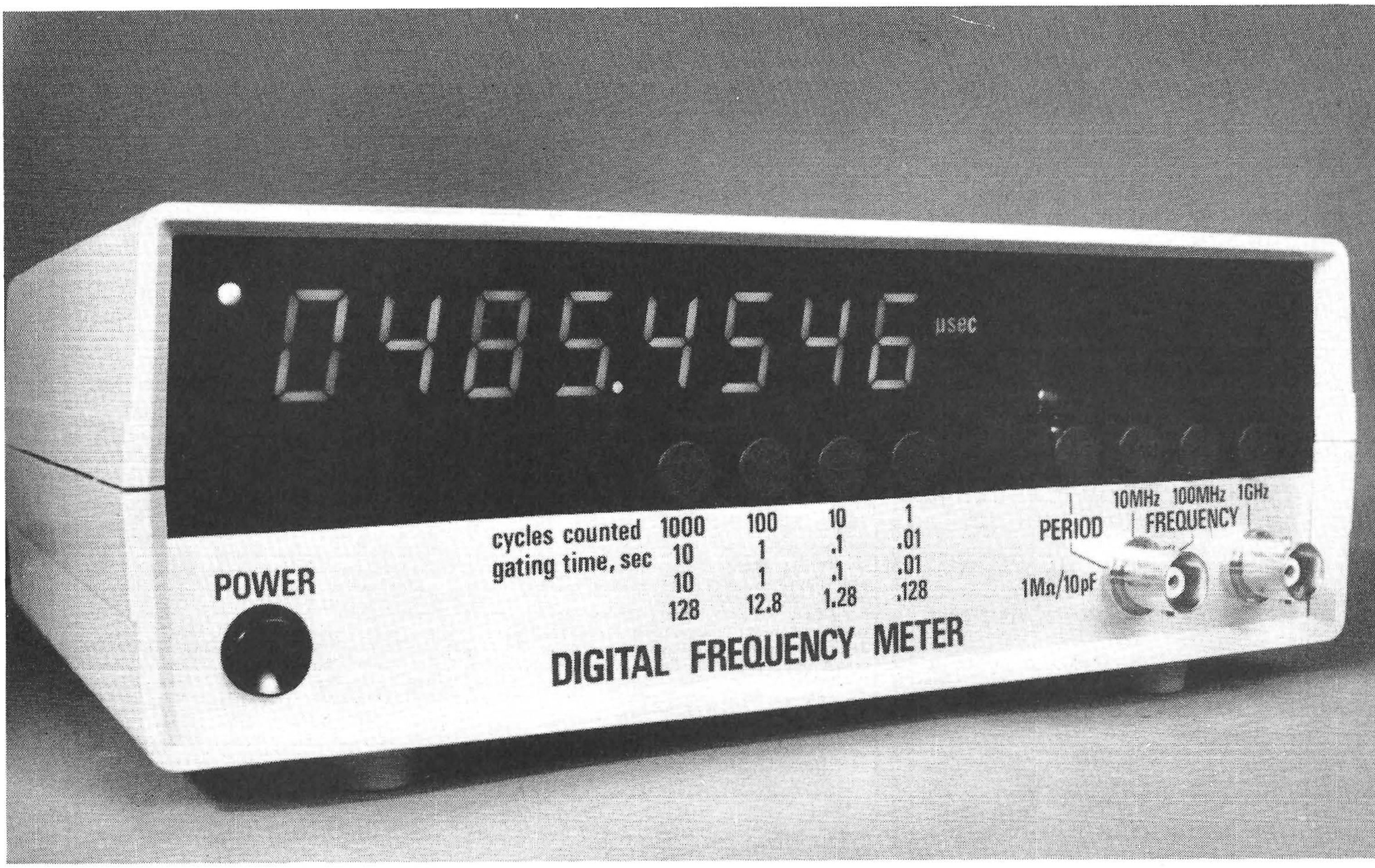



# Build this superb

SILICON CHIP



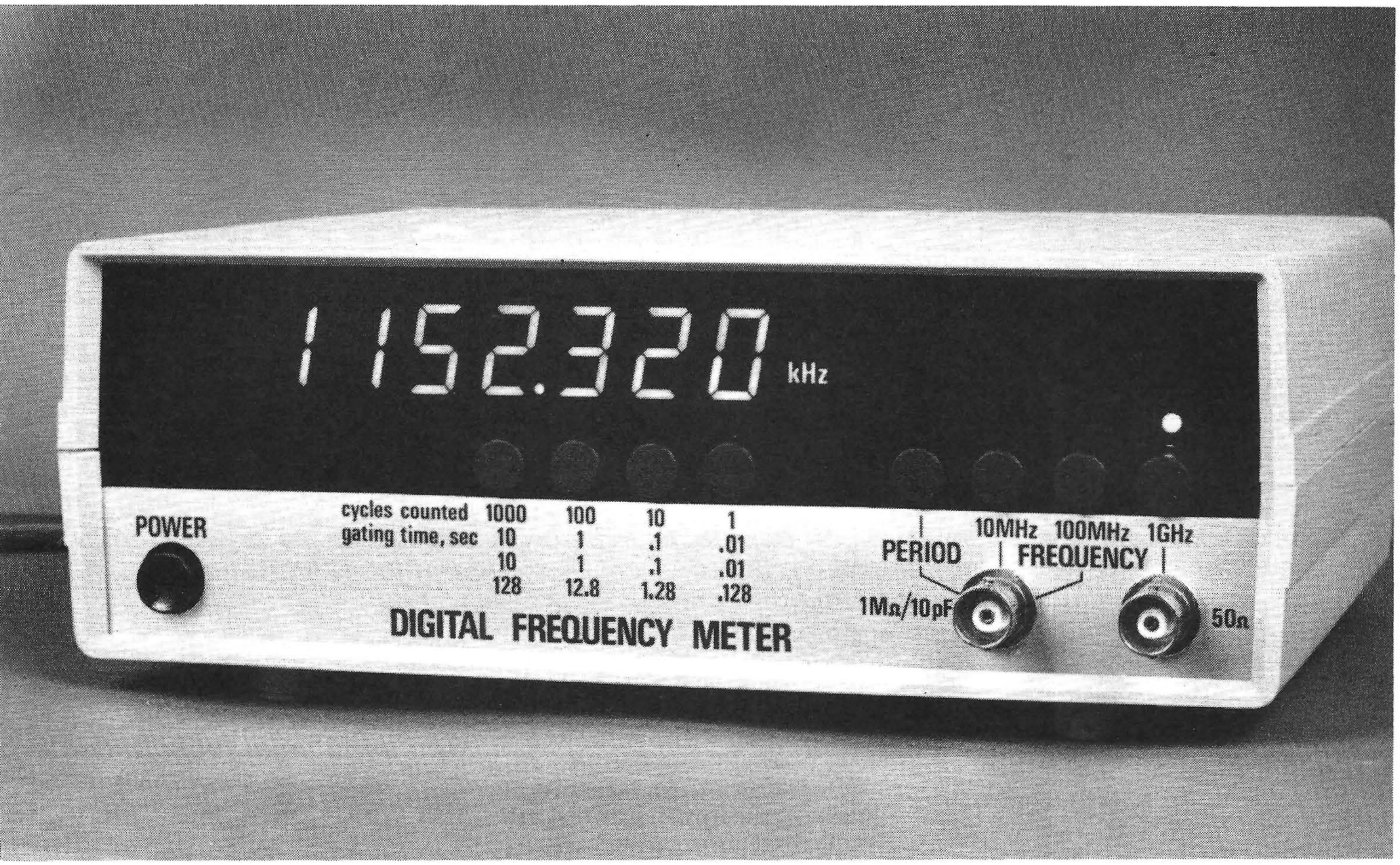
# 1GHz Digital Frequency Meter

By STEVE PAYOR

***This superb 1GHz Digital Frequency Meter will outperform any other instrument in its price range. It uses the highest performance ICs, provides both frequency and period measurements, and features an 8-digit LED readout.***

There is only one way to describe the performance of our new 1GHz Digital Frequency Meter — it's superlative!

The design brief for this instrument was simple: it had to be the best DFM for its price available in Australia. It also had to include both frequency and period measurement modes, a frequency




**These two views show the new counter in period mode (left) and frequency mode (right). The unit is housed in an attractive plastic instrument case, with the LED displays hidden behind a red acrylic panel. Note kHz and μsec indicators.**

response to 1GHz, switchable gating times, and an 8-digit readout with switchable decimal points and overflow indication.

And, as if that wasn't enough, the all-up kit price had to be kept to less than $300!

It took a lot of doing, but we've managed to come up with a very refined design that beats the socks off anything else going. This design not only outperforms existing kit DFMs but also commercial units costing many times more.

To meet our design objectives, we selected three key parts for the circuit: Intersil's ICM7216A LSI frequency counter, Motorola's MC10116 triple differential line driver, and Philips' SAB6456 1GHz divide-by-64 prescaler/amplifier.

The ICM7216A counter IC was chosen because it contains all the circuitry necessary to count, generate gating signals, latch data, and drive an 8-digit multiplexed LED display. It also includes a high-frequency oscillator and control inputs for decimal point placement and gating time.

The 10116 and SAB6456 ICs are used at the inputs of the 0-100MHz and 1GHz ranges respectively. Both are high-speed ECL devices and feature excellent sensitivity across their respective bandwidths — around 20mV in the case of the 10116 and 10mV (max.) for the SAB6456.

The 10116 has been around for a number of years and has been used as a 0-100MHz preamplifier in many commercial DFMs. The SAB6456 is a more recent device, originally designed as a switchable prescaler for use with UHF/VHF television tuners It has a guaranteed range of operation from 70-1000MHz.

Three other ECL devices have also been used in the circuit: two 10131 dual-D flipflops which have been configured as divide-by-five and divide-by-two counters, and a 10100 three input NOR gate.

Finally, a few inexpensive CMOS chips round out the IC count in our new DFM. These devices are used for frequency division and logic switching.

## Main features

Let's take a look at some of the features of the unit.

As seen from the front of the instrument, there are two groups of four pushbuttons: the RANGE buttons, which move the position of the decimal point, and the FUNCTION buttons which select the various period and frequency modes. Throughout the following circuit description, these buttons will be referred to as R1, R2, R3, R4 and F1, F2, F3 and F4 respectively.

The RANGE buttons select the gating time when in frequency mode, and the number of cycles counted when in period mode.

The FUNCTION buttons select the various operating modes: either period or three frequency ranges (0-10MHz, 0-100MHz or 10MHz-1GHz). Immediately below these pushbuttons are two BNC input sockets. One of these has an input impedance of 1MΩ shunted by 10pF and is used for period and frequency measurements up to 100MHz.

