electronics today INTERNATIONAL

MARCH 1978

45p

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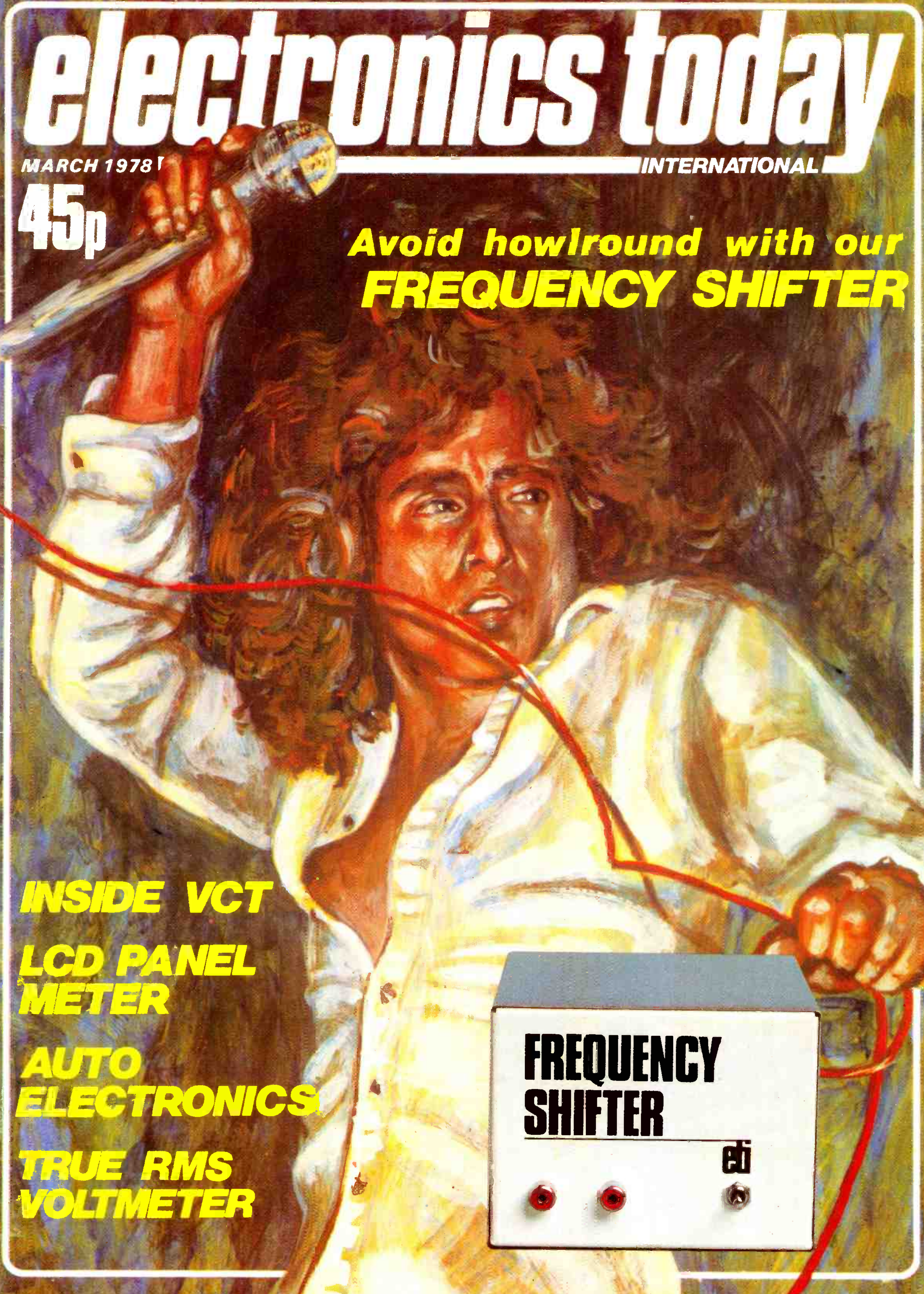

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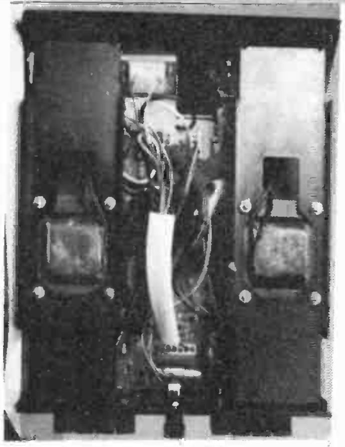

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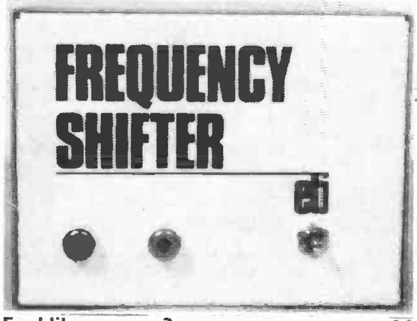

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AC176K	24p	BC183L	9p*	BFX84	18p	TIP42C	38p	2N2221A	16p
AC187	16p	BC184	9p*	BFY50	12p	TIP2955	65p	2N2222	15p
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AC188	16p	BC212	10p*	BFY52	12p	ZTX107	6p*	2N2369	10p
AC188K	20p	BC212L	10p*	MPSA05	22p*	ZTX108	6p*	2N2904	14p
AD161/162MP	80p	BC213	10p*	MPSA06	22p*	ZTX109	7p*	2N2904A	15p
AF139	30p	BC213L	10p*	MPSA55	22p*	ZTX300	7p*	2N2905	14p
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BC118	10p*	BCY71	12p	OC72	12p	ZTX502	12p*	2N2007A	13p
BC147	8p*	BCY72	12p	OC75	10p	2N696	10p	2N2926G	8p*
BC148	8p*	BD115	40p	OC81	14p	2N697	10p	2N2926Y	7p*
BC149	8p*	BD131	35p*	TIP29A	35p	2N706	7p	2N3053	12p
BC154	16p*	BD132	37p*	TIP29B	36p	2N706A	8p	2N3055	35p
BC157	9p*	BF115	17p	TIP29C	38p	2N708	8p	2N3702	7p*
BC158	9p*	BF167	19p	TIP30A	36p	2N1302	12p	2N3703	7p*
BC159	9p*	BF173	20p	TIP30B	37p	2N1303	15p	2N3704	6p*
BC169C	10p*	BF180	25p	TIP30C	38p	2N1304	15p	2N3903	11p*
BC170	8p	BF181	25p	TIP31A	32p	2N1307	18p	2N3904	11p*
BC171	6p*	BF182	25p	TIP31B	33p	2N1308	22p	2N3905	11p*
BC172	6p*	BF183	25p	TIP31C	34p	2N1309	22p	2N3906	11p*
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No 16133 150 75mA Sil Fast switching diode like IN4148 40p
No 16134 50 750mA Sil top hat Rects 40p
No 16135 20 3 amp Sil stud Rect 40p
No 16136 50 400mw Zeners D O 7 case 40p
No 16137 30 NPN Plastics trans like BC107 8 40p*
No 16138 30 PNP Plastic trans like BC177 8 40p*
No 1613[illegible] NPN trans like 2N69 2N1711 [illegible] 40p
No 16140 25 PNP Trans like 2N2905 To 39 40p
No 16141 30 NPN Trans like 2N706 To 18 40p
No 16143 30 NPN Plastic trans like 2N3906 40p*
No 16144 30 PNP Plastic trans like 2N3905 40p*
No 16145 30 PNP Germ trans like OC71 40p
No 16147 10 NPN To 3 Power trans like 2N3055 80p

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Our Mix
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BA100	6p	BY100	15p	BYZ19	28p	IN34	5p	IN5404	13p
BA115	5p	BY127	10p*	OA47	5p	IN60	6p	IN5406	16p
BA144	5p	BYZ10	32p	OA70	5p	IN914	4p	IN5407	17p
BA148	10p	BYZ11	32p	OA79	7p	IN4148	4p	IN5408	19p
BA173	10p	BYZ12	32p	OA81	7p	1S44	3p		
BAX13/		BYZ13	30p	OA85	7p	IN5400	10p		
OA200	5p	BYZ16	30p	OA90	6p				

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Order No			
16213	60 ¼W	100 ohm-820 ohm	
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ALL 4 AT SPECIAL PRICE OF			**£1.60**
16217	40 ½W	100 ohm-820 ohm	
16218	40 ½W	1K8 2K	
16219	40 ½W	10K-82K	
16220	40 ½W	100K-820K	
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TBA810	12 pin QIL	£1.00*	UA703	TO99 (Plastic)	20p	72558	(Dual 748) TO99	45p
TBA820	14 pin QIL	80p*	741P	8 pin DIL	18p	MC1310P	14 pin DIL	£1.25*
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LM381	14 pin DIL	£1.35*	UA741C	TO99	20p	NE555	8 pin DIL	32p
72709	14 pin DIL	28p	72747	14 pin DIL	55p	NE556	14 pin OIL	60p
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New Consignment ZN414 Radio Chip **75p***

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High Voltage (Typ 80V) High gain
10 pieces 5NPN and 5 PNP
Data Sheet supplied
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2nd QUALITY LED PAK

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5 m of 18 sw Multi-core Solder
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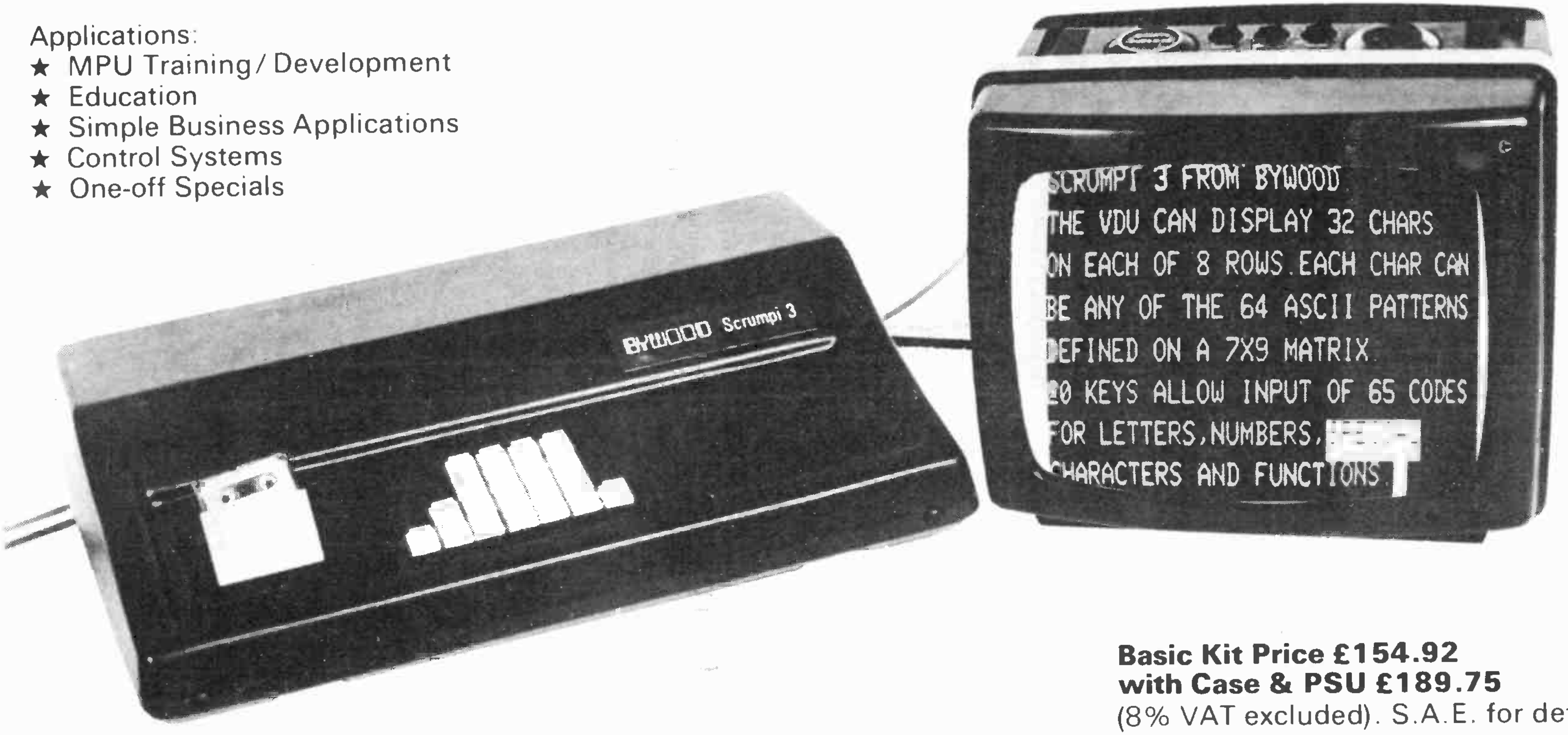

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news digest........

RED TAPE GAGS THE QUEEN!

In the wee small hours of January 19th 1903, Marconi established the first two-way communication across the Atlantic. Messages were exchanged between the American president Theodore Roosevelt and the British King Edward VII. To mark the 75th anniversary of this event, the Cornish Radio Amateur Club have organised a team of sixty local amateurs to run GB3 MSA (Marconi's Seventy-fifth Anniversary). The station was run 24 hours a day, from the 14th to the 22nd January, from the lounge of the Poldhu Hotel in sunny Cornwall – only metres away from the spot Marconi used.

Transmitting on 80m, 20m and 2m the team had already made 1 100 contacts in 51 countries when ETI contacted them on the 16th! All the equipment was owned by the club and its members and set up for the week specially. On the American side was another station, KM1 CC, based in Cape Cod. KM1 CC was run by the local Barnstaple, Mass. radio club with the help of the Radio Club of America.

Now for the red tape . . President Carter sent a message via KM1 CC and the Queen wanted to send a reply via GB3 MSA, just like Edward VII did back in 1903. The Home Office said that if she did, it would break a condition in all British amateurs licences – namely the one about not passing on messages from 3rd parties! So after 2 years preparation the Cornish Amateurs and the Queen were denied permission to reply to President Carter.

Bureaucracy reigns?!

now you see it

Following the tremendous success of the 'Light Fantastic' Exhibition in 1977, the Royal Academy of Arts is staging 'Light Fantastic 2' – this time sponsored by Guiness.

Since the first exhibition there have been several innovations in Holographic technique, at long last the public can see 3-dimensional semi-nude dancing ladies – frozen in mid-air. Other new techniques include experimental 'Head Up Displays' for supersonic aircraft, and multiple exposure Holograms.

Running from 12th January for three months Light Fantastic 2 gives you another chance to see Holograms in real life.

Royal Academy of Arts,
Piccadilly, London. W1V 0DS.

the new 36 24 36

This gentlemen is the replacement for all those nubile 'Miss Jones's' cavorting in slinky fashion around the offices in Britain. A right gang of spoilsports called Optimisation intend to replace all of that with all of this. Called the Mind Reader (it's a good job Miss Jones's weren't mind readers) the box is basically a memory system combined with stop watch, calendar and clock. Information and 'things to do' can be filed away under each day with the machine dutifully displaying the required information on the required day.

The keyboard is touch operated it is 10½ by 7½ by 4½ – not a patch on 36–24–36– it weighs nine pounds and sells for around £300.

Optimisation, 45 South Street, Bishops Stortford, Hertfordshire.

P.S. I bet it makes lousy tea and looks *terrible* in a bikini . . . . .

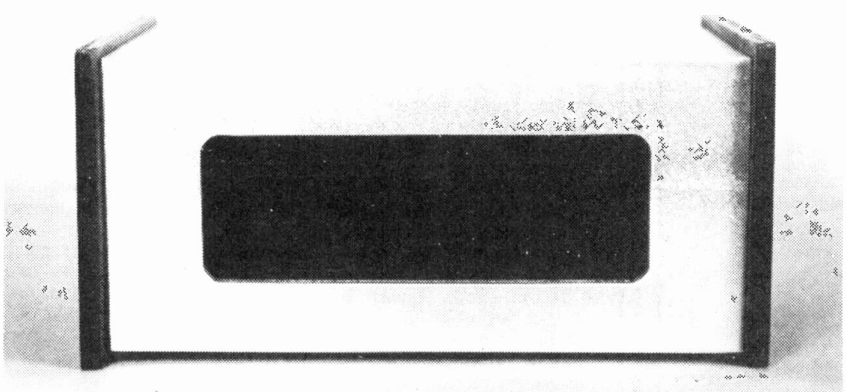
the little cb that santa forgot

Citizen Band radio manufacturers around the world are crying into their transceivers after Xmas. They expected a boost to sales to revive their drooping business, and it didn't materialise. Seems no-one wanted to contact anyone else – not even the reindeer.

chrysler lit up

HP have signed a $400,000 contract to supply Chrysler with LED lamps and displays for this years car ranges. They are to go into digital radios (?) fitted to some prestige models. Twinkle Twinkle little car . . .?

sounds boxy



The biggest problem with building things is *still* finding something to build things in. Whenever we hear of a new box (and there aren't all that many are there?) we endeavour to let you know.

This offering caught our attention whilest meandering around Metac in Edgeware Road. Constructed in one piece of 3mm thick aluminium, with wooden (REAL!) end-pieces the box has a 75mm by 25mm cut out in the front panel for displays etc, and three pre-punched holes in the box for switches and one for a mains lead. Overall measurements are approx. 120mm x 50mm x 80mm (or four and three quarters by two by three and a quarter if you haven't yet let go of the Empire!) Price is £2.80 all inc. from Metac, 327 Edgeware Road, London W2.

....news

on the road

Not so very long ago Edgware Road was *the* place to go for components. The pavements were lined with resisors – any value, any range – and most anything thing the constructor desired was there somewhere.

Even less long ago the road died. Shops closed up, and retailers, with a few notable exceptions, became surly and distinctly unhelpful. Edgeware Road was not the place to go to buy *anything*, except maybe a dead duck or two.

However things seem to have changed yet again. Recently three new component stores have opened, Metac, Audio Electronics and Marshalls. Even a couple of hi-fi emporiums have rematerialised from the ether and things are looking up. Certainly going into Edgeware was a shift of more than just the kitchen sink for Metac. Their shops are best known for their range of watches, clocks and TV games. Now however the Edgeware Road branch is to major in components, although it will still carry an excellent array of time keeping machinery.

In addition to this the shop acts as an inlet for Metac's TV game service facilities, and will carry a range of MPU equipment when set up.

Anyone who has followed the beaten path to Edgeware Road in search of the trappings of our art will have felt the edge of indifference wearing them a little thin at times. We can but hope that Metac and the rest of the reinforcements bring with them their present high standard of service.

colourfull sounds PAL

The Videograph is a new product that provides a means of displaying colourful "music inspired" patterns on any domestic colour TV set. The basic Videograph circuitry generates a green background upon which blue and orange stripes are superimposed. Each of these stripes can be modulated, rather like the display on a 'scope', by audio signals fed to the Videograph's two audio inputs. The two audio signals will usually be derived from the Left and Right outputs of a stereo amplifier thus turning the TV into a sophisticated sound to light unit.

The circuitry is mounted on two boards, the larger taking care of sync generation, audio signal handling and 'stripe generation' while the other provides the colour modulator.

This latter board is interesting in itself as unlike some colour modulators it does not require complex drive signals, i.e U and V inputs, but operates on three separate R, G and B signals. This modulator, with the addition of a small interface circuit, can provide a colour facility for games based on the ubiquous AY-3-8500 which means most tele football games.

The Videograph comes in kit form and, if the instructions provided are followed carefully, can be built up in a few hours. If there are any problems with the unit however, the manufacturers will put things right for you at a small fee.

The Videograph is available from:– W. P. Stuart-Bruges at 137, Billericay Road, Herongate. Brentwood, Essex. CM13 3SD.

The complete Videograph costs £15.95 but the modulator is available separately at £5.50.

horseplay

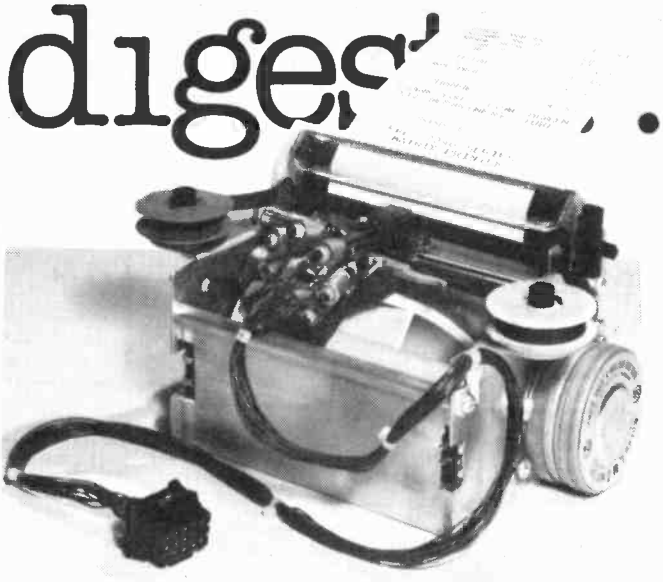
From Rapid Recalls Stable have come three ICs designed as motor drive devices. The three models have 1 A (8510), 2 A (8520), and 2.7 A (8530) output current capability and a standard 741 input characteristic.

They are of hybrid construction, and consist of a 741, driver chip and complementary output pair with frequency compensation. Short circuit protection is provided on chip, with the current into such a load set by external resistors.

One suggested application not to do with controlling actuators, is for a programmable PSU consisting of a D to A convertor, 8520 etc, and thumbwheel switches to control the D to A. Output can then be set to ± 0.1V.

Rapid Recall, 9, Betterton Street, Drury Lane, London WC2H 9BS.

diges' .

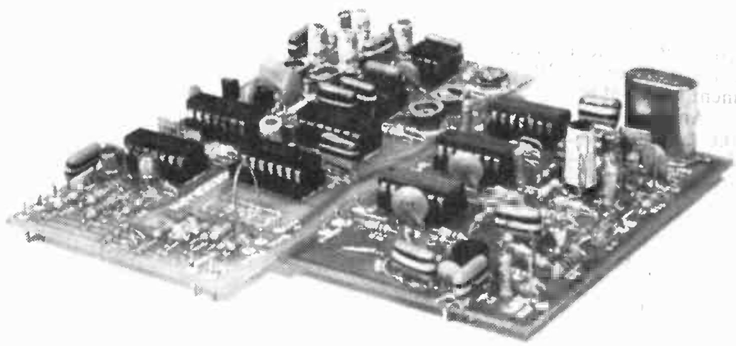


quite.a.ChArAcTeRXXxxX...

Looking a first glance like a cross between Heath Robinson and IBM, this endearing little machine is actually a compact dot matrix printer introduced by Impectron Ltd.,

Print speed is one 3.3 in line per second (40 characters) with a character height of 0.123 in. Multiple copies can be arranged, and power supply requirements are 40 V DC at 3.6A peak. (0.8A average). With its small size (8 in x 4 in x 5 in approx.) and low cost the 7040 will probably find many at home. Accesories to extend usage are available. Details from:

Impectron Ltd., Impectron House, 23–31 King Street, London. W3 9LH.



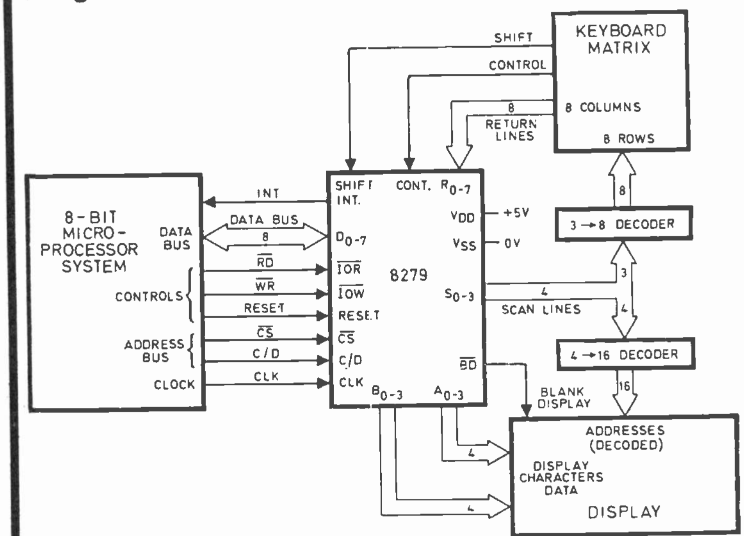
amplfying news

A very worthwhile kit of the ETI 100 W amp has come to our attention, using a more compact PCB and output transistors to bring down cost. The board is well made, and top quality components are used throughout. The firm perpertrating the act are Kingsley Services of Newcastle Prices are extremely reasonable at £16.25 + £2.10 VAT etc. for a built amp module. PSU costs £7.10 + £1.57. Recommended for aspiring 100 W merchants without the confidence to undergo the ritual of the hot iron.

Kingsley TV Service,
40/42 Shields Road,
Newcastle Upon Tyne,
NE6 1DR.

. . . news

key development



Since Data input and display form an important part of microprocessor systems, a new Intel device, a new programmable single-chip keyboard/display interface device. Known as the 8279 will be of interest to many. The device is suitable for use with 8-bit microprocessors, (such as the 8080A) it relieves the CPU in a system from the task of monitoring and servicing the keyboard, and from updating the output display.

Key depressions can be either 2-key or n-key rollover. All keyboard entries are 'de-bounced' within the chip and are stored in a first-in, first-out memory (FIFO) where they are queued for input to the microprocessor when it has time to read them. If more than eight characters are loaded into the FIFO, the 8279's overrun status flag is set.

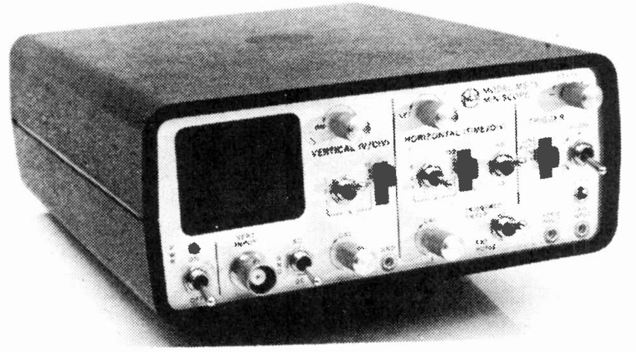
The CPU has full access to the display memory and the display memory address can be incremented automatically on memory read or write.

Intel Corporation (UK) Ltd., 4 Between Towns Road, Cowley, Oxford, OX4 3NB.

game set

The FTC in America has come out with a report on tests they conducted which show that normal use of a TV game will not result in damage to a set. And about time, too.

not much scope



The MS15 is a completely new battery oscilloscope manufactured by Non Linear Systems. Sockets are provided for external triggering and X deflection and a one volt internal calibrator is provided. Lawtronics Limited, 139 High Street, Edenbridge, Kent. TN8 5AX.

digest . . .

bit on the out-side

The BBC has recently been using an experimental 2-channel digital transmission system to asses the feasibility of conveying high-quality stereo sound programme signals from OB sites to London in digital form.

When signals originating at Outside Broadcast (OB) sites are to be propogated throughout the UK, they have to be sent first to London where they are mixed into one or other network programme. Analogue contribution circuits are normally used for this purpose, but their quality is generally inferior to that of the digital distribution circuits that take the the signals out from London to the network of VHF transmitters

The first two broadcasts handled in this way were of a 'Music to Remember' concert at Cardiff on 4th December 1977 and a concert at Lancaster University on 15th December. In both cases the digital signals were transmitted on a radio link from the OB site to a convenient BBC centre, using 4-phase DPSK (differential phase shift keying) modulation. They were then conveyed to London in suitably transcoded form on a television circuit, and mixed into the Radio 4 programme.

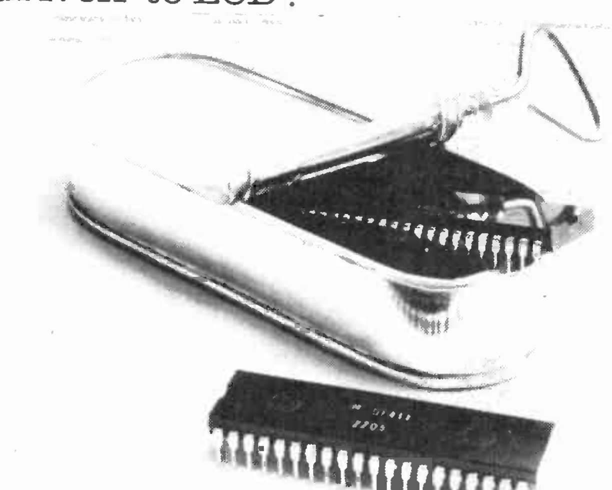
This meant that the transmitted signal quality was virtually identical to that at the OB site itself.

its a wide word

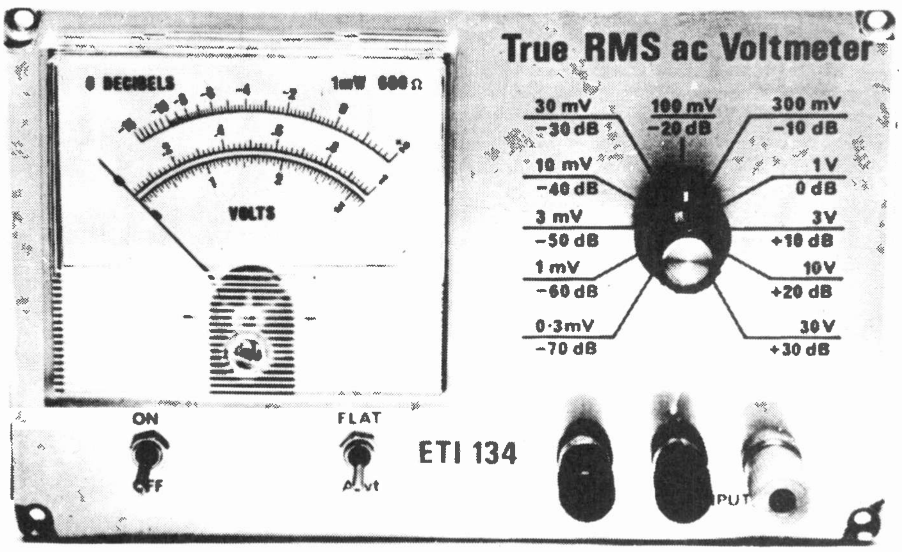
Intel, Zilog and Motorola are taking their places in the front rank on the grid for this years expected race to 16 bit MPU sales. All three have completed development, and will probably show the nature of their teeth at next months US Solid State Circuits Conference. The pause between this and letting loose of the hounds as it were will almost certainly mean late autumn production.

On yer marks ....

driven to LCD?



This new DF411 Siliconix chip carries on board all the clever bits necessary to decode and display up to four multiplexed digits of BCD information in liquid crystal fashion. They can be persuaded to gang up if more than 4 digits are required. Supply requirements are 3–8 V.
Siliconix Ltd., Morristor, Swansea, SA6 6NE.



The use of a special IC results in performance greatly improved over conventional designs.

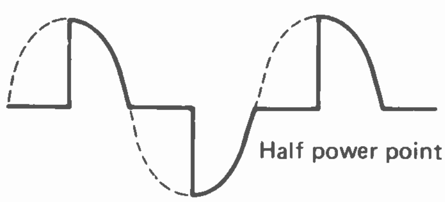
TRUE RMS VOLTMETER

MOST METERS which can measure AC signals do so by rectifying the signal and then measuring the average voltage. With a sinewave the average voltage is 0.637 of the peak voltage while the RMS value is 0.707 of the peak. Therefore a correction factor of 1.11 is built into the meter to give the RMS value of the signal.

Provided you stick with sinewave signals these meters are adequate. With any other waveform, however, they are not accurate. With a square wave the error is 11% and with pulse wave forms the error increases.

Before continuing we should explain what RMS means and its significance . Without getting mathematical, the RMS value of any wave form is the same as a DC value which would produce the same heating effect in a resistor. For example:

Power in a load can be varied by using phase control (i.e., light dimmer) where the time the load is connected to the mains is variable. The RMS value is difficult to calculate except at the point where it is half on—half off. The power then is obviously half power.



If the input voltage is 240 V and the load is 240 ohms the power (maximum) is given by

$$P = \frac{E^2}{R} \text{ or } \frac{240 \times 240}{240} = 240\text{ W}$$

Half power therefore is 120 W. The voltage corresponding to this is given by

$$E = \sqrt{P \times R} \text{ or } 170\text{ V (RMS).}$$

On a "normal" meter this will read 120 V or an error of 30%.

This design uses an RMS detector IC, which is basically a small, special-purpose analogue computer to mathematically calculate the true RMS value for any waveform.

Design Features

The design of the voltmeter is basically simple, starting with an attenuator in the front end, then an amplifier with a high input impedance and switchable gain which, with the attenuator, gives the range selection. A filter is then added to give the "A" weighting and the RMS detector IC (LH 0091) does the rest

The output of the input amplifier is 60 mV, independent of range selected, for an input corresponding to the full scale reading. This gives a maximum gain of 46 dB on the 0.3 mV range. There is a loss of about 2.3 dB in the filter (at 1 kHz) and the spare amplifier in IC2 is used to provide a gain of 20 dB giving 500 mV (for full scale reading) before the RMS detection is done. The RMS detector has unity gain with 500 mV RMS in giving 500 mV DC out.

