switch position, the binary number generated will depend on whether the frequency or period mode is selected. For example, on the 0-10MHz range, the number required is binary 00 (B1 and B2 low) for frequency measurements, and 11 binary for period measurements. Function switch S4b provides the appropriate compensation for the mode selected.

IC2, the BCD to decimal decoder, drives transistors Q1 to Q5 via 4.7kΩ base current limiting resistors. In addition, 27Ω resistors are included in the collector circuits of the driver transistors to limit the peak current through the decimal point indicators. The reason for the low resistor value here is that, although the driver stage provides continuous power to the appropriate indicator, the whole display is still scanned by the digit multiplexing. Hence, the





The diagram at right shows the extra wiring to the display PCB. Note the cuts to be made to the copper track linking the decimal points.

decimal point indicators have a low duty cycle and require high current pulses.

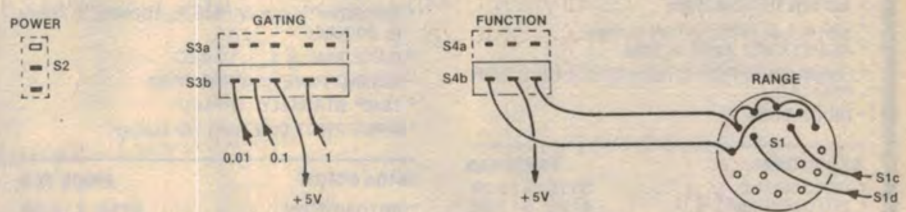
Before moving on to the construction, we should point out that this simple circuit does have some minor limitations. In all, some seven different multiplier values are required to correctly decipher all possible readings on the 500MHz DFM – ie. seven different decimal point locations are required. The problem is that this circuit is only capable of driving five different decimal points.

One of the missing decimal points occurs in the frequency mode with the 0-10MHz range and 10s gating selected. This combination results in a divide by 10^6 "multiplier", which corresponds to a decimal point at the eighth digit. Since the display only has seven digits (D0-D6), it is clearly impossible to display this point.

The other missing decimal point is at the second digit (D1), and is required when the DFM is in the period mode with 0-10MHz and .01s gating selected. In both cases, however, the position of the decimal point can be quickly established by altering the setting of the range switch or the gating switch.

The remaining problem has to do with the fact that the DFM has leading zero suppression. This means that for readings less than 0.1MHz or 0.1μs, leading zeros between the decimal point and the most significant digit are suppressed. In practice, there is no difficulty in counting the number of blank digits between the decimal point and the most significant digit.

Undoubtedly, all the above problems could be solved by a more elaborate circuit, but this would be difficult to retrofit to existing units. For this reason, the simple circuit described here is a good solution, as the drawbacks are relatively minor.



This diagram shows the additional wiring to the front panel switches. The +5V connections can be derived from S1a and S1b (see text).

FREQUENCY MODE		INPUTS				OUTPUTS		
RANGE	GATING	A1	A2	B1	B2	S3	S2	S1
0 10MHz	10	0	0	0	0	0	0	0
	1	1	0	0	0	0	0	1
	0.1	0	1	0	0	0	1	0
	0.01	1	1	0	0	0	1	1
0-50MHz	10	0	0	1	0	0	0	1
	1	1	0	1	0	0	1	0
	0.1	0	1	1	0	0	1	1
	0.01	1	1	1	0	1	0	0
10-500MHz	10	0	0	0	1	0	1	0
	1	1	0	0	1	0	1	1
	0.1	0	1	0	1	1	0	0
	0.01	1	1	0	1	1	0	1

TABLE 1: truth table for IC1 when the 500MHz DFM is in the frequency mode. Outputs S1, S2 and S3 are decoded by IC2, which turns on the appropriate driver transistor (Q1-Q5).