The second input has an input im-

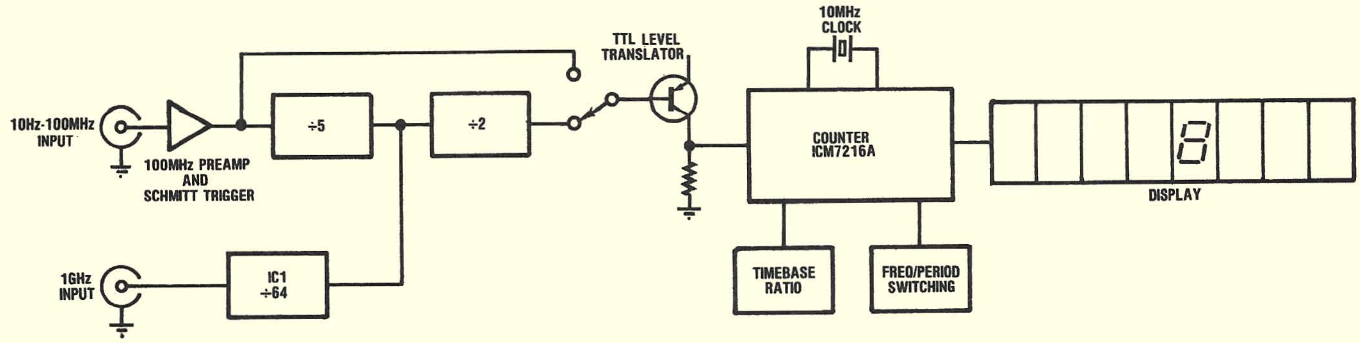



**Fig.1: this diagram shows the main circuit blocks of the counter. Signals applied to the 10Hz-100MHz input are amplified, and divided by 10 or fed direct to the base of a TTL level translator (Q2). Similarly, signals applied to the 1GHz input are divided by 128 before reaching Q2. Q2, in turn, clocks an Intersil ICM7216A counter IC which drives the LED display.**

pedance of 50Ω and is used for frequency measurements up to one gigahertz (1GHz).

An interesting feature of the unit is the provision of four switchable gating times: .01, 0.1, 1 and 10 seconds for the 10Hz to 100MHz input, and 0.128, 1.28, 12.8 and 128 seconds for the 1GHz input.

The gating time is simply the time over which measurements are made before the display is updated. A long gating time means a higher count and greater resolution, but the drawback is slow update times.

Selectable gating times thus make for a more versatile unit. You can opt for high resolution or fast update time, or a compromise between the two, as the situation demands.

In the period mode, the gating switches select the number of cycles counted before the reading is displayed — either 1, 10, 100 or 1000. This mode allows very accurate measurement of low frequency signals (ie, those below about 10kHz). As before, you can opt for high resolution, fast update time, or a compromise between the two.

All readings are displayed directly in kilohertz (kHz) or microseconds (μsec), depending on the mode selected. As you can see from the photographs, the display features both kHz and μsec indicators, together with LED indication of the mode selected. Another LED, situated in the top left-hand corner of the display, provides overflow indication.

## Easy to build

We've put a lot of work into making this unit easy to build so that the specs of your assembled kit will match those of the prototype.

All parts, with the exception of the power supply components, are mounted on two printed circuit boards which are soldered together at rightangles by means of matching solder pads. A red acrylic panel fitted with a Scotchcal label is attached to the display PCB by means of the BNC input sockets. The whole assembly then slides into matching grooves in a compact plastic instrument box.

A third PCB accommodates the power supply components and is mounted together with the transformer, on the rear panel. We did this so that heat-generating components, such as the power transformer and a voltage regulator IC, were as far away from the sensitive counter circuitry as possible.

## Circuit description

Before getting down to details, it is interesting to note that only two logic families are used in this frequency meter: the aforementioned ECL (Emitter Coupled Logic) for the high-speed "front end" circuitry, and CMOS for the remainder. All the ICs are common types except for the 1GHz ECL prescaler (Philips SAB6456) and the main CMOS counter/display driver (Intersil ICM7216A).

Another interesting feature is the complete elimination of front-panel wiring. This was made possible by using PCB-mounted pushbutton switches and by electronically switching signal paths. Normally, one would expect to see a bank of mechanically latched and interlocked pushbuttons, but here the mechanics have been replaced by CMOS logic circuitry.

Viewed as a whole, the circuit is quite a jigsaw puzzle, so we will examine it one section at a time, starting with the inputs.

## The 0-100MHz input

This input is used for period measurements to 0.4μs (2.5MHz) when function button F1 is pressed, and frequency measurements up to 100MHz. The input impedance is nominally 1MΩ with protection against all but the worst overloads.

Firstly, any DC component of the signal is removed by the 0.047μF input coupling capacitor. The signal is then clipped by a pair of BAW62 high-speed silicon diodes in conjunction with a series 180kΩ current-limiting resistor. Note: do not substitute other types here as these diodes have exceptionally low capacitance (1pF typ.) and a high current rating.

To maintain a flat frequency response, the 180kΩ resistor is shunted by an 18pF capacitor (C1) which compensates for the stray capacitance to ground across the 820kΩ resistor of about 4-5pF (due to the diodes and JFET Q1).

A JFET source-follower (Q1) is used to buffer the input signal, and the voltage gain of this stage is about 0.7. Not shown on the circuit diagram, but connected to the source of the JFET, is a small "guard" track which surrounds the input circuitry on the PCB. This helps to minimise the stray capacitance around the input components, and the net result is an effective circuit input capacitance of only 6pF.

In practice, by the time we add an input socket and plug, it is closer to 10pF.

### 100MHz preamp

This part of the circuit amplifies the incoming signal and converts it to a "clean" square wave suitable for the logic and counting circuitry.

At first glance, the requirements of high gain and a frequency response flat to 100MHz may seem a little daunting, but this is achieved with a standard ECL differential line receiver (10116) and careful circuit layout.

Note: readers unfamilar with the internal circuitry of ECL should refer to the accompanying panel.

The 10116 contains three differential amplifiers, each with complementary outputs. Also provided is a DC bias voltage, VBB (pin 11), which we have used to bias the inputs of the first stage (IC2b).

The signal is capacitively coupled from the JFET buffer stage and, by keeping as much symmetry in the layout as possible, most of the noise picked up at this point is effectively cancelled by the balanced differential input. This is important because the proximity of the 8-digit multiplexed LED display makes for a very noisy environment.

The DC balance of the first stage is adjusted by VR1. Since each input draws approximately 13$\mu$A of bias current, this 1kΩ multi-turn trimpot can shift the DC input voltage by ± 13mV.

The voltage gain of the first stage is about seven.

The second stage (IC2c) has some negative feedback to reduce its gain. This feedback is applied from one output to its corresponding inverting input by two 100Ω resistors. If IC2c was an operational amplifier, it would have a gain of −1 via the inverting input and +2 via the non-inverting input, giving a total differential gain of three. But since the open loop gain is only seven (instead of practically infinity in the case of an op amp), the actual stage gain is closer to two.

There are reasons for reducing the gain here. First, using all the available gain would make the circuit too sensitive. To give a good stable reading, a DFM must be able

## All About Emitter Coupled Logic

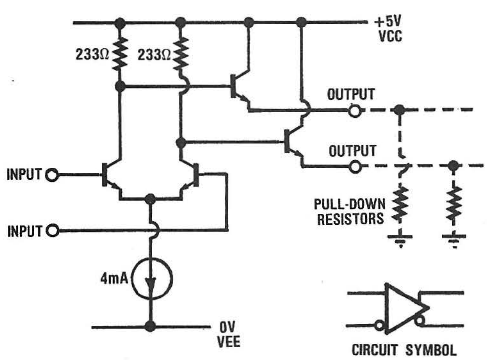



Fig. 2 BASIC ECL DIFFERENTIAL AMPLIFIER

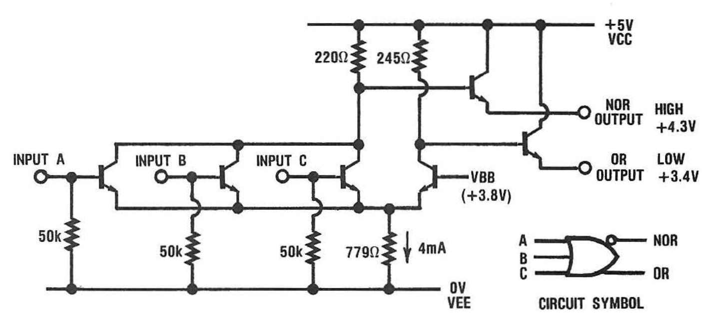



Fig. 3 BASIC ECL LOGIC GATE

Emitter Coupled Logic (ECL) was one of the first forms of bipolar logic to be produced as monolithic integrated circuits, back in the early 1960s. Today, it is still the fastest form of logic available, with propagation delays of less than one nanosecond per gate quite common.

The ECL 10,000 series ICs used in this project are slowed internally to make them less critical to use with normal circuit wiring. The propagation delay is 2ns and the rise and fall times have been slowed to 3.5ns.

ECL ICs are normally designed to run from a −5.2V supply (VEE), but they also work quite well from a +5V supply; ie, VCC = +5V and VEE = 0V.

Fig.2 shows the basic structure of an ECL differential amplifier. Depending upon which input is at the higher voltage, either the left or the righthand transistor in the differential pair will be turned on and the voltage across its collector load will be about 0.9V while the collector of the other transistor will be at VCC. Each collector output is buffered by an emitter follower, which gives an output voltage swing between +3.4V (logic low) and +4.3V (logic high).

An external pull-down resistor is required on each used output.

Fig.3 shows how this basic structure is modified to form a logic gate. A number of transistors (one for each input) are connected in parallel on one side of the differential circuit, while the transistor on the other side is connected to an internally generated bias voltage (VBB) which is half-way between the high and low logic levels; ie, about +3.8V. When one or more of the inputs is taken above +3.8V, the current shifts from the right to the left hand side of the emitter-coupled circuit and the NOR output goes low, while the OR output goes high.

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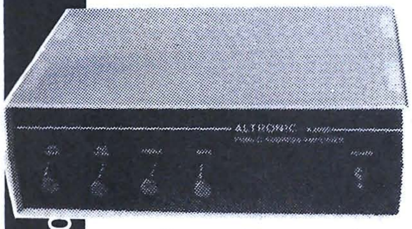

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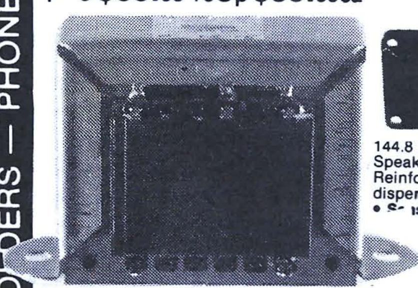

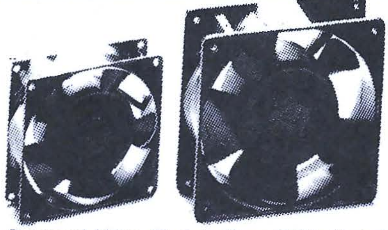

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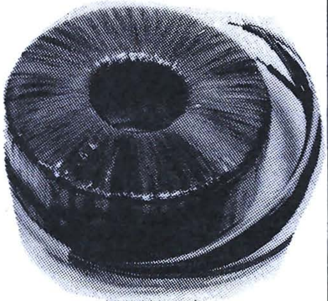

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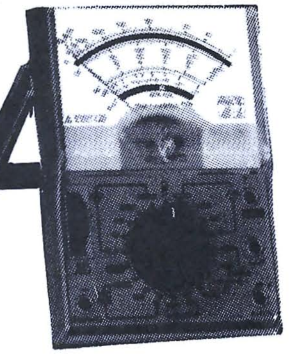

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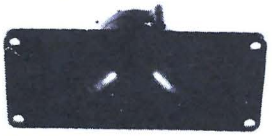

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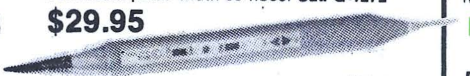

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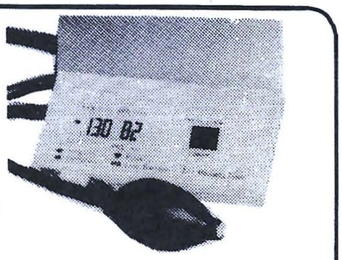