However things are never that simple. With a total of 60-odd dB gain, along with the requirement for a 1 M input impedence, we have an excellent formula for an oscillator. With the third try (yes, we have failures too) with ade-

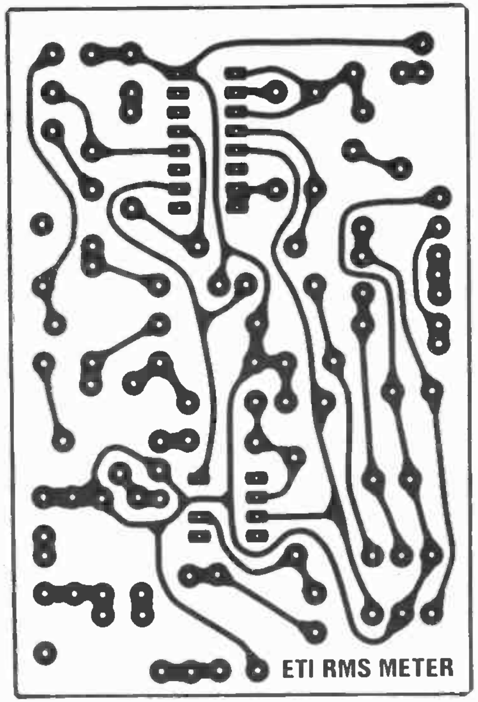
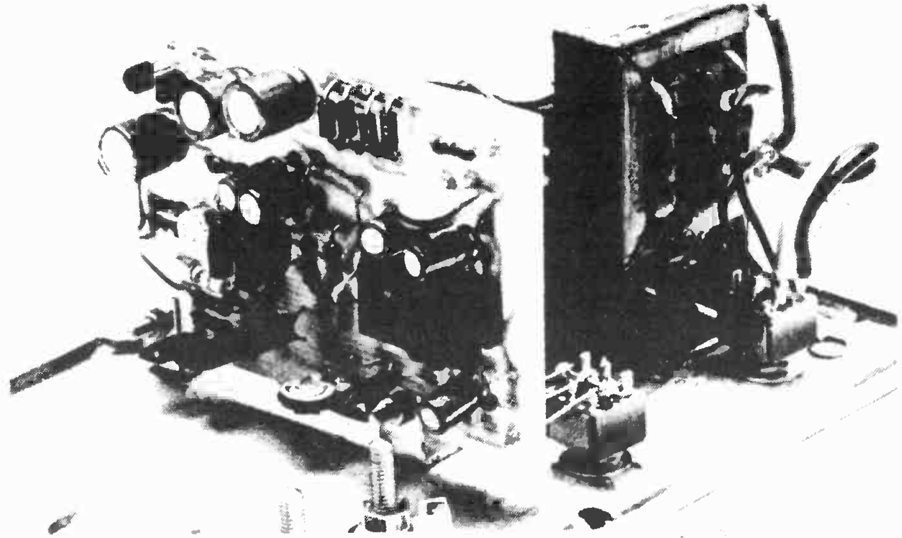


Fig 4. Printed circuit layout.
Full size 90 x 60mm.



Internal view of the RMS voltmeter, showing how the PCB is mounted within the box relative to the mains transformer.

PARTS LIST

RESISTORS

All ½ W 5%, except where marked.

R1	1M	1%
R2,6	100k	1%
R3,7	10k	1%
R4,16	12k	1%
R5	150k	
R8	56R	1%
R9	1k	
R10	120R	1%
R11	3k9	
R12	390R	1%
R13,19	47k	
R14	1k5	1%
R15,17	39k	
R18,20,21,24	27k	
R22,23	270k	
R25	330R	

POTENTIOMETERS

RV1	100k
RV2	200R

CAPACITORS

C1,9,10	100n	polyester
C2*	15p	ceramic
C3*	150p	ceramic
C4*	1n5	polyester
C5,6*	27n	polyester
C7	15p	ceramic
C8	100u	25 V
C11	10n	polyester
C12	820n	ceramic
C13	4n7	polyester
C14–C18	10u	25 V
C19,20	100u	25 V

*These capacitors should be as accurate as possible as they affect accuracy above 10kHz.

SEMICONDUCTORS

IC1	CA3140
IC2	LH0091
IC3	78L15
IC4	79L15
D1–D4	1N4001 or similar

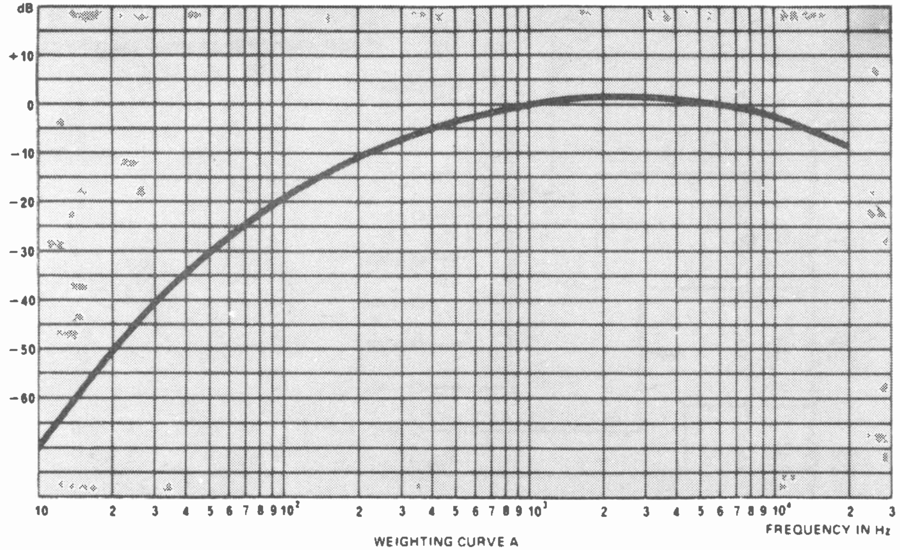
SWITCHES

SW1	2 pole 11 position
SW2	SPDT minature toggle switch
SW3	DPDT minature toggle switch

MISCELLANEOUS

T1	28 V secondary
M1	Meter 1mA scaled as shown

3 terminals (red, black, green), Box to suit, Metal brackets and shields, 3 core flex and plug, 16 pin socket for IC2, Knob.



The response in the "A" weight position.

quate shielding and layout, stability was obtained and this final design is presented here.

The spare IC in the LH0091 is normally used to buffer, filter or amplify the output of the convertor, but used before so as to buffer the filter network and save an additional op amp (the input impedance of the RMS convertor is only 5k). The output voltage from the convertor is only 500 mV but this is adequate to drive a meter. We could have provided more gain in the buffer stage so giving a higher output but this would lead to greater errors with high crest factor waveforms.

We have limited this instrument to AC signals as this eliminates the need for balance controls to correct for drift when measuring low level signals. This normally is of no consequence as most signals, i.e., output of a tape recorder, sound level meter, etc, have no DC component. If DC capability is needed capacitors C1, 8, 9, 14, 15 and 16 have to be shorted out, a zero adjustment potentiometer added to IC1 along with the potentiometers needed to offset adjust IC2 (see data sheet).

Construction

The wires associated with the rotary switch should be no longer than necessary to minimise any pickup. The box should be earthed to the mains earth and the front panel earth terminal (left hand one) should also be connected to earth.

Use

When measuring low level signals there may be 50 Hz pickup unless the common side of the input signal is connected to ground. This may be done either in the unit under test or on the meter (hence the earth terminal). Also with the meter terminals open circuited the meter will give some reading. However, as the output impedance of low level signals (0.3 mV and less) is normally relatively low this is normally no problem. ETI

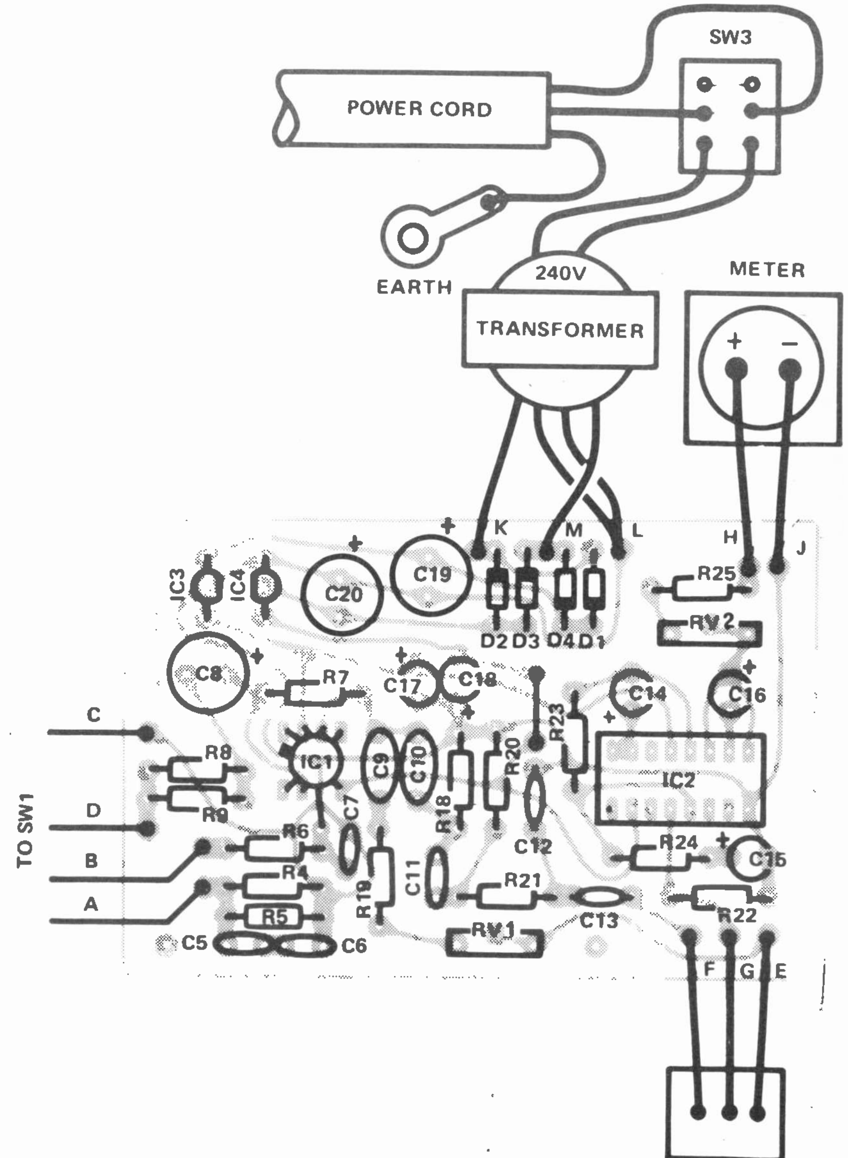
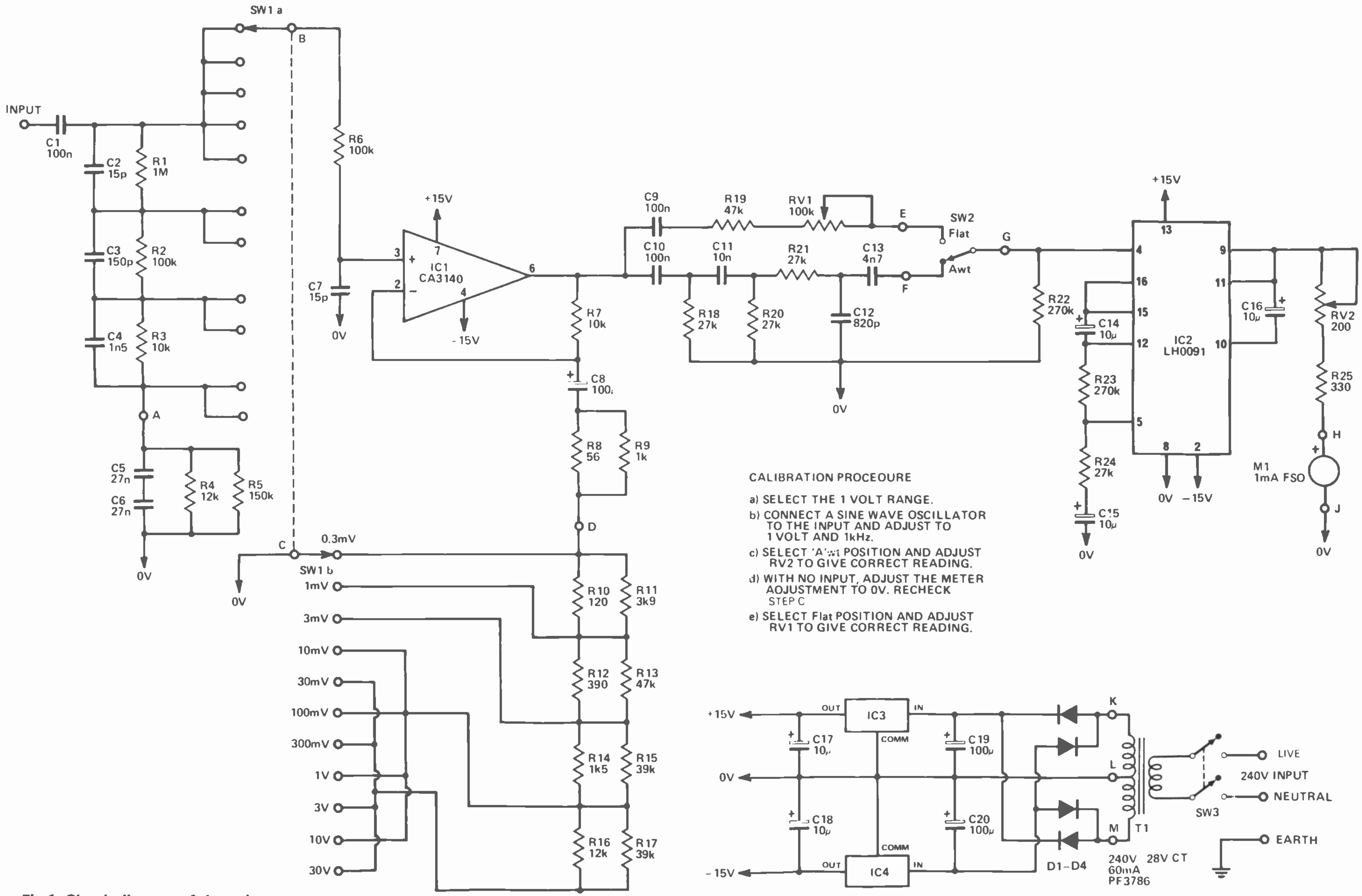


Fig 5. Component overlay and wiring diagram. See Fig 3 for switch wiring.



CALIBRATION PROCEDURE

a) SELECT THE 1 VOLT RANGE.

b) CONNECT A SINE WAVE OSCILLATOR TO THE INPUT AND ADJUST TO 1 VOLT AND 1kHz.

c) SELECT 'Awt' POSITION AND ADJUST RV2 TO GIVE CORRECT READING.

d) WITH NO INPUT, ADJUST THE METER ADJUSTMENT TO 0V. RECHECK STEP C

e) SELECT Flat POSITION AND ADJUST RV1 TO GIVE CORRECT READING.

Fig 1. Circuit diagram of the voltmeter.

HOW IT WORKS

The input signal is attenuated by the network R1–R5 and C2–C6; the appropriate attenuation is selected by SW1a. This gives 0 dB, 20 dB, 40 dB and 60 dB. The output of SW1a is buffered by IC1 which is a FET input op-amp. This amplifier has a gain which is switchable giving 5.56 dB, 15.56 dB, 25.56 dB, 35.56 dB and 45.56 dB. By selecting a combination of these two variables the eleven ranges from 0.3 mV to 30 V are obtained. The output of IC1 for full scale reading is 60 mV.

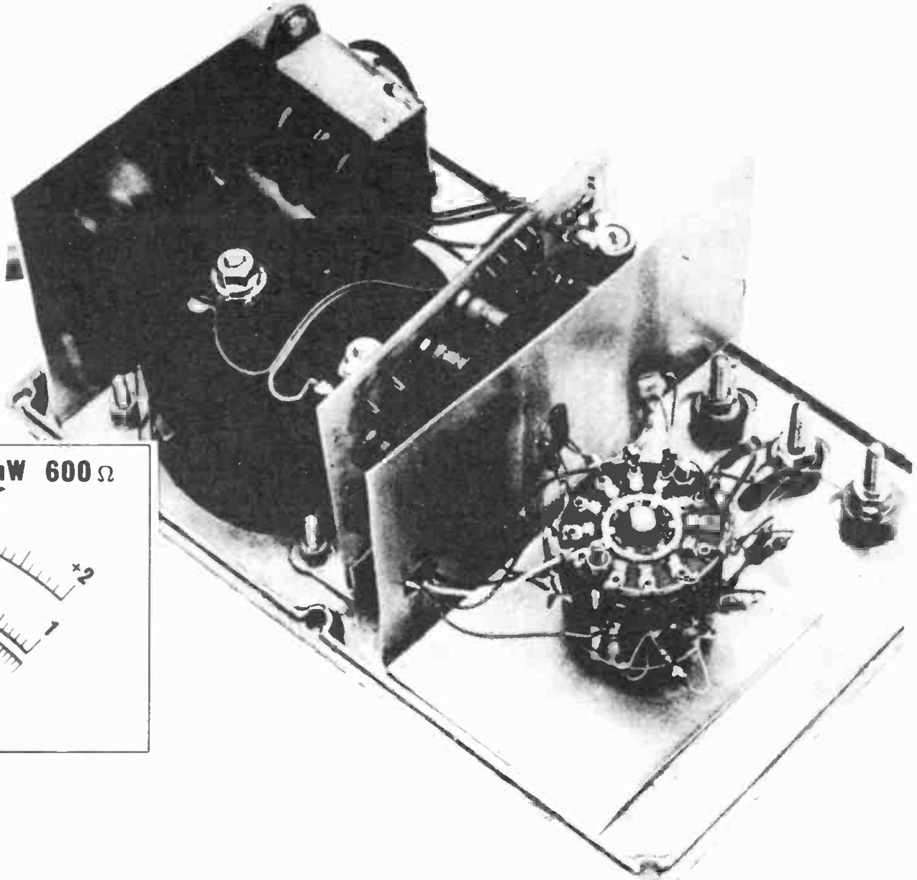
The output of IC1 goes to the 'A' wt filter network and also directly (via R19) and RV1) to SW2. This selects either 'A' weighting or flat response. As the filter has 2.3 dB loss at 1 kHz the "flat" position is also attenuated (hence R19, RV1) to maintain calibration.

The RMS detector IC provides a gain of 20 dB before the detector; the output of the detector is about 500 mV for full scale reading.

The power supply is simply a full wave rectified supply giving both plus and minus voltages of about 20 V, which are then regulated to ±15 V by IC3 and IC4.

BUYLINES

The only 'hard-to-get' component in this design is the LH0091 true RMS detector, Marshalls have arranged to stock it for ETI readers and can supply most of the other components as well. The PCB will be available from normal suppliers Crofton, Ramar, Tamtronik who advertise at the back of the magazine.



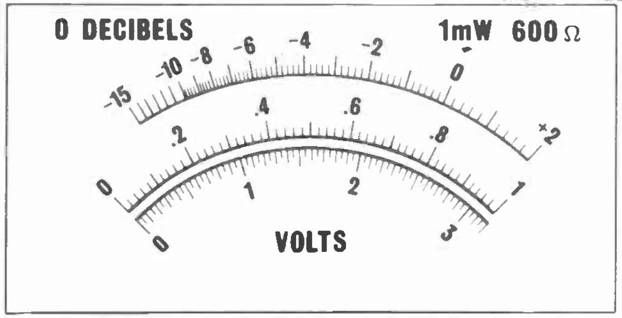


Fig 2. Meter scale shown full size.

SPECIFICATION

Meter Type	RMS reading AC only
Ranges	0.3, 1, 3, 10, 30, 100, 300 mV 1, 3, 10, 30 V
Accuracy	+3% nominal (crest factors up to 3) −8% at crest factory of 10
Input Impedance	1M in parallel with 25p
Weighting Networks	Flat or 'A' weight
Frequency Response	10 Hz – 20 kHz

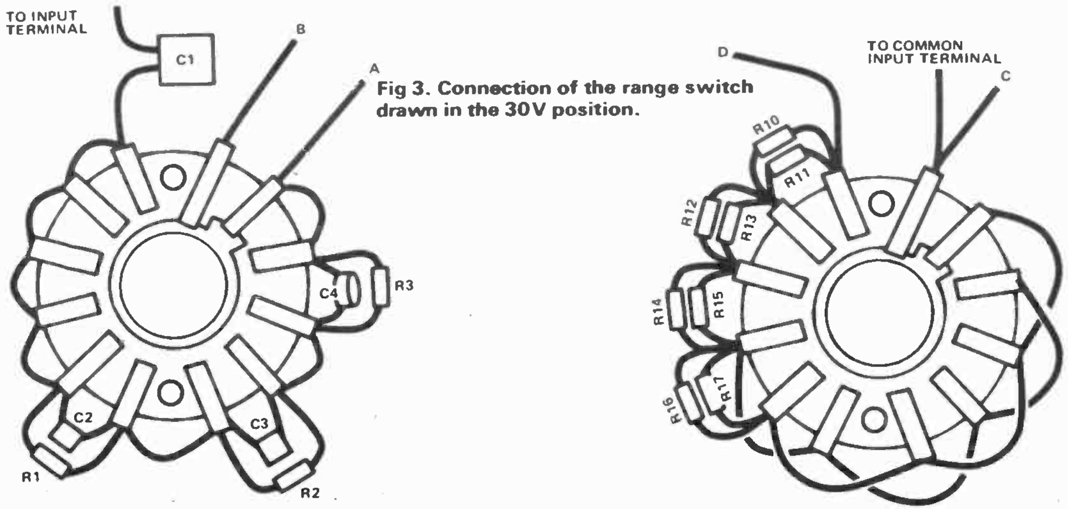


Fig 3. Connection of the range switch drawn in the 30V position.

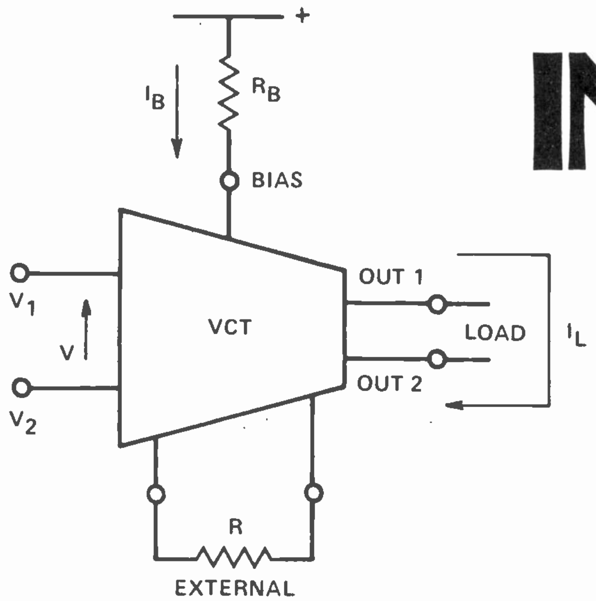


Fig 1. VCT symbol and external connections.

INSIDE VCT

In the January 1977 issue of ETI Ron Harris reviewed the recent development of the Voltage-Current Transactor (VCT), perhaps the most important device innovation of recent years for not only is the VCT expected to perform all the functions we now expect of the op-amp but to perform them either better or with fewer additional components.

The earlier article briefly covered the VCTs development and its terminal properties, together with basic circuit applications. This article describes the VCTs internal functioning. It has been written for ETI by Dr. J. E. Morris of the Department of Physics, Victoria University of Wellington, New Zealand.

THE CIRCUIT SYMBOL for the VCT is shown in Fig. 1 along with the necessary bias supply and an external resistor R which determines terminal gain. The name "voltage-current transactor" is derived from the translation of differential input voltage into a proportional output current.

As with the conventional op-amp, the input impedance is made as high as possible to minimise loading of any practical source of input voltage, but the main difference between the VCT and an op-amp lies in the output port. As a current source rather than one of voltage, the port impedance is high rather than low. Furthermore, whereas the op-amp output signal is usually single-ended and referenced to ground, the VCT output is completely floating. The VCT is thus a true four terminal device and either terminal of either port may be used as a common point. It will also be apparent from Fig. 1 that there is no external feedback element involved in a simple amplification application.

The internal circuit is shown in Fig. 3 and as explained in this article there is no overall feedback concealed within the unit. With no feedback, there can be no feedback stability problems and thus a major headache of op-amp design vanishes.

VCT Circuit

Modern ICs are generally very complex and involve many functional blocks. At first glance a circuit diagram often appears to have more relevance as a design for a maze than as a sensible means of serving these required electronic functions. The trick is to identify the functional blocks. Once their patterns are recognized, circuit operation may be deduced. For example it is obvious that the VCT is essentially symmetrical about the centre, so only one side need be considered in detail. And the input transistors (Q_1 Q_2 on side 1) clearly form a Darlington pair and may be regarded as a single composite transistor (Q_D say) in any simplified analysis.

Most of the functional blocks in the circuit are derived constant current sources and these will be briefly reviewed before seeing how they fit together to form the VCT.

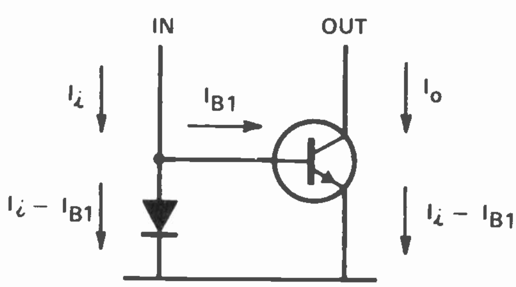


Fig 2. Basic constant current source. I_o is fixed by injected I_i.

The obvious solution to the impedance matching problem might appear to be the use of a common-base transistor stage which has low input impedance into the emitter and the same high output impedance from the collector as above. In an equivalent situation to Fig. 3 however, a PNP transistor is required and the sign of I_o is reversed. A minimum of three supply voltages would then be required instead of the two implied by Fig. 3.

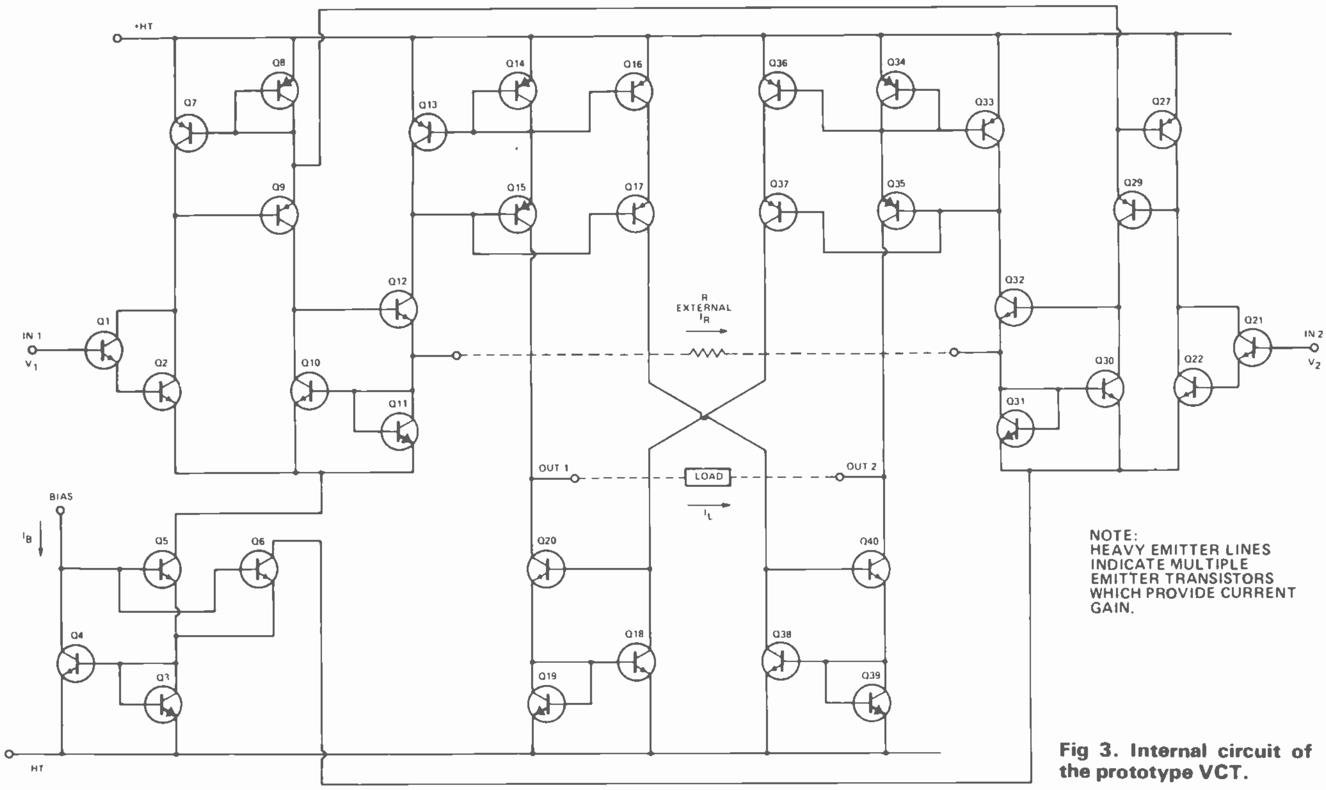


Fig 3. Internal circuit of the prototype VCT.

IC Current Sources
A) Mark I

The derived current source performs a similar impedance matching function with respect to current to that which an emitter follower provides in voltage circuits. A circuit commonly employed in ICs is shown in Fig. 2 where the essential requirement for operation is that the diode is matched to the B-E junction of the transistor. For a given diode voltage equal to the B-E voltage, identical currents must flow through the diode and emitter junction. By inspection $I_o = I_i - 2I_{B1}$ in this case and $I_o \approx I_i$ provided transistor gain β is high. The input inpedance is low and the output impedance is high to provide the current in/current out impedance matching required. In addition the input DC level (V_{BE}) is low and the output DC voltage (V_{CB}) will depend upon the nature of the load.

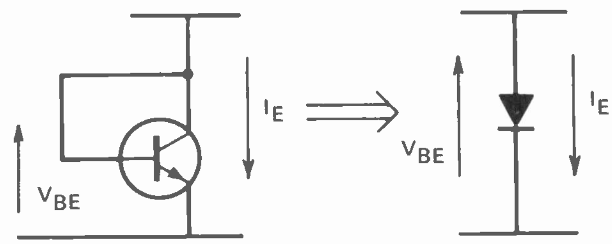


Fig 4. IC diode format.

B) Diodes

The crux of the design in Fig. 2 is the matching of the diode to the B-E junction. One major feature of the modern IC is the close matching which may be achieved between adjacent transistors on a chip. Whereas the absolute values may vary quite considerably, and such variation occurs almost identically in nearby transistors. Tight thermal coupling also ensures that the characteristics remain matched independent of external temperature fluctuations and local Joule heating. The diode employed in the VCT is actually a normal transistor with the base shorted to the collector (see Fig. 4). If this transistor is adjacent to the current source transistor and physically identical to it, then the fact that V_{BE} is common to both ensures an identical emitter current in each (Fig. 2). To a first approximation only, the particular configuration also provides

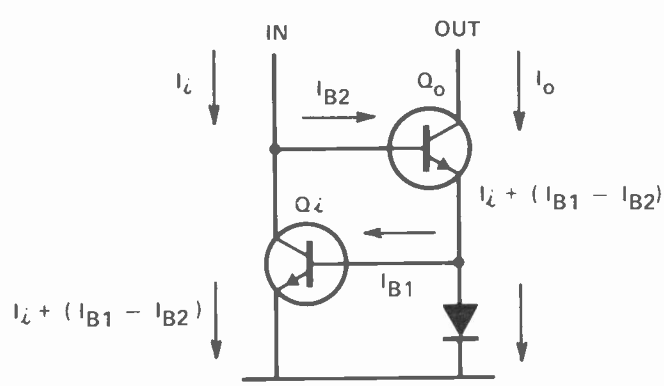


Fig 5. Constant current source employed in the VCT.

for a similar distribution of I_E between I_B and I_C. Truly identical transistors will not, however, possess identical current gains in the circuit due to the differences in V_{CB} (zero for the diode transistor).

C) Mark II

The problem with the single circuit of Fig. 3 is the requirement of high transistor gain. A partial solution is provided by the circuit of Fig. 5 which is the basis of all the functional blocks of the VCT. Here $I_o = I_i + 2(I_{BI} - I_{B2})$ and is made to closely approximately I_i by ensuring that $I_{BI} \approx I_{B2}$ rather than relying only on a large β. Note that the improvement is at the cost of an increased input impedance and DC input level ($V_{BEi} + V_{BEo}$). If $I_{BI} = I_{B2}$ exactly, β must be slightly greater for Q_o than for Q_i (which is reasonable since V_{CBo} will be greater than $V_{CBi} = V_{BEo}$).

Each of the functional blocks involves further modification of this circuit. These will each be described in turn.

D) Multiple Emitters

The multiple emitter structure has been mentioned before. All it means is that the transistor emitter current is increased for a given V_{BE} by increasing the emitter area. In this way the multiple emitter, when used in the output side of a derived current source, can provide current gain. A current gain of two for each of the multiple emitter stages in the VCT leads to the prototype device specifications quoted by Harris and is assumed below.

Bias Circuit

The bias circuit has been redrawn in Fig. 6 where the multiple emitter transistor Q_3 has been split and is shown as two separate diodes. Current amplification leads to the defined bias current $I_B = (V_S - 2V_{BE})/R_B$ being drawn equally from each of the two sides of the VCT.

Note that while the total symmetry shown in the diagram implies that the introduction of a multiple emitter structure requires β_5, β_6 to be twice β_4, this conclusion is misleading. In fact one would be more likely to vary the the multiple emitter area slightly off two, such that (i) all β's were approximately equal as before (ii) diode currents become $I_B + \frac{1}{2}I'$, and (iii) the base current of Q_4 reverts to $(\frac{1}{2}I') + (\frac{1}{2}I')$.

Differential Input

It should be clear by now that the VCT relies upon defined current sourcing and multiple emitter current amplification to function. The input signal however is defined as a differential voltage ($V_1 - V_2$) and must be converted to a proportional current. This is the purpose of the external resistor R as shown by the simplified view of Fig. 7 where I_R is clearly $(V_1 - V_2)/R$ provided symmetry is maintained. (Q_D is the Darlington combination Q_1 and Q_2; Q11 functions as a diode).

It will be seen shortly that the existance of a finite I_R upsets the symmetry — in fact this is how the circuit functions. So once again, our ideal is not quite possible since the diodes carry different currents at slightly different voltages. In fact $I_R \gtrsim (V_1 - V_2)/R$.

The next step is to see how I_R is converted to an output current.