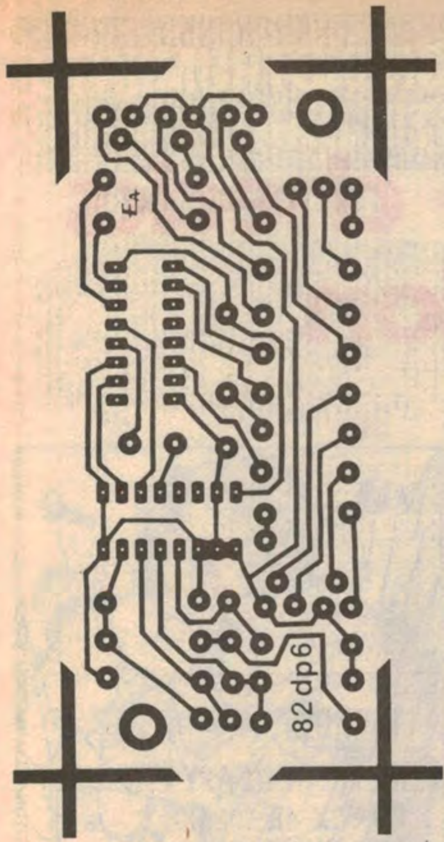
Construction

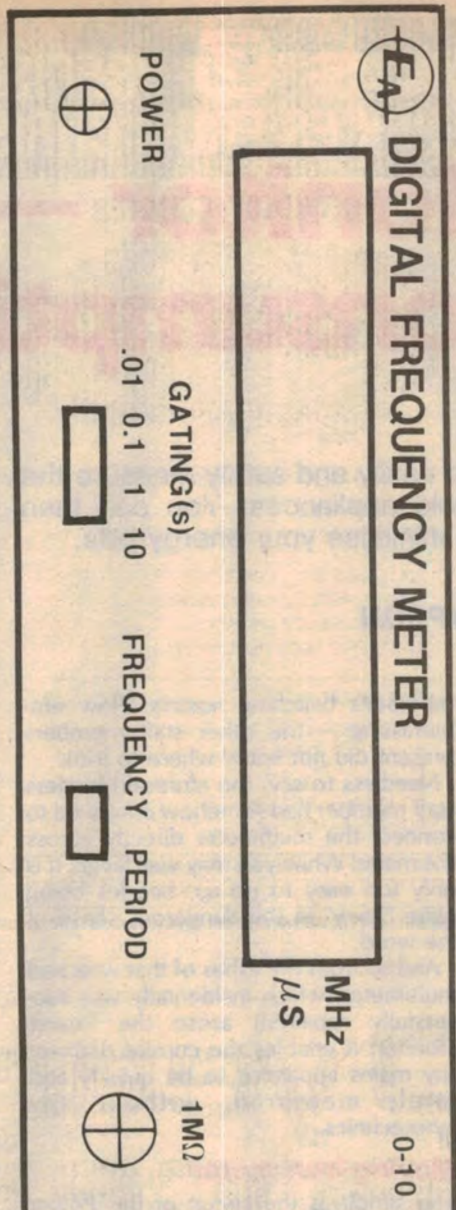
Construction is straightforward, with all components mounted on a printed circuit board (PCB) coded 82dp6 and measuring 90 × 41mm. Assemble the PCB according to the overlay diagram, leaving the two ICs till last. The ICs are CMOS devices, so observe the usual precautions: connect the barrel of your soldering iron to the earth track on the PCB (use a small clip lead), and solder the supply pins (pins 8 and 16) first.

With assembly complete, sit the PCB adjacent to the rear panel of the DFM and commence the wiring to the front panel switches and the display board. Full details are shown in the accompanying diagrams. Note that switches S3 and S4 will have to be replaced with double pole types if these are not already fitted.

Access to switches S3 and S4 can be gained by temporarily lifting the main PCB assembly out of the case. The +5V supply for the circuit and to S3b and S4b can be derived from any convenient

> We estimate that the cost of parts for this project is approximately
>
> **$7.50**
>
> This includes sales tax but does not include the optional Scotchcal front panel or replacement switches for S3 and S4.





Above and right are actual size artworks for the PCB and front panel.

point on the main PCB, or from S1a and S1b (see circuit p45, December 1981). The use of rainbow cable is recommended for all wiring connections.

Connections to the display PCB involve running leads to the decimal point indicators (pin 5) of digits D2 to D6. No connections are made to D0 or D1. Note that it will be necessary to cut the track linking the decimal point indicators, as shown on the overlay diagram for the display PCB.

The decimal point PCB can now be mounted on the rear panel using machine screws and nuts, and the unit re-assembled and tested. If the decimal point appears in the wrong position, check your wiring to S3b, S4b and to the display PCB. If you are unable to get any decimal point indication at all, check the +5V and earth connections to the PCB.