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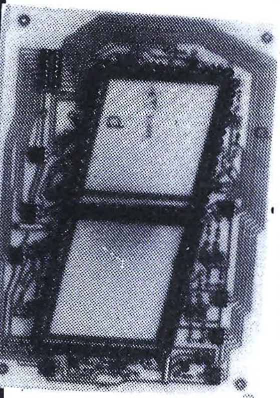

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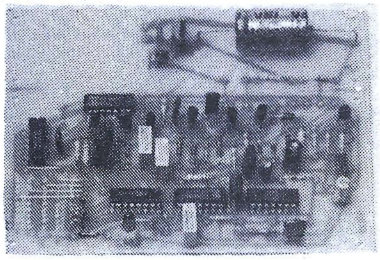

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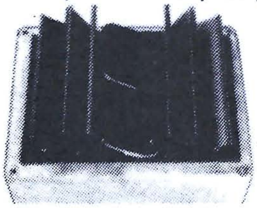

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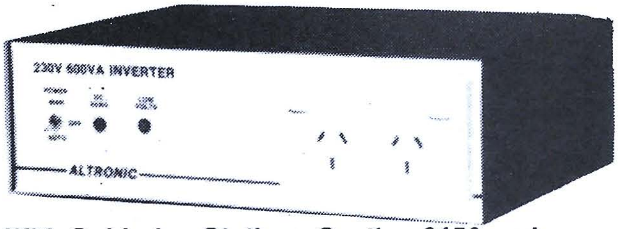


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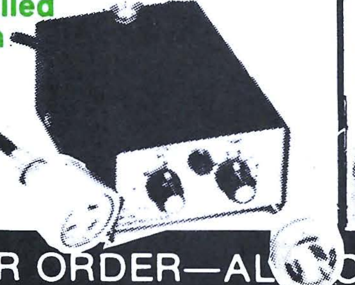

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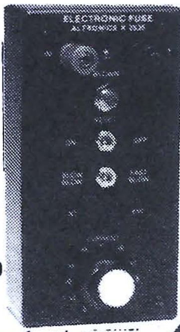


All you do is clip the unit across the DC fuse holder (fuse removed), dial up the required current (max. 10A) and if the circuit draws more than this then the circuit "trips" or opens. Thus power is removed from the device.

**Features:** Fast blow - slow blow setting • Manual reset button • LED fuse tripped indicator • Operates off 1 single 9V battery (not supplied) • Two current ranges 0-1A & 0-10A • Any current setting available up to 10A • Current Settings easily adjustable via. a pot and calibrated scale. • Housed in a rugged Jiffy Box.

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(At onset of clipping)

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(Measured at 1 W and 100W Levels)

**Input Sensitivity**
1 Volt RMS for full output

**Hum**
98db below full output

**Noise**
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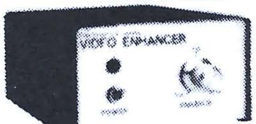


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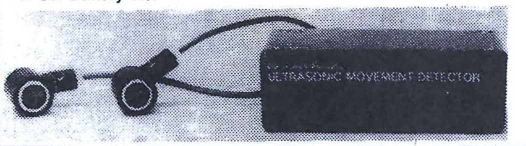


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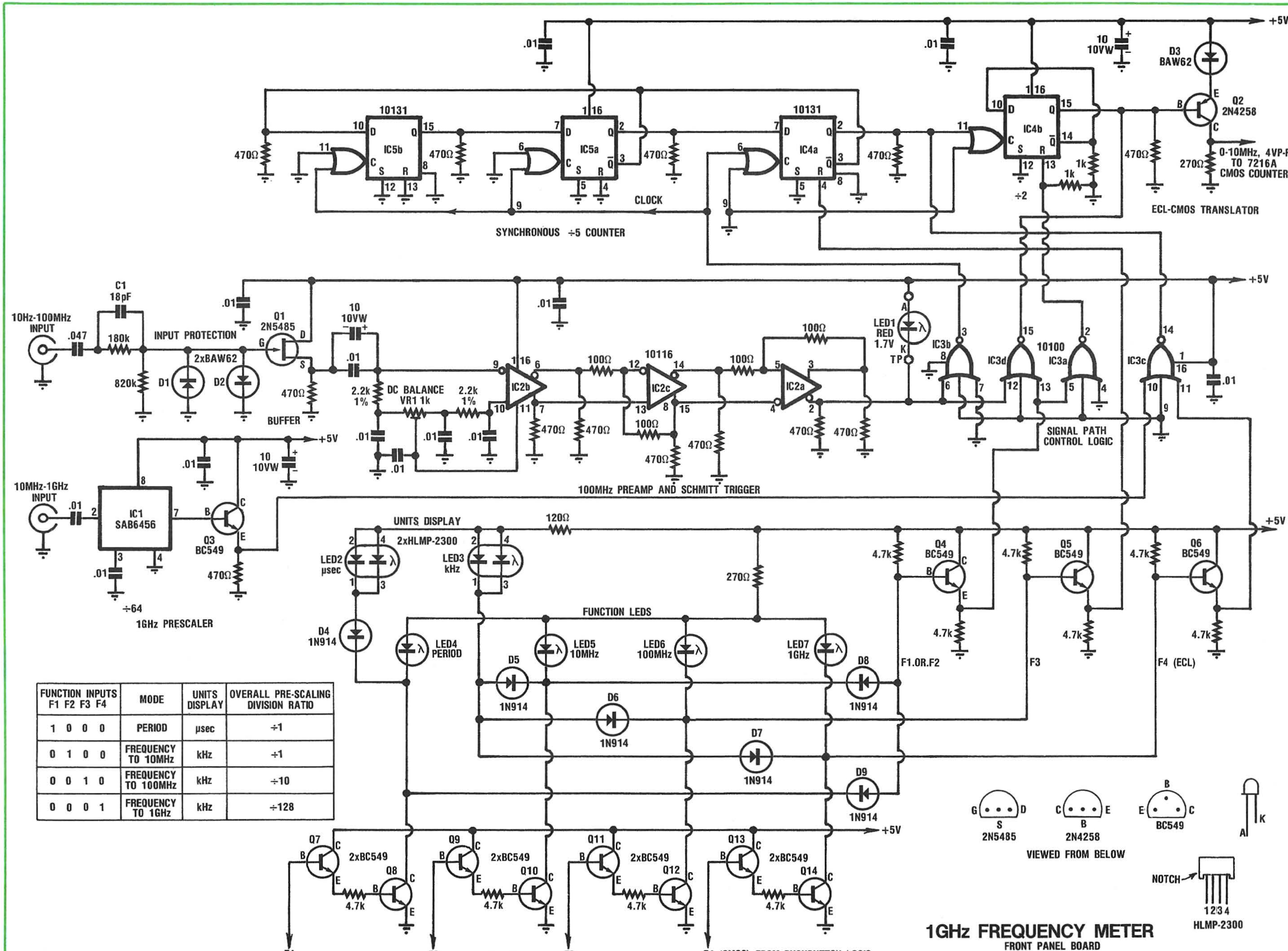
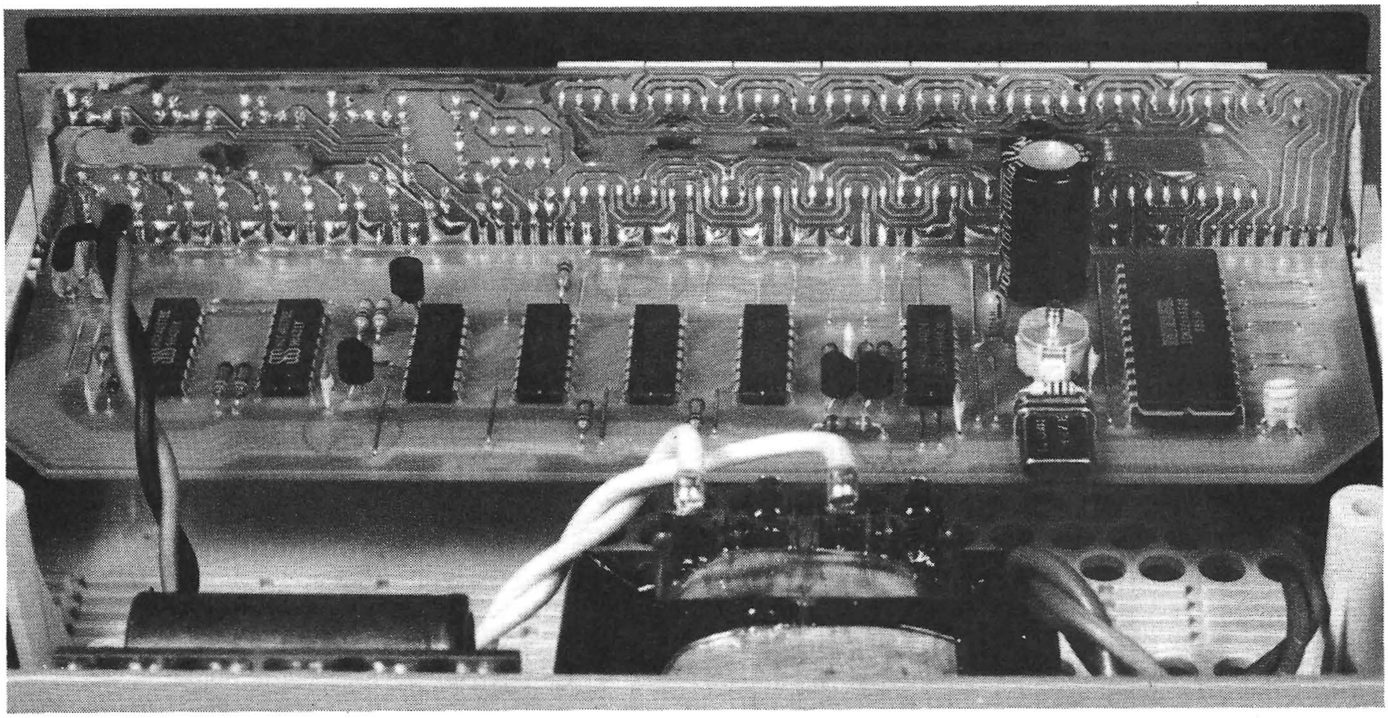



| FUNCTION INPUTS F1 F2 F3 F4 | MODE | UNITS DISPLAY | OVERALL PRE-SCALING DIVISION RATIO |
|---|---|---|---|
| 1 0 0 0 | PERIOD | µsec | ÷1 |
| 0 1 0 0 | FREQUENCY TO 10MHz | kHz | ÷1 |
| 0 0 1 0 | FREQUENCY TO 100MHz | kHz | ÷10 |
| 0 0 0 1 | FREQUENCY TO 1GHz | kHz | ÷128 |

**Fig.4: the front panel circuitry. Signals from the 100MHz preamp (IC2) and 1GHz prescaler circuits (IC1) are fed to NOR gate IC3. The signals are then divided by counter stages IC4 and IC5, or fed direct to the base of level translator Q2.**



**Most of the counter circuitry is mounted on two PCBs which are soldered together at rightangles. This view shows the parts on the main counter PCB. The Intersil ICM7216A is at the right.**

to ignore the noise which is always present on the signal. The sensitivity we have chosen is about optimum for most audio and RF measurements without the need for an input attenuator.

The second reason for using negative feedback has to do with maintaining the high-frequency performance, which will be discussed a little later.

The third stage, IC2a, may appear similar to the second stage, but in this case the feedback is positive rather than negative. This means that IC2a functions as a Schmitt trigger rather than as a linear amplifier.