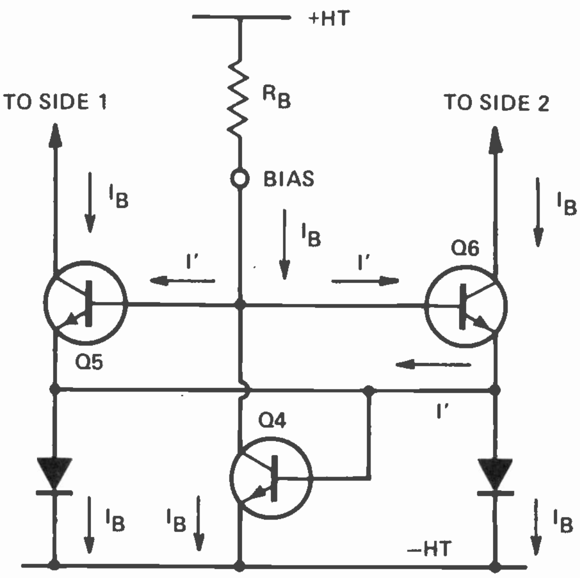


Fig 6. Bias circuit as an example of the multiple-emitter diode.

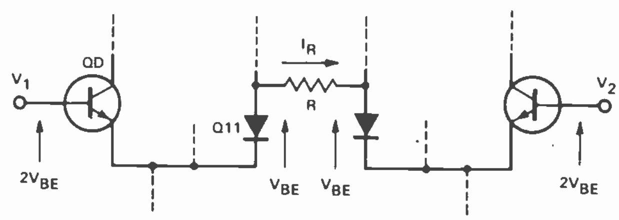


Fig 7. Simplified view of the differential input circuit.

Input Circuit

The input section of one side of the VCT is redrawn in Fig. 8. Q_8 services both sides of the circuit and has been split in the diagram. Assume for the moment that some current I_x flows down through Q_7 and then the Darlington Q_D. The Q_7, Q_8, Q_9 current sourcing circuit requires I_x to also flow through Q_9 and Q_{10}. Similarly Q_{11} should draw $2I_x$ due to the double emitter. The total $4I_x$ must equal the bias current I_B and hence the currents are as shown with Q_{12} also carrying I_B. The principle of this input circuit is summarised for reinforcement in Fig. 9 which should be compared with Figs. 7 and 8.

It has already been stated that V_{CB} of the source output transistors will vary under operating conditions and cause deviations from ideal behaviour due to resultant in β. In Q_{12} the base current I_{B12} (assuming constant β to first order) can no longer equal I_{B10}. Current source operation must therefore deteriorate under operational conditions.

▶

Output Circuit

The next step is to determine how the input signal current I_R is translated into a proportional floating output. Fig. 10 shows the remainder of side 1 of the VCT, designated as the output circuit. Clearly transistors Q_{18} to Q_{20} form a derived current source with gain equal to two. But it may be more difficult to see that Q_{13} forms part of two similar sources: with Q_{14}/Q_{15} to give a gain of two, and with Q_{16}/Q_{17} for unity gain.

So the current drawn by Q_{12} (Fig. 8) is converted into two proportional currents. The first ($I_B + 2I_R$) flows into the node "OUT 1" while the second ($I_R + I_B/2$) is delivered to side 2. A corresponding current from side 2 ($-I_R + I_B/2$) flows into Q_{18} and the amplified signal ($I_B - 2I_R$) is drawn from the "OUT 1" terminal. The net current delivered to the load (I_L) is therefore $4I_R$

In the paragraph before last, the detailed operation of Q_{14} to Q_{17} was hurriedly glossed over in order to first cover the principle of the output circuit. The diode function of Q_{14} should be familiar by now, but the reason Q_{15} has also been made with a double emitter is to keep $V_{BE}15$ with $(I_B + 2I_R)$ equal to $V_{BE}17$ with half that current. In this way, the collector and base terminals of Q_{16} are linked by a virtual short circuit and Q_{16} is constrained to also function as a diode.

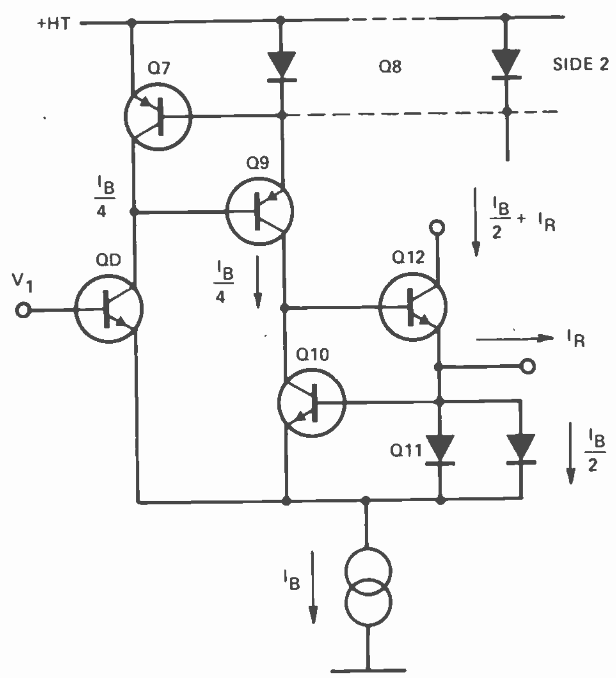


Fig 8. Input circuit — side 1.

Overall Principle

When side 1 and side 2 are considered together, as in the simplified equivalent of Fig. 11, one can appreciate the overall concept of the VCT. The input signal ($V_1 - V_2$) causes a current imbalance $(V_1 - V_2)/R$ to be superimposed on the null input bias levels (Fig. 9). With current gain mixed into the process, the bias currents are then balanced out leaving a net differential load current $4(V_1-V_2)/R$ in the load (Fig. 11).

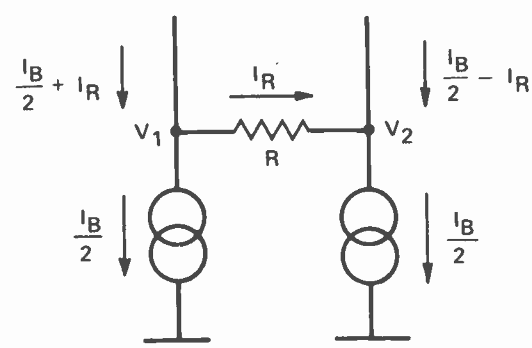


Fig 9. Equivalent input circuit.

Device Properties

Each multiple emitter in the prototype VCT has been assumed to give a gain of two. Clearly, it would be simple to vary this; indeed it would appear feasible to provide gain in other parts of the circuit as well as or instead of those shown. Nevertheless, for the prototype as shown, $I_L = 4(V_1-V_2)/R$. For voltage gain, one might merely insert a load resistor R_L for a totally floating output gain $4R_L/R$. Other elementary circuit configurations have been described by Harris.

The absolute linear range of the VCT is restricted in both current and voltage. Transistor cutoff when $2I_R=I_B$ (See Fig. 10) limits output current $I_L=4I_R$ to a maximum of $\pm 2I_B$: I_B being set by the circuit designer. Either output current or load is also limited by load voltage and the onset of saturation in the output transistors, i.e the load voltage $I_L R_L$ may not exceed the total power supply range minus $4V_{BE}$. For + 15 V supplies and 10 mA bias current the load impedence limit is 1k4 if the full output current range is to be available. Note also that wide signal excursions from the symmetrical design bias point lead to loss of linearity, since V_{CB}s of the current source output transistors are moved off bias values causing β to shift. The need to maintain V_{CB} and β close to design values also limits the acceptable power supply variation — about 10 to 15% according to Harris. These figures would suggest that linearity may be seriously degraded by voltage swing well before the saturation limit is reached.

High input impedence R_{in} is a fundamental requirement of the VCT concept and is the reason for the use of Darlington inputs. To the grossest of approximations, small signal R_{in} ($=\beta_1 \beta_2 R/\beta_{10}$) is critically dependent upon the input stage current gain and maximising it leads to a whole series of tradeoffs, (e.g R. should be low for high transconductance, β_{10} high for current source operation).

Common mode rejection ratio and required offset will both depend upon the degree of symmetry attainable in mass production but there is no reason to be pessimistic about them. High slew rates have been reported and are undoubtedly due to the fact that currents vary in only half of the circuit transistors and that the signal only proceeds sequentially through about half of these.

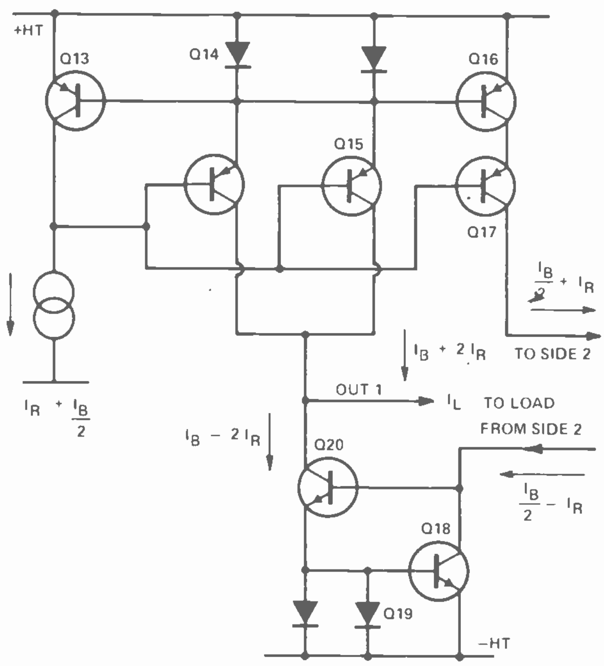


Fig 10. Output circuit — side 1.

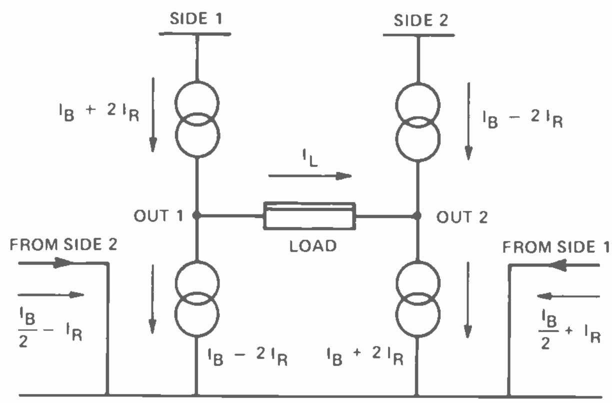


Fig 11. Equivalent circuit of the differential current output.

Conclusion

The main objective of this article has been the explanation of the principles of circuit operation. A secondary aim was to point out some unwanted second order effects and practical limitations. Such limitations occur in all devices and must not be ignored by either the designer or the user.

The immediate question is whether the VCT will survive through to production or remain just another bright idea. Simplicity is a major advantage to any technological innovation and despite the plethora of transistors, the VCT is very simple in principle. Furthermore its implementation will rely totally on existing technology — its future looks bright.

I should like to thank my students whose curiosity and questions led directly to this article. ETI

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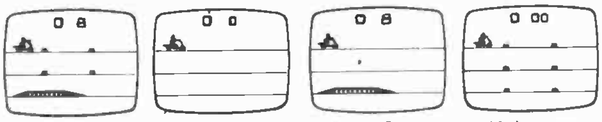

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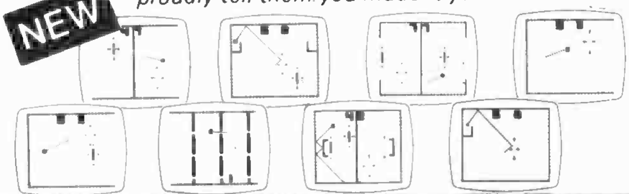

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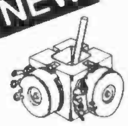

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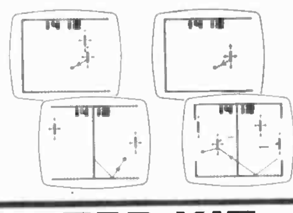

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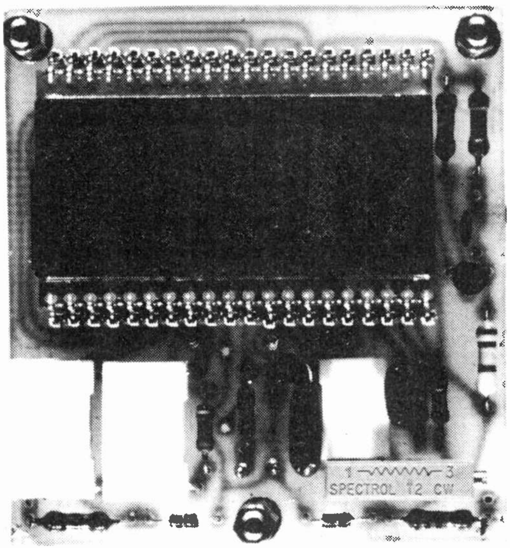


This simple, economical yet highly accurate voltmeter uses a large liquid crystal display for easy reading and low power consumption. It will be the basis of future projects as well as being a useful meter in its own right.

WE INITIALLY purchased a number of Intersil evaluation kits for our own use but soon realised that while they were very good electronically, the physical layout wasn't too hot. We therefore redesigned the PCB, reducing the size dramatically, adding the decimal point drive circuitry and some dropping resistors and zener diodes to allow the board to run from a dual power supply of +/– 5V or more (e.g. with op-amps). This resulted in a very useful device which we decided to run as a project. While it is basically a panel meter suitable for DC voltages and current (with a shunt) it will be the display module for several future projects.

Construction

To save on real estate, the main IC is mounted under the display. We used the Soldercon pins supplied with the evaluation kit for the display and soldered the IC directly into the board. If you want to mount the IC in a socket a low profile type should be used, with a high one for the display. As a socket is not available for the display a standard 40 pin one can be cut up to fit.

However before fitting either the display sockets or the IC, fit all the other components first. The overlay in Fig. 2 shows the positioning of the components. Most of the components come with the evaluation kit. The large capacitors are laid on their side to minimise height.

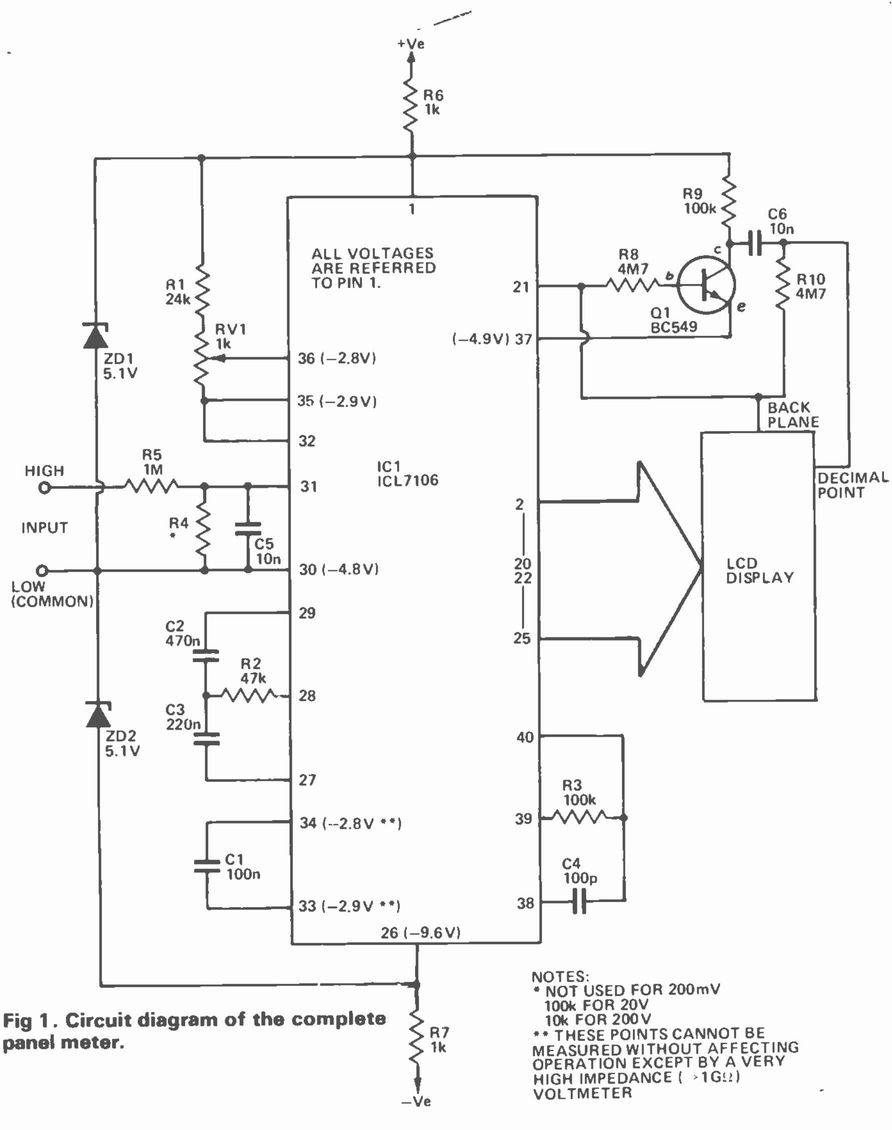


Fig 1. Circuit diagram of the complete panel meter.

SPECIFICATION

Full scale reading	200mV
Resolution	100μV
Accuracy	<1 digit
Display	3½ digit LCD
Input impedance	$>10^{12}$ ohms
Input bias current	≈2 pA
Polarity	automatic
Conversion method	dual slope
Reference	internal
Power supply	±5V to ±15V DC 1mA @ ±5V

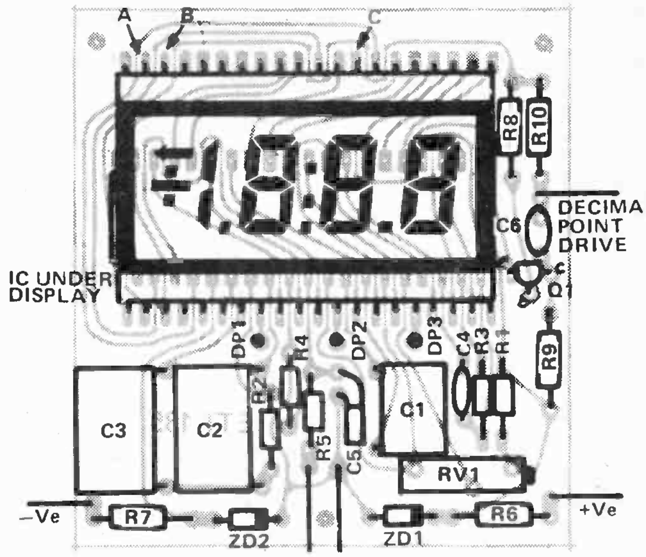


Fig 2. Component overlay with the display in place. Points marked A, B and C are the unused display segments — the vertical part of the + sign, the arrow and the semicolon respectively.

BUYLINES

The Intersil Evaluation kit is available from Rapid Recall, 9 Betterton Street, Drury Lane, London WC2H 9B5 at a cost of £23.29 all inc. If you want to just build the ETI version, Doram and Marshalls stock the chips and display, Watford stock everything as a kit. The PCB is available from all the 'usual' suppliers e.g. Ramar, Tamtronik etc.

PARTS LIST

RESISTORS all ½ W 5%	
R1*	24k
R2*	47k
R3*, 9*	100k
R4	See circuit diagram
R5*	1M
R6,7	1k
R8,10	4M7
POTENTIOMETER	
RV1*	1k 10 turn type

CAPACITORS		
C1*	100n	Polycarbonate
C2*	470n	Polycarbonate
C3*	220n	Polycarbonate
C4*	100p	Ceramic
C5*, 6	10n	Ceramic
SEMICONDUCTORS		
IC1*	ICL7106	
Q1	BC549 or similar	
ZD1,2	5V1 400 mW	

MISCELLANEOUS
PCB, LCD 3½ digit display*, soldercon pins*.

* These components are supplied with the Intersil evaluation kit.

HOW IT WORKS

Not much can be said on how this project works as everything is done by one IC and if anything goes wrong it is usually the IC. We have included some waveform diagrams and voltages for reference purposes. The conversion works on the dual-slope integration technique, which is the most reliable of the simple methods available. A capacitor is charged up at a rate proportional to the input voltage for a predetermined time (in this case 1000 clock pulses), then it is discharged at a constant rate until it reaches the starting point again. The time taken to do this (i.e. the number of clock pulses) is proportional to the input voltage.

It is a true dual polarity system where the integration direction depends on the polarity of the input voltage. Provided AC ripple on the input averages to zero over 1000 clock pulses it will be rejected, hence where 50Hz mains is to be rejected a 50 kHz clock should be used, giving 80 ms sample time (4 cycles of 50 Hz). The clock can be adjusted by varying R3 if desired.

For further details of the IC see the data sheet in this issue.

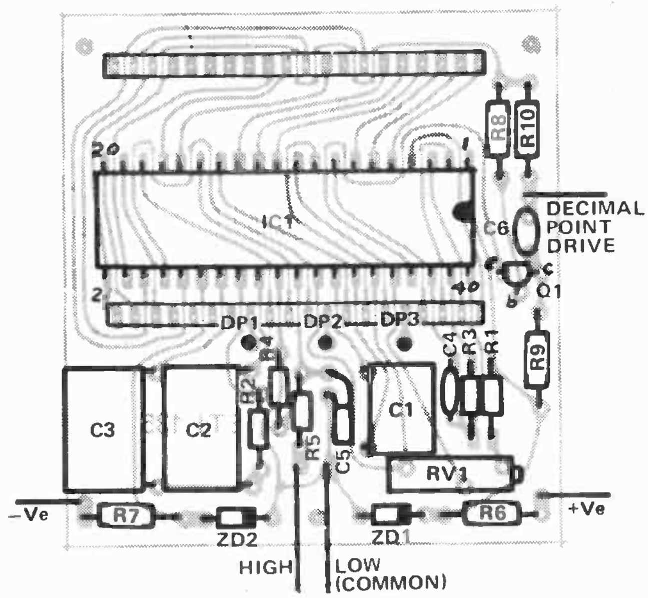
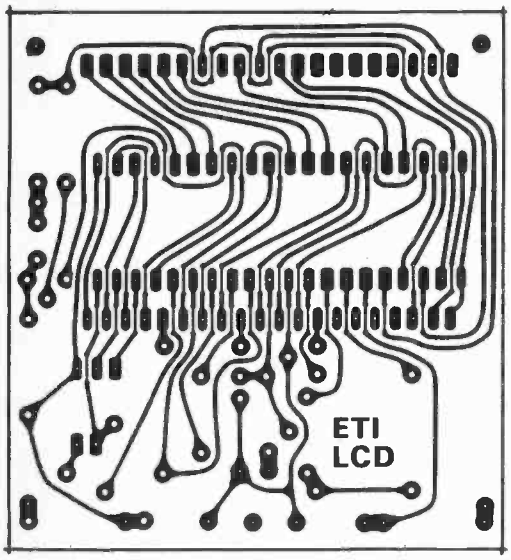


Fig 3. The component overlay without the display showing the positioning of the integrated circuit.



Foil pattern for LCD panel meter, shown full size. (65 x 70 mm).

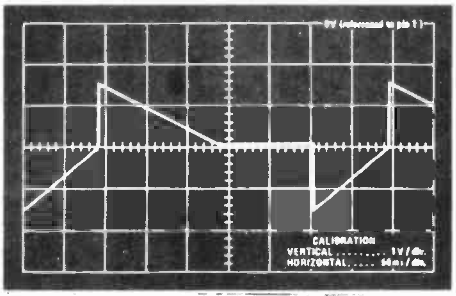


Fig 4. The waveformat pin 27 with a negative input of 170mV.

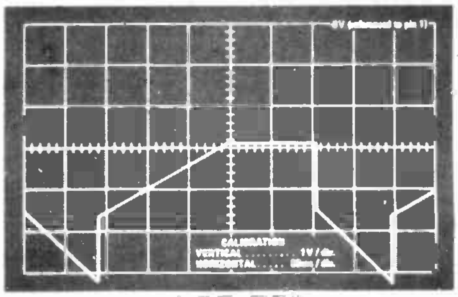


Fig 6. The output of the master oscillator on pin 38.

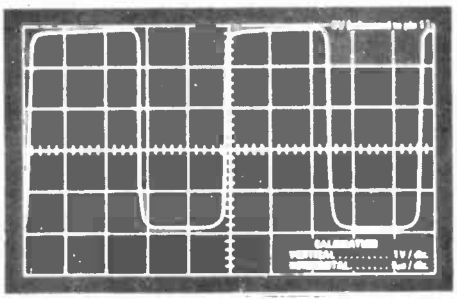


Fig 5. The waveform at pin 27 with a positive input of 170mV.

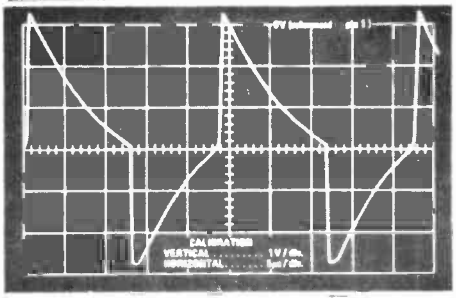


Fig 7. The input of the oscillator-pin 40.

When fitting the IC solder pins 1 and 26 first (the power supply pins) so that the protection diodes on the inputs can operate, thus preventing damage by static electricity. It is necessary that a small tipped iron and fine solder be used to prevent bridging tracks. The IC sockets can now be fitted in two strips of 20 with the top connecting pieces being broken off using long nosed pliers after they are soldered in.

As there are no polarity marks on the display it is necessary to hold it at an angle to the light and look for the outline of the digits. The full format of the display is shown in Fig. 3. In this unit the arrow, semicolon and the vertical part of the + sign are not used. ETI

DIODES/ZENERS

1N914	100v	10mA	.05
1N4005	600v	1A	.08
1N4007	1000v	1A	.15
1N4148	75v	10mA	.05
1N753A	6.2v	z	.25
1N758A	10v	z	.25
1N759A	12v	z	.25
1N4733	5.1v	z	.25
1N5243	13v	z	.25
1N5244B	14v	z	.25
1N5245B	15v	z	.25

SOCKETS/BRIDGES

8-pin	pcb	.25	ww	.45
14-pin	pcb	.25	ww	.40
16-pin	pcb	.25	ww	.40
18-pin	pcb	.25	ww	.75
22-pin	pcb	.45	ww	1.25
24-pin	pcb	.35	ww	1.10
28-pin	pcb	.35	ww	1.45
40-pin	pcb	.50	ww	1.25

Molex pins	.01	To-3 Sockets	.45
2 Amp Bridge		100-prv	1.20
25 Amp Bridge		200-prv	1.95

TRANSISTORS, LEDS, etc.

2N2222	NPN	(Plastic .10)	.15
2N2907	PNP		.15
2N3906	PNP		.10
2N3054	NPN		.35
2N3055	NPN	15A 60v	.50
T1P125	PNP	Darlington	.35
LED Green, Red, Clear			.15
D.L.747	7 seg 5/8" high com-anode		1.95
XAN72	7 seg com-anode		1.50
FND 359	Red 7 seg com-cathode		1.25

C MOS

4000	.15
4001	.20
4002	.20
4004	3.95
4006	1.20
4007	.35
4008	.95
4009	.30
4010	.45
4011	.20
4012	.20
4013	.40
4014	1.10
4015	.95
4016	.35
4017	1.10
4018	1.10
4019	.60
4020	.85
4021	1.35
4022	.95
4023	.25
4024	.75
4025	.35
4026	1.95
4027	.50
4028	.95
4030	.35
4033	1.50
4034	2.45
4035	1.25
4040	1.35
4041	.69
4042	.95
4043	.95
4044	.95
4046	1.75
4049	.70
4050	.50
4066	.95
4069	.40
4071	.35
4081	.70
4082	.45

– T T L –

7400	.15
7401	.15
7402	.20
7403	.20
7404	.15
7405	.25
7406	.35
7407	.55
7408	.25
7409	.15
7410	.10
7411	.25
7412	.30
7413	.45
7414	1.10
7416	.25
7417	.40
7420	.15
7426	.30
7427	.45
7430	.15
7432	.30
7437	.35
7438	.35
7440	.25
7441	1.15
7442	.45
7443	.85
7444	.45
7445	.65
7446	.95
7447	.95
7448	.70
7450	.25
7451	.25
7453	.20
7454	.25
7460	.40
7470	.45
7472	.40

7473	.25
7474	.35
7475	.35
7476	.30
7480	.55
7481	.75
7483	.95
7485	.95
7486	.30
7489	1.35
7490	.55
7491	.95
7492	.95
7493	.40
7494	1.25
7495	.60
7496	.80
74100	1.85
74107	.35
74121	.35
74122	.55
74123	.55
74125	.45
74126	.35
74132	1.35
74141	1.00
74150	.85
74151	.75
74153	.95
74154	1.05
74156	.95
74157	.65
74161	.85
74163	.95
74164	.60
74165	1.50
74166	1.35
74175	.80

74176	1.25
74180	.85
74181	2.25
74182	.95
74190	1.75
74191	1.35
74192	1.65
74193	.85
74194	1.25
74195	.95
74196	1.25
74197	1.25
74198	2.35
74221	1.00
74367	.85
75108A	.35
75110	.35
75491	.50
75492	.50
74H00	.25
74H01	.25
74H04	.25
74H05	.25
74H08	.35
74H10	.35
74H11	.25
74H15	.30
74H20	.30
74H21	.25
74H22	.40
74H30	.25
74H40	.25
74H50	.25
74H51	.25
74H52	.15
74H53J	.25
74H55	.25

74H72	.55
74H101	.75
74H103	.75
74H106	.95
74L00	.35
74L02	.35
74L03	.30
74L04	.35
74L10	.35
74L20	.35
74L30	.45
74L47	1.95
74L51	.45
74L55	.65
74L72	.45
74L73	.40
74L74	.45
74L75	.55
74L93	.55
74L123	.55
74S00	.55
74S02	.55
74S03	.30
74S04	.35
74S05	.35
74S08	.35
74S10	.35
74S11	.35
74S20	.35
74S40	.25
74S50	.25
74S51	.45
74S64	.25
74S74	.40
74S112	.90
74S114	1.30

74S133	.45
74S140	.75
74S151	.35
74S153	.35
74S157	.80
74S158	.35
74S194	1.05
74S257 (8123)	.25
74LS00	.35
74LS01	.35
74LS02	.35
74LS04	.35
74LS05	.45
74LS08	.35
74LS09	.35
74LS10	.35
74LS11	.35
74LS20	.35
74LS21	.25
74LS22	.25
74LS32	.40
74LS37	.35
74LS40	.45
74LS42	1.10
74LS51	.50
74LS74	.65
74LS86	.65
74LS90	.95
74LS93	.95
74LS107	.85
74LS123	1.00
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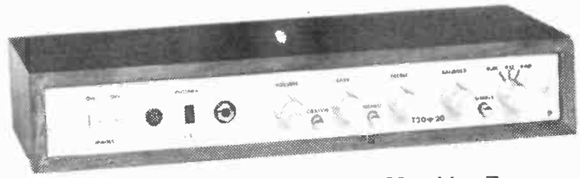

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Just how will the role of the driver be changed by the rapid advances and increasing implementation of electronics in the motor car? Dr Peter Sydenham examines the most recent equipment to give us a glimpse of the standard accessories of the future.

AUTO ELECTRONICS

IT WAS IN THE LAST DECADE of the nineteenth century that the motor car was born. Most designs of what we now call *veteran* cars used internal combustion engines, for which the main use of electrics was to ignite the fuel in the combustion chamber. Storage batteries were used in some designs of the 1890s to drive the high-tension ignition device and to power an electric warning bell.

Sparkplugs, magnetos, ignition distributors, starter motors, and headlights followed in the 1900 to 1910 era, then a DC generator was added to the engine to keep the battery charged.

Electrical direction signals were in common use by the 1930s, along with stop lights, reversing lights, and courtesy lights. At that time instrumentation of vehicle speed, engine revs, engine temperature and oil pressure almost always used non-electrical methods. Usually the only panel instrument using electrical indication was the ammeter for battery charge or discharge. Regulation of battery charge was controlled by moving the "third" brush of the generator and a summer-winter switch position was available to adjust the system for seasonal temperature change.

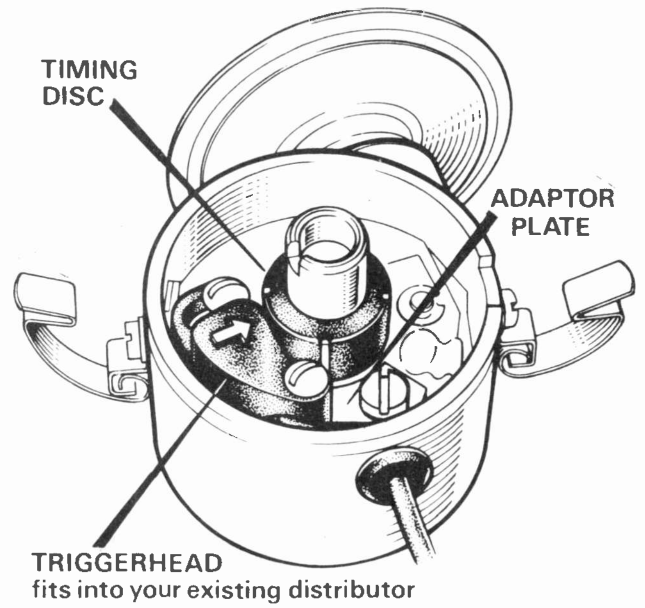
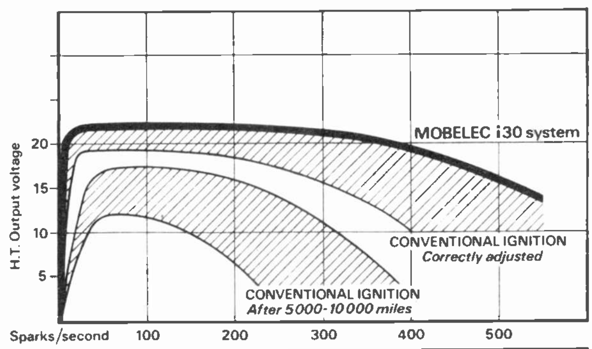


Fig 1. Contactless electronic ignition is available for just about any car. This changeover system is used in the Mobelec system.