The positive feedback around IC2a causes it to latch in either the 1 or 0 state when no signal is present. To toggle the output, the signal amplitude must exceed the hysteresis voltage which is about 450mV.

By working backwards from the here, we can calculate the theoretical sensitivity of the instrument; ie. 450mV divided by 2 (second stage gain) divided by 7 (first stage gain) divided by 0.7 (JFET buffer) divided by 0.82 (input protection) = 56mV p-p, or 20mV RMS.

Any noise signal with an amplitude of less than 56mV peak-to-peak will thus be ignored.

At frequencies above 50MHz, the sensitivity of the Schmitt trigger is degraded somewhat by the phase shift (propagation delay) within the ECL amplifier. Thus, the positive feedback becomes less positive. At the same time, the negative feedback around the previous stage becomes equally less negative; ie. the gain of the second stage actually increases slightly.

The serendipitous result is a relatively constant sensitivity up to around 100MHz, without the need for small "peaking" capacitors across the feedback resistors.

Fig.6 shows the measured performance of one of the prototypes. The sensitivity was better than 20mV RMS over most of the frequency range, rising to around 90mV at 140MHz. The small "bumps" at 50Hz and 500Hz were caused by internal noise — from mains hum and the multiplexed digital display respectively.

This noise slightly degrades the theoretical noise immunity, reducing the maximum amount of "ignorable" noise at the input socket from 56mV p-p to about 30mV p-p.

A test point is provided at the output of IC2a for setting up and testing the above circuitry. The state of the Schmitt trigger can be monitored by plugging a 1.7V red LED into a pair of Molex pins on the PCB. The number of turns of trimpot VR1 required to turn the LED on or off provides a convenient check of circuit operation.

Following IC2a, the now digital signal is routed to the base of TTL level translator Q2 via one of two paths: either directly via ECL OR gate IC3d when F1 or F2 is selected, or via IC3b and a high-speed divide-by-10 counter when function F3 is selected.

## The 1GHz input

This input is used for frequency measurements from 10MHz to above 1GHz, and is selected by pressing function button F4.

Surprisingly, this is one of the simplest parts of the circuit, thanks to the use of a Philips SAB6456 UHF prescaler (IC1). As mentioned above, this IC is normally intended for use in TV tuners where its function is to divide down the frequency of the local oscillator, as part of a frequency synthesiser circuit. Because it is designed to be driven by small-amplitude sinusoidal signals over a wide frequency range, it is ideal for our application.

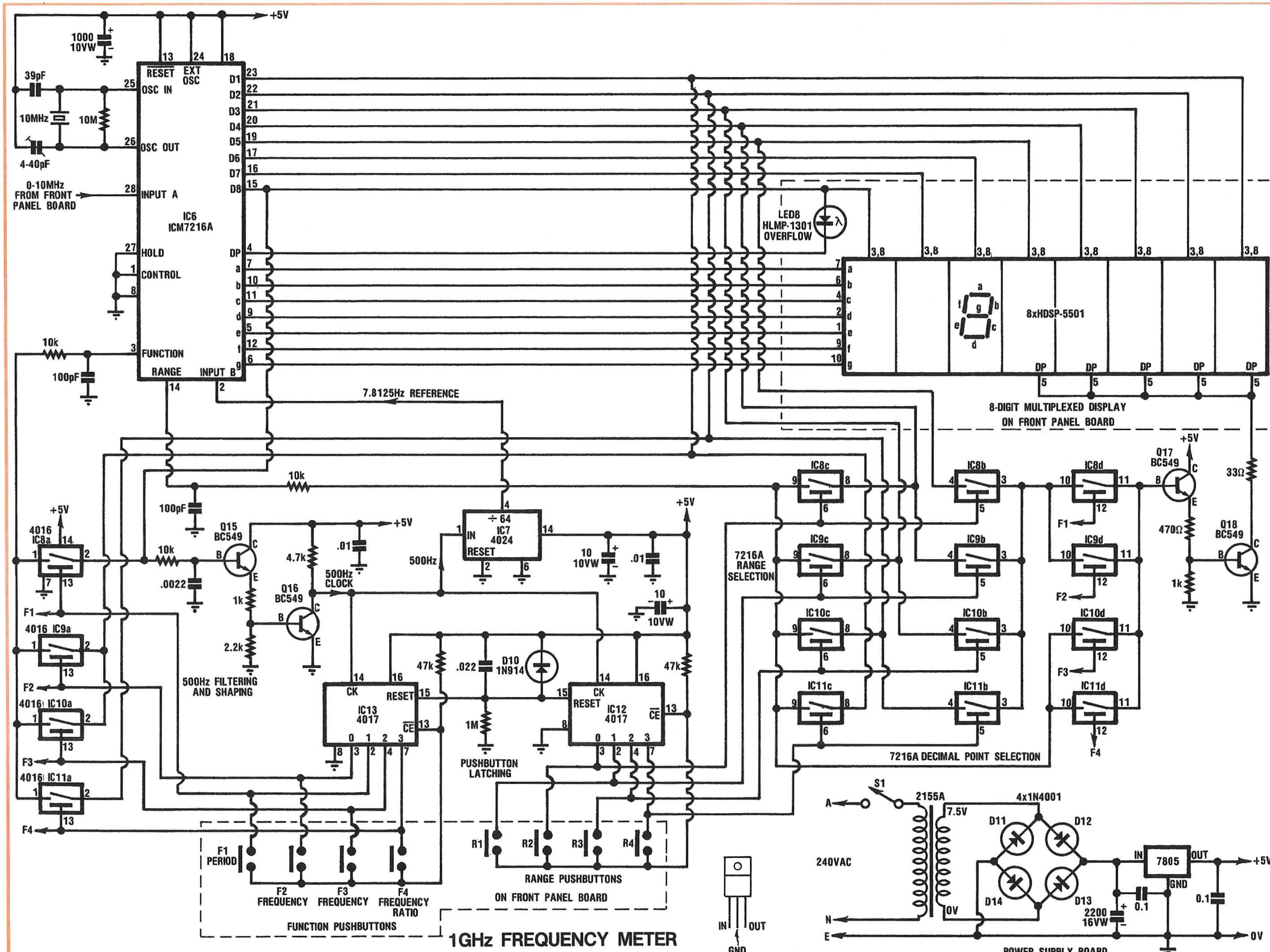



Fig.5: diagram showing the counter, display and power supply circuitry. Also shown is the latching circuitry for the function and range pushbuttons (IC8-12). This section will be described next month.

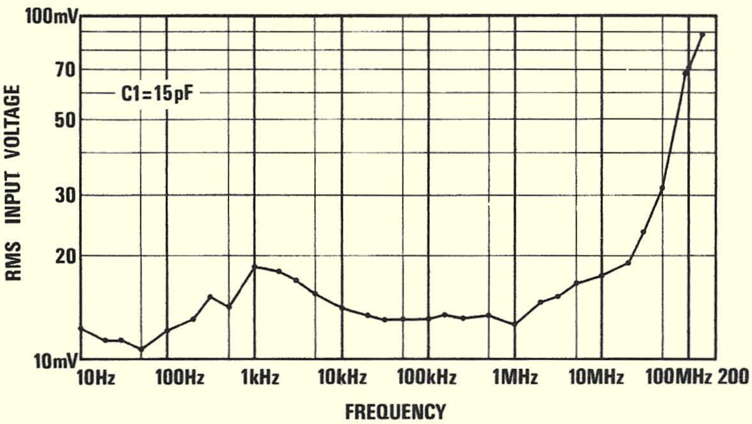



**Fig.6: the measured sensitivity of the prototype was better than 20mV RMS over most of the range, rising to about 90mV at 140MHz.**

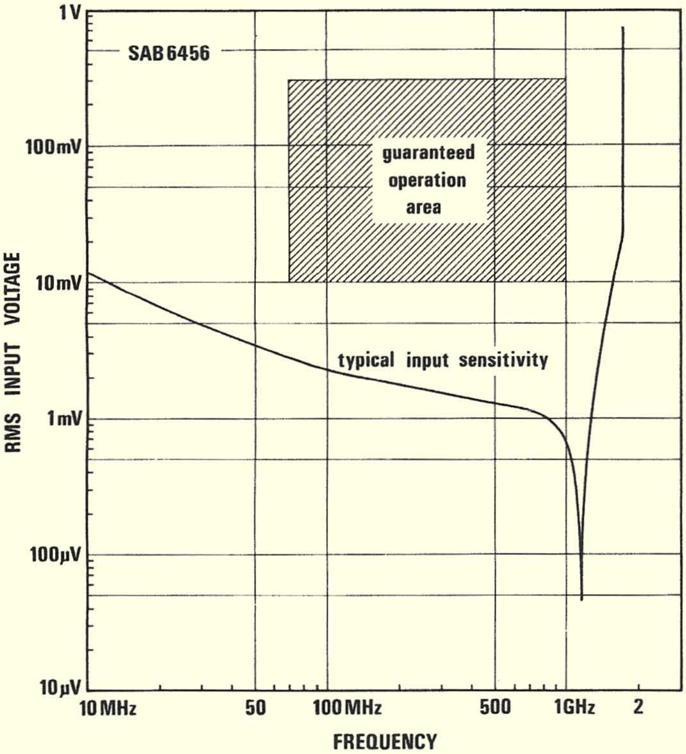



**Fig.7: the SAB6456 has a guaranteed range of operation from 70-1000MHz with a sensitivity of 10mV. Actual devices have a cutoff frequency of typically 1.7GHz.**

Pins 2 and 3 are differential ECL inputs, which are biased internally, so that the only external parts needed are two input coupling capacitors. These capacitors should ideally be leadless ceramic "chip" types, since the inductance of the leads on ordinary ceramic capacitors can be a problem at 1GHz. However, we have found that Philips miniature ceramic plate capacitors (2222-629 series) are useable, provided they are seated right down on the PCB, with an absolute minimum of lead length.

Note: this applies to all the 0.01µF ceramic capacitors used throughout the circuit for high-frequency coupling and bypassing.

No overload protection is provided on the 1GHz input since the usual pair of back-to-back diodes would provide too much of a capacitive load at 1GHz. In any case, most applications will not require a solid connection to this input. The sensitivity is very high, and according to the manufacturer's specifications, is guaranteed to be better than 10mV RMS from 70MHz to 1GHz (Fig.7).

The typical input sensitivity at 1.2GHz is, in fact, a mere 50µV RMS, and the input will usually oscillate at this frequency when no signal is applied. In practice, this is of no consequence since the prescaler will stop oscillating when a valid signal is present. In fact, this self-oscillation provides us with a convenient way of checking the DFM operation on the 1GHz range — pressing the F4 button, with no input connected, should give a reading of around 1.2GHz.

Note that the maximum input voltage for reliable counting is 300mV RMS. The input impedance is 560Ω is parallel with 5pF at low frequencies, and 30Ω in parallel with 1.5pF at 1GHz.

Inside the SAB6456 (IC1) is a binary counter which can be set to divide by 64 or 256, depending upon the mode control pin (pin 5). With pin 5 open circuit the division ratio is 64.

What we would really like is a divide-by-10 or divide-by-100 prescaler, but such devices are quite expensive. Instead, we have managed to make do with the divide-by-64 option, followed by an additional divide-by-2 stage implemented with normal ECL circuitry. The fact that our 1GHz signal is divided by 128 instead of 100 does not cause any real problems, as will be shown next month.

As shown in Fig.7, the actual cutoff frequency for the SAB6456 is typically 1.7GHz. After dividing by 128, this leaves a signal of 13MHz for the ICM7216A counter chip. Since typical 7216 devices can count to 15MHz, our DFM can comfortably exceed its nominal 1GHz specification.

The differential outputs of the SAB6456 are at pins 6 and 7 and the output voltage swing is typically from + 4V to + 5V. The addition of emitter follower stage Q3 to pin 7 gives us normal ECL signals and

## PARTS LIST FOR 1GHz DFM

- 1 plastic instrument case, 200 x 160 x 70mm (W x D x H)
- 1 display PCB, code sc041-1187-1, 194 x 61mm
- 1 main counter PCB, code sc041-1187-2, 190 x 55mm
- 1 power supply PCB, code sc041-1187-3, 54 x 44mm
- 1 translucent red acrylic panel, 195 x 64 x 1.5mm
- 1 Scotchcal label, 195 x 27mm
- 1 10MHz parallel AT-cut crystal
- 2 BNC panel sockets
- 8 momentary contact pushbutton switches
- 1 2155 power transformer
- 1 push on/push off SPDT mains switch
- 1 mains cord and plug
- 1 cord clamp grommet
- 1 two-way mains terminal block
- 3 solder lugs
- 2 PC pin connectors
- 2 5mm metal standoffs
- 3 25mm 6BA screws and nuts
- 1 7mm dia. plastic plug (as used with mains sockets)
- 4 rubber feet

**Semiconductors**

- 1 SAB6456 prescaler IC (Philips)
- 1 10116 ECL line driver
- 1 10100 ECL 3-input quad NOR gate
- 2 10131 ECL dual D flipflops
- 1 ICM7216A 10MHz universal counter
- 1 4024 7-stage binary counter
- 4 4016 quad bilateral switches
- 2 4017 decade counters
- 16 BC549 NPN transistors
- 1 2N4258 PNP transistor
- 1 2N5485 N-channel FET
- 3 BAW62 high-speed silicon diodes
- 4 1N4001 silicon diodes
- 7 1N914 silicon diodes
- 1 7805 5V 3-terminal regulator
- 8 common anode LED displays, Hewlett-Packard HDSP-5501 or equivalent
- 2 red light bar modules, Hewlett-Packard HLMP-2300
- 5 miniature red LEDs
- 1 red LED (for testing)

**Capacitors**

- 1 2200μF 16VW axial electrolytic
- 1 1000μF 16VW PC electrolytic
- 5 10μF tantalum
- 2 0.1μF ceramic
- 15 0.01μF Philips miniature ceramic plate, type 2222-629 (0.2-inch lead spacing)
- 1 0.047μF ceramic
- 1 0.022μF ceramic
- 1 0.0022μF ceramic
- 1 100pF ceramic
- 1 39pF NPO ceramic
- 1 18pF ceramic
- 1 4-40pF trimmer capacitor

**Resistors** (0.25W, 5%)

2 x 10MΩ, 1 x 1MΩ, 1 x 820kΩ, 1 x 180kΩ, 2 x 47kΩ, 3 x 10kΩ, 11 x 4.7kΩ, 3 x 2.2kΩ 1%, 4 x 1kΩ, 15 x 470Ω, 2 x 270Ω, 1 x 120Ω, 4 x 100Ω, 1 x 33Ω, 1 x 1kΩ multi-turn trimpot

**Miscellaneous**

Mains rated cable (32cm), hook-up wire (50cm), heatshrink tubing.

these are applied to pin 10 of IC3c which forms part of the signal path control logic.

## Control logic

IC3 is a quad NOR gate, type 10100, which selects the appropriate signal routing. Pin 9 of this IC is a common enable input which is grounded, so that IC3a, b, c and d function as 2-input NOR gates.

When button F1 (period) or F2 (frequency to 10MHz) is pressed, pin 13 of IC3d and pin 5 of IC3a go low. IC3a is used as an inverter, so its output goes high and resets flipflop IC4b. At the same time, IC3d gates the signal from IC2a through to the ECL-CMOS level translator (Q2).

Note that when two ECL gates share a common output pull-down resistor, either or both gates can take the output high, and so an OR function is obtained without using any extra gates. Thus, the ECL-CMOS translator (Q2) can be driven by IC3d when the output of IC4b is low, and by IC4b when IC3d is low.

When button F3 is pressed (frequency to 100MHz), we need to insert a divide-by-10 circuit. This is done in two stages: a divide-by-5 stage consisting of IC5a, IC5b and IC4a, and a divide-by-2 stage consisting of IC4b.

Before we discuss how the divide-by-5 and divide-by-two counters work, note that IC4 and IC5 are dual D flipflops, with two clock inputs per flipflop which are ORed together. Pin 9 is a common clock input for both flipflops, while pins 6 and 11 are separate clock inputs. Either input can be used to clock the flipflop, provided the other is taken to a logic 0, or grounded.

The D flipflops operate as follows: when the clock input goes to a logic 1, the data present at the D input is latched by the flipflop and appears at the Q output.

## The divide-by-5 counter

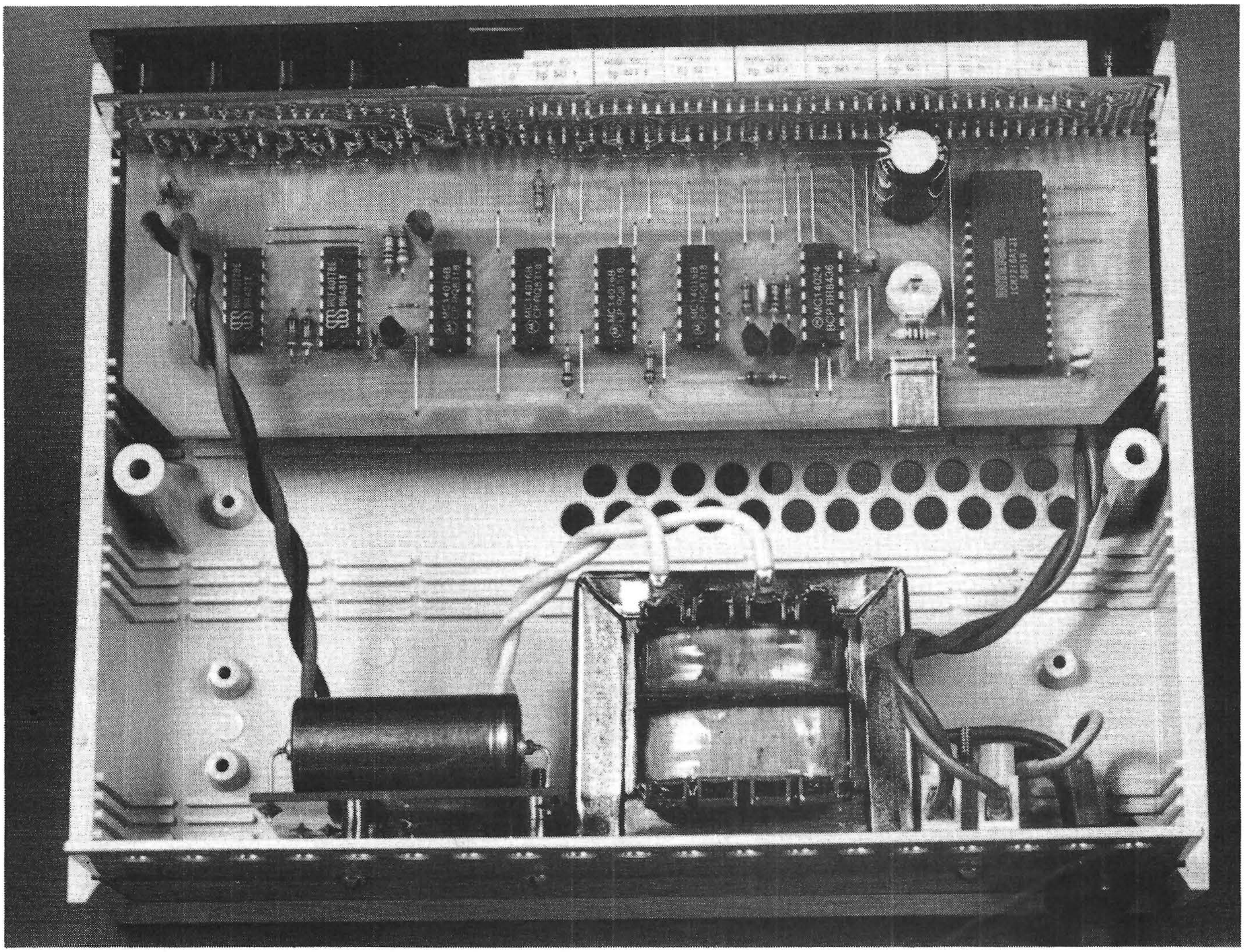
This is a synchronous counter. All three flipflops (IC5b, IC5a and IC4a) are clocked simultaneously from the 100MHz Schmitt trigger output via IC3b. When the counter is not needed, it is stopped by applying a logic 1 to the Reset input (pin 4) of IC4a. However, if F3 is pressed, pin 4 of IC4a goes low and the counter functions again.

The three flipflops are connected to operate as a shift register; ie, each input is connected to the output of the previous flipflop. The input to the first flipflop, however, is connected to the OR of the Q-bar outputs of the last two stages. This gives a count sequence which divides the clock signal by 5.

The divide by two counter (IC4b) is wired with the Q-bar output connected to the D input. This means that each cycle of the clock signal causes the flipflop to toggle and so provide a divide-by-two function. As before, the counter is stopped by applying a logic 1 to its Reset input (pin 13).

Now let us look at the function button logic which involves ten transistors from Q4 to Q14. This part of the circuit controls the signal switching to the ECL-CMOS translator (Q2). Normally, Q4 to Q6 are on while Q7-Q14 are off.

Let's say that function button F1 is pressed (ie, period mode is



**Electronic switching means that internal wiring has been kept to an absolute minimum. Matching slots at the front of the case accept the main PCB and front panel assembly, while power supply components are mounted on the rear panel.**

selected). When this happens, the F1 line is latched high by IC13 (4017) and so transistors Q7 and Q8 are turned on. This then turns on LED 4 and LED 2 which are the period mode and µsec display indicators respectively.

Q8 also controls Q4 via diode D9. Normally, Q4 is turned on by its 4.7kΩ base resistor and pin 13 of IC3d and pin 5 of IC3a are both held high. When F1 is pressed, however, Q8 turns on and pulls Q4's base low via D9. Q4 thus turns off and pin 13 of IC3d and pin 5 of IC3a are pulled low by Q4's 4.7kΩ emitter resistor.

IC3d is now enabled and gates the signal from the 100MHz preamp through to the base of the ECL-CMOS level translator (Q2), as discussed previously.

Note that, during this time, IC4b is held reset by the high on the output (pin 2) of IC3a, while IC4a is held reset by Q5 which is on. Thus, the divide-by-5 and divide-by-2 counters are disabled. Q6 is also on and disables IC3c which controls the signal routing for the 1GHz input.

If F2 (10MHz) is now pressed, Q7 and Q8 turn off and Q9 and Q10 turn on. This turns on LED 5 and LED 3 (via D5) which are the mode and kHz indicators respectively. Q4 is again turned off, this time via D8, and so IC3d again gates through the signal from IC2a to the base of Q2.

If F3 (100MHz) is pressed, Q11 and Q12 are turned on and light LED 6 and LED 3 (via D6). Q12 also turns off Q5 which releases the reset on IC4a and thus enables the divide-by-5 counter. At the same time, pin 2 of IC3a goes low and enables IC4b. As a result, signals from the 100MHz preamp are now gated via IC3b and pass through the divide-by-5 and divide-by-2 stages before being fed to the ECL-CMOS translator.