Sparks/second		100	200	300	400	500
cylinders	4	3000	6000	9000	12000	
	6	2000	4000	6000	8000	10000
	8	1500	3000	4500	6000	7500

Engine RPM

Fig 2. Comparative chart of electronic ignition with the conventional rapidly-dating contact-points method.

Cars of the '40s and '50s were little improved. In the 1960s, however, things rapidly began to change. The DC generator was replaced with a much smaller and more efficient AC alternator, which required solid-state diodes for rectification. The day had come when the average do-it-yourself owner could no longer confidently tackle the auto-electrics of the car. Regulators changed from electro-mechanical relays to solid-state circuitry; some cars introduced electronically-controlled fuel-injection, others introduced electronic ignition.

What we saw in the progressive designs of the '60s and early '70s are fast becoming standard equipment today. This study of the 1977 new models and accessory market reveals that there is still a long way yet to go. ▶

Engine And Mechanics

Electronic ignition is becoming standard in an increasing number of cars — Ferrari, Renault, Chrysler and Mercedes use it, while US cars have had it since 1975.

A do-it-yourself kit is available which enables the standard distributor to be used with a change-over "points" component that replaces the contacting points with a non-contact sensor (Fig. 1).

Advantages provided by electronic ignition are lower fuel consumption, easier starting, better idling, improved timing accuracy, and constancy of timing with period of operation, plus no points to need replacing. One maker, Mobelec Ltd, issues a chart showing high-tension voltage output produced by conventional methods compared with their electronic system, shown in Fig. 2. It is seen that the electronic alternative gives the best high-tension performance and holds it over time, unlike the points method that wears.

The next stage of ignition improvement is to replace the rather cumbersome, and not really adequate, automatic vacuum and centrifugal ignition timing control. The latest US Cadillac Seville and Fleetwood Brougham cars have an "electronic spark selection system", which uses electronic logic circuits to monitor engine speed and inlet manifold vacuum, and signal the appropriate spark advance or retard. Thinking it through, it is not hard to see that once electronic ignition is used, with engine speed being measured electronically, it is relatively simple to add a vacuum measuring transducer and use a phase-shift spark time control circuit arrangement. Overall this should be cheaper than the conventional vacuum advance mechanics — and much more reliable and predictable.

Pollution And Economy

Economy is now a strong sales point, so manufacturers are seeking ways to reduce fuel consumption, and the level of pollutants produced by an engine. Fuel injection has been used by a few makers for many years now, and some have reached sophisticated levels of electronic "computer-brain" injector control.

Electronic analysers are used to tune the carburettor for minimum CO emission, but Volvo cars of 1977 now go one step further in the interest of economy and emission control. Their Lambda-Sond electronic air/fuel ratio sensor system uses a "ruggedised" zirconium dioxide oxygen gas content probe in the exhaust manifold. The level of O_2 in the exhaust is measured as an electric signal equivalent that is fed back automatically to control the fuel-injector equipment made by Bosch. This has, it is claimed, enabled the Volvo engines to meet stringent low-emission requirements at less cost than other methods. A snag is that the sensor at present needs replacement at 30 000km periods. They next hope to apply this principle to conventional carburettor control.

A Datsun answer to economy is to provide the driver with a simple "go"-"no-go" indicator of the lead-footedness of the driver. "Drive it on the green" is their slogan for the new 1977 Laurel Six saloon. Above the steering column block are two lights — the left green, the right orange. Economy is very much a matter of keeping the inlet manifold vacuum within limits and this

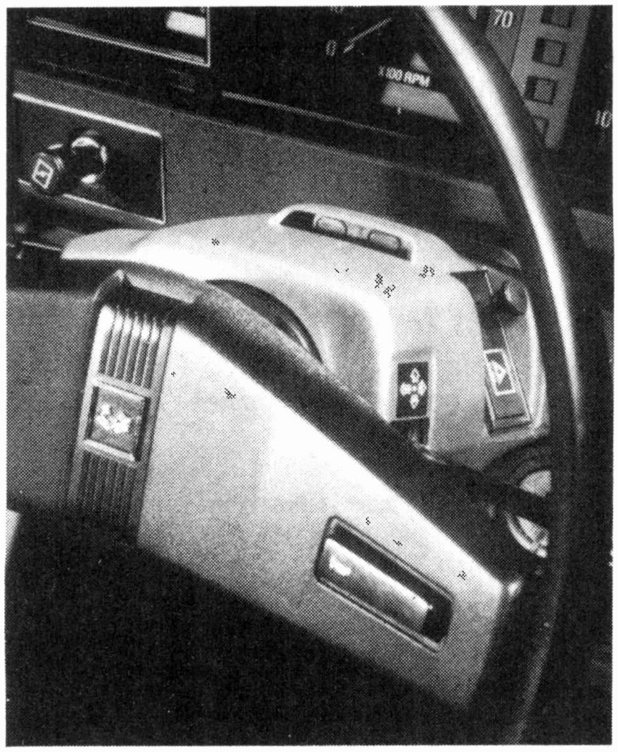


Fig 3. "Drive-it-on-the-green" is the Datsun Laurel slogan. Two lights, seen here above the steering wheel centre, indicate when the driver is operating the engine within good economy limits.

Fig 4. Retrofit cruise control is possible with this kit. The right chain-coupled unit stores the throttle position required. It is operated by the left-hand push button unit. The brake pedal electric connection is used to cancel the position during deceleration.

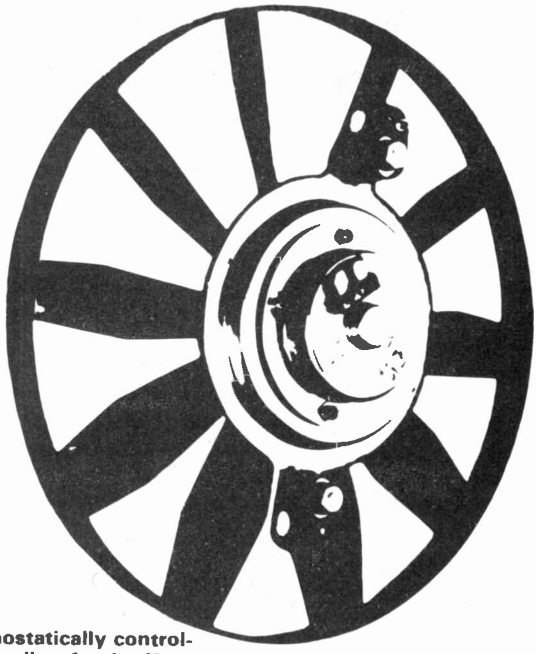


Fig 5. Thermostatically controlled engine cooling fan by Kenlowe.

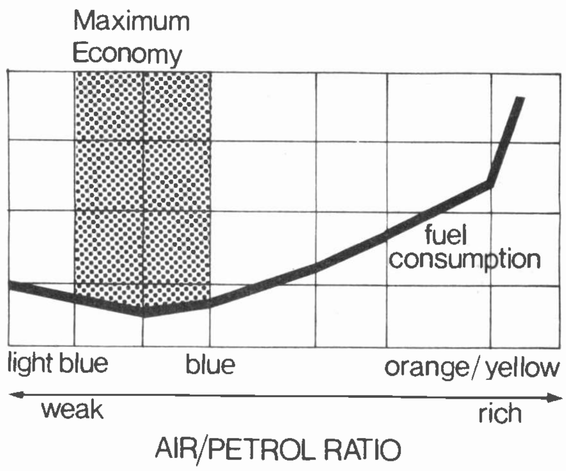


Fig 6. Different air/fuel ratios burn with different colours. Maximum economy is obtained when the colour is in the blue region.

Fig 7. Needle indicators will soon disappear from the dash panel. They will be replaced by solid-state light-emitting diode "scales" that preserve the advantages of the moving-scale method of indication.

is largely decided by the throttle setting for the speed existing.

The 1978 Cadillac Sevilles released in Britain will incorporate the "Tripmaster" facility. This is a central electronic data processing unit. Amongst many other things their display will give digital readout of instantaneous fuel consumption (they call it fuel economy now!) and average trip economy, a calculation which requires the addition of a petrol flow-rate sensor.

Steady driving greatly increases economy, and automatic electronic car speed maintenance — called "cruise control" — is now available on some models. The 1978 US Chevrolet Caprice and some US Ford models have it fitted as a standard addition. The latter have finger-tip touch pads mounted in the crossbar of the steering wheel — to hold the speed reached just touch the button. A retro-fit package produced by Holdspeed Productions Ltd is shown in Fig. 4. The small push-button unit is mounted on the facia and an electro-magnetic throttle "memory" unit is connected in series with the throttle cable to clamp the cable upon electronic demand. Slight movement of the brake pedal releases the unit when the stop light is energised, but it returns to the preset throttle position after acceleration conditions.

The next logical step might be to maintain the car's speed by closed-loops control, using vehicle speed to vary the throttle setting to suit the load. This is, however, yet to be proven as a useful and safe function to provide.

Another way to reduce consumption a little is to replace the engine-driven fan with an electric thermostatically controlled unit. This is not a new idea, but it is at last being adopted to reduce loss and engine noise. The fan still consumes energy, of course, but comes on only when the engine really needs it. It can, it is claimed by Kenlowe Accessories, whose fan is shown in Fig.5, release up to 9% more engine power. It makes sense to cool the engine this way, and has the added advantage of faster warm-up, and quieter peak engine speed noise.

These systems are thermostatically controlled and, therefore, require a temperature sensor to be added to the water jacket. This can be fitted easily by the use of a special rubber fitting placed under the hose connection, and the temperature control point is set by a dial on the control unit.

Gunson's "Colortune 500" engine tuning system has been on sale for several years now. It is not a complex electronic device but simply a special spark-plug through which the observer can see the colour of the ignition process happening inside the combustion chamber. It is remarkably simple to use, and AA certified tests on five cars made in 1974 showed conclusively that this method could be used to set the carburettor for a better economy. They commented that whilst the drivers could detect no performance difference after tuning, the petrol consumption tests showed fuel consumption was reduced in each case by amounts of 4.45% to 17.39%. Fig. 6 illustrates the colours seen for various mixtures. This device demonstrates the possibility of a closed-loop method that monitors combustion colour using a sensor of this type to control the mixture.

Electronic tuning meters are now marketed in many shapes and forms. Depending on make and model, these enable the setting of breaker points to obtain correct ignition timing, measurement of points contact res

Fig 8. Stereo speaker equipped headrests can provide better listening. These will also be used for road information services that go only to the driver (or co-pilot!)

istance, and general electrical fault chasing. These are best used in the driver's cabin so that measurements can be checked during actual driving conditions. Once the correct timing is available as an electronic signal, the next stage will be to check this automatically and continuously as one function of a microprocessor diagnostic centre.

Instrumentation

It is clear that the engine will be one significant area of future motor cars in which electronic measurement and control will become a vital part of improving economy, reducing emission, and sensing the need for maintenance.

Electronics will also blossom in the instrumentation of the car. Electric indication of battery charging state, oil pressure, and temperature is now commonplace, the direct hydraulic lines and vapour expansion tubes having been replaced with electrical "senders" many years back. Now also standard are indicators of oil level, seat belts not fastened, brakes not functional, and parking brake on.

Recent additions to the range have been the disc-brake pad-wear warning lights (found in the Renault 20TL), battery condition indication, and a warning light to tell the driver if all doors are not properly shut.

The Cadillac Seville "Tripmaster" also offers digital readout of estimated arrival time, miles still to go to destination, air temperature, fuel remaining and, of course, speed, the function being chosen via a keyboard mounted on the dash. Many of these functions are provided in the futuristic six-wheel Panther 6 vehicle, which also features a miniature television for the passengers' pleasure, and a panel light-bulb check routine incorporated in the panel.

The days of the electromagnetic instrument movement are numbered. Solid-state analogue-style displays, in which position on a graduated dial is indicated by a lengthening line formed by successively energised light-emitting diodes, are now available. An Austrian tachometer by Intron is shown in Fig. 7.

Utility Without

The motorist's involvement with electrics and electronics does not stop inside the car's compartment. Electronic rear-end levelling is standard in Cadillacs. Height is sensed by an electronic sensor, using photoelectric methods, and this operates an electrically-driven air compressor that alters the height actuators.

Fig 9. This small hand-set is the control for radio-controlled garage doors.

When you arrive at the petrol station the fuel is now monitored with advanced metering electronic systems that compute cost and quantity, and which can provide fixed-sum or cash batching. Many countries — Sweden and USA are examples — have banknote recognising, self-service outlets. Credit-card recognisers will ultimately displace these.

When you arrive home there is no need to get out to open the garage door. When you are within 10 m just press the button on your radio transmitter, shown in Fig. 9, and the door will open by remote control. (A licence is required to operate such transmitters.)

Electronics will even help you sell or buy your car. Private car owners in the London area can now market their cars by a computer service. Computacar's sales service, by Unilever Ltd, begins with the owner registering the car for sale. The data are filed in a computer data bank that updates daily until the vehicle is cleared. Buyers have access to a sorted list of the desired car characteristics, thus saving all that hunting through the massive lists of cars offered in published weeklies.

Future Drive

Without a doubt the car of the very near future will be bristling with more and more electronic devices, but, to date, no one car has all the features mentioned in this review.

As many additions are marketed independently of the car maker, it is likely that the overall reliability may fall along with the standard of low-priced expert servicing. Somewhere there will be a trade-off point between complexity of operation, servicing, cost and the benefits gained. Just where this will be will only be found as a result of practical use. ETI

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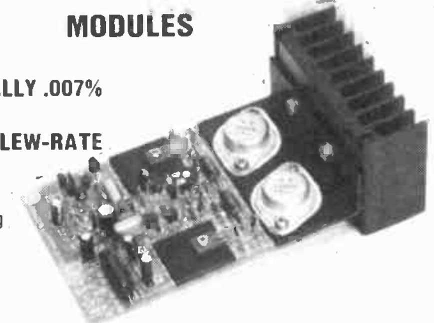

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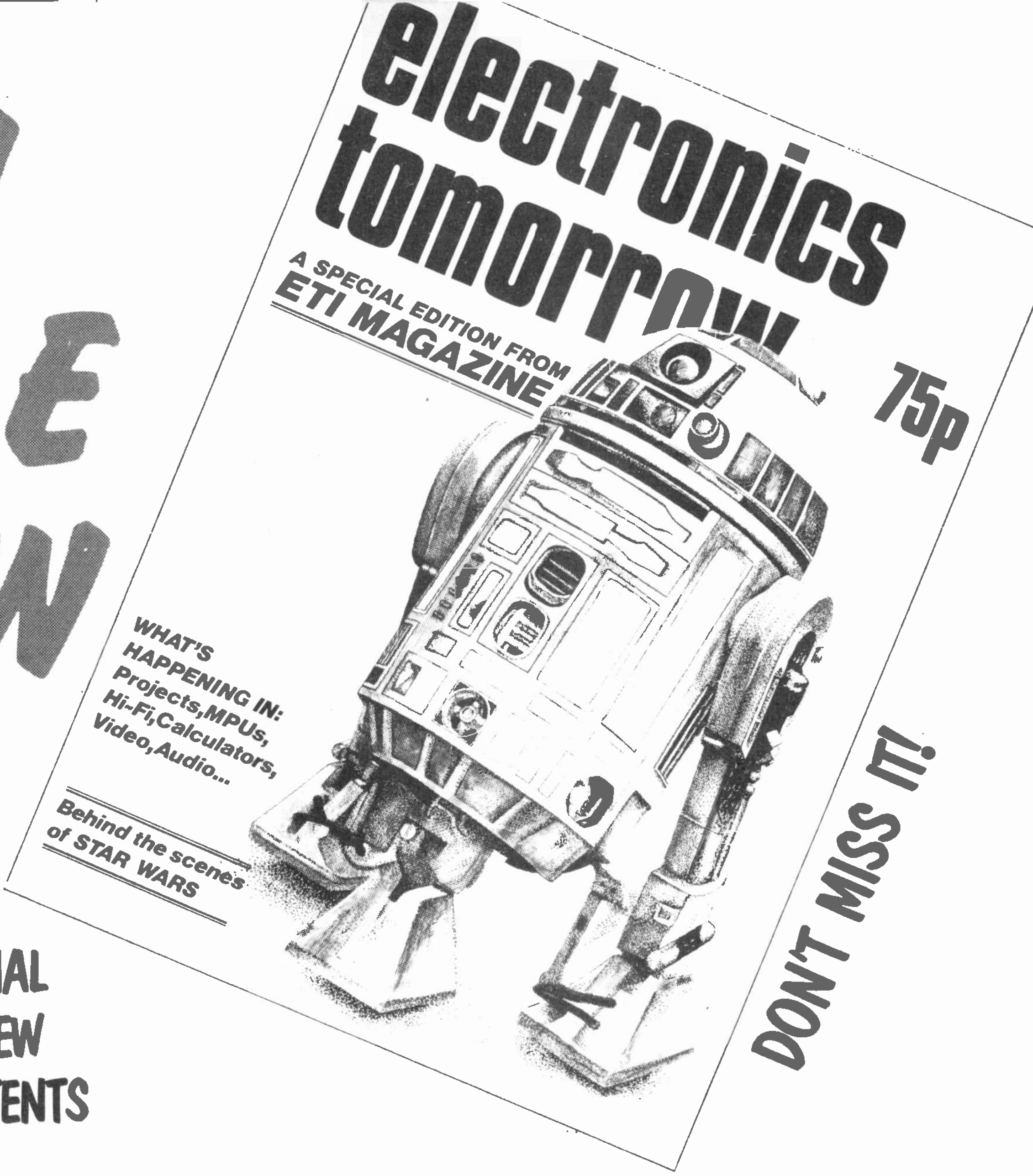

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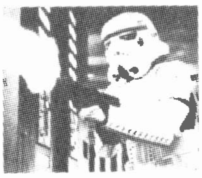
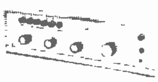


STAR WARS: Already the most successful film ever made and a MUST for all sci-fi fans. ETI gets behind the scenes to find out how the effects were effected!



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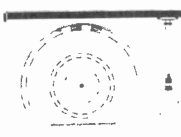
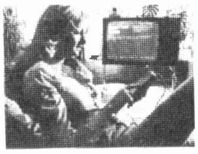
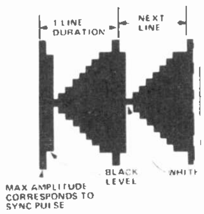


HIFI 2008: Ron Harris had help here — someone somewhere up in the future sent us a history book. So we know this one is true!

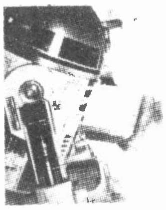


VIDEO TOMORROW: Angus Robertson peers into his crystal CRT and discovers the future is plain today if you know where to look. (Like in his article.)



VIDEO MODS: How to convert your own little tele to act as a terminal for anything producing a decent signal. (More important — how NOT to convert it!)

SINCLAIR STORY: Clive Sinclair talks to ETI in an amazingly frank and open manner about the ups and downs in his company's never boring rise to power! (Don't miss this!)



R2D2: The undisputed star of STAR WARS. What makes him tick? Who hides within? Does he have two legs or three? Both! Exclusive in depth profile!

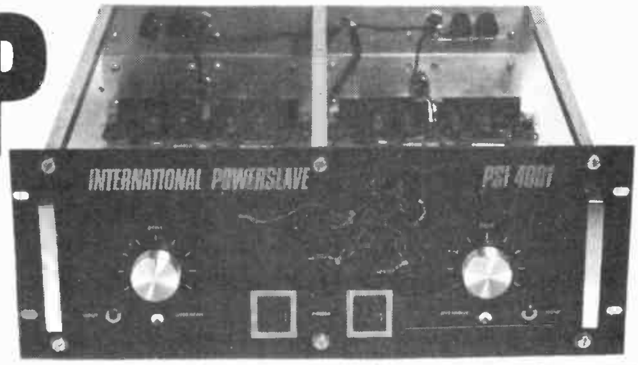
HOME COMPUTERS: Our own micro-man Gary Evans casts his runes to see what MPU men will be up to in the future, and makes some startling admissions in the process!

BENCH SUPPLY: A perfect project for the tyro, or for anyone well into electronics, but who has just never got around to building a PSU, i.e. YOU!

electronics today international

What to look for in the April issue: On sale March 3rd

200 W AMP



Most magazines (including ETI) have produced designs for 100W amplifiers, but it seems that our readers are a power hungry lot and want more! So by popular request we proudly present our 200W per channel International Powerslave. Specially designed for ETI by Powertran the monster is a superb piece of audio design. Distortion is well below 0.1% at all output levels and CCIR weighted noise a negligible —101dB. Perfect for PA systems and high power discotheques, with reliability a main consideration, the International Powerslave should satisfy most readers' cravings for power!

GAS MONITOR

Designed originally for use in small boats, the ETI Gas Monitor senses any build-up of petrol vapour or propane, and prevents electrical equipment being switched on (bang!) when danger exists. ETI readers will no doubt find many other situations where this device will be useful.

FREE! 108 PAGE TANDY CATALOGUE

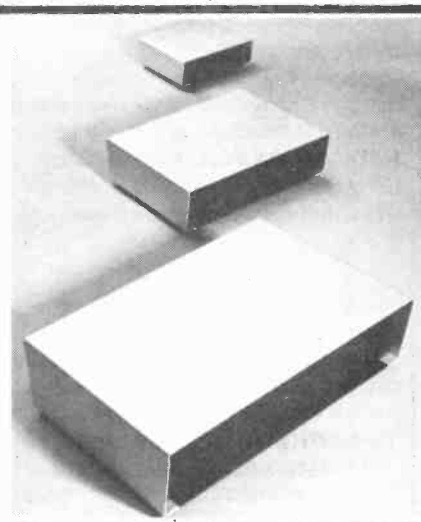
Discount voucher worth 50p also included! The catalogue will be inside all UK newstand and subscription copies, but we regret will not be in overseas copies.

PET REVIEW

Available soon in Britain, Commodore's self-contained personal computer (PET) has been given the once (and twice) over by our Canadian office. With exclusive internal photographs, read all about it in next month's ETI.

CASING SURVEY

The days of the biscuit tin amplifier are over. The modern constructor has a huge — often bewildering — choice of cases and racking systems to wrap around their project. The choice of a suitable case can make the project look a lot more professional when completed, so read all about the various brands next month in ETI.



Special Offer: Commodore 5R39 £14.95!

Articles mentioned here are in an advanced state of preparation but circumstances may affect the final contents.

FREQUENCY SHIFTER

A useful device for squeezing a few extra dB out of most PA systems. Designed by our shifty project team.

ANYONE WHO HAS USED a microphone in public address work has come across problems with feedback. These are caused by the level of sound reaching the microphone from the speaker approaching or exceeding that from the person originating the sound. As the reflected sound approaches the level of the original signal, the sound becomes distorted or 'coloured', then audible ringing occurs and finally complete oscillation or howl-round occurs as the reflected sound exceeds the level of the original signal.

The most effective method of eliminating this problem in most cases is to use the correct location for the speakers and the correct choice of microphone.

However in certain environments the most effective use and selection of microphone/speakers does not help the problem of feedback. These are the halls and rooms which have little sound-absorbing material on the walls and are very 'live'. If a frequency response curve is drawn for such a room it will be found that there are many peaks and troughs, normally only 4 or 5 Hz apart, along with perhaps major resonances.

Solutions

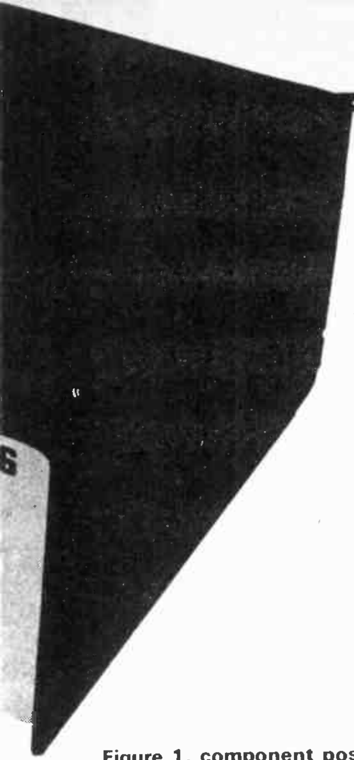
There are various electronic devices which have been developed to deal with this problem, the main ones being the graphic equalizer, the variable notch filter and the frequency shifter. The first two (especially the notch filter) are ideal for eliminating major resonances. These however also alter the frequency response of the original sound. They can also help if the offending 'echo' is actually a direct path and not dependent on the room (i.e. if the speakers are behind the microphone). The other method, frequency shifting, is described here.

With a frequency shifter the echo signal is of slightly different frequency on each path round the loop and cannot directly reinforce itself so that while on the first echo it may strike a room resonance the second time it will probably be in a null. This tends to even out the frequency response of the room and allows 5 to 8 dB higher levels to be used in the average room. Also the onset of howl-round is not as dramatic as with the conventional system and the distortion which normally occurs below the howl-round level is not as noticeable. The system does not however do a great deal for howl-round not associated with room resonances.

Only a small shift is normally required and it does not matter if it is an increase or a decrease. We chose to increase the frequency by about 5 Hz as it is easier to tell if a vocalist is flat rather than sharp. As the frequency response of the unit is good it is suitable for vocal work as well as general public address use. The frequency shift and the slight amplitude modulation cannot be detected by most people.

SPECIFICATION

Frequency shift	**5Hz upwards**
Maximium input voltage	**3V**
Frequency response +½ dB, −3dB	**30Hz – 20kHz**
Signal to noise ration re 3V output	**70 dB**
Distortion @ 1kHz, 2V out	**0.25%**
Amplitude modulation	**100Hz – 10kHz < 1dB**
Phase shift network 50Hz – 20kHz	**$90^\circ \pm 5^\circ$**



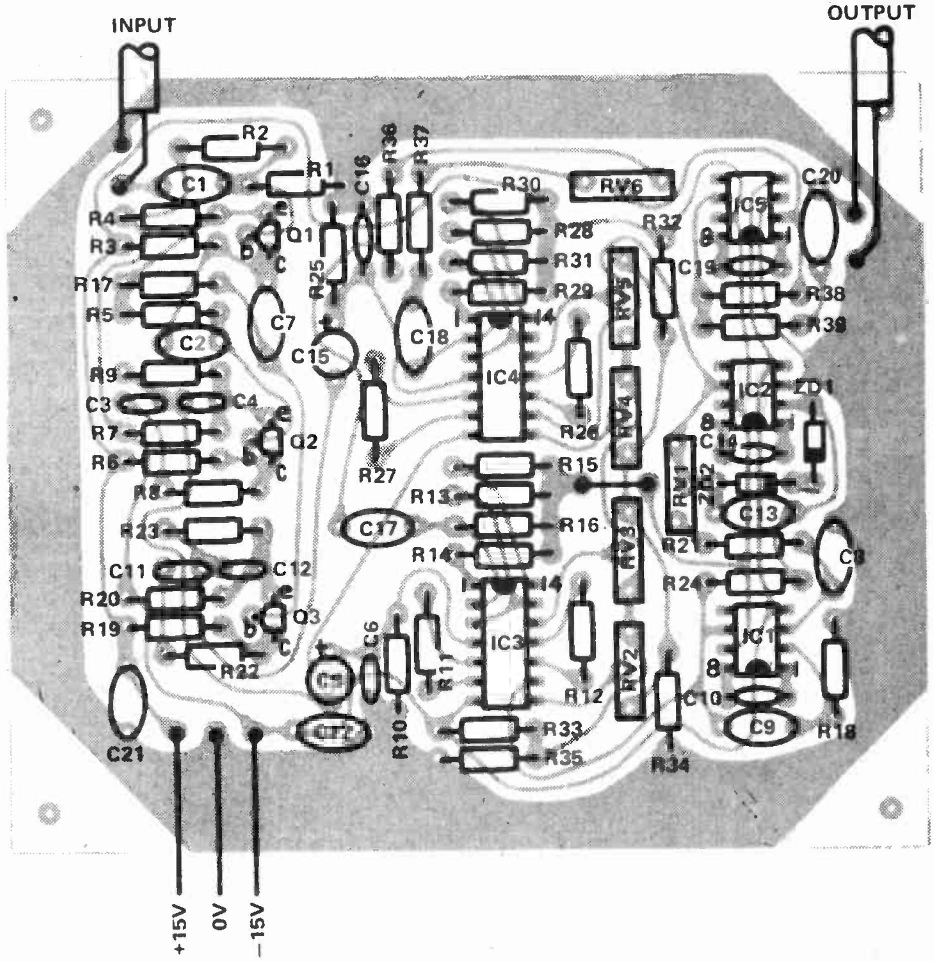


Figure 1, component positioning for the frequency shifter board.

Alignment

Equipment needed — a sensitive AC voltmeter (100 mV or less) or preferably an oscilloscope and an audio oscillator.

1. Check the output of the 5 Hz oscillator and adjust RV1 until it stops. If it cannot be completely stopped, try a link across C9.
2. Apply a signal of about 1 — 2 V amplitude at about 1 kHz to the input and measure the output of IC3 at pin 2. (If your meter does not reject DC, measure at the junction of C17 and R36). Adjust RV3 to give the minimum output.
3. Measure the output of IC4, pin 2 (or the junction of C18 and R37) and adjust RV5 for minimum output.
4. Measure the output of the 5 Hz oscillator on pin 6 of IC1 and adjust RV1 until it starts, then adjust to give about 1.25 V RMS.
5. With no input signal, measure the output of IC3 (or the junction...) and adjust RV2 for minimum output.
6. Measure the output of IC4 (or...) and adjust RV4 for minimum output.
7. If an oscilloscope is available, monitor the output with a 1 — 2 V input signal and adjust RV6 to give the minimum amplitude modulation. Alternatively, by using an amplifier and speaker, RV5 can be adjusted by ear. The unit is now set up. ETI

PARTS LIST

Resistors	all ½ W 5%
R1	150k
R2	100k
R3,4	2k7
* R5	22k
R6,7	2k7
* R8	3k6
* R9	24k
* R10	15k
R11	4k7
R12	2k2
R13	15k
R14—R16	3k3
* R17	56k
R18	330k
R19,20	2k7
R21	330k
* R22	3k9
* R23	27k
R24	330k
* R25	15k
R26	2k2
R27	4k7
R28	15k
R29—R31	3k3
R32,33	10k
R34,35	1k
R36,37	100k
R38	1M
R39	100R
Potentiometers	
RV1	250k trim
RV2—RV5	25k trim
RV6	100k trim

Capacitors	
C1	100n polyester
* C2.	56n polyester
* C3.	6n8 polyester
* C4.	1n0 polyester
C5.	10µ 25V electro
* C6.	1n5 polyester
* C7.	100n polyester
C8,9	100n polyester
C10	33p ceramic
* C11	22n polyester
* C12	4n7 polyester
C13	100n polyester
C14	33p ceramic
C15	10µ 25V electro
* C16	5n6 polyester
C17,18	100n polyester
C19	33p ceramic
C20—C22	100n polyester
Semiconductors	
IC1,2	LM301A
IC3,4	MC1495
IC5	LM301A
Q1—Q3	BC549
ZD1,2	5.1V 300mW
Miscellaneous	
PC board	
Power supply ± 15V 40mA	

* For best results the components should be as accurate as possible, preferably 1% tolerance or selected to be within 1%.

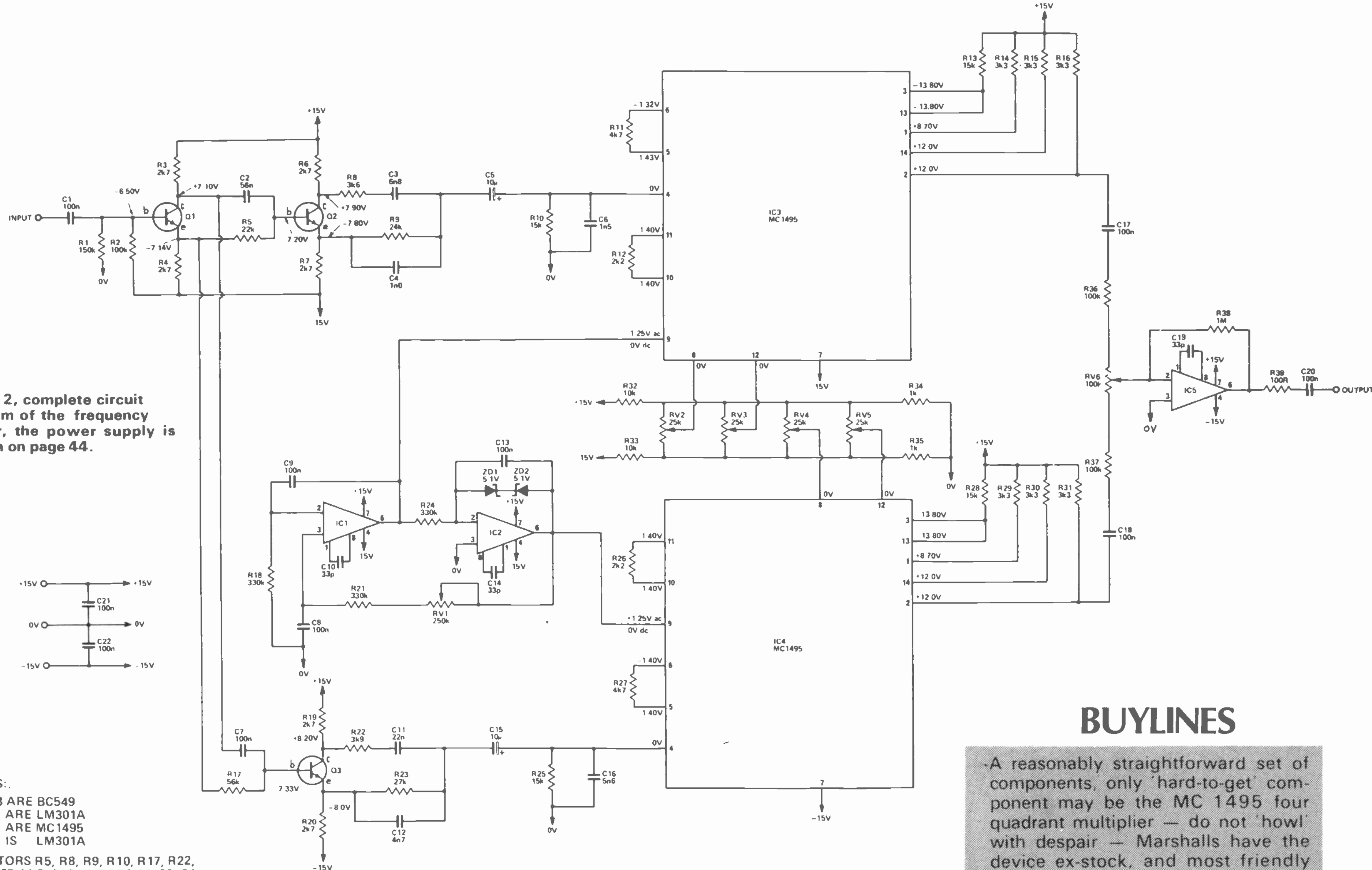


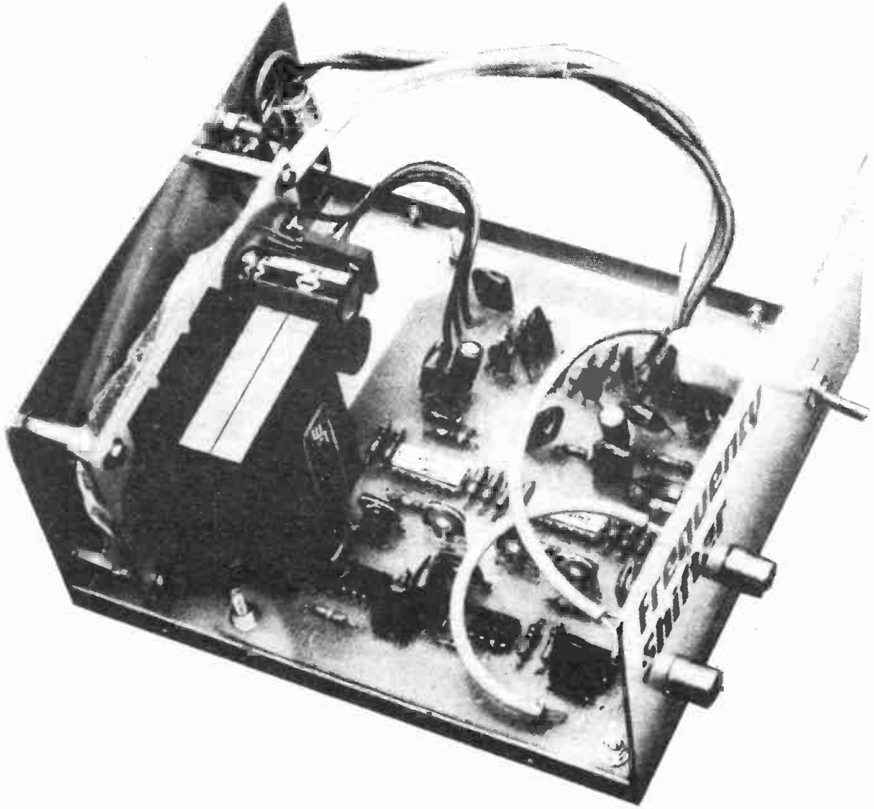
Figure 2, complete circuit diagram of the frequency shifter, the power supply is shown on page 44.

NOTES:
Q1–Q3 ARE BC549
IC1,2 ARE LM301A
IC3,4 ARE MC1495
IC5 IS LM301A

RESISTORS R5, R8, R9, R10, R17, R22, R23, R25 AND CAPACITORS C2, C3, C4, C6, C7, C11, C12 AND C16 SHOULD BE 1% TOLERANCE OR SELECTED TO BE WITHIN 1% FOR BEST RESULTS.
VOLTAGES GIVEN ARE OF THE PROTOTYPE AND SHOULD BE TYPICAL.

BUYLINES

A reasonably straightforward set of components, only 'hard-to-get' component may be the MC 1495 four quadrant multiplier — do not 'howl' with despair — Marshalls have the device ex-stock, and most friendly component stores should be able to supply it to order. PCBs from the usual suppliers.



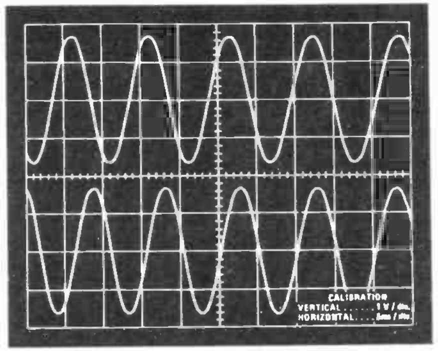


Fig. 3. Oscilligram showing relationship between input (upper) and output (lower) signals — note change in frequency.

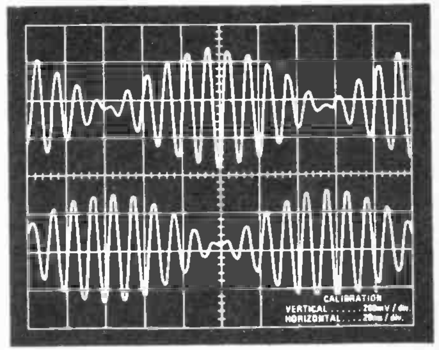
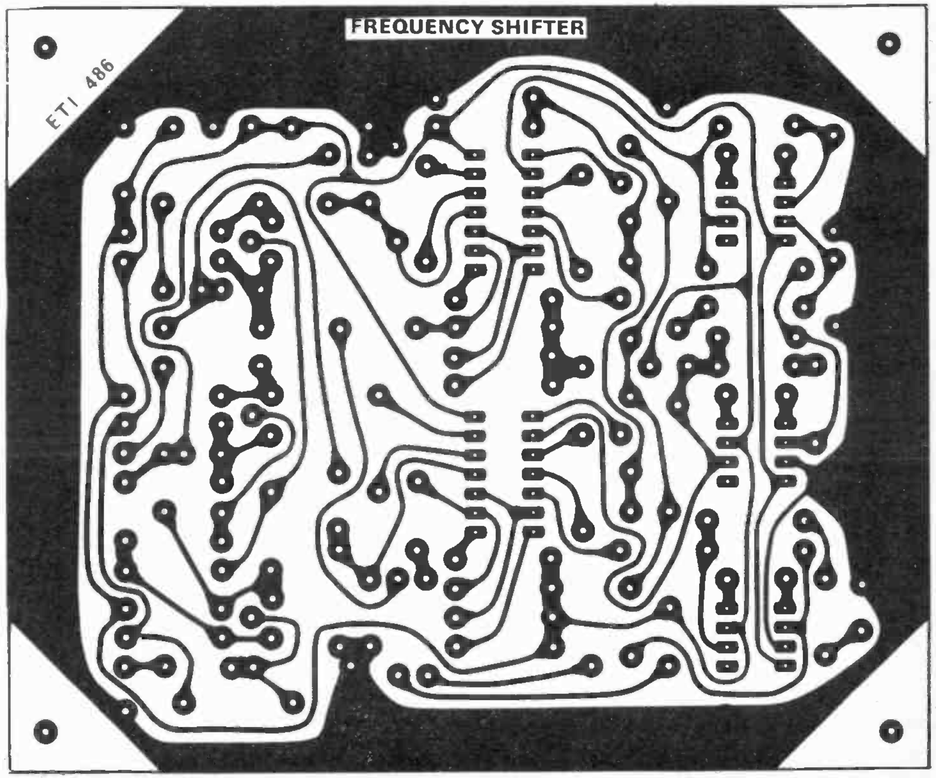


Fig. 4. Oscilligram showing output of IC3 (upper) and IC4 (lower); signal is 100 Hz, note phase difference. Below, full size foil pattern for the shifter (120 x 100 mm).



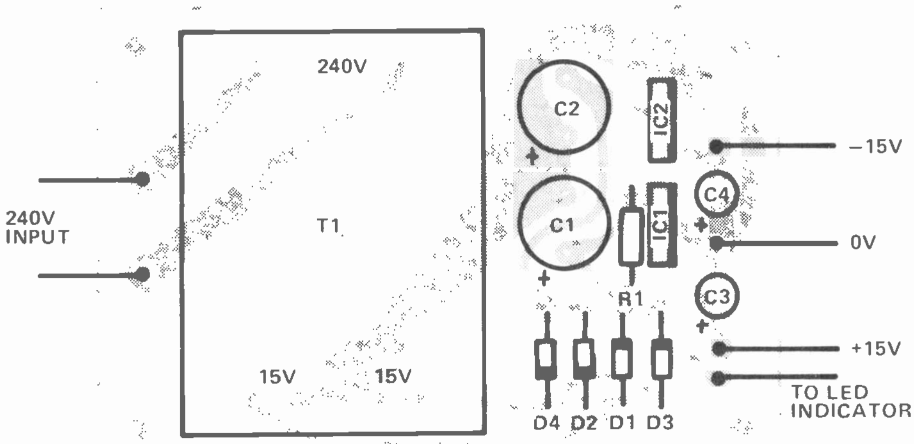
HOW IT WORKS

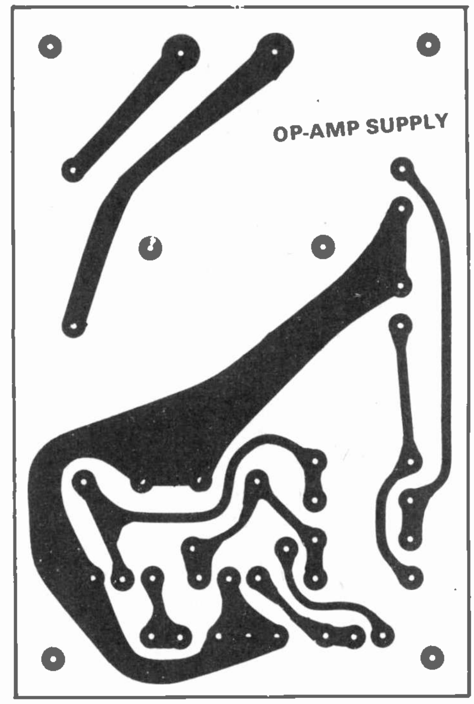
The audio input is split into two circuits which provide a frequency-related phase shift as shown in Fig. 4. The amplitude however remains constant. Due to the different component values in the two networks the phase shifts are not the same but differ by 90° at all frequencies (50 Hz – 20 kHz +/- 5°).

IC1 and IC2 form a quadrature sine wave oscillator with the frequency set by R18, R21, R24, C8, C9 and C13. Amplitude stability is provided by ZD1 and ZD2 along with RV1 (see adjustment section). The outputs from these two op amps are the same amplitude but 90° phase shifted.

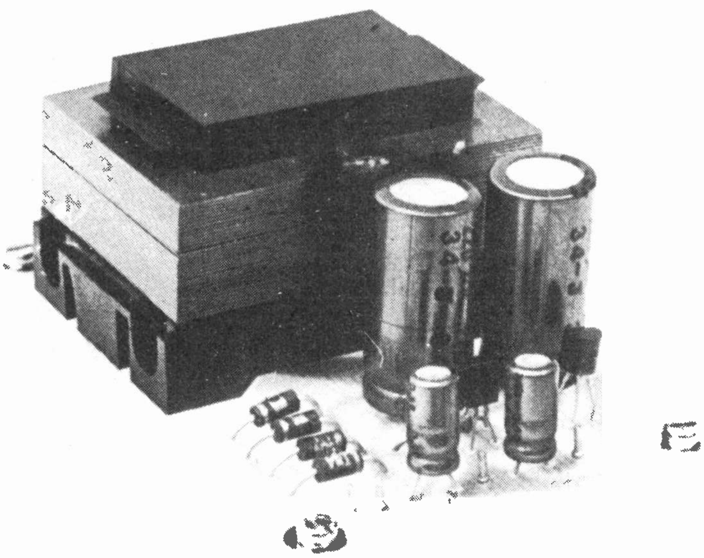
We now multiply (the MC1495 is a four-quadrant multiplier) one of the audio signals by one of the 5 Hz outputs and the second audio input by the second 5 Hz signal. When we multiply two waveforms together the output consists of the sum of the two frequencies and their difference. This means that if the audio signal is 100 Hz the output will contain a 95 Hz signal and a 105 Hz signal. These will beat with each other to produce a 10 Hz beat note as shown in Fig. 2. Due to the phase shift between the inputs of the multipliers the 105 Hz components of the outputs are in phase, while the 95 Hz components are 180° out of phase. Therefore by adding the outputs of the two multipliers in IC5 the 95 Hz components cancel out, leaving only the 105 Hz signal. Provided the multiplier inputs have the 90° phase relationship there will always be a 5 Hz shift, independent of frequency.

Due to the inability to maintain exactly the 90° phase relationship, the 95 Hz, or lower sideband, will not completely cancel and the result is a slight beat giving rise to an amplitude modulation effect (we had about 1 dB). This is not normally noticeable on speech or music.

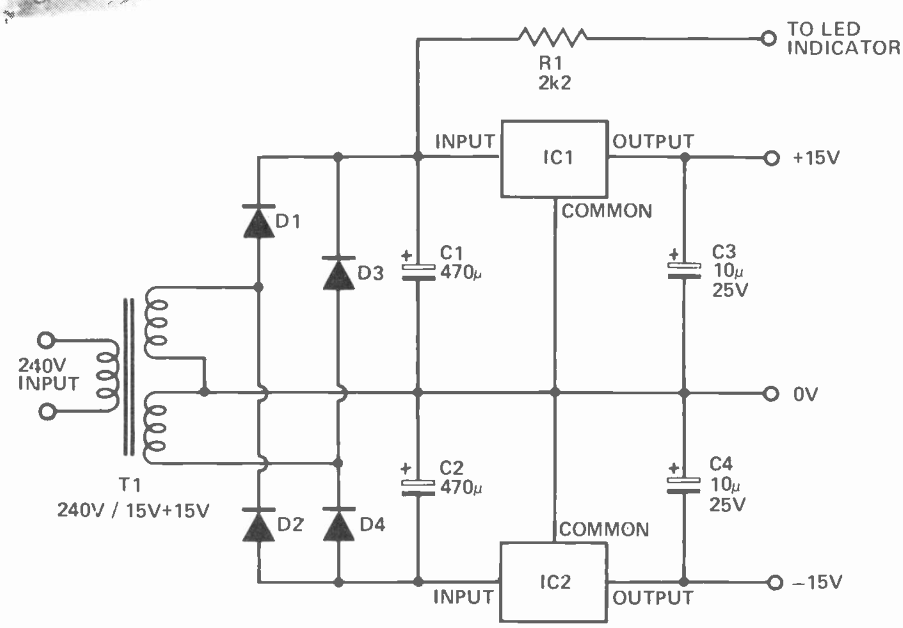




Component positioning and foil pattern for a suitable power supply (60 x 90 mm).



Circuit diagram for suitable power supply, in the prototype the option of LED1 was not used. Note that this power supply can be used by itself and in fact is a useful project in its own right.



PARTS LIST

R1	Resistor	2k2 ½W 5%
C1,2	Capacitor	470u 35V
C3,4	"	10u 25 V
D1–D4	Diodes	1N4001
LED1	Indicator	
IC1	Regulator	7815
IC2	"	7915
T1	240V: 15V 0-15V	

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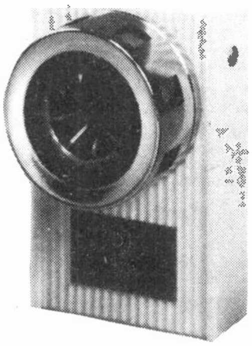


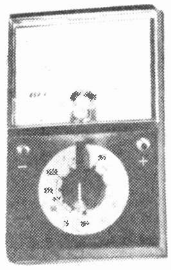
A small extremely simple device that creates a lot of noise!! Everyday there are fresh reports of mugging, burglaries etc — with this siren you can feel safer. Fit it to a door or window, or take it with you when you go out. Its powerful noise will arouse a lot of attention!! Operates from 4 x HP7 batteries (36p extra) and is entirely portable so can be placed where it will cause most surprise.
Size overall
110 x 75 x 60mm

£1.75

MICROSCOPE

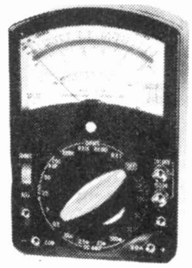
An extremely modestly priced yet very efficient microscope capable of magnification up to 750 times with clear sharp images. This model is self illuminating and incorporates an easily rotatable four position turret magnifying lens with rack and pinion focusing. The crackle black metal body houses the batteries for adjustable light illumination. Instructions for use are included and there is also a sample slide provided.

£10.95



Model LT101
A low cost useful meter ideal for carrying around in the pocket 1000 ohms per volt sensitivity
Ranges. DC Volts. 0-10-50-250 1000
AC Volts. 0-10-50-250-1000
DC Current 0-1-100mA
Resistance. 0-150k (Mid Scale 2 5k)
Size 90 x 60 x 35mm

Price £6.00



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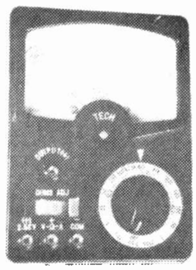
Ranges: DC Volts 0-0.5-5-25-50-250-500-1000
AC Volts 0-10-50-250-500-1000
DC Current 0-10µ-A-2.5mA-25mA-500mA
Resistance 0-10k-1M-10M-100M (Mid Scale 130-13k-130k 1.3M)
dB s −20 to +62
Size 152 x 102 x 44mm

Price £23.18

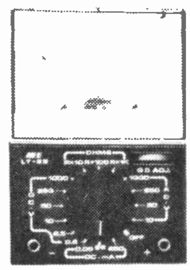
Model C7081
A 45 range meter with exceptional performance: mirror scale, 50,000 ohms per volt, rigid carrying handle, diode protected, 15µ A motor movement)
Ranges: DC Volts, 0-0.25-0.5-1.25-2.5-5-10-25-50-125-250-500-1000
AC Volts. 0-1.5-3-5-10-25-50-125-250-500-1000
DC Current.0-25-50µ-A-2.5-5-25-50-250-500mA-5 10A
Resistance. 0-16-160k-1.6M-16M (Mid Scale 100-1k-10k-100k)
dB s. from—20 to +62 in 10 ranges.
Size. 160x120x63mm

Price £22.90



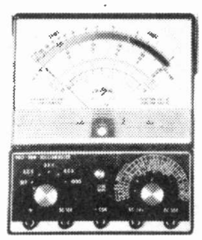
Model ITI-2
A popular model with 20000 ohms per volt sensitivity. Compact easy to use model giving good value for money. Protected movement.
Ranges: DC Volts. 0-5-25-50-250 500-2500
AC Volts. 0-10-50-100-500-1000
DC Current 0-50µ A-2.5mA-250mA
Resistance. 0-60k-6M (Mid Scale 250-25k)
Capacitance & dB scales
Size 105 x 85 x 30mm

Price £11.30



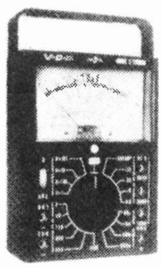
Model LT22
Probably one of the lowest priced meters featuring a mirror scale overload protection and 20,000 ohms per volt sensitivity. A modern styled meter with unusually clear scale markings
Ranges: DC Volts 0-0.5-2 5-10-50-250-1000
AC Volts 0-10-50-250-1000
DC Current 0-50µ-A-25mA-250mA
Resistance 0-50k-500k-5M (Mid Scale 300-3k-30k)
db s 4 ranges −20db to +42dB
Size 130 x 90 x 42mm

Price £11.70



Model C7080
An instrument for theprofessional: incorporates a 130mm long mirror scale, really well laid out easy to read scales. A top quality meter for anyone seriously interested in electronics
Ranges: DC Volts. 0-0.25-1-2 5-10-50-250-1000-5000
AC Volts. 0-2.5-10-50-250-1000-5000
DC Current. 0-50µA-1-10-100-500mA-10A
Resistance. 0-2-200-20000k (Mid Scale 12-1.2k-120k)
dB s. from—20 to +50
Size. 185x160x80mm

Price £29.90

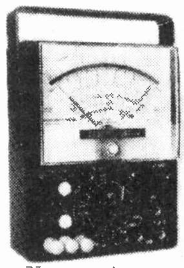


Model C7200
Similar in appearance to the C7081 but at a much lower cost. This model has a mirror scale and is 20,000 ohms per volt
Ranges DC Volts 0-6-30-120-600-1200
AC Volts 0-6 30 120-300-600-1200
DC Current 0-60uA-6-60-600mA
Resistance 0-6k-600k-6M-30M-60M
dB s −20 to +63
Size 152 x 108 x 52mm

Price £14.64

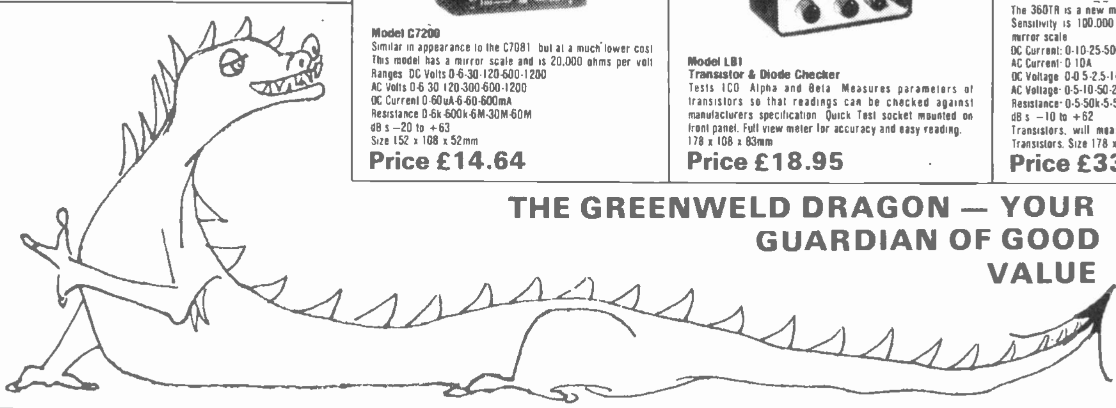
Model LB1
Transistor & Diode Checker
Tests ICO Alpha and Beta. Measures parameters of transistors so that readings can be checked against manufacturers specification. Quick Test socket mounted on front panel. Full view meter for accuracy and easy reading.
178 x 108 x 83mm

Price £18.95



The 360TR is a new model incorporating a transistor tester. Sensitivity is 100,000 ohms/volt and the instrument has a mirror scale
DC Current: 0-10-25-500 A-5 10-500mA-10A
AC Current: 0 10A
DC Voltage 0-0 5-2.5-10 50-250-1000V
AC Voltage: 0-5-10-50-250-1000V
Resistance: 0-5-50k-5-5M
dB s −10 to +62
Transistors, will measure gain, leakage etc. of NPN/PNP Transistors. Size 178 x 140 x 70mm

Price £33.27



THE GREENWELD DRAGON — YOUR GUARDIAN OF GOOD VALUE

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SEMICONDUCTORS

DIODES

Type No.	Case	Rating V	Rating A	Price
IN1084	Plastic	400	0.25	8p
IS109	Stud (S016)	1000	0.75	24p
IN4001	Plastic	50	1	5p
IN4002	..	100	1	5p
IN4003	..	200	1	6p
IN4004	..	400	1	7p
IN4005	..	600	1	7p
IN4006	..	800	1	8p
IN4007	..	1000	1	9p
BYX94	..	1250	1	10p
BY127	..	1250	1.5	12p
IN5171	..	50	2	8p
IN5172	..	100	2	9p
IN5173	..	300	2	10p
IN5174	..	400	2	10p
IN5175	..	500	2	11p
IN5176	..	600	2	12p
IN5177	..	800	2	14p
IN5178	..	1000	2	16p
IN5401	..	100	3	12p
IN5402	..	200	3	13p
IN5403	..	300	3	14p
IN5404	..	400	3	15p
IN5405	..	500	3	16p
IN5406	..	600	3	18p
IN5407	..	800	3	20p
IS410	Stud (S010)	100	3	24p
IS413	..	400	3	29p
IS415	..	800	3	35p
IS421		200	10	40p
IS423	..	400	10	48p
IN1183	.. (D05)	50	35	90p

ZENERS

400mW 2.7V to 36V 5% **10p** each
1.3W 3V3 to 200V 5% **20p** each
10W 4V3 to 200V **93p** each

BRIDGES

50V	1A	**26p**	200V	1A	**32p**
400V	1A	**36p**	100V	2A	**48p**
400V	2A	**58p**	100V	4A	**65p**
400V	4A	**80p**	100V	6A	**74p**
400V	6A	**98p**	400V	10A	**124p**

SCR's

0.8A	60V	T092	**35p**
1A	400V	T05	**60p**
4A	200V	T0220	**52p**
4A	400V	T0220	**70p**
6A	200V	T0220	**56p**
6A	400V	T0220	**75p**
6A	400V	T066	**80p**
10A	100V	T0220	**82p**
10A	200V	T0220	**87p**
10A	400V	T0220	**120p**
10A	600V	T0220	**148p**

TRIACS

6A	400V	T0220	**98p**
8A	600V	T0220	**135p**
15A	200V	Stud	**135p**
15A	400V	Stud	**220p**

TRANSISTORS

AC127	18p	BC158	10p	BCY31	98p
AC128	18p	BC159	10p	BCY32	1.05
AC132	35p	BC161	40p	BCY33	80p
AC151	25p	BC168C	12p	BCY34	90p
AC176	18p	BC171	10p	BCY42	26p
AC176k	28p	BC172	10p	BCY43	24p
AC187	20p	BC177	15p	BCY54	89p
AC188	20p	BC182	12p	BCY59	16p
ACY21	47p	BC183	12p	BCY70	15p
ACY22	59p	BC184	12p	BCY71	15p
ACY39	60p	BC204	10p	BCY72	14p
AD149	70p	BC207	10p	BD112	1.70
AD161	40p	BC208	10p	BD123	90p
AD162	40p	BC209	10p	BD131	38p
AD726	4.32	BC212	14p	BD132	40p
AF114	20p	BC213	14p	BD133	48p
AF115	20p	BC214	14p	BD135	35p
AF116	20p	BC237	10p	BD136	35p
AF117	20p	BC252	18p	BD137	40p
AF127	26p	BC267	18p	BD138	40p
AF139	40p	BC297	24p	BD139	42p
AF239	40p	BC301	24p	BD140	44p
AF279	75p	BC302	24p	BD163	73p
ASY27	40p	BC303	26p	BD234	60p
ASZ23	1.50	BC304	28p	BD238	60p
BC107	12p	BC307	12p	BD241A	45p
BC108	10p	BC308	11p	BD362	47p
BC108C	12p	BC309	12p	BD437	72p
BC109	12p	BC320	15p	BD510	54p
BC109C	15p	BC327	16p	BD525	47p
BC114	12p	BC328	16p	BD526	47p
BC116A	15p	BC337	20p	BD527	47p
BC118	10p	BC347	14p	BDX32	2.00
BC119	22p	BC348	12p	BDY10	80p
BC126	20p	BC351	26p	BDY90	2.25
BC136	13p	BC413	24p	BF115	20p
BC137	13p	BC441	32p	BF137	55p
BC139	24p	BC461	32p	BF152	18p
BC140	24p	BC547	10p	BF167	22p
BC143	24p	BC548	10p	BF173	20p
BC147	10p	BC549	11p	BF178	24p
BC148	10p	BC558	12p	BF179	24p
BC149	10p	BCX33	15p	BF180	30p
BC157	10p	BCY30	90p	BF181	30p

TRANSISTORS (cont'd)

BF182	30p	341	20p	2N3773	3.10
BF183	24p	450	19p	2N3792	3.72
BF184	20p	500	18p	2N3819	28p
BF185	20p	503	20p	2N3821	70p
BF194	10p	510	16p	2N3824	64p
BF195	10p	550	19p	2N3831	43p
BF196	10p	2C444	5.71	2N3904	15p
BF197	12p	2G220	8.19	2N3906	15p
BF200	28p	2G302	12p	2N3947	32p
BF244B	30p	2G374	18p	2N3962	24p
BF258	26p	2G385	27p	2N4052	5.93
BF259	30p	2N336	42p	2N4062	12p
BF311	20p	2N549	60p	2N4063	81p
BF337	30p	2N550	47p	2N4124	15p
BF338	33p	2N697	30p	2N4255	90p
BF362	47p	2N706	18p	2N4399	5.67
BF458	45p	2N706A	20p	2N4401	10p
BFR39	24p	2N708	22p	2N4402	10p
BFR79	26p	2N711	63p	2N4403	10p
BFW11	65p	2N779A	57p	2N4410	40p
BFW43	32p	2N865	42p	2N4416A	58p
BFX11	24p	2N918	35p	2N4418	10p
BFX29	22p	2N930	27p	2N4919	88p
BFX48	32p	2N956	28p	2N4931	56p
BFX84	22p	2N976	51p	2N5191	62p
BFX88	22p	2N985	51p	2N5192	64p
BFX93A	27p	2N995	28p	2N5193	48p
BFY18	40p	2N1043	86p	2N5194	68p
BFY19	21p	2N1091	48p	2N5195	73p
BFY39	17p	2N1131	30p	2N5245	43p
BFY50	18p	2N1142	37p	2N5294	52p
BFY51	18p	2N1170	42p	2N5345	1.23
BFY52	18p	2N1204A	83p	2N5401	35p
BFY56A	22p	2N1257	32p	2N5447	36p
BFY64	24p	2N1304	40p	2N5449	19p
BFY77	21p	2N1306	44p	2N5485	55p
BFY90	1.10	2N1307	44p	2N5831	42p
BFZ10	84p	2N1309	48p	2N6027	55p
BLY47A	2.15	2N1487	82p	2N6028	60p
BLY65	4.82	2N1502	91p	2N6106	71p
BRY39	40p	2N1535	1.20	2N6108	54p
BRY56	40p	2N1536	1.32	2N6109	54p
BSV64	70p	2N1539	1.14	2N6123	64p
BSX20	20p	2N1545	1.32	2N6133	69p
BSX24	17p	2N1613	24p	2SC536	11p
BSX28	21p	2N1700	1.10	2SD234	64p
BSX29	19p	2N1711	26p	40673	60p
BSY38	16p	2N1757	93p		
BSY95A	16p	2N1893	28p		
BU100	1.92	2N1905	93p		
BU108	2.62	2N1924	47p		
BU133	1.94	2N1974	52p		
BU205	2.16	2N1991	43p		
BU206	2.74	2N2015	4.60		
BU208	2.80	2N2040	36p		
BUX54	92p	2N2077	2.39		
C1131	26p	2N2137	1.22		
MEU21	35p	2N2157	4.86		
MJ423	5.20	2N2190	62p		
MJ2955	1.20	2N2218	26p		
MJE340	80p	2N2219	26p		
MM1614	28p	2N2222A	22p		
MM1712	28p	2N2223	2.30		
MM3003	47p	2N2239	1.96		
MM4003	1.30	2N2243	35p		
MPS2369	15p	2N2369	25p		
3563	18p	2N2484	24p		
3640	21p	2N2612	2.18		
3642	28p	2N2644	1.89		
3646	31p	2N2646	60p		
6515	20p	2N2722	2.18		
6521	23p	2N2784	93p		
6534	22p	2N2802	46p		
MPSA66	38p	2N2894	34p		
MPSU52	46p	2N2904	26p		
MPSU55	60p	2N2905	21p		
OC19	90p	2N2906	23p		
OC23	90p	2N2907	24p		
OC24	60p	2N2920	2.16		
OC25	90p	2N2926	12p		
OC29	90p	2N3013	22p		
OC35	90p	2N3053	28p		
OC36	90p	2N3054	52p		
OC42	28p	2N3055	50p		
OC44	22p	2N3375	3.92		
OC45	20p	2N3439	1.52		
OC70	18p	2N3442	1.30		
OC71	24p	2N3478	61p		
OC72	28p	2N3502	28p		
OC75	38p	2N3552	92p		
OC77	80p	2N3567	28p		
OC810	18p	2N3583	82p		
OC139	74p	2N3585	1.44		
OCP71	1.20	2N3612	1.20		
PBC108	12p	2N3638	15p		
SE7055	46p	2N3702	10p		
TIP30	40p	2N3703	10p		
TIP34	65p	2N3704	10p		
TIP41A	56p	2N3705	10p		
TIP42A	66p	2N3706	10p		
TIP2955	86p	2N3707	10p		
TIP3055	42p	2N3708	10p		
TIS43	35p	2N3710	10p		
TIS44	12p	2N3712	90p		
TIS55	12p	2N3713	1.40		
ZT82	45p	2N3715	1.30		
ZT3439	86p	2N3716	2.47		
ZTX107	15p	2N3725	60p		
212	18p	2N3731	2.70		
300	15p	2N3739	1.25		
303	20p	2N3740	1.70		
304	22p	2N3772	1.62		
311	15p	2N3743	1.79		
313	19p	2N3771	1.94		

IC's

74 SERIES

				74107	37p
7400	12p	7447	84p	74121	36p
7401	14p	7450	15p	74122	51p
7402	14p	7451	14p	74123	64p
7404	17p	7453	14p	74132	56p
7405	23p	7454	14p	74141	63p
7406	28p	7460	14p	74150	173p
7408	14p	7472	29p	74151	79p
7410	14p	7473	29p	74154	144p
7413	28p	7474	29p	74155	73p
7414	62p	7475	51p	74157	66p
7420	14p	7476	29p	74159	200p
7427	36p	7483	91p	74164	126p
7430	14p	7485	132p	74174	110p
7432	28p	7486	40p	74179	120p
7437	36p	7490	46p	74180	120p
7438	36p	7491	75p	74190	188p
7440	15p	7492	52p	74191	158p
7442	65p	7493	52p	74192	120p
7445	88p	7495	73p	74193	120p
7446	88p	7496	85p	74367	120p

C-MOS

4000	18p	4018	84p	4054	100p
4001	18p	4022	90p	4055	110p
4002	18p	4023	18p	4060	96p
4007	18p	4024	64p	4071	18p
4011	18p	4027	48p	4081	18p
4012	48p	4028	78p	4510	132p
4013	48p	4040	110p	4511	212p
4016	48p	4047	78p	4528	124p
4017	84p	4049	48p	4588	256p

LINEAR

LM301	8dil	40p
LM380	14dil	100p
555	8dil	40p
556	14dil	100p
561	16dil	400p
567	8dil	200p
709	8dil	.35p
709	T099	32p
741	8dil	25p
741	14dil	30p
741	T099	30p
710	T099	40p
748	8dil	40p
ZN1034E	14dil	225p
MC1303	14dil	140p
CA3046	14dil	65p
LM3900	14dil	65p
MC3302	14dil	120p
ZN414	T018	130p
MC1310	14dil	150p

OPTO

0.125" LED's: Red **12p**; Yellow **26p**; Green **23p**
0.2" LED's: Red **18p**; Yellow **28p**; Green **25p**
7-Seg LED's: 0.3" Common Cathode or Anode **95p**
7-Seg LED's: 0.6" Common Cathode or Anode **£1.95**
GN4 Nixie Tubes **£1.25**. ORP12 **60p**. OCP71 **£1.20**. RPY58A **65p**. H61 for paper tape readers, etc. Dark current 0.01 μA. Light current 250 μA. Size 2mm dia x 12mm long **70p**.