Finally, when F4 (1GHz) is pressed, LED 7 and LED 3 light and Q6 is turned off by Q14. Q5 is on and so IC4a will now be disabled. The divide-by-2 counter (IC4b), however, will still be enabled by the low on pin 2 of IC3a. Thus, when F4 is selected, signals from the 1GHz divide-by-64 prescaler are gated by IC3c and fed to the divide-by-2 counter (IC4b).

That's all we have space for this month. When we resume next month, we'll describe the counter circuitry and the latching circuitry for the pushbutton switches. In addition, we'll give you all the construction details.

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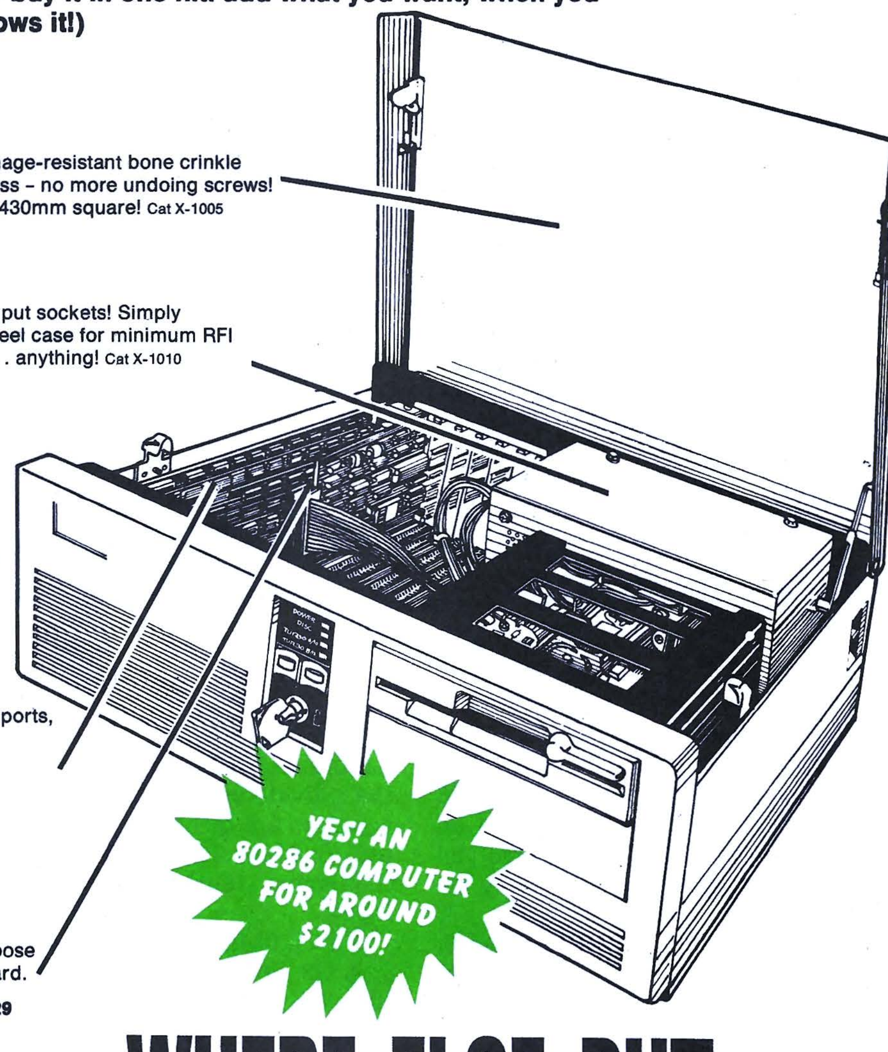


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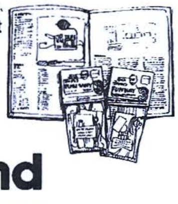

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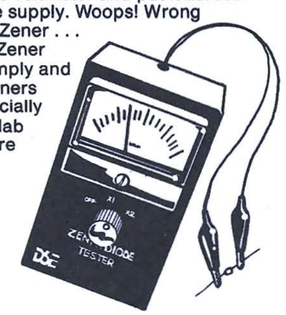


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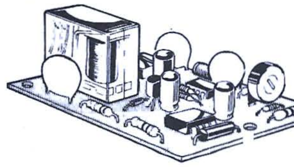

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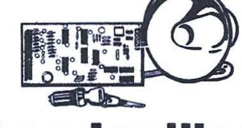

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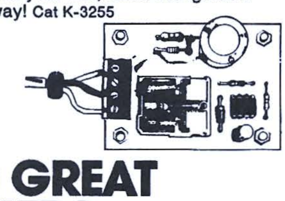

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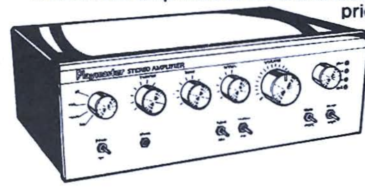

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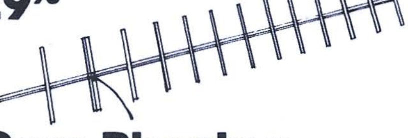

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# SERVICEMAN'S LOG

## With friends like that

***"With friends like that, who needs enemies?" So goes the popular saying, implying that someone one trusted as a friend has not come up to scratch in a crisis or, worse, has deliberately betrayed that friendship, usually for his own personal gain. Cynical though the expression may be, there seems to be a lot of it going around.***

These thoughts were prompted by a recent experience involving a customer and a video recorder. He was one of my regular customers and the recorder was a model AV14 manufactured by Mitsubishi and marketed by AWA. This is a relatively recent model which first appeared about three years ago, and one with which I am reasonably familiar.

So when the customer opened the conversation with the innocent remark, "Will you have a look at this recorder for me?", I expected some fairly routine electrical or mechanical fault. "Sure", I replied, "What seems to be the problem?"

Then he dropped the bombshell: "It's been dropped".

That rocked me somewhat. Of all the things one should not do to a video recorder, dropping it would be at the top of the list. Of course there is dropping and dropping — how far had it fallen, on what had it landed, and at what angle? These were questions I wanted to ask, if only to help me assess the likely damage and chances of repair. But the sheepish look on the customer's face when he made the announcement suggested that such questions might not be diplomatic, at least at this stage.

Picking up the machine, I turned it over and gave it a casual inspection for obvious signs of damage. At first I found nothing, then a closer look revealed a slight flattening of the metal top cover in the rear left hand corner, amounting to only a few millimetres. Well, at least I could visualise the angle at which it had landed. And with only that much damage externally, maybe the situation wasn't so bad.

But when I looked through the front loading opening it was a different story. The cassette carrier was at a nasty angle relative to the opening, with the left hand side several millimetres higher than it should have been. That set my imagination racing; I could visualise the main frame being twisted or, more likely, fractured, in which case the machine would be a write-off.

I passed these thoughts on to the customer, and suggested that he leave it with me until I had time to open it up and take a more detailed look. And if the damage wasn't as drastic as I feared, I could probably give him some idea of what it would cost to fix. And so we left it at that.

### A closer look

A few days later, when things were a bit slack, I pulled the top cover off the machine and took a closer look. The mechanical deck is well covered by the main printed circuit board, which would have to be lifted before I could examine the main frame. However, I was agreeably surprised to find that the board itself did not appear to have suffered in any way. I later confirmed that there were no cracks of any kind.

Moving the board clear is a somewhat fiddly job in this model. As well as removing the screws holding the board itself it is necessary to remove the front panel and undo a number of screws which hold the operating controls. These are attached to the main board by flexible leads and some care is needed to ensure that these are not damaged as the board is folded back.

In fact, this part of the exercise was completed without incident, and I was then able to get a good look at the main frame. Strangely enough, the real problem was not immediately obvious. As far as I could see, the frame was neither bent nor cracked and, possibly due to some kind of optical illusion, it took me a few seconds to work out how it was that the cassette carrier was crooked, even though neither it nor the main frame seemed to be damaged.

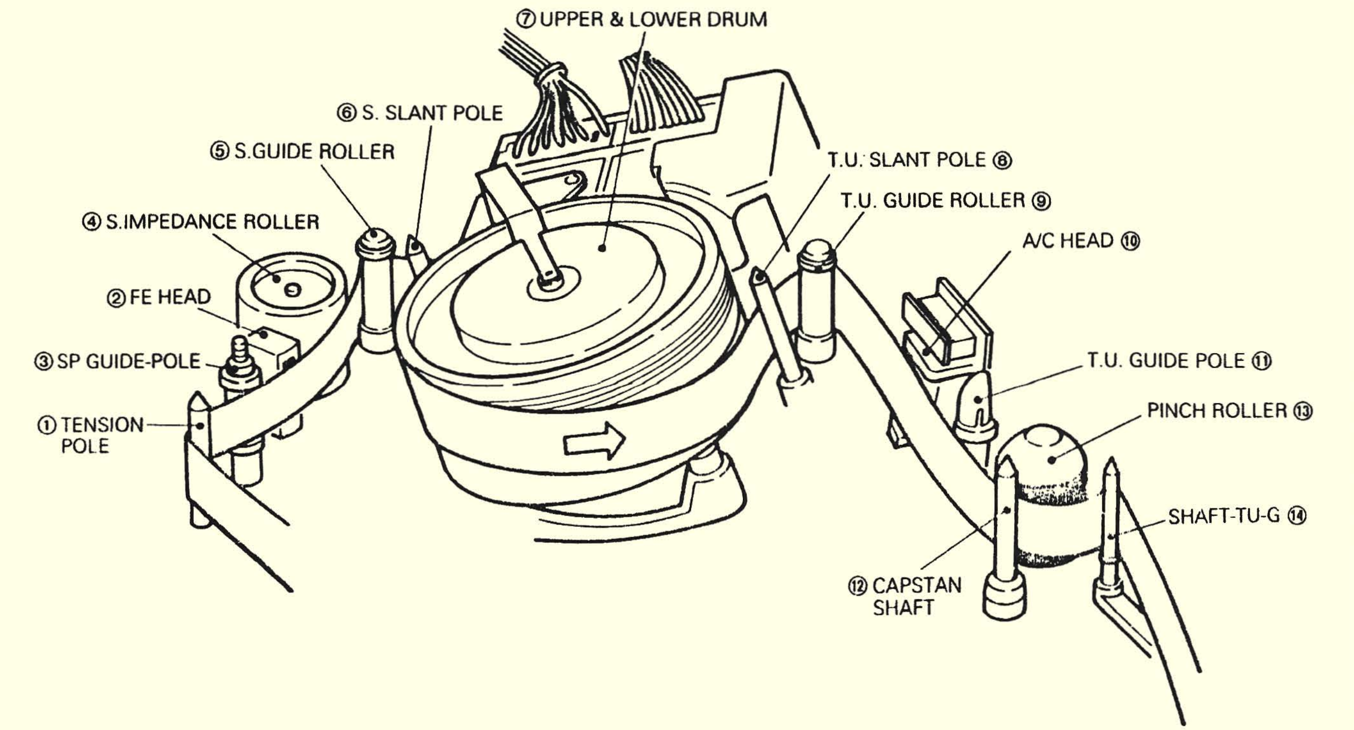
### A frame-up

But suddenly all became clear. The main frame was sitting at an angle, relative to the case, and this was why the cassette carrier did not line up with the front opening. And closer examination revealed just why the frame was at this odd angle.

The frame is of cast aluminium and is supported in the case by four round pins, or spigots, about 5mm in diameter, which are part of the casting. They are fitted with rubber bushes which, in turn, fit into recesses moulded into the plastic case. And this was where the

**Special Notice**

These notes are being contributed by the author who, from 1950 until July of this year, wrote "The Serviceman" in another magazine. We feel sure that regular readers of that series will welcome the opportunity to continue following his electronic adventures in *Silicon Chip*.




**This schematic diagram of a VCR deck layout should help readers envisage the components affected by the unfortunate sequence of events involving the customer's "mate".**

damage had occurred.

The spigot near the front left hand corner of the frame had broken off, together with a small piece of the frame, about half the size of a little finger joint. But that was not all; it had wedged itself under the frame in such a way as to lift the left hand corner of the deck, thus creating the odd angle. Such are the weird things that happen when the irresistable force meets the immovable object.

It wasn't much of a job to retrieve the piece of broken casting, whereupon the frame moved back into place and, in spite of the missing support, sat reasonably firm. So normal did everything appear, in fact, that I decided to try loading a cassette. And if it loaded, perhaps it would even play.

So I applied power and, when there was no smoke or other signs of distress, pushed a cassette into the carrier. The carrier accepted it and deposited it on deck in the usual way. Well, so far so good and, thus encouraged, I pressed the play button. For a moment I thought this function was going to work also, but I was disappointed. The two guide rollers — (5) and (9) in the accompanying diagram — which normally pick up the tape and wrap it around the drum, moved only a short distance, then jammed.

Finding this fault took a little more time and proved even stranger than what had happened so far. I withdrew the cassette and examined the deck in greater detail. To understand what I found it will be necessary to refer to the accompanying diagram and in particular to the tension pole (1) on the extreme left hand side.

This pole, as its name implies, is used to tension the tape on the supply side of the drum after the two guide rollers have wrapped it around the drum. It is mounted on a small plate, pivotted on a pin and held in place with a circlip, and which has a short rod extending downwards through the deck. This rod is engaged by a lever which exerts the required tension on the tape via the tension pole.

This mechanism sits in close proximity to the curved cut-out in the deck through which the guide rollers, and particularly the supply side guide roller (5) moves during the tape wrapping process. And, by some queer quirk of the forces generated by the fall, the short downward projecting pin on the plate had been forced out of its own opening and into the guide roller slot, effectively jamming the guide roller.

And while the fact that this had happened at all was puzzling, the real surprise was yet to come. I couldn't believe that this displacement had taken place without some degree of distortion to some of the parts involved, particularly the tension pole plate.

I removed the circlip, pulled the plate out, and examined it carefully. It did not appear to be bent or to have suffered any other form of damage. I replaced it in its correct position, refitted the circlip, then tried the cassette again. And this time it worked; the carrier accepted the cassette, deposited it on the deck and, when I pressed the play button, the two guide rollers picked up the tape, wrapped it around the drum, and set it in motion.

I had connected the machine to a TV set and was gratified to see a picture come up on the screen. Granted, there was evidence of tracking error — not surprising considering what it had been through — but I felt confident that this would respond to routine adjustment.

## So much for complacency

All of which was very encouraging and I felt that I could now regard the machine as repairable and even make a fair estimate as to what it would cost. So much for my complacency. The setup had been running for only a few minutes when the picture suddenly went very snowy, and I had visions of all kinds of nasty faults involving hairline cracks in the main board and the time that might be necessary to track them down.

Fortunately, I made a few simple tests first. I stopped the tape, switched the TV set to an off-air channel, and was rewarded with a snowy picture in that mode also. Further investigation showed that the condition could be created or cured by simply wriggling the plug in the "RF OUT" socket on the recorder. Well, that meant a repair job in that section, but I didn't anticipate that it would be all that difficult.

So it was time to contact the owner, explain the situation, indicate the likely cost of repair, and see what he wanted to do about it. I rang his home number and the phone was answered by his wife. When I explained who I was and that I was calling about the video recorder the reply was a rather flat and slightly aggressive "Oh that".

It didn't need Sherlock Holmes to deduce that there was some lack of domestic agreement in the matter of the video recorder.

Naturally, I wasn't keen to become the meat in any sandwich but, on the other hand, I needed someone to make a decision. But before I could say any more, the lady launched into the story about the recorder, "People seem to take my husband for a soft touch. He bought this recorder in a pub for a hundred dollars, from one of his mates".

She went on to explain that this mate had been involved in a marital breakup and was short of ready cash. So he had offered my customer "this beaut video recorder for a hundred dollars".

Of course, he had conveniently forgotten to mention anything about the recorder's unfortunate encounter with a hard floor, and so the deal was struck, my customer believing that he had acquired a real bargain. It was only when he brought the machine home and tried to use it that he found it wouldn't even accept a cassette. Exactly how he eventually learned what had happened to the machine was not revealed. Perhaps he tackled his mate; perhaps he heard it from somebody else. But one thing is certain: with friends like that, who needs enemies?

## So much for history

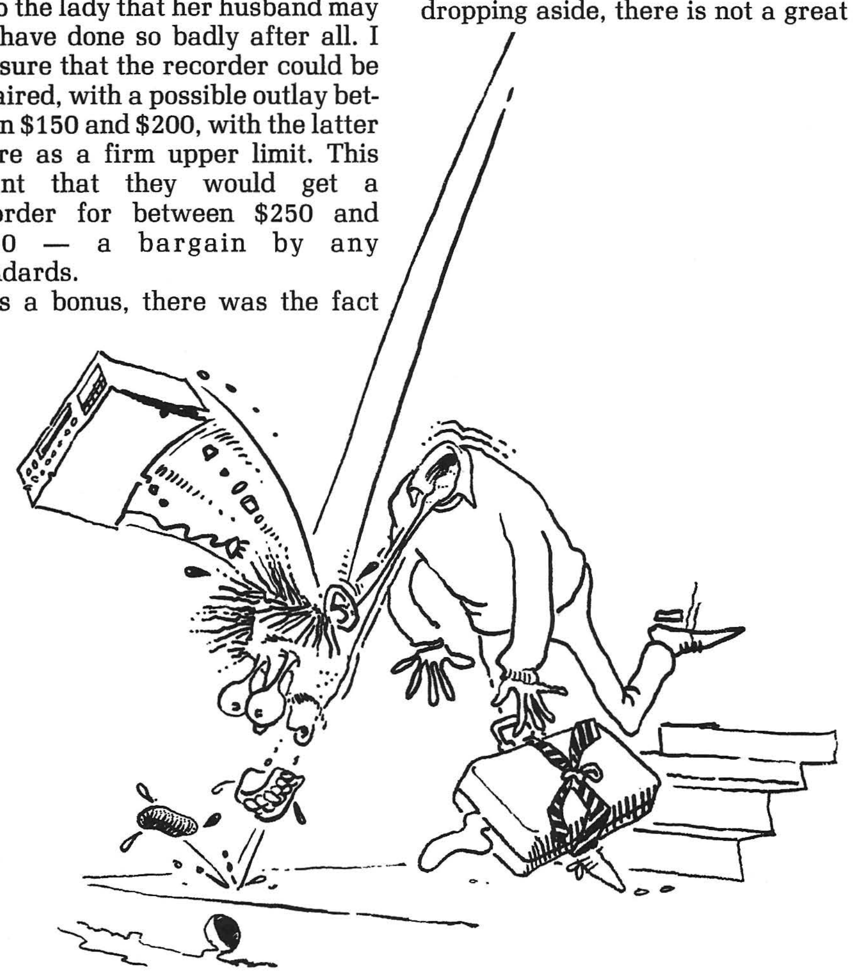
So much then for the history. What about the present? I explained to the lady that her husband may not have done so badly after all. I felt sure that the recorder could be repaired, with a possible outlay between $150 and $200, with the latter figure as a firm upper limit. This meant that they would get a recorder for between $250 and $300 — a bargain by any standards.

As a bonus, there was the fact that the machine was a current model and, based on my examination of it, one that had had very little use. In that sense it was almost brand new.

Apparently I was a better salesman than I realised because, by the time I finished, the lady gave me the go-ahead to fix the machine, without waiting to discuss it with her husband. (Curse my fatal charm).

But now I had to deliver the goods. The most important job was to somehow refit the spigot to ensure that the deck would remain stable. Fortunately, the nature of the break made this easier than it might otherwise have been. First, there was the fact that the spigot had not broken off cleanly but had taken a piece of the main frame with it. And second, the angle of the break was such that such stress as it would normally encounter would, if anything, tend to press the two pieces of metal together, rather than the reverse.

There was also the fact that, dropping aside, there is not a great



THE VIDEO HAD BEEN INVOLVED IN A MARITAL BREAK UP......

deal of stress on these spigots; they merely support the weight of the deck. Taking all these factors into account, the repair I envisaged was somewhat unorthodox but, I felt, quite practical. It was based on an epoxy mixture called "Plasti-Bond"; a product which, if mixed correctly, cures to a rock hard finish.

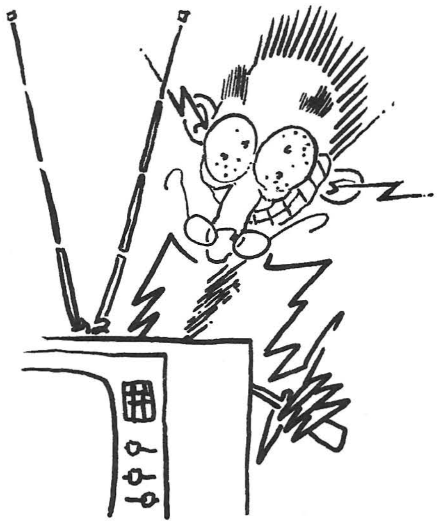
So I mixed up a batch, coated the two mating surfaces to provide an adhesive function, pressed them together, then built up a thick coating around the joint, taking advantage of as many irregular contours of the frame as possible to provide the best possible grip. The result was a substantial block of epoxy around the joint which should withstand any reasonable stress it is likely to encounter.

The next thing to be tackled was the fault involving the "RF OUT" socket. This socket is mounted on a metal box which contains the splitter amplifier and getting at this is quite a job. It is closely linked to the tuner as well as the main board and a lot of leads have to be undone, many needing the solder sucker, before the box can be withdrawn far enough to work on it. Then the soldering iron is needed to open the box because the lid is soldered on.

I eventually gained access to the inside of the box and the rear of the socket. The pin from the socket protrudes through a hole in a printed circuit board and is soldered to a narrow copper pattern surrounding the hole. The hole is rather larger than the pin, the solder forming a bridge across the gap.

This arrangement doesn't impress me very much because even normal plugging and unplugging likely to be encountered in typical use must tend to move the pin slightly, putting a stress on the soldered joint and copper pattern. In this case there had been an abnormal stress on it because the body of the socket was bent several degrees relative to its mounting lugs, and the copper pattern had been pulled away from the board and broken, although making intermittent contact.

I removed the socket, straightened it, then refitted it. I ran some solder around the pin in an effort to fill up the hole in the board and provide mechanical rigidity, then replaced the missing copper pattern with a short length of fine wire. I reasoned that if there was any movement by the pin, the wire should be flexible enough to cope with it.


..SUPPOSED TO RUN AT 15V, BUT WAS, IN FACT, CLOSER TO 100V~~~~

Looking at the damage to the socket etc, I evolved a theory as to how it had come about. I suspect that the lead from the "RF OUT" socket to the TV set was rather short and, when the recorder fell, this lead took most of the weight, even if it wasn't short enough to prevent one corner of the machine hitting the floor.

We'll never know for sure, of course, but something had certainly put a lot of stress on that socket. And it had also contributed a lot to the cost of the repair, due to the difficulty of getting at the fault.