VOLTAGE REGULATORS

78L12	T092	12V	150mA	75p
723	14dil	2-37V	150mA	50p
MC1469R	T066	2½-37	500mA	150p
78M05	T05	5V	500mA	85p
78M12	T05	12V	500mA	85p
1405	T0126	5V	600mA	85p
1412	T0126	12V	500mA	95p
7715	T0220	15V	750mA	120p
7805	T0220	5V	1A	150p
7812	T0220	12V	1A	150p
LM309K	T03	5V	1.2A	150p
LM323	T03	5V	3A	650p

SIGNAL DIODES

IN4148	4p
OA81	5p
OA91	8p
BAY72	7p

DARLINGTON PHOTO TRANSISTOR SPECIAL OFFER!!!

Better than 2N5777 Metal Case, TO18 configuration, **40p each**, 10 for **£3.50**, 25 for **£7.50**, 100 for **£25**.

RESISTORS

⅓rd watt carbon film miniature Mullard CR25 or similar Size 7 5 x 2 5mm All values from 1R to 1M 5% E12 series 1M2 to 10M 10% E12 series, also E24 values from 5R1 to 910k All **1 ½p** each

Wirewounds 1W 0R22-600R **6p;** 3W 0R22-15k **8p;** 5W 0R47-22k **10p;** 7/8W 2R-22k **12p;** 9/10W 6R8-25k **14p;** 15W 1R-100K **16p.**

Variable resistors
Sub min presets 0 1W V or H 47R to 4M7 **7p;** std presets 0.3W V or H 100R to 4M7 **9p.** Std pots 500R to 2M 1in **24p;** 5k-2M log **24p;** 5k-2M log DPSW **48p;** 5k-2M dual lin or log **72p.**

CLOSE TOLERANCE RESISTORS — list of 1% 0.1% and even 0 01% now ready — over 400 listed from 9p Send SAE for copy

CAPACITORS

50V Min. Ceramic

Tolerance 22pF-1000pF 5%. 1500pF-01μF — 20+50%. .015μF-047μF —20+80%. Available as follows
1 8 2.2 2 7 3 3 3 9 4 7 5 6 6.8 8 2 10 12 15 18 22 27 33 39 47 56 68 82 100 120 150 180 220 270 330 390 470 560 680 820pF 1000pF **3p** each
1500 2200 4700 6800pF .01 015 022 033 047μF **4p** each.

160V 5% Polystyrene

10 12 15 18 22 27 33 39 47 56 68 75 82 100 110 120 150 180 200 220 270 330 390 470 560 680 820pF **4p** each
1000 1200 1500 1800 2200 2700 3300 3900 4700 5600 7500 8200 10000pF **6p** each

100V 10% Mylar

1000 1200 1500 1800 2200 2700 3300 3900 4700 6800 8200 10,000pF **4p** each

250V Polyester

01 015 .022 033 047 068μF **4p** each
1 15 22μF **5p** each
0 33 **10p;** 0 47 **12p;** 0 68 **15p;** 1 **18p;** 1 5 **21p;** 2 2 **24p;** 3 3 **29p;** 4 7 **35p;** 6 8 **48p;** 10μF **62p.**

400V Polyester

1000 1500 2200 3300 4700 6800pF 01μF **7p** each
0 15 022 033μF **9p**. 047 068 1 **11p;** 22 **16p;** 33 **19p;** 47 **22p;** 1μF **25p.**

1000V Wire Ended

1000 1500 2200 3300 4700 6800pF 01 022 033 047μF **15p** each
0 1 **22p;** 0.22 **28p;** 0 47 **52p.**

High Voltage Discs

1kV		3kV	
470pF	4p	200pF	9p
680pF	4p	1500pF	12p
1000pF	5p	1650pF	12p
5000pF	8p	1800pF	14p
		2500pF	16p
2kV		4700pF	21p
15pF	4p		
47pF	5p		
82pF	5p	4kV	
91pF	5p	68pF	9p
100pF	6p	130pF	9p
120pF	6p	300pF	10p
150pF	6p	4500pF	22p
180pF	6p		
220pF	7p		
330pF	8p	8kV	
390pF	9p	200pF	11p
470pF	10p	220pF	11p
2200pF	13p	270pF	11p

Electrolytics

μF/V 1/25. 2 2/25 4 7/25 6 8/25 10/25. 22/25. 33/25. 47/25. all **7p;** 100/25. 150/25. 220/16. **8p;** 220/25 330/25. 470/10. **10p;** 220/40. 330/25. 470/10 470/16. **12p;** 470/25 **15p;** 1000/16 **19p;** 1000/25 **23p;** 1000/40 **30p;** 1000/63 **45p;** 2200/10 **19p;** 2200/16 **24p;** 2200/25 **33p;** 2200/50 **56p;** 3300/10 **24p;** 3300/25 **45p;** 4700/16 **45p;** 4700/25 **58p.**
Electrolytics, cans
470/100 **23p;** 1000/100 **54p;** 2200/63 **64p;** 4700/40 **72p;** 6800/16 **51p;** 10 000/10 **58p;** 10 000/16 **72p;** 10,000/25 **84p;** 15,000/6 **47p;** 15,000/16 **87p.**
Tantalum Bead
0 1 0 15 0 22 0 33 0 47 0 68 1 1 5 2 2 3 3. all 35V **12p;** 4 7 6 8 10/35 15/20 22/16 33/10 47/6 68/3 100/3 all **14p**
Compression trimmers
3-40pF **19p;** 30-250pF **26p;** 100-500pF **33p.**

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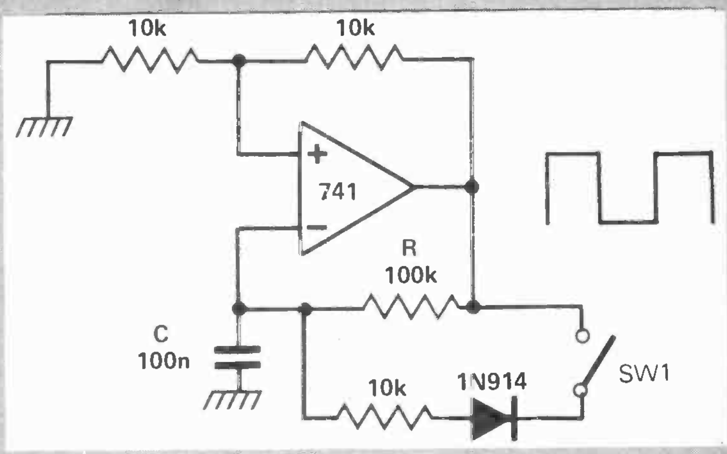
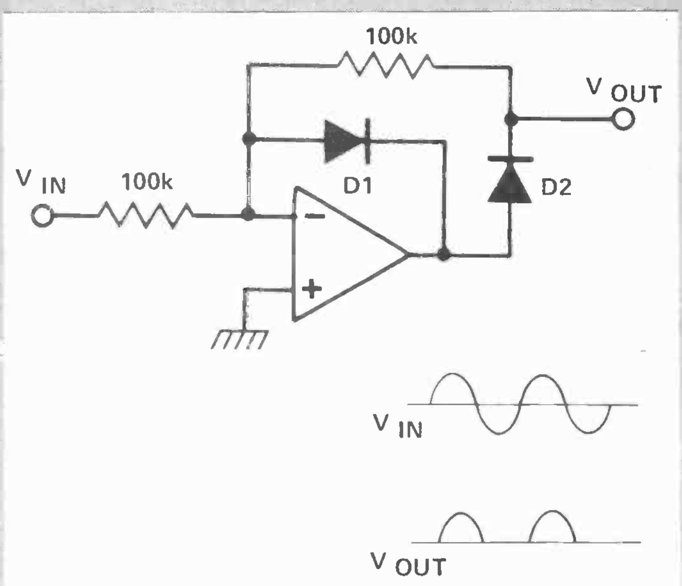
OP AMPS PART 2

In the first part of this series Tim Orr discussed the theory and operation of op-amps. This month he moves on to give some circuit applications for this ubiquitous device, and explains how and why it can do what it does!

Single Op Amp Oscillator

This circuit has a Schmitt trigger and a 'sort of integrator' all built around one op-amp. The postive feedback is via the 10k resistors. The 'integration', or rather, the timing, is controlled by the RC network. The voltage at the inverting input follows that of the RC charging exponential, except that it is confined to be within the upper and lower hysterysis levels. Thus the hysterysis levels and the RC time constant determine the frequency of the operation. It is possible to make the output square wave have a large mark to space ratio. By closing the switch SW1, the discharge time of the capacitor becomes eleven times faster than the rise time. Thus a square wave with an 11:1 mark space ratio is generated.





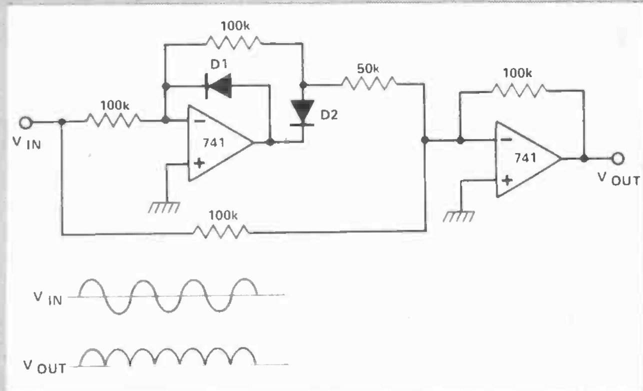
Precision Half Wave Rectifier

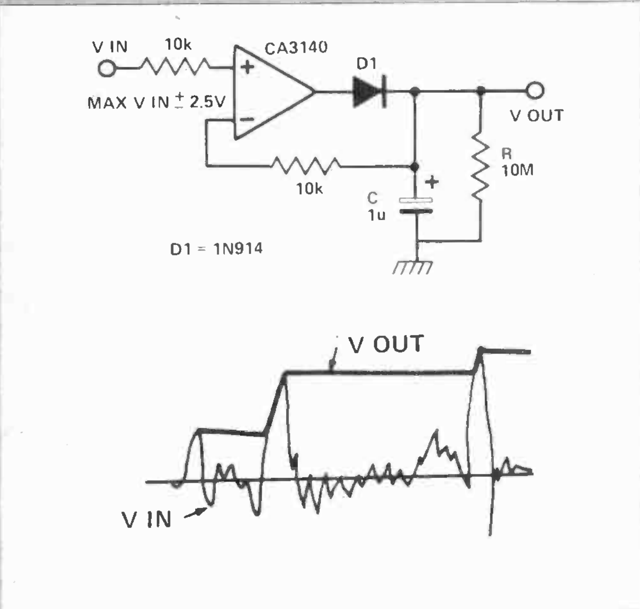
Rectifying small signals with any accuracy can be very difficult with just diodes due to their forward voltage drop of about 0.6 V. However, an op-amp can be used to reduce this voltage drop to apparently nothing. Consider the circuit shown. There is negative feedback so that 'virtual earth' circumstances exist. When Vin is positive, D1 conducts to maintain the virtual earth, D2 is reverse biased and so the output is just a 100k resistor connected to 0 V. When Vin goes negative, the output rises positively, D2 is turned on and D1 turned off. As the virtual earth is being maintained, the output voltage is the exact inverse of the input voltage. This is true for all negative inputs. Therefore, the output is composed of positive going half sinewaves. A precision half wave rectification has occurred. In fact the diode error is very small, being equal to

$$\frac{600\text{ mV}}{\text{(surplus voltage gain)}}$$

Therefore as the input frequency increases, and the surplus voltage gain decreases, the amount of precision also falls.

By adding the original and the half wave recitifed signals together in the right ratio, it is possible to fill in the half cycle gaps and thus to generate a precise full wave rectification. The addition of one summing op-amp and three resistors is all that is needed as shown opposite.



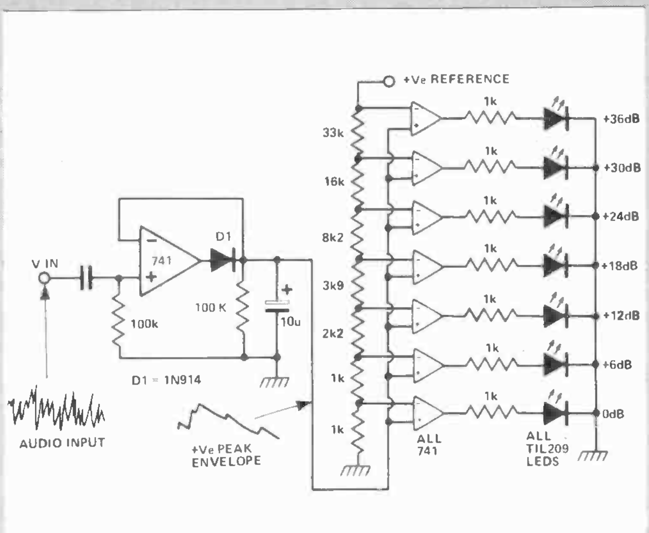


Precision Peak Voltage Detector with a Long Memory Time

The circuit shown has negative feedback only for positive signals. That is, the inverting input can onlv get some feedback when diode D1 is forward biased and this can only occur when the input is positive. When a positive input signal is applied the output of the op-amp rises until the inverting input reaches the same potential. In so doing, the capacitor C is also charged to this potential. When the input goes negative, the diode D1 becomes reverse biased and so the voltage on the capacitor remains there, being slowly discharged by the op-amp input bias current and the resistor R (10M). The op-amp used has a MOS FET input, having an exceptionally low input bias current of 10 pico amps. Thus the discharge of the capacitor is dominantly controlled by the resistor R, giving a time constant of ten seconds. Thus the circuit detects the most positive peak voltage and remembers it.

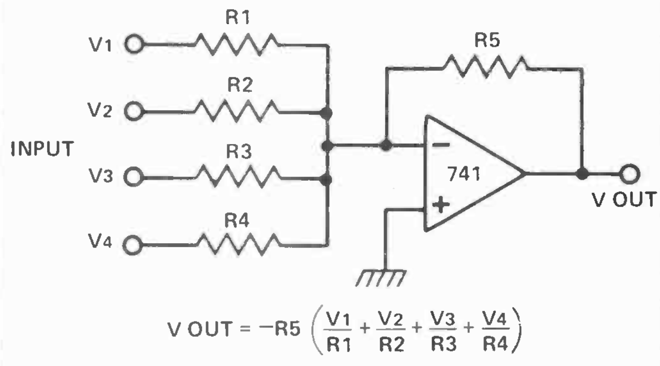
Led Bar PPM Display for Audio

The peak voltage detector can be used to control an illuminated audio level monitor displaying the same characteristics as a PPM (Peak Programme Meter). A bar column of LEDs is arranged so that as the audio signal level increases, more LEDs in the column light up. The LEDs are arranged vertically in 6 dB steps. A fast response time and a one second decay time has been chosen so as to give an accurate response to transients and a low 'flicker' decay characteristic. The op-amps that drive the LEDs are being used as comparators. On each of their inverting inputs they have a DC reference voltage, which increases in 6 dB steps up the chain. All of their non-inverting inputs are tied together and connected to the positive peak envelope of the audio signal. Thus as this envelope exceeds a particular voltage reference, that op-amp output goes high and the LED lights up. Also, all the LEDs below this are illuminated.

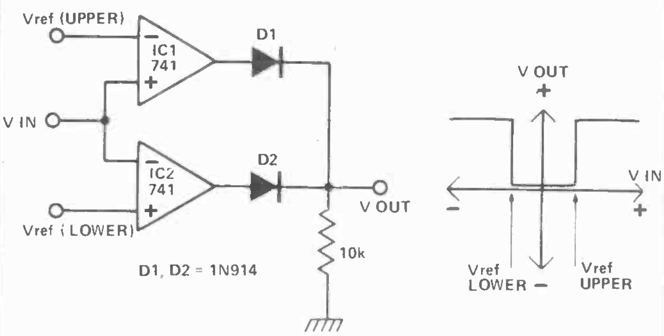


Basic Summing Circuit (Mixer)

A virtual earth amplifier can be used to mix several signals together. The output voltage is a mixture of all the inputs. The amount of an input that appears at the output in inversly proportional to the input resistor. If the input voltages are fed into potentiometers before being fed to the mixer, then their individual levels can be manually adjusted. This is the basis of most audio mixers, although only the cheaper units use op-amps. Most op-amp mixers will degrade the signal to noise ratio of the signals by more than a good discrete component amplifier.



$$V_{OUT} = -R5\left(\frac{V1}{R1} + \frac{V2}{R2} + \frac{V3}{R3} + \frac{V4}{R4}\right)$$

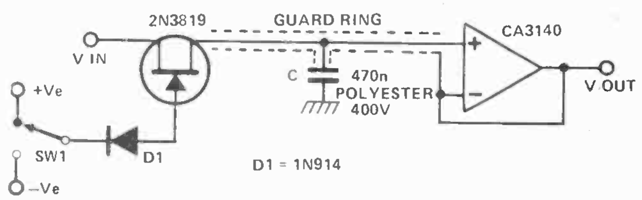


Window Comparator

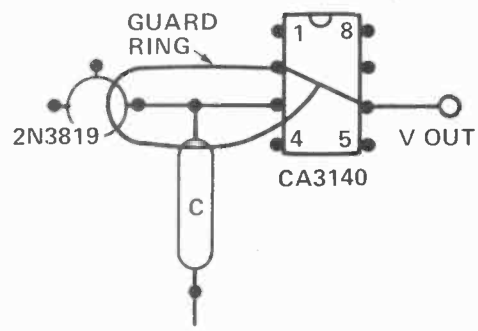
A window comparator gives an output which in this case is 0 V, when an input voltage lies in between two specified voltages. When it is outside this 'window', the output is positive. The two op-amps are used as voltage comparators. When Vin is more positive than Vref (upper) the output of IC1 is positive and D1 is forward biased. Otherwise the output is negative, D1 reverse biased and hence Vout is 0 V. Similarly, when Vin is more negative than Vref (lower), the output of IC2 is positive; D2 is forward biased and thus Vout is positive. Otherwise Vout is 0 V. Thus only when Vin lies within the window set by the reference voltages is Vout 0 V.

High Performance Sample and Hold

It is often necessary to have a circuit that will sample an analogue voltage and then remember it for a long time without any significant corruption of that voltage. This is known as a sample and hold circuit and one use of it is to store the voltage from the keyboard connected to an electronic music synthesiser. The voltage is then used to control the pitch of a voltage controlled oscillator and so it is very important to have a high performance sample and hold. A drift of less than one semitone, (80 mV), in ten minutes is required. A sample and hold is simply an electronic switch, a storage capacitor and a high input impedance voltage follower. In the circuit shown, when switch SW1 is positive the FET is turned on, and has a resistance of about 400R. Thus the input voltage charges up the capacitor through the FET. When SW1 is negative, the FET is turned off, (pinched off), and can have a resistance of thousands of Megohms. To get a long storage time the op-amp must have a very low input bias current. For the CA3140, this current is about 10 pico amps, i.e., 10^{-11} amps. Therefore the rate at which the capacitor will be discharged by this current can be worked out from the equation, C(dv/dt) = i



PRINTED CIRCUIT BOARD LAYOUT

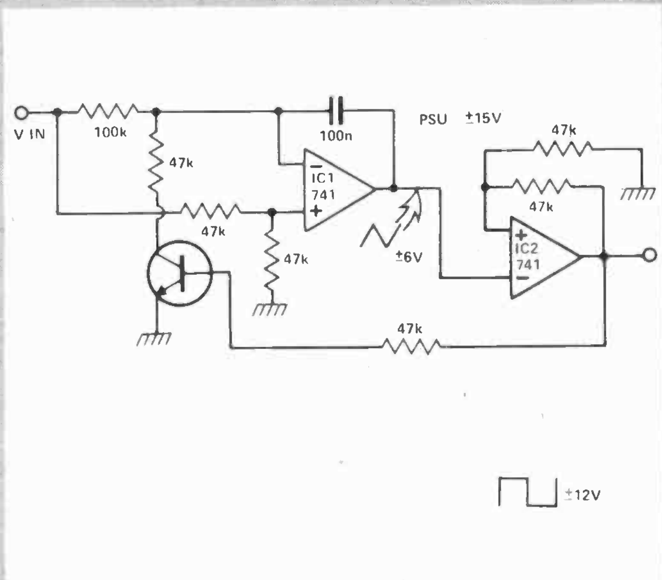


where dv/dt is the rate of change of voltage on the capacitor.
Therefore:

$$\frac{dv}{dt} = \frac{i}{C} = \frac{10^{-11}}{0.47 \times 10^{-6}} \quad 22\mu V/s$$

This is a very low drift rate, much better than we need. However, the actual drift rate will probably be in excess of this, due to surface leakage on the printed circuit board, leakage through the FET, and internal leakage in the capacitor. It is advisable to use a high voltage, non-polarised capacitor in this circuit to keep the leakage currents to a minimum. Also, to stop surface leakage a simple PCB trick can be used, that of making a guard ring around the sensitive components.

Normally any potential stored on the capacitor may leak to ground across the surface of the PCB, but if we make the surrounding surface a conducting track held at the same potential as that of the capacitor then the potential difference is virtually always zero, and hence the surface leakage is greatly reduced.



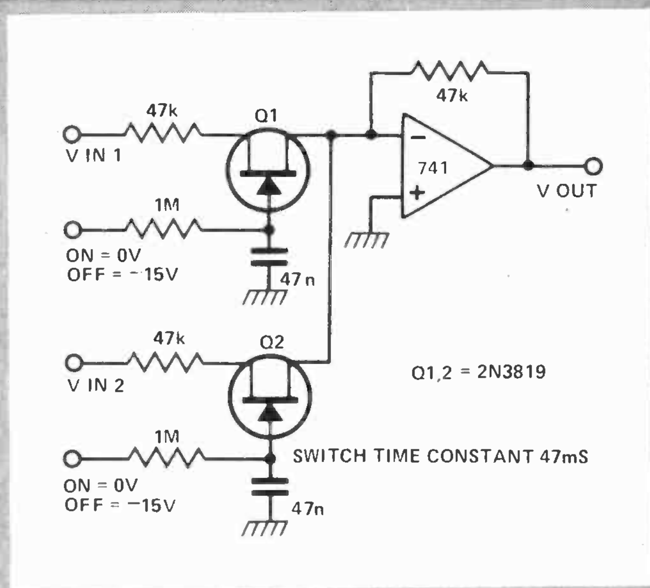
Linear Voltage Controlled Oscillator

This oscillator is very similar to the triangle square wave oscillator shown in Part 1, except that this one is voltage controlled. The integrator and Schmitt trigger action are the same as before, but the feedback has been altered. The input voltage Vin, is applied differentially to the integrator via the resistor network. The larger the value of Vin, the faster the integrator ramps up and down. Thus the frequency of the operation is determined by an external positive control voltage. The frequency is linearly proportional to this control voltage.

When the output of the Schmitt is low, Q1 is off and so all the input voltage is applied to the inverting input. Half of the input voltage is always applied to the non-inverting input. Therefore the integrator's output ramps downward until the Schmitt flips into its positive state. Now, Q1 is switched on and the voltage at the inverting input is negative with respect to the non-inverting input. Hence the integrator now ramps upwards.

Silent Audio Switching

Sometimes electronic switches for audio signals are required. FETs can be used to perform the switching, but they can cause distortion, the resultant output impedance is not very low and clicks generated by the switching signal can break through. The circuit shown virtually eliminates all of these problems. By using an op-amp a very low output impedance is obtained as well as the possibility of selecting or mixing one or more of many input channels. Because of the virtual earth mixing, the voltage across any FET that is switched on is very small. If the input voltage is 1V and the FETs ON resistance is 470R, then the voltage across the FET is about 10 mV. When large voltages are applied to a turned on FET, the distortion is large, but if the voltage is small, (10 mV say), the distortion could be less than 0.1%. Thus the virtual earth mixing enables low distortion operation. Lastly, to stop the generation of switching clicks, a time constant of 47 msec has been enforced at the gate of the FETs.



To be continued. Next month sees circuits for exponential voltage to current convertors, musical chime generators, triangle to square wave convertors, squarewave generators with auto level adjustment and variable mark-space ratio — amongst other things.

DATA SHEET

ICL 7106/7107 INTERSIL — DIGITAL PANEL METER

THE ICL7106 and 7107 are high performance, low power, CMOS 3½ digit A/D converters that contain all the necessary active devices on a single monolithic IC. Each has parallel seven-segment outputs which are ideal for use in a digital panel meter. The ICL7106 will directly drive a liquid crystal display including the backplane drive. The ICL7107 will directly drive instrument size LEDs without buffering. With seven passive components, display and power supply, the system forms a complete digital voltmeter with automatic zero connection and polarity. (see figs. 1 and 3).

Both ICs use the time-proven dual slope integration technique with all its advantages, i.e. non-critical components, high noise rejection, non-critical clock frequency and almost perfect differential linearity. Both the ICL7106 and 7107 can be used not only with its internal reference, but true ratiometric reading applications may also be accomplished over a full scale input range of 199.9 mV to 1.999 V.

The accuracy of conversion is guaranteed to plus or minus 1 count over the entire plus or minus 2000 counts and the auto-zero facility provides a guaranteed zero reading for 0 volts input. However, the chip does provide a true polarity output at low voltages for null detection. Both chips have an on-board clock and reference circuitry, as well as overrange detection.

The Clock

The chip carries the active parts of an RC oscillator which runs at about 48 kHz and is divided by 4 for use as the system clock. The integration period (1000 clock pulses) is therefore 83.3 ms. Each conversion requires 4,000 clock pulses, i.e. 3 readings per second. For optimum 50 Hz line frequency rejection, the clock should be set to a multiple of 50 Hz, e.g. 50 kHz.

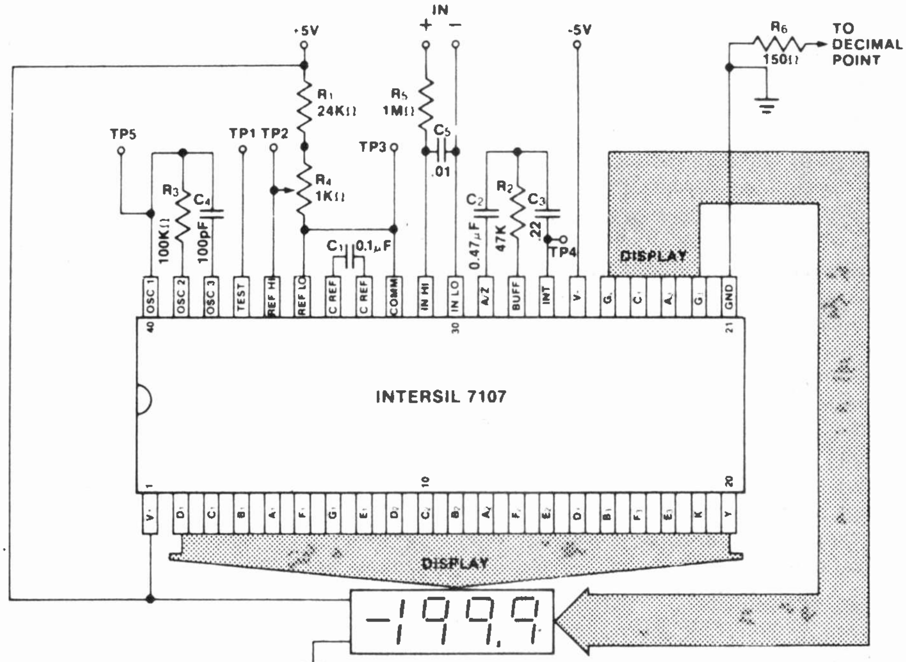


Fig. 1 LED Digital Panel Meter using ICL 7107

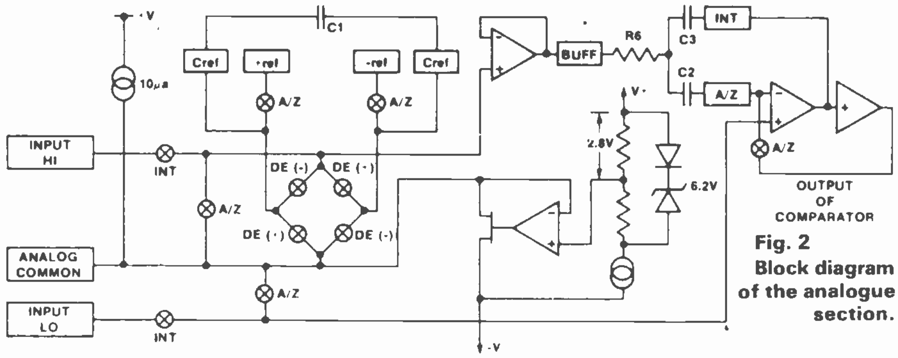


Fig. 2 Block diagram of the analogue section.

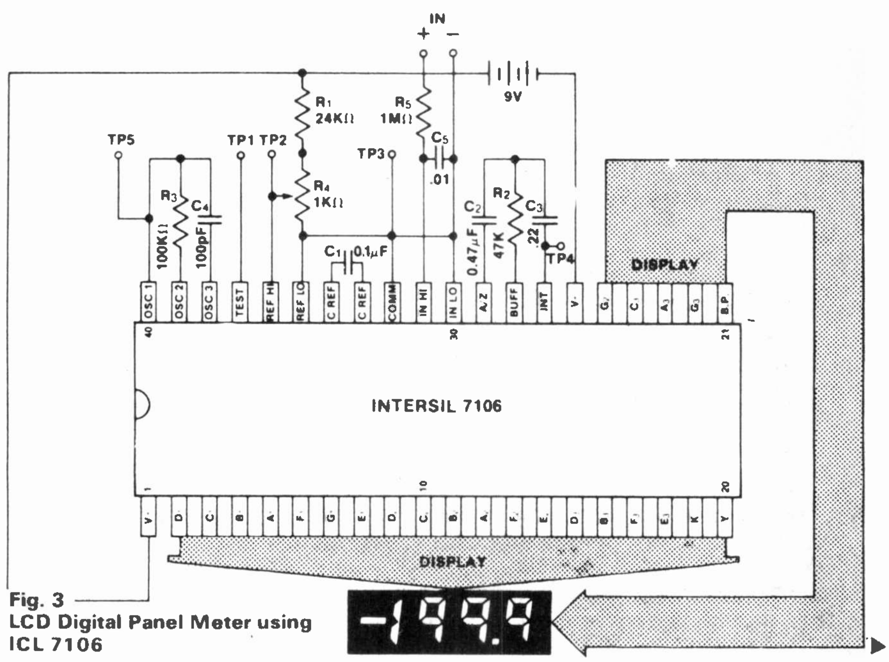
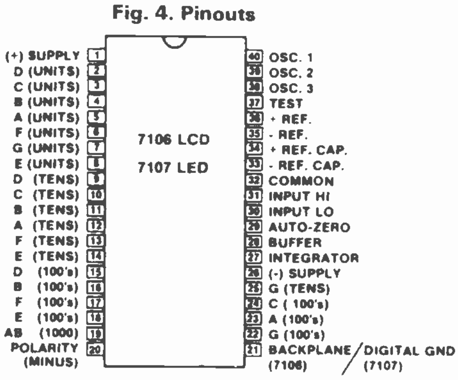


Fig. 3 LCD Digital Panel Meter using ICL 7106

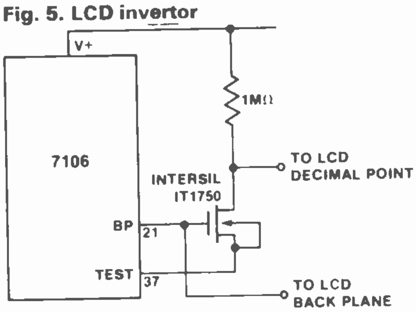
Fig. 4. Pinouts



Displays and DPs

The additional components required to build a DPM are a display (either LCD or LED), 4 resistors, 4 capacitors, and an input filter if required. Liquid crystal displays become polarised and damaged if a DC voltage is continuously applied to them, so they must be driven with an AC signal. To turn on a segment, a waveform 180 degrees out of phase with the backplane drive (but of equal amplitude) is applied to that segment. The 7106 generates the segment drive waveform for all digits internally, but does not generate segment drive for the decimal point. This must be done using an inverter or exclusive-OR logic (see fig. 5 below). For use with LED displays the 7107 pull-down FETs will sink about 8 mA per segment, which produces a bright display suitable for almost any indoor application. A fixed decimal point can be turned on by tying the appropriate cathode to ground through a 150 ohm resistor.

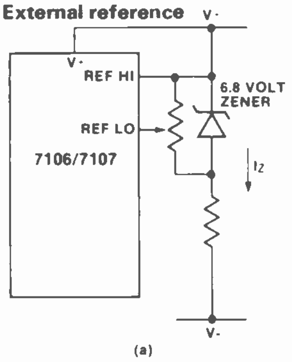
Fig. 5. LCD invertor



The Reference

For 200.0 mV full scale, the voltage applied between REF Hi and REF Lo should be set at 100.0 mV. For 2.000 V full scale, this should be 1.000 V. The reference inputs are floating, and the only restriction on the applied voltage is that it should lie in the range V– to V+.

Fig. 6. External reference

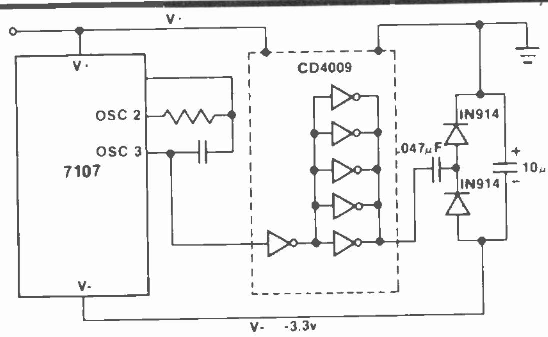


For many applications, the internal reference of 2.8 V between V+ and COMMON is adequate, but power dissipation in the 7107 LED version can wreck this. However, an external reference can be added as shown in Fig.6.

Electrical Specifications @ +25°C unless otherwise specified

Full Scale Voltage Range	±200mv (5.0V min V+ to V–) ±2.0V (6.0V min V+ to V–)
Full Scale Digital Range	±2000 Counts
Common Mode Voltage Range	V+ minus 0.5V to V–, plus 1V
Accuracy 10°C to 50°C with external reference	<1/2 Count
Noise referred to Input	15μV typical
Zero width	0–1 transition at .7 to .9 counts
Turnover	< 1 Count
Input circuit	Differential
Input Bias Current	2pA
Input Impedance	> 10^{12} ohm
Polarity	Automatic with neg sign displayed
Reference (Internal)	Internal 2.8V, referenced to V+ Temperature Coefficient 100ppm/°C typical.
Reference (External)	External reference must be in the range V+ to V–
Recommended External Components 200mV Full Scale C_3= Int Cap 220n C_2= AZ Cap 470n C_1= Ref Cap 100n C_4= Clock Cap 100p R_6= Int Res 47k R_3= Clock Res 100k R_2= Short	2V Full Scale C_3= Int Cap 220n C_2+ AZ Cap 47n C_1= Ref Cap 100n C_4= Clock Cap 100p R_6= Int Res 470k R_3= Clock Res 100k R_2= Short
Clock Frequency	48kHz divided by 4 An internal divide by 4 counter is provided to count external oscillators down to 12kHz, the internal dual slope clock.
Display Outputs (LED ICL7107)	22 Current limited segment drives plus one current limited neg sign drive plus LED common Note: The 2 die in the 1k bit are in parallel
Display Outputs (LCD ICL7106)	22 segment drives plus one neg sign drive plus LCD back plane drive
LED (7107) current @ +5.0V	5.5 to 8.0ma
Power Requirements	LCD: Ima @ 4.5 – 6V LED: 1ma @ 4.5 – 6V, plus LED current
Power supply configuration (7107)	Dual +4.5 to +6V and –3 to –6V @ 1ma Note: for inputs that remain within the CM voltage range only a single supply is required
Digital input Signals (7106)	Test Single 5 to 12V A high on the test input turns on all segments and the minus sign.
Read Rate	3 Readings per second with 12kHz internal clock (48kHz external clock). Accurate from .1 to 15 reading per second.

Fig. 7. Deriving a negative supply



Power Supplies

The 7106 will run from a single 5 to 12 V supply. If INPUT Lo is shorted to COMMON, this will cause V+ to sit 2.8 V positive with respect to INPUT Lo, and V– at 6.2 V negative with respect to INPUT Lo.

The 7107 requires dual supplies, +4.5 to +6 V and –3 to –6 V at 1 mA. A negative supply may be derived from +5 V using the circuit given in Fig 7.

Evaluation kits for the 7016 and 7107 are available from Rapid Recall, 9 Betterton Street, Drury Lane, London WC2H 9BS. The kits are supplied with full data sheets and an application note, further Intersil application notes are also available on request:

The individual devices are becoming widely available, sources known to ETI include, Audio Electronics, Doram, Marshalls and Watford Electronics.

ETI

LIGHT DIMMER

A versatile design that provides a high quality light dimmer and, with the addition of a simple interface, a building block that forms the basis of many other light effect circuits.

THE DIGITAL LIGHT bulb has been with us for a few years now. What's a digital light bulb you ask — well in case you don't recognise the term it's just a clever, well if not clever, at least obscure, way of describing the common domestic light bulb we all know and love. These bulbs may just about be described as digital as, essentially, they are either on or off — we said we were being obscure and we were not joking.

Light Fantastic

Now this two state nature of le bulb ordinaire can be rather dull, however, the application of electronics makes a number of more interesting things possible. We can, for instance, vary a bulb's brightness smoothly from almost nothing to full output, sequence a number of lights according to a prearranged pattern, turn bulbs on and off in time with music and you can probably think of many other things in this vein. The circuit described here, although presented primarily as a light dimmer, can form the basis of many of these other systems.

Bright Idea

While it would be possible to control the brightness of a lamp by placing a variable resistor of a large power rating in series with same, this type of control would have a number of serious disadvantages, not the least of which is the large amount of heat that would be generated. The use of phase control provides a means of accomplishing the desired effect that is both simple and efficient.

A Passing Phase

Phase control means simply that power is supplied to the load, in this case a lamp, for only part of each AC cycle. Usually phase control circuits are referred to the "zero crossing" of the AC supply and power is supplied to the load at some time after this point continuing then until the next zero crossing. In this way the energy supplied (light output) can be controlled.

Many domestic controllers use a circuit similar to that shown in Fig. 1. This consists of a simple phase control network with a diac to "fire" the triac that controls the load. We have chosen to use a different type of circuit (Fig. 2) that we feel gives a better and more reliable control. The triac is retained but the triggering circuitry is quite different, consisting as it does of a PUT (Programmable Unijunction Transistor) in a phase control network with triggering of the triac being accomplished by a pulse transformer.

As this unit is intended to form the basic building block of a number of different systems we have chosen not to mount the potentiometer RV1 directly onto the PCB as would have been the case if this were simply a light dimmer. Instead the pot is connected via flying leads to the PCB as shown in our photos. This leads (please pardon the pun — we cannot resist puns or aliterations) to a more versatile board. The basic dimmer can, for instance, depending on the configuration of these leads, either be at full brilliance upon switch on, dimming as RV1 is rotated or alternatively, be at minimum output at switch on bringing the light to full brilliance as RV1 is rotated.

Light Construction

Construction of the light dimmer should pose no problems if the specified components are carefully mounted onto the PCB according to the overlay shown in Fig. 3.

We specify a ready made pulse transformer although those masochists amongst you might like to make this component yourself by evenly winding thirty turns of 32 SWG wire on a half inch long quarter inch diameter ferrite rod to form the primary. After a layer of insulation a further thirty turns of the same wire forms the secondary.

The coil L1 is formed by winding fifty turns of 22 SWG wire on a ferrite rod that is one inch long by quarter inch diameter.

It can then be fixed on to the PCB using quick-set epoxy, after soldering the leads.

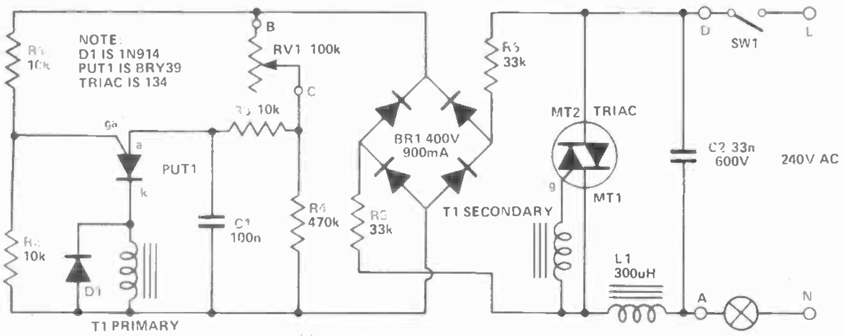
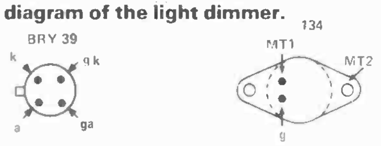


Fig. 2. Full circuit diagram of the light dimmer.



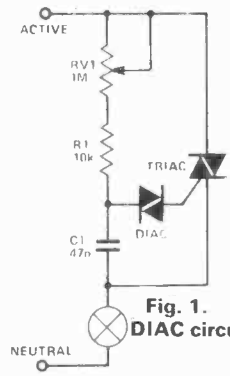


Fig. 1. DIAC circuit

BUYLINES

In order to ensure satisfactory performance of this circuit we recommend that only the components specified in the parts list are used. These components are available from stockists of RS components, which means most people.

HOW IT WORKS

The light dimmer circuit can conveniently be broken down into two sections, the trigger circuitry and the triac itself that supplies power to the load.

We shall first discuss the trigger circuitry that is formed by PUT 1 and its associated circuitry. The BRY39 PUT (Programmable Unijunction transistor) is a four layer semiconductor device that is similar in action to a thyristor. The BRY39 has lead-outs connected to each of the four semiconductor layers that make up the device. Our application only requires three of the terminals, the anode (a), cathode (k), and the anode gate (ga) — the cathode gate (ka) is left unconnected. For a full description of this device you should refer to one of the many text books that deal with semiconductor devices.

For our purposes the BRY39 can be thought of as a switch which can either present a high impedance between its anode and cathode terminals (off) or a low impedence (on). The device is switched from the "off" to the "on" state by taking the anode gate negative with respect to the anode which is, of course, the same as taking the anode positive with respect to the anode gate. (The device can also be controlled by the cathode gate.)

When in the "on" state the device can only be returned to the "off" state by reducing the current through the device to a valve below the holding current (usually a low value). In this respect the BRY39 is similar to a thyristor.

Thus the BRY39 is turned "on" when the voltage at the junction of R3 and C1 reaches a value that is just greater than that at the junction of R1 and R2.

The trigger circuitry is powered by the unsmoothed full-wave rectified output of BR1. The bridge is fed via dropper resistors R5 and R6 of which more later.

The relationship between the voltage applied to the BRY39's anode and cathode is dependent upon the value of RV1. A full analysis of the phase control network of the anode circuit (RV1, C1, R3 and R4) would require an article in its own right. However, it can be thought of more simply by considering C1's action as "slowing up" the rise in the full-wave rectified voltage at the PUT's anode. Thus C1 introduces a phase lag at this point. The component values have been chosen to provide the required range of control.

As the PUT is triggered the energy stored in C1 is applied to the primary of the pulse transformer, this induces a pulse in the secondary of T1 which is responsible for firing the triac. D1 prevents any back EMF which would upset circuit operation.

The load is controlled by the triac which can be thought of as a biconducting version of an SCR. The signal applied to the gate controls the triac's action for current in either direction. The pulse induced in the secondary of the pulse transformer causes the triac to conduct, supplying power to the load until the next zero crossing of the mains waveform causes the current in the triac to fall below its holding value thus turning off the triac.

Note that with the triac on there is no power available to the trigger circuit. The only current required by the trigger circuit is that required to charge C1 and a very small amount consumed by R1 and R2 across the supply. The total current is thus very small and the dropper resistors R5 and R6 can be low wattage components.

Capacitor C2 and coil L1 are provided to reduce the effects of RF1.

Loaded Question

So far we have described the basic light dimmer but by connection of the interface (trendy word) circuit shown in Fig. 5 the versatility of the unit can be greatly extended. With this interface circuit installed a DC voltage of between 5 and 7 V applied to the LED that forms the mains and as such should be treated with respect at all times.

Just a couple of final points. The first being that the maximum load we recommend for this circuit is 500 W, which should be adequate for most domestic applications. The second point to note is that this circuit is not isolated from one half of the opto-isolator, provides for full control of the load connected to the dimmer.

The unit can now provide remote control of loads by simply running a length of wire between the control pot and the dimmer (this is not recommended with the basic unit as the control leads are not isolated from the mains). The circuit can now provide a sound to light unit by simply connecting it to an amplifier or a sequencer by driving it from, for example, a clocked CMOS counter.

We are working on a few of these ideas and would hope to present some of them in a couple of months time.

ETI

PARTS LIST

RESISTORS	
R1,2,3	10 k
R4	470 k
R5,6	33 k
POTENTIOMETERS	
RV1	100 k lin with switch
CAPACITORS	
C1	100 n Polyester
C2	33 n 600 V DC
SEMICONDUCTORS	
PUT 1	BRY 39
TRIAC	6A 400 V TO66 case
BRI	400 V 900 mA
TRANSFORMER	
T1	1:1 pulse (see text)
COIL	
L1	See text
MISCELLANEOUS	
PCB as pattern.	

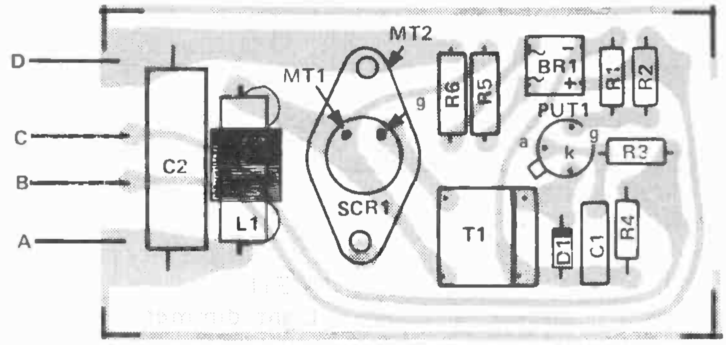


Fig. 3. PCB overlay for light dimmer.

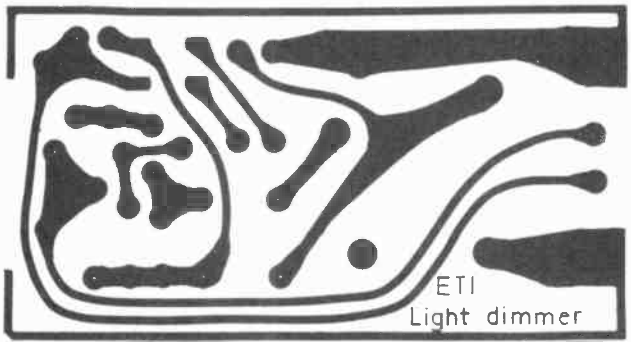


Fig. 4. Foil pattern shown full size.

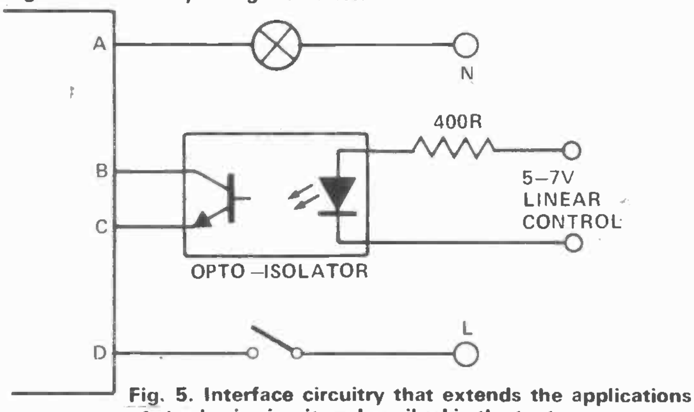
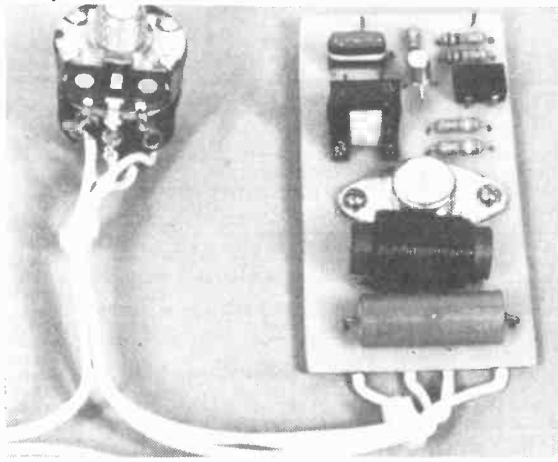


Fig. 5. Interface circuitry that extends the applications of the basic circuit as described in the text.



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SOFTWARE

System 68

ETIBUG 2 is the second software PROM for the System 68 CPU card. The IC fits into socket marked IC9 ready for use. The ETIBUG monitor does an automatic test for the presence of ETIBUG2 (test for an 'E' at location EC00) during its command, and if it is inserted ETIBUG will automatically branch to it, so there is no need to alter any other part of the card.

New Commands

The new commands included in ETIBUG2 are intended to make machine code programming easier. The first command will dump 128 bytes of memory to the VDU. This command is entered by typing 'H' followed by the hex address from which the dump is to begin. The dump always begins at the top of the VDU 'page' and fills half the screen. If the command is not 'H' then control passes to 'X TEST'.

'X'ecuting your programs

The second new command allows a program to be run without the long-winded procedure of modifying the Stack dump area to change the program counter (PC), to the address where you want execution to begin. The command if operated by entering X and then the hexadecimal address of the start of your program. (This command will not operate if the stack pointer is not pointing to A042 when executed).

More Interruptions

One of the most useful features of the 6800 during Machine Code programming is the Software Interupt (3F instruction). When this instruction is found it causes a Stack dump of the registers, a display of this data on the VDU and a branch back to the CONTRL loop. Thus you can code several bytes of program followed by a 3F followed by some more coding and another 3F, etc. When the 3F instruction dumps the registers it dumps the address of the 3F instruction as the PC address, thus a subsequent G command from the keyboard causes control to be passed back to that 3F instruction and thus it is re-executed. To continue by using ETIBUG or MIKBUG it is necessary to update the stored PC by 1 and then use the G command. With ETIBUG2 in your system you need only enter the command letter C to Continue executing after the 3F instruction. Like the Xecute command the Continue command updates the stored PC and then branches into the G command.

424F52494E4720535452494E4753 ....

From the heading of this paragraph you can see how boring and complex it can be to enter a string of ASCII characters into memory using the Memory Examine/Modify command as each character has to be entered by using its ASCII code rather than its keyboard code.

The ETIBUG2 'K' followed by a hex address command allows you to specify a starting address and enter a string of characters from the keyboard into memory until an EOT (Hex 04) character is entered, upon which control jumps back to the Hex. Dump Subroutine.

Shifting Memories

The ETIBUG2 S command allows areas of memory to be copied from one location to another. The 'from' address can be any valid hex address covering RAM, PROM, I/O device addresses, etc; the 'to' address can also be any valid hex address but will usually be RAM. A 'Not RAM' check has not been included as it may be possible to use this command to Shift data from memory to a device port (or vice-versa) and thus use the command as for I/O operations.

The Shift command is started by entering the command letter S, ETIBUG2 will then ask for a START ADDR, a TO ADDR and a LENGTH all of which require a valid four digit hexadecimal input. At the end of the copy control returns to the CONTRL loop. As well as the above commands.

Tape Out

This subroutine outputs a block of data to a cassette unit via the TTYOUT subroutine. The parameters for the output must be stored by the user in address locations A018-A021 before using the subroutine. The routine starts the tape by pulsing the TAPSTRT flip-flop and then waits about 5 seconds before starting the output.

Output first is the Start address, length and six byte label from the parameter area. Data is then output from the Start Addr until the number of bytes specified by the Length parameter have been output. As each data byte is output it is added to the checkdigit byte (which starts at zero), this checkdigit byte is output as the last character of each block. The routine allows a 5 second delay before stopping the tape and returning to the user program which called this subroutine.

The TAPOUT routine can be called from a user program as a sub-routine or can be called by jumping to XED8F.

Tape In

The TAPIN routine does the reverse of the TAPOUT routine. When the routine is executed and the tape started, the first bytes input are read into the parameter area and then the data is read into the area defined by the Start ADDR and Length now defined by the parameter area. As each byte of data is read in a checkdigit is generated in the same way as that generated by the TAPOUT routine. When the Length parameter indicates that all data has been read in the routine reads one more byte which it assumes to be the output checkdigit. Both the output checkdigit (A022) and the generated checkdigit (A023) are stored in the parameter area for user checking.

TAPIN can also be used by previously setting up the Start Addr and Length in the parameter area and executing TAPOUT3 (EDA7). If used in this way note that the length specified should be one less than the length expected and that the last data byte will appear at A022 instead of the location expected. This is because TAPOUT expects the checkdigit to follow the last data byte, if your tape was not generated on a System 68 it may not have a checkdigit following the data (although most tape systems do have one).

Tape In or Out

The cassette I/O routines act on a block of data at each execution, the parameters for the address, length, label, etc for this block have to be set up before output and are also available to the user after input of a block. To save you checking the parameters by dumping the appropriate area of RAM we have included a TAPE CHECK command which is called by entering the command letter T. The data for a tape I/O are stored as follows.

A018,9	Address of start of block of data.
A01A,B	Length of block of data excluding this parameter data.
A01C-21	Six character ASCII label area.
A022	Checkdigit byte for output (Auto-generated).
A023	Checkdigit byte from input (Auto-generated).

For a valid read the checkdigit which was on the tape (A022) should be the same as that generated during the read (A023), the label area is not used by ETIBUG2 but can be used to identify a record by the user.

The T command performs a formatted print of these parameters for use before output or after input.

TTYIN

This subroutine accepts data from a UART whenever the DAV bit indicates that a byte has been received by the UART. After input the DAV flip-flop is reset. Data is input to ACCA and status to ACCB.

TTYOUT

This subroutine outputs data to a UART if the UART is not already BUSY. There are two entry points —

TTYOUT assumes that the index register points to the address of the next byte for output.

TTYOUT2 assumes that the output data is already in ACCA.

Data is output from or via ACCA with the UART status being saved in ACCB.

ETIBUG2 completes the basic PROM software for System 68 for the time-being, next we hope to bring you a Tiny BASIC or ASSEMBLER.

ETIBUG2 can be obtained in an MM5204 PROM from Bywood Electronics for £25.95 plus VAT.

ETIBUG 2 LISTING

This is a complete listing of the ETIBUG2 PROM which has been written to make machine code programming on System 68 easier.

Address	Op-code		Label	Mnemonic	Description
EC00	45				LETTER 'E' FOR ETIBUG
EC01	C1	48	H TEST	CMP B H	IS COMMAND H?
EC03	26	31		BNE X TEST	NO, JUMP TO X-TEST
EC05	BD	EE47		JSR EE47	GET ADDRESS FROM KBD
EC08	CE	8800	H DUMP	LDX 8800	
EC0B	FF	A014		STX A014	SET VDU CURSOR TO TOP
EC0E	5F			CLR B	
EC0F	CE	A00C	NEXT RO	LDX A00C	
EC12	BD	EEC8		JSR EEC8	PRINT ADDRESS
EC15	FE	A00C	NEXT H	LDX A00C	LOAD ADDRESS OF BYTE
EC18	BD	EECA		JSR EECA	PRINT BYTE
EC1B	FF	A00C		STX A00C	STORE ADDRESS OF NEXT BYTE
EC1E	5C			INC B	
EC1F	C5	07		BIT B 07	HAVE 8 BYTES BEEN PRINTED?
EC21	26	F2		BNE NEXT H	NO, LOOP BACK TO NEXT H
EC23	BD	EECC		JSR EECC	YES, PRINT SPACE
EC26	C5	0F		BIT B 0F	HAS A ROW BEEN COMPLETED?
EC28	26	EB		BNE NEXT H	NO, LOOP BACK TO NEXT H
EC2A	86	0D		LDA A 0D	YES, LOAD CR CHARACTER
EC2C	BD	EFD1		JSR EFD1	PRINT CARRIAGE RETURN
EC2F	C5	7F		BIT B 7F	IS DUMP FINISHED?
EC31	26	DC		BNE NEXT RO	NO, DO NEXT ROW
EC33	7E	EEE3		JMP EEE3	YES, JUMP TO CONTROL
EC36	C1	58	X TEST	CMP B 'X	IS COMMAND X?
EC38	26	09		BNE C TEST	NO, JUMP TO C TEST
EC3A	BD	EE47		JSR EE47	GET ADDRESS OF PROGRAM START
EC3D	FF	A048		STX A048	STORE ADDRESS AT A048
EC40	7E	EF0F	RUN	JMP EF0F	JUMP TO 'RUN' IN ETIBUG
EC43	C1	43	C TEST	CMP B 'C	IS COMMAND C?
EC45	26	09		BNE K TEST	NO, JUMP TO K TEST
EC47	FE	A048		LDX A048	TRANSFER PC TO X-REGISTER
EC4A	08			INX	INCREMENT X-REGISTER
EC4B	FF	A048		STX A048	TRANSFER X BACK TO PC
EC4E	20	F0		BRA RUN	JUMP TO RUN ROUTINE
EC50	C1	4B	K TEST	CMP B 'K	IS COMMAND K?
EC52	26	29		BNE S TEST	NO, JUMP TO S TEST
EC54	CE	ED16		LDX MESS 3	LOAD START OF MESS 3
EC57	BD	EE7E		JSR EE7E	PRINT MESSAGE 3
EC5A	BD	EE47		JSR EE47	GET ADDRESS FROM KBD
EC5D	FF	A018		STX A018	STORE ADDRESS
EC60	FE	A018	K LOOP	LDX A018	
EC63	BD	EFAC		JSR EFAC	GET CHARACTER FROM KBD
EC66	A7	00		STA A X	STORE CHARACTER
EC68	A1	00		CMP A X	WAS CHARACTER STORED?
EC6A	27	03		BEQ K LOOP 2	YES, JUMP TO K LOOP 2
EC6C	7E	EEE3		JMP EEE3	NO, JUMP TO CONTROL
EC6F	08		K LOOP 2	INX	INCREMENT ADDRESS COUNTER
EC70	FF	A018		STX A018	STORE NEXT ADDRESS
EC73	81	04		CMP A 04	WAS CHARACTER EOT?
EC75	26	E9		BNE K LOOP	NO, LOOP BACK TO K LOOP
EC77	7E	EC08		JMP H DUMP	JUMP TO HEX DUMP
EC7A	00				NO OPERATION
EC7B	00				NO OPERATION

Address	Op-code	Label	Mnemonic	Description	
ED19	42			B	
ED1A	44			D	
ED1B	20				
ED1C	54			T	
ED1D	4F			O	
ED1E	20				
ED1F	04			END OF TEXT	
ED20	0D	MESS 4		CARRIAGE RETURN	MESSAGE 4
ED21	54			T	
ED22	41			A	
ED23	50			P	
ED24	45			E	
ED25	20				
ED26	43			C	
ED27	48			H	
ED28	45			E	
ED29	43			C	
ED2A	4B			K	
ED2B	3B			;	
ED2C	53			S	
ED2D	54			T	
ED2E	41			A	
ED2F	52			R	
ED30	54			T	
ED31	20				
ED32	41			A	
ED33	44			D	
ED34	44			D	
ED35	52			R	
ED36	20				
ED37	04			END OF TEXT	
ED38	4C	MESS 5		L	MESSAGE 5
ED39	45			E	
ED3A	4E			N	
ED3B	47			G	
ED3C	54			T	
ED3D	48			H	
ED3E	20				
ED3F	04			END OF TEXT	
ED40	4C	MESS 6		L	MESSAGE 6
ED41	41			A	
ED42	42			B	
ED43	45			E	
ED44	4C			L	
ED45	20				
ED46	20				
ED47	04			END OF TEXT	
ED48	43	MESS 7		C	MESSAGE 7
ED49	48			H	
ED4A	4B			K	
ED4B	44			D	
ED4C	49			I	
ED4D	47			G	

```
EC7C  00                                NO OPERATION
EC7D  C1  53    S TEST    CMP B 'S      IS COMMAND S?
EC7F  26  43              BNE T TEST    NO, JUMP TO T TEST
EC81  CE  ED00            LDX MESS 1    LOAD ADDRESS OF MESS 1
EC84  BD  EE7E            JSR EE7E      PRINT MESSAGE 1
EC87  BD  EE47            JSR EE47      GET "FROM" ADDRESS
EC8A  FF  A018            STX A018      STORE ADDRESS
EC8D  CE  ED11            LDX MESS 2    LOAD ADDRESS OF MESS 2
EC90  BD  EE7E            JSR EE7E      PRINT MESSAGE 2
EC93  BD  EE47            JSR EE47      GET "TO" ADDRESS
EC96  FF  A01A            STX A01A      STORE ADDRESS
EC99  CE  ED38            LDX MESS 5    LOAD ADDRESS OF MESS 5
EC9C  BD  EE7E            JSR EE7E      PRINT MESSAGE 5
EC9F  BD  EE47            JSR EE47      GET LENGTH FROM KBD
ECA2  FF  A01C            STX A01C      STORE LENGTH
ECA5  FE  A01C  S LOOP    LDX A01C      LOAD LENGTH
ECA8  27  18              BEQ EXIT 1    IF ZERO, GO TO EXIT 1
ECAA  09                  DEX           DECREMENT LENGTH
ECAB  FF  A01C            STX A01C      STORE LENGTH
ECAE  FE  A018            LDX A018      LOAD FROM ADDRESS
ECB1  A6  00              LDA A X       LOAD CHAR AT FROM ADDRESS
ECB3  08                  INX           INCREMENT FROM ADDRESS
ECB4  FF  A018            STX A018      STORE NEW FROM ADDRESS
ECB7  FE  A01A            LDX A01A      LOAD TO ADDRESS
ECBA  A7  00              STA A X       STORE CHAR AT TO ADDRESS
ECBC  08                  INX           INCREMENT TO ADDRESS
ECBD  FF  A01A            STX A01A      STORE NEW TO ADDRESS
ECC0  20  E3              BRA S LOOP    BRANCH BACK TO S LOOP
ECC2  20  39    EXIT 1    BRA EXIT 2    GO TO EXIT 2
ECC4  C1  54    T TEST    CMP B 'T      IS COMMAND T?
ECC6  26  35              BNE EXIT 2    NO, JUMP TO EXIT 2
ECC8  CE  ED20            LDX MESS 4    YES, LOAD ADDRESS OF MESS 4
ECCB  BD  EE7E            JSR EE7E      PRINT MESSAGE 4
ECCE  CE  A018            LDX A018      LOAD ADDRESS OF START
ECD1  BD  EEC8            JSR EEC8      PRINT ADDRESS OF START
ECD4  CE  ED38            LDX MESS 5    LOAD ADDRESS OF MESS 5
ECD7  BD  EE7E            JSR EE7E      PRINT MESSAGE 5
ECDA  CE  A01A            LDX A01A      LOAD ADDRESS OF LENGTH
ECDD  BD  EEC8            JSR EEC8      PRINT LENGTH
ECE0  CE  ED48            LDX MESS 7    LOAD ADDRESS OF MESS 7
ECE3  BD  EE7E            JSR EE7E      PRINT MESSAGE 7
ECE6  CE  A022            LDX A022      LOAD CHECK SUMS
ECE9  BD  EEC8            JSR EEC8      PRINT CHECK SUMS
ECEC  86  04              LDA A 04      LOAD A WITH EOT CHARACTER
ECEE  B7  A022            STA A A022    STORE EOT AFTER LABEL
ECF1  CE  ED40            LDX MESS 6    LOAD ADDRESS OF MESS 6
ECF4  BD  EE7E            JSR EE7E      PRINT MESSAGE 6
ECF7  CE  A01C            LDX A01C      LOAD ADDRESS OF LABEL
ECFA  BD  EE7E            JSR EE7E      PRINT LABEL
ECFD  7E  EEE3  EXIT 2    JMP EEE3      GO TO CONTROL

ED00  48        MESS 1                  H                MESSAGE 1
ED01  49                                I
ED02  46                                F
ED03  54                                T
ED04  20
ED05  4D                                M
ED06  45                                E
ED07  4D                                M
ED08  52                                R
ED09  59                                Y
ED0A  3A                                :
ED0B  46                                F
ED0C  52                                R
ED0D  4F                                O
ED0E  4D                                M
ED0F  20
ED10  04                                END OF TEXT
ED11  20        MESS 2                                   MESSAGE 2
ED12  54                                T
ED13  4F                                O
ED14  20
ED15  04                                END OF TEXT
ED16  4B        MESS 3                  K                MESSAGE 3
ED17  45                                E
ED18  59                                Y
```

```
ED4E  20
ED4F  04                                            END OF TEXT
ED50  B7  7205  TAP IN      STA A 7205              PULSE TAP STRT FLIP-FLOP
ED53  7F  A023              CLR A023                CLEAR CHK CHAR 2
ED56  CE  A018              LDX A018                LOAD PARAMETER ADDRESS
ED59  BD  EDD5  TAP IN 2    JSR TTY IN              GET TTY CHARACTER
ED5C  A7  00                STA A X                 STORE AT X
ED5E  08                    INX                     INCREMENT X
ED5F  8C  A022              CPX A022                ARE ALL PARAMETERS STORED?
ED62  26  F5                BNE TAP IN 2            NO, LOOP BACK FOR NEXT ONE
ED64  FE  A018  TAP IN 3    LDX A018                YES, LOAD START ADDRESS
ED67  FF  A024              STX A024                STORE AT START 2
ED6A  FE  A01A              LDX A01A                LOAD LENGTH
ED6D  FF  A026              STX A026                STORE AT LENGTH 2
ED70  FE  A024  TAP IN 4    LDX A024                LOAD START 2
ED73  BD  EDD5              JSR TTY IN              GET CHARACTER FROM TTY
ED76  A7  00                STA A X                 STORE IT AT X
ED78  BB  A023              ADD A A023              ADD CHARACTER TO CHK CHAR 2
ED7B  B7  A023              STA A A023              STORE CHK CHAR 2
ED7E  08                    INX                     INCREMENT ADDRESS
ED7F  FF  A024              STX A024                STORE NEW ADDRESS
ED82  FE  A026              LDX A026                LOAD LENGTH
ED85  09                    DEX                     DECREMENT
ED86  FF  A026              STX A026                STORE NEW LENGTH
ED89  26                    BNE TAP IN 4            IF NOT ZERO LOOP BACK
ED8B  B7  7206              STA A 7206              PULSE TAPE TAP STOP FLIP-FLOP
ED8E  39                    RTS                     RETURN FROM SUBROUTINE
ED8F  B7  7205  TAP OUT     STA A 7205              PULSE TAP STRT FLIP-FLOP
ED92  7F  A022              CLR A022                CLEAR CHK CHAR
ED95  CE  FFFF              LDX FFFF
ED98  BD  EDF0              JSR DELAY               JUMP TO DELAY ROUTINE
ED98  CE  A018              LDX A018                LOAD ADDRESS OF PARAMETERS
ED9E  BD  EDE3  TAP OUT 2   JSR TTY OUT             JUMP TO TTY OUT ROUTINE
EDA1  08                    INX                     INCREMENT X
EDA2  8C  A022              CPX A022                HAVE ALL PARAM'S BEEN PRINTED?
EDA5  26  F7                BNE TAP OUT 2           NO, GO TO TAP OUT 2
EDA7  FE  A01A  TAP OUT 3   LDX A01A                LOAD LENGTH
EDAA  00                                            NO OPERATION
EDAB  00                                            NO OPERATION
EDAC  00                                            NO OPERATION
EDAD  27  16                BEW TAP OUT 4           IF LENGTH = 0 GO TO TAP OUT 4
EDAF  09                    DEX                     DECREMENT LENGTH
EDB0  FF  A01A              STX A01A                STORE LENGTH
EDB3  FE  A018              LDX A018                LOAD ADDRESS OF START
EDB6  BD  EDE3              JSR TTY OUT             OUTPUT CHARACTER AT START
EDB9  BB  A022              ADD A A022              ADD CHARACTER TO CHK CHAR
EDBC  B7  A022              STA A A022              STORE NEW CHK CHAR
EDBF  08                    INX                     INCREMENT START ADDRESS
EDC0  FF  A018              STX A018                STORE NEW START ADDRESS
EDC3  20  E2                BRA TAP OUT 3           JUMP TO TAP OUT 3
EDC5  CE  A022  TAP OUT 4   LDX A022                LOAD CHK CHAR
EDC8  BD  EDE3              JSR TTY OUT             OUT PUT CHK CHAR
EDCB  CE  FFFF              LDX FFFF
EDCE  BD  EDF0              JSR DELAY               JUMP TO DELAY
EDD1  B7  7206              STA A 7206              PULSE TAP STOP FLIP-FLOP
EDD4  39                    RTS                     RETURN FROM SUBROUTINE
EDD5  F6  7201  TTY IN      LDA B 7201              GET STATUS TO B FROM UART
EDD8  C5  10                BIT B 10                TEST DATA AVAILABLE BIT
EDDA  27  F9                BEQ TTY IN              IF NOT READY GO TO TTY IN
EDDC  B6  7200              LDA A7200               GET DATA TO A
EDDF  B7  7204              STA A 7204              RESET DAV
EDE2  39                    RTS                     RETURN FROM SUBROUTINE
EDE3  A6  00    TTY OUT     LDA A X                 LOAD A FROM ADDRESS X
EDE5  F6  7201  TTY OUT 2   LDA B 7201              GET STATUS TO B
EDE8  C5  08                BIT B 08                TEST FOR TBMT BIT SET
EDEA  27  F9                BEQ TTY OUT 2           IF BUSY GO TO TTY OUT
EDEC  B7  7202              STA A 7202              PUT A TO VART
EDEF  39                    RTS                     RETURN FROM SUBROUTINE
EDF0  8C  0000  DELAY       CPX 0000                DOES X = 0?
EDF3  26  01                BNE DELAY 2             NO, GO TO DELAY 2
EDF5  39                    RTS                     RETURN FROM SUBROUTINE
EDF6  09        DELAY 2     DEX                     DECREMENT X
EDF7  7D  0000              TST 0000                WASTE A FEW CYCLES
EDFA  7D  0000              TST 0000                AGAIN
EDFD  00                                            NO OPERATION
EDFE  20  F0                BRA DELAY               GO TO DELAY
```

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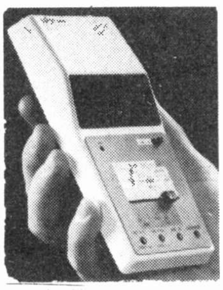

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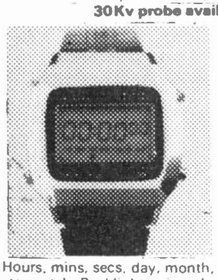

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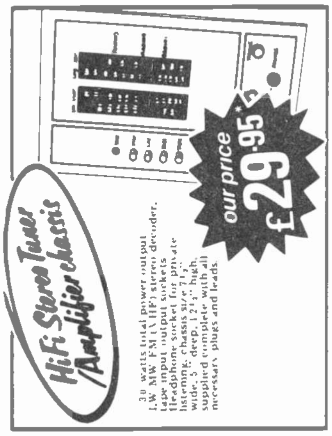

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audiophile......