Only the tracking now remained to be adjusted and this was a fairly routine job. When it was finished, the recorder turned in a first class performance and I had no qualms about have advised the owner to let me go ahead with it. The final bill came out about midway between the figure I had quoted and the owner paid up quite happily.

All that was several weeks ago, but the owner was in the shop a few days ago on another matter and confirmed that the recorder is performing beautifully and had been given "a bit of a flogging". I also gained the impression that any initial reservations on the part of his good lady, concerning his "bargain", had long since been dispelled.

So I not only saved a recorder; I might have saved a marriage as well!

## A fallen General

My next story is on a quite different theme although some aspects of it are just as puzzling. It concerns a General GC-181 48cm colour TV set, one of several belonging to a local motel and used in the guests' apartments. And the initial description from the owner was simple enough; no picture and no sound.

This description was confirmed when I finally switched the set on in the workshop; there was no sound — and neither was there any picture for the very good reason that we had a classic case of frame collapse. Initially, I couldn't decide whether this was likely to be two separate faults, or whether there was a common factor, such as a supply rail, which could be responsible for both.

But before trying to track the faults on a logical basis I decided to give the set a routine check, dictated by long experience. This set consists of a chassis and main board mounted horizontally in the bottom of the cabinet, plus several auxiliary boards mounted vertically on the main boards by means of plugs and sockets. Among these are the IF Board, Vertical/Power Board, Audio/Horizontal Board etc, plus a Neck Board on the tube.

Most of the plugs and sockets are 6-pin types, some boards using two or more such devices to provide the necessary connections. The setup is a very convenient one for servicing, but has not been without problems of its own. The plugs, or male connectors, are mounted on the main board and the sockets on the auxiliary boards, and connections between these are prone to failure.

It is the plugs on the main board which are the main offenders. The pins pass through the board and are soldered to the copper pattern on the underside, and it is here that faulty joints are frequently encountered. As a result, I have long since made it a practice to tackle these joints as a matter of routine whenever I encounter one of these sets, regardless of the fault. And it is surprising how often nothing more is needed to fix the fault.

This procedure is further encouraged by the fact that the underside of the main board is fairly easy to get at. Undoing three screws will release the main chassis and allow it to be pulled back far enough in the cabinet to reveal most of the main board underside. And, being a relatively small set, it is easy to tip the cabinet on its side to make it easy to work on.

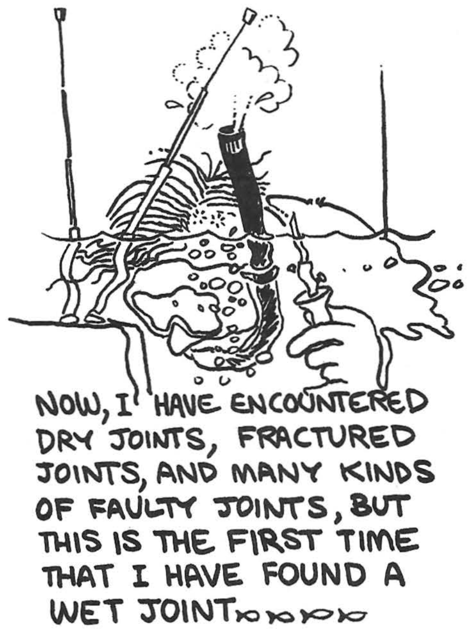
Having done this, and prompted by the frame collapse, I naturally looked first to the two plugs which feed the vertical board. And there it was; around one of the pins (pin 12 of P403) was a tiny patch of what looked like green corrosion. The green lacquer on these boards made it difficult for me to be certain until I checked with a jeweller's loupe, but then there was no doubt.

But there was something strange about the condition. For one thing, it appeared to be quite small and confined to this one spot. And even stranger, the corrosion was quite wet. Now I have encountered dry joints, fractured joints, and many kinds of faulty joints, but this is the first time that I have found a wet joint. But there it was, and I can offer no logical explanation for it. I checked carefully for evidence of spillage of any kind around the cabinet or anywhere inside the set, but there was not the slightest sign.

So I set to repair the damage. Having cleared away the corrosion I soldered a short length of tinned copper wire to the pin and then soldered this to the copper pattern some little distance away, where it should bypass any long term corrosive effects on the copper track. Then I switched on the set and tried again.

## Still no sound

It came good, at least in that I had a picture. But there was still no sound. So it appeared that there were two separate faults. I pulled




out the audio/horizontal board, which, as its name implies, carries the audio output stage and horizontal oscillator stage, and reconnected it via extension leads, of which I have several for this set. Then I reached for the voltmeter for a routine check.

I didn't get far. The supply rail for the audio stages is supposed to run at 15V but was, in fact, closer to 100V. Just where this was coming from I had no idea initially, but I didn't like the chances that the three transistors involved — the two output transistors and the driver — had survived the situation.

It was the physical location of the audio board that gave me the clue. It sits alongside the vertical board which had suffered the faulty plug connection. More importantly, this plug is directly alongside the plug for the audio board, and pin 12 of the latter which carries the 15V supply is alongside pin 12 for the vertical board, which sits at around 106V. What's more, the two copper tracks run side by side for some distance.

And that's where the trouble was. What ever the moisture was that had corroded the joint had also apparently penetrated the board and created a path between the two tracks. It is not the first time I have encountered such leakage problems and I have developed a treatment which has proved very effective in the past.

The idea is to dig a trough between the two tracks. I use a very small drill, driven by a variable speed power drill, and used as a simple router. It requires a little skill but is not all that difficult if one takes one's time. I took about 15 minutes to do this job but, at the end of that time, all signs of the spurious voltage had vanished. I finished it off with a spray of CRC Clear Urethane Seal Coat, 02049, which is available in an aerosol pack.

Then I turned my attention to the audio board and the transistors. As it turned out, only the two output transistors, TR952 and 953, had been damaged and, interestingly enough, one of them had gone open circuit. This was fortunate because, otherwise, the spurious voltage would not have been so immediately apparent. Y'gotta win sometimes!

Anyway, that was it. Two new transistors put the sound section back into action and, after a routine check-up, the set was returned to its owner. But I'm still puzzled about the corrosion and what caused it. And why was it so isolated?

## We'll never know

We'll never know I suppose, but here is one other interesting point. My regular readers will recall that several years ago — September 1983 to be exact — I told a story about a set from a motel, a Precedent GC-181 (no relative of the General GC-181), in which severe corrosion was the major problem. In that case, the corrosion was almost certainly caused by the previous proprietor attempting to repair some soldered joints using spirits of salts as a flux.

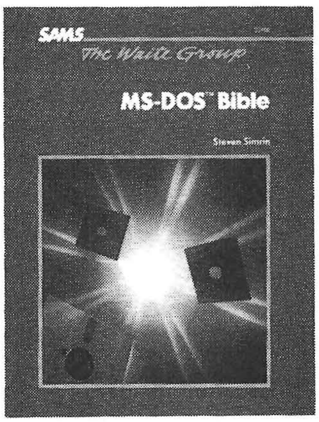
Well, this latest case came from the same motel. Was this another legacy from our heavy-handed plumber-cum-serviceman, but one which had lain dormant for all these years? I agree that the time factor is against this theory, unless the degree of pollution was extremely slight, and it took all these years and perhaps some excessive humidity to provide the final straw.

So what do you think? SC

# BOOKSHELF

## Be the boss of DOS

*MS-DOS BIBLE, by Steven Simrin. Published 1985 by Howard W. Sams, Inc Indianapolis, Indiana. Soft covers, 190 x 248mm, 385 pages. ISBN 0 672 22408 9. Price $39.95.*




Anyone who buys an IBM PC or PC-compatible immediately comes up against the mysteries of DOS which stands for Disc Operating System. IBM PCs use PC-DOS while compatibles use MS-DOS but both are virtually identical since they were created by the same company, Microsoft.

Some DOS manuals are positively labyrinthine in their approach while others are quite good. Ultimately, the hard road of experience is the only way to become proficient at using DOS commands but you can be helped along considerably by a well-written book on the subject. And even if you are quite proficient at using DOS and may be using it for quite advanced programming, a reference book on DOS can still be very useful.

Such a book is the MS-DOS Bible, written by Steven Simrin.

The MS-DOS Bible assumes no prior knowledge on the part of the reader. The only assumption it makes is that you have just purchased or have otherwise gained access to a PC and want to know how to turn it on. Most people buying a PC will also have a specific purpose for which they have purchased software and therefore their initial involvement with DOS will be as minimal as possible. As time goes on though, you need DOS more and more if you are to fully utilise the power of your computer.

At *Silicon Chip* we found ourselves in just this situation when we began setting up our computers to cope with the task of preparing and editing copy, and transmitting it via modem to the typesetters.

We found MS-DOS Bible quite helpful as we created batch files, disc directories, installed hard disc drives and otherwise readied the systems for work.

There are twelve chapters in all, plus a number of appendices.

Some of the chapter headings are as follows: MS-DOS Files, Directories, Paths and Trees, Installing a Fixed Disc, MS-DOS Batch Files, Redirection, Filters and Pipes, EDLIN, the MS-DOS Text Editor and Structure of MS-DOS.

As with MS-DOS itself, you only need to use as much of the book as is required for the task of the moment. It makes a very good reference. Highly recommended. Our sample copy came from Jaycar Electronics.

## Logic made clear

*Understanding Digital Logic Circuits, by Robert G. Middleton. Published 1982 by Howard W. Sams Inc, Indianapolis, Indiana. Soft covers, 136 x 215mm, 392 pages, copiously illustrated with diagrams. ISBN 0 672 21867 4. Price $34.95.*

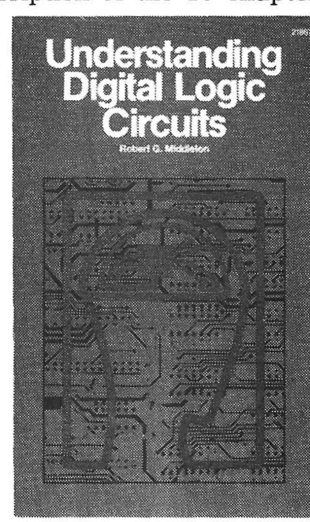
For people who have grown up with the analog side of electronic circuitry, the transition to digital logic can be difficult. There is such a large range of new devices to learn about and the different logic families are not compatible.

There is one consolation that we can offer to anyone who is presently making that transition: when you finally do become familiar with logic circuitry, there is less to it than meets the eye. Certainly, it is not as complex as the great range of analog circuitry.

Now we have just come across an ideal book to teach yourself about logic circuits. Entitled "Understanding Digital Logic Circuits" by Robert G. Middleton, it is written specifically for service technicians. They are now having to repair some of the more exotic equipment such as radio scanners, two-way radios, pushbutton TV tuners, VCRs and so on, all of which contain more and more logic circuitry.

While the book is written with technicians specifically in mind, anyone who has a smattering of electronics will find it easy to follow. It starts off with two chapters on gates which are really worthwhile. If you fully absorb all that is in those two chapters, including the material on negated (or reverse) logic, you will be well up on the subject.

We won't bother to give a full description of the 19 chapters but




suffice to say that the subject of logic circuitry is very well covered with a practical approach throughout. There are chapters on Adders, Flipflops, Registers, Counters, Encoders and Decoders, Parity Generators and Checkers, Multiplexers and Demultiplexers, Memories, Digital Voltmeters and Transmission Lines.

We can highly recommend this text. It is one of the best we have come across and is available from Jaycar Electronics.