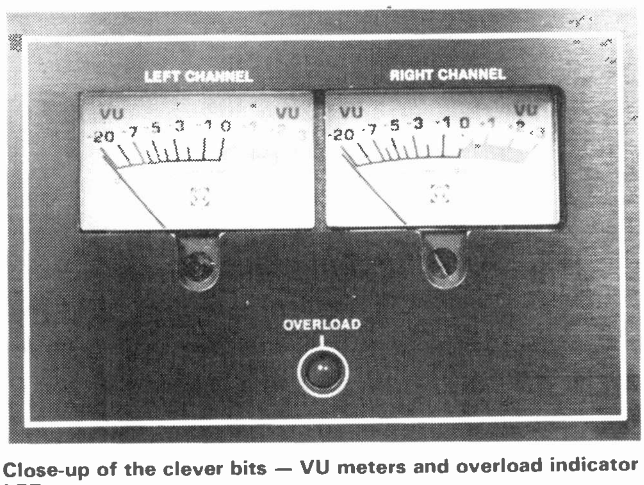
This month Ron Harris lends both ears to the new Koss E-10 electrostatic headphones. Placed at the top of Koss's range, and costing £180 a pair they promise much. Do they deliver? Read on ....

HEADPHONE LISTENING has much to commend it — isolation from the wallpapered box which produces so much colouration in any loudspeaker system for one thing. Neighbours the world over would be a happier race if we all took to hanging our transducers around our heads instead of knocking down their living-room walls with them.

In terms of absolute quality too, electrostatic (and the better moving coil) units have few if any equals amongst loudspeakers, and their cost will always be lower. So for someone starting down the slippery slope to hi-fi bliss, and who either lives in a flat or yearns for greater accuracy than his budget allows, headphones must provide a serious alternative to those ubiquitous wooden boxes.

Energise . . .

This brings us neatly onto the energiser itself. Superbly finished in black metal with a wood grain panel, the box gives new life to the theory of collapsed matter. For its size it is impossible **heavy,** due of course to the two huge transformers present within. The meter and overload circuitry is contained on a single large PCB, with all connections being made via removable plugs. Although untidy to look at, the internal construction is to a very high standard, and we can envisage no problems being caused here.



Close-up of the clever bits — VU meters and overload indicator LED

Two VU meters are provided to monitor signal level, and these operate in conjunction with the overload LED positioned beneath them. Sockets exist for two sets of phones, and the single on/off switch switches the audio back to the speakers once the headphones are switched off. Back panel connections are by spring terminal, and Koss provide four suitable leads to accomplish this.

In practise the overload facility worked well, cutting off the audio (and lighting the LED) for about ten seconds once the trigger level is exceeded. This level is represented by full scale deflection on the meters, which appear to leap into the red all too readily! We found the cut-off point to be too low for our liking sometimes, but accept that it is a perfectly good compromise.

On heavy rock signals, with any bass boost all (not needed really — see later!) the overload operated at a level which would not always satisfy the devilish tastes for loudness exhibited in this field. In fairness though this is a minor point, and personally I tend to agree with Koss's choice, as sustained listening at even near maximum allowed level amounts to audio suicide of the eardrums.

Down to sound

Now to the sixty-four thousand watt question — how do they sound? In a word they don't! Without qualification the E10s provided the most neutral and uncoloured sound yet to assail our ears. It was very very easy to forget the phones totally, and listen through to the earlier links of the chain and thus to the music itself, assuming high quality source equipment of course.

Expect no mercy — the E10s will ruthlessly expose shortcomings in anything of lesser stature, be it electronics or records, but their even response means that surface noise is not emphasised unduly as is the case with a rising treble characteristic, and no tonal correction was found necessary at any stage in the listening tests.

Here is a transducer to make you question your ideas of fidelity. All speakers possess a character of their own, and probably the E10s do as well. But this is so inobtrusive as to be negligible — and we've waited a long time to be able to say that about any piece of hi-fi!

Pecurniary conclusions

The only possible drawback to the E10 Auditors is their price — £180 all in for phones, energiser, PSU and leads. Quality never comes cheap of course, but we did wonder how much the meters and associated circuitry added to the price.

Still, as we said earlier £180 wouldn't buy a pair of loudspeakers in this class, and so maybe we shouldn't quibble — but seeing as how we're at it — how about some more headroom on the overload?

Overall then, the E10s are probably the nearest thing to transparent transducers on the market, but cost is high and heavy rock fanatics who have a thing for un-natural boom in the bass may not be impressed by their lack of colouration in that area. Definitely a connoisseur's item and one that all hi-fi followers should hear at least once!

HOW IT WORKS

Like other electrostatic headphones, the E10 employ the electrostatic push-pull principle. Referring to fig. 1a, the audio is applied across the plates superimposed upon the polarising voltage Vp. Since one plate is fixed and one can move freely, the latter will be vibrated by electrostatic forces much the same as those that hold dust to LPs and LPs to turntable mats. Vp is there to provide an initial displacement about which the audio signal can induce movement. Resistor R loads the polarising signal, and C decouples the audio input.

The push-pull design overcomes some of the drawbacks of the basic principle and lowers distortion, especially even harmonics. Fig. 1b shows the basis of the design. A second fixed plate is added, so that the moveable plate sits in a sandwich. The audio signal is fed in through an isolating transformer, the secondary of which is centre-tapped to provide anti-phase signals for the two plates.

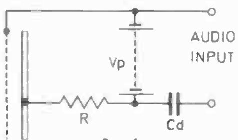


Fig 1a

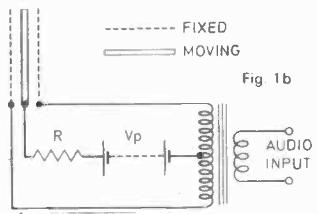
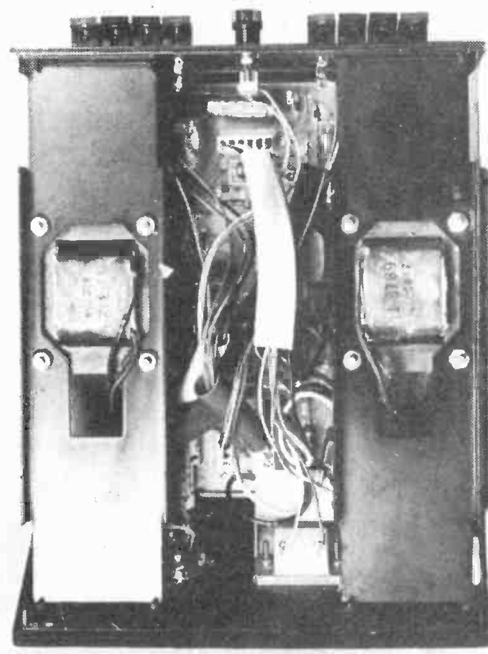


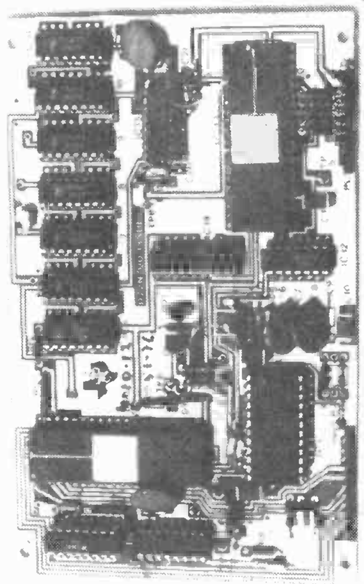
Fig 1b

This is the task of the energiser, and those transformers can be a limiting factor in the performance. Koss have made their inductors massive, such that a 20 Hz signal can pass unhindered. (In theory).

In the E10 energiser the overloaded sensing is set to operate at around 5 V (pink noise) signal at the input. This represents around 103 dB SPL at the ears, which explains the Koss setting mentioned in the text. The energiser presents a load to the amplifier which varies in phase angle, linearly, from a $+30^o$ at 20 Hz to -30^o at 15 kHz and an impedance characteric with minimum of 3 R (20 Hz) and maximum of 180 R at 800 Hz



Internal view of the energiser box, note the massive audio transformers.



DIGITAL ELECTRONICS

RIPPLE COUNTERS are useful and simple, but they are not ideal for high counting speeds, nor for large counter chains. The problem arises from the use of the output of each flip-flop as the clock for the next flip-flop, so that changes must "ripple through" all the stages of the counter. This, as indicated in the previous section, causes difficulties with time delays.

Although these delays are not large, perhaps 60 nS or less per flip-flop, they accumulate to a significant amount over a large number of counter stages and can cause the race hazards mentioned earlier.

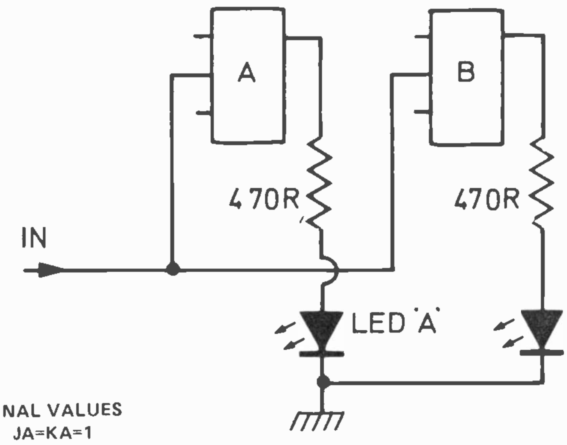
Synchronous Counters

A different principle is used for synchronous counters. The input pulses are used to clock *each* flip-flop of a chain, hence the name synchronous. The count sequence is then determined by voltages applied to the J and K terminals, and these voltages must be obtained in such a way that any given count on the flip-flop will cause the J and K voltages to be set to the voltages needed to change to the next digit up or down.

This is much more easily illustrated by an example which we can test on our board. In this example we shall follow the pattern of design steps (with some modifications) which is usually used for synchronous counters.

Basic Two-Step

Let us imagine a very basic counter using two flip-flops and resetting at the count of four. We must start by making a table showing the count, the present state, and the next state for each flip-flop. This means that for each number of the count we list the value of Q (1 or 0) and also the value to which Q will change at the next count. For example, when the count is 1 (01), the next count is 2 (10) and both outputs will change — A from 1 to 0, and B from 0 to 1. On the next count (3), A changes from 0 to 1, and B does not change. The complete table for two flip-flops is shown in Fig 1(b).



FINAL VALUES
JA=KA=1
JB=KB=QA

	A		B		J K VALUES			
COUNT	Q PRESENT	Q NEXT	Q PRESENT	Q NEXT	JA	KA	JB	KB
0	0	1	0	0	1	X	0	X
1	1	0	0	1	X	1	1	X
2	0	1	1	1	1	X	X	0
3	1	0	1	0	X	1	X	1

Fig. 1 (Above) A simple synchronous counter, no J-K connections shown.
(a) Circuit. Note that the input clock is taken to each stage.
(b) Table of changes, with J and K values for the changes.

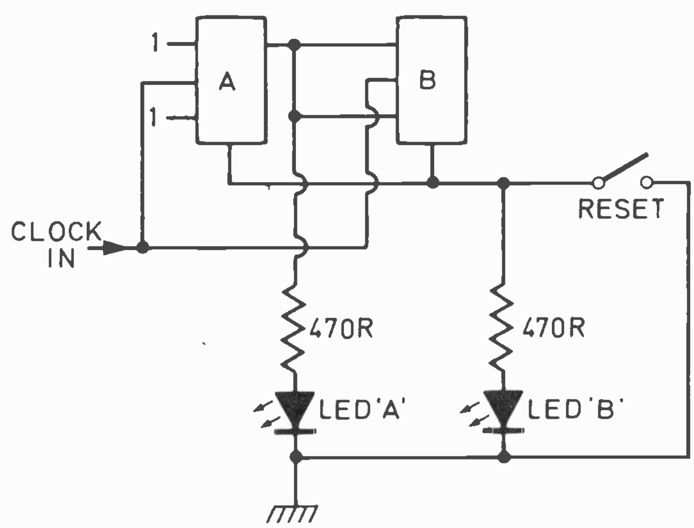
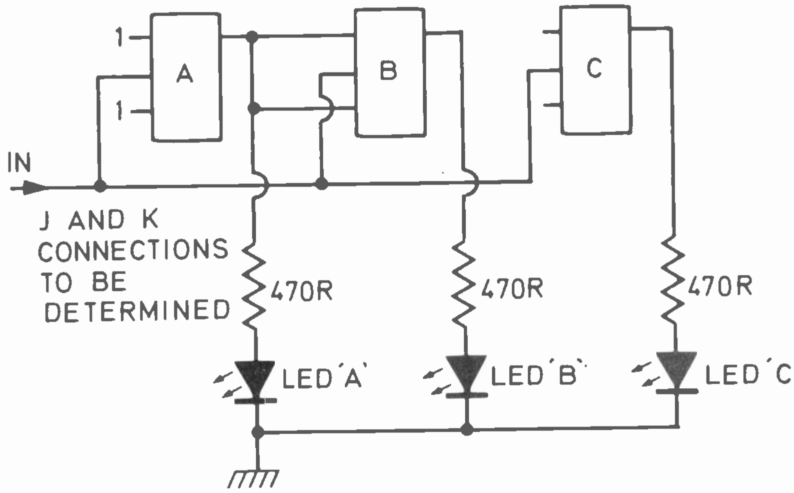


Fig. 2 (Above). Complete two-stage synchronous counter circuit, with J-K connections shown. Try this out on your blob-board.

BY EXPERIMENT PART 6

Now we have to decide what voltages are needed at J and K of each flip-flop to carry out the changes from present state to next state. Here we have some options — for example, if we want to change from 1 to 0, we may have J=K=1, or J=0 and K=1; either state will carry out the change. When this is possible, we can write J=X, K=1, where X means don't care, since either value of J is equally suitable.

Add more columns to the table to indicate these values of J and K for each flip-flop, and we are ready to start designing. The object now is to obtain the J and K voltages for each flip-flop from somewhere else in the circuit in such a way that all the J and K voltages are correct for each stage of the count. The formal method of doing this involves a technique called *Karnaugh mapping,* but is seldom necessary for only a few counter stages. It is rather difficult to apply for a large number of stages, so only the 'intuitive' look-and-see method will be discussed here.



COUNT	PRESENT QA	QB	QC	NEXT QA	QB	QC	JA	KA	JB	KB	FIRST JC	KC	FINAL JC	KC
0	0	0	0	1	0	0	1	1	QA	QA	0	X	0	0
1	1	0	0	0	1	0	1	1	QA	QA	0	X	0	0
2	0	1	0	1	1	0	1	1	QA	QA	0	X	0	0
3	1	1	0	0	0	1	1	1	QA	QA	1	X	1	1
4	0	0	1	1	0	1	1	1	QA	QA	X	0	0	0
5	1	0	1	0	1	1	1	1	QA	QA	X	0	0	0
6	0	1	1	1	1	1	1	1	QA	QA	X	0	0	0
7	1	1	1	0	0	0	1	1	QA	QA	X	1	1	1

JC=QA AND QB
KC=JC

Fig. 3 (Above). A three-stage synchronous counter.
Top: (a) Circuit, J and K connections still to be determined.
Bottom: (b) Table of changes, showing how J and K values are determined.
The "first" Jc-Kc table shows possible values of Jc and Kc, the "final" table shows the most convenient values to use.

Table Talk

At the zero count, Qa=0, Qb=0 and the change at the end of the clock pulse will be from Qa=0 to Qa=1. This will happen if Ja=1 and for Ka=0, or Ka=1. We therefore fill in a 1 in the Ja column, and an X (either value) in the K column.

Still at the zero count, Qb=0 and does not change at the end of the clock pulse. This can be done if Jb=0, Kb=X, so that these values 0 and X appear in the Jb and Kb columns.

These columns are filled in similarly for each change listed — remembering to use X in any case where a value is unimportant — using the J-K table that we used in Part 4 of this series of articles.

We can now inspect the complicated tables to see if any values can be fixed or derived from values of Qa or Qb. The tables for Ja and Ka are easily dealt with — since the values are either 1 or X, we can use 1 for all these values, and make Ja=1, Ka=1, as for the ripple counter. The Jb, Kb tables are slightly more involved, but for each definite value of one quantity (J or K) there is an X for the other, so that we can again connect J and K. We then find that the values of J and K are identical to the values of Qa, so that Jb and Kb can be connected to Qa.

For practical work on synchronous counters it is useful to have a clock pulse line, and one of the spare lines on the board can be used. Connect up the circuit as shown, with a slow clock pulse taken to each clock input, and wire connections linked from Qa to Jb and Kb. Use LEDs as before to check the state of each flip-flop output. Connect a common reset line to each flip-flop and to a switch so that the counter can be reset. Switch on and check that the count is correct and that resetting to zero is possible.

Third Stage Development

Let us now extend this to a third stage, building on what we have done before. Once again we can build up a table of values of Q, J and K for each stage, but we have made life easier for ourselves by having done the two stage counter, so we can ignore the Ja, Ka and Jb, Kb columns and concentrate on the Jc, Kc column.

Using the same principles as before, we fill in the values of J and K which will be needed at each clock pulse or flip-flop, concentrating on the necessary values, and putting an X ▶

where the value is immaterial. When we do this (Fig. 3b) we find two important states. One is at the count of 3, where Jc must change from 0 to 1; the other is at the count of 7 when Kc similarly changes from 0 to 1.

The change of Jc from 0 to 1 occurs when the count changes to 110 so that we could use an AND gate connected to Qa and Qb. The output of this gate will be zero for any count up to 2 and then will be 1 at a count of 3. It will change to zero again to become 1 at the count of 7, but the value of Jc is unimportant beyond the count of 3 anyway.

Looking at Kc we find that the important value of 1 occurs at a count of seven when Jc may also be 1. We can therefore connect Jc and Kc together and feed from an AND gate supplied with Qa *and* Qb.

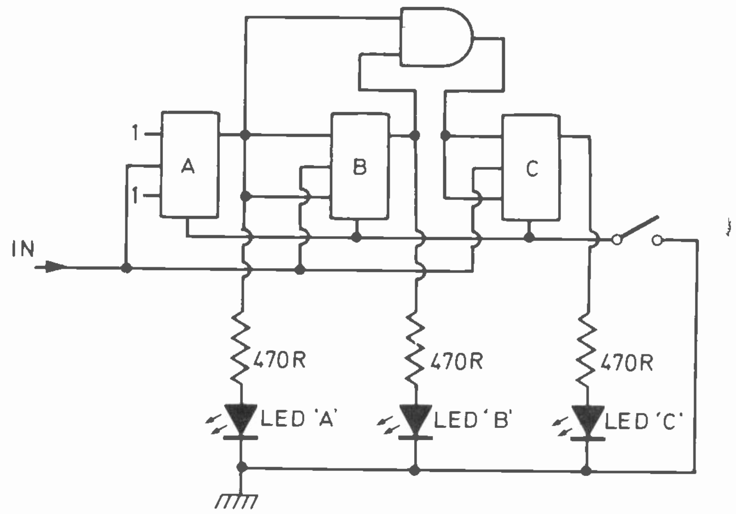


Fig. 4 (Above). The circuit of the three-stage synchronous counter. Try this out on your blob-board.

Third Stage On Board

Making up a three-stage synchronous counter on the circuit board needs some additional connections. Since we are not using AND gates, the gate used will have to be made up from a NAND gate and an inverter. As the 7400 contains four two-input NAND gates and the 7414 contains six inverters, one of which is used for the clock oscillations, there is no shortage of gates. We are working with a low frequency clock, so there should be no ill-effects caused by the number of wires soldered across the board, but a high speed counter would have to be built on a PCB designed for the purpose, using copper tracks on each side and with decoupling capacitors between +ve and —ve lines close to each flip-flop. Such PCBs can be made up quite rapidly by using the new sketch'n'etch technique (P.B. Electronics) for one-off PCBs.

Can you now go one step further to design a four stage synchronous counter and try it out on the board?

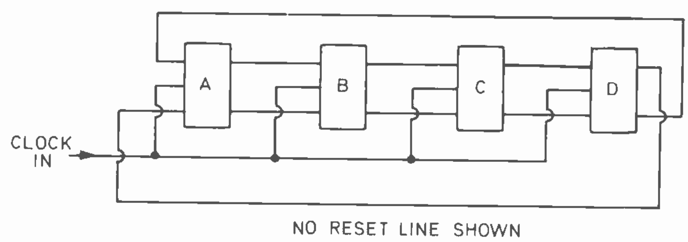
Twisted Logic

A different type of synchronous counter is shown in Fig. 5. This is a Johnson, or 'twisted-ring', counter and consists of four flip-flops connected so that the output of one drives the J and K inputs of the next. Three of the connections are made up with Q to J and $\bar{Q}$ to K, but the feedback connection is made with Q to K and $\bar{Q}$ to J — hence the alternative name of twisted-ring. Remembering that $\bar{Q}$ is always the inverse of Q, can you plan out the values of Q and $\bar{Q}$ for each counter? Use the table headings shown in Fig. 5(b) and remember that Qa=Jb, Qb=Jc, Qc=Jd, Qd=Ka and so on.

A Johnson counter uses a completely different count sequence from conventional binary counters, and the maximum count number is twice the number of flip-flops. The counters are synchronous, very easy to design and also very simple to decode for use with lamp indicators.

Build up the four stage (count of 8) Johnson counter of Fig. 5(c) on your circuit board and check that your calculations are correct. ETI

To be continued



CLOCK	JB QA	KB $\bar{Q}$A	JC QB	KC $\bar{Q}$B	JD QC	KC $\bar{Q}$C	KA QD	JA $\bar{Q}$D
0								
1								
2								
3								
4								
5								
6								
7								

Fig. 5. A Johnson counter of four stages.
Top: (a) The circuit, note the "twisted ring" connection.
Bottom: (b) Table to complete so that the counter action can be predicted.
Below: (c) Truth table. Build the circuit on your blob-board and complete this table.

COUNT	A	B	C	D
0				
1				
2				
3				
4				
5				
6				
7				

microfile.......

Gary Evans looks at a couple of earth bound micro systems and then journeys to a stella system for a game of intergalactic proportions.

THE FIRST ITEM WE look at is from a company thought by some to like the cloak and dagger game, but then so do quite a few semiconductor manufacturers, Science Of Cambridge — don't mention Sinclaur. At the time of going to press they have just launched their MK14 with an advertisement in a magazine that is generally not associated with a dedicated commitment to micros.

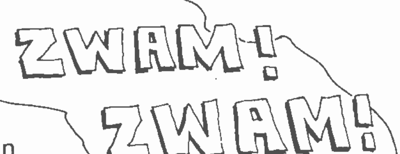
SCAMP and Chips

The MK 14 is described as a keyboard addressable microprocessor. At a price of just under forty four pounds one might not expect all that much but the SCAMP based system provides a hex keyboard, eight digit LED display, 512 bytes PROM with resident monitor, 256 bytes of RAM together with 4MHz crystal plus power supply stabiliser.

I do not have much information of the MK14 and so I can say nothing about the versatility of the monitor, the ease with which the system can be extended, the quality of the documentation and any number of other interesting topics.

The MK14 comes as a thirty-one piece kit and is, apparently, available now. At just less than forty four pounds this kit should, if nothing else, provide the cheapest way of getting hands on experience with a micro which, in my opinion, is the only way to understand these little fellows.

Before leaving the MK14 it is interesting to note that Science Of Cambridge have chosen the National SCAMP as the heart of their system. This device has been overshadowed by the likes of the 8080, 6800 and lately the Z80. Suffering as it does from a limited instruction set, lack or many on board registers, limited addressing modes and inability to handle stacks it is fair to say that the reception afforded to this MPU by the OEM boys was less than enthusiastic. Despite large campaigns to try and rekindle interest in this area it seems that National are resigned to the fact that SCAMP will forever be known as a Simple Cost effective AMateur Processor.



The fact that demand for the SCAMP has not been overwhelming of late means that there should be plenty of stocks of this device and hopefully Science Of Cambridge will have no supply problems with the MK14.

Zee Micros Mit Z80

Another product launched recently is the latest in micro-computers based on the Z80. The system, from the Micros company, costs £550 and includes a Z80 CPU, monitor in ROM, 2K bytes of RAM, audio cassette interface, video monitor interface, UHF TV modulator, 53 key contactless ASC11 keyboard, power supplies and cabinet. Doesn't sound too bad does it.

The company has under development a BASIC compiler, teletext decoder (I would like to see that — it seems such an obvious move) and a selection of games.

My appetite has been wetted by the above description and I shall try to bring you more information plus photos next month.

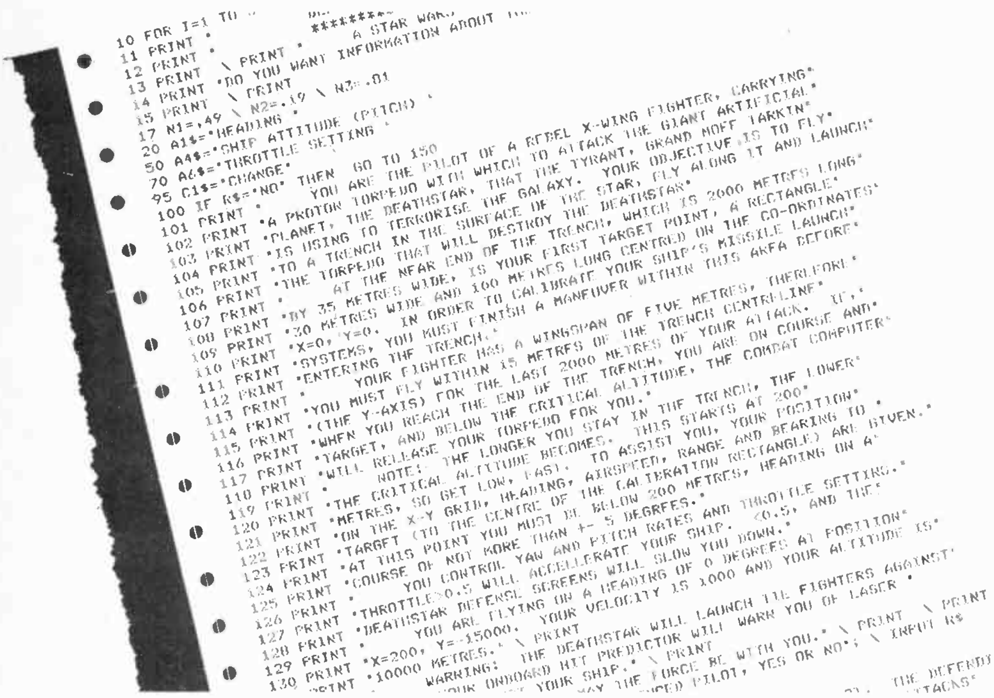
Meanwhile, if you want further details contact Micros at 1 Station Road, Twickenham, Middx.

Star Software

Until now there does not seem to have been much point in publishing programs in anything other than the machine language of anything but the most popular of micros. However, the arrival of a range of systems with a BASIC interpreter resident on our market would seem to indicate that there will soon be a demand for programs written in this high level language.

We have been sent a BASIC program which, although too long to publish in full, I feel might be of some interest to many of you. The program provides the opportunity for you to emulate my current hero, that handsome clean cut Luke Skywalker, from the film Star Wars. In case you have been off planet for the last year or so I'll sum up the story for you.

Good guys beat up bad guys. ▶



```
10 FOR I=1 TO ...
11 PRINT '          ********
12 PRINT '            A STAR WARS
13 PRINT \ PRINT 'DO YOU WANT INFORMATION ABOUT ...
14 PRINT \ PRINT
15 PRINT
17 N1=.49 \ N2=.19 \ N3=.01
20 A1$='HEADING '
50 A4$='SHIP ATTITUDE (PITCH) '
70 A6$='THROTTLE SETTING '
95 C1$='CHANGE'
100 IF R$='NO' THEN GO TO 150
101 PRINT '     YOU ARE THE PILOT OF A REBEL X-WING FIGHTER, CARRYING'
102 PRINT 'A PROTON TORPEDO WITH WHICH TO ATTACK THE GIANT ARTIFICIAL'
103 PRINT 'PLANET, THE DEATHSTAR, THAT THE TYRANT, GRAND MOFF TARKIN'
104 PRINT 'IS USING TO TERRORISE THE GALAXY.  YOUR OBJECTIVE IS TO FLY'
105 PRINT 'TO A TRENCH IN THE SURFACE OF THE STAR, FLY ALONG IT AND LAUNCH'
106 PRINT 'THE TORPEDO THAT WILL DESTROY THE DEATHSTAR'
107 PRINT '     AT THE NEAR END OF THE TRENCH, WHICH IS 2000 METRES LONG'
108 PRINT 'BY 35 METRES WIDE, IS YOUR FIRST TARGET POINT, A RECTANGLE'
109 PRINT '30 METRES WIDE AND 100 METRES LONG CENTRED ON THE CO-ORDINATES'
110 PRINT 'X=0, Y=0.  IN ORDER TO CALIBRATE YOUR SHIP'S MISSILE LAUNCH'
111 PRINT 'SYSTEMS, YOU MUST FINISH A MANEUVER WITHIN THIS AREA BEFORE'
112 PRINT 'ENTERING THE TRENCH.'
113 PRINT '     YOUR FIGHTER HAS A WINGSPAN OF FIVE METRES, THEREFORE'
114 PRINT 'YOU MUST FLY WITHIN 15 METRES OF THE TRENCH CENTRELINE'
115 PRINT '(THE Y-AXIS) FOR THE LAST 2000 METRES OF YOUR ATTACK.  IF,'
116 PRINT 'WHEN YOU REACH THE END OF THE TRENCH, YOU ARE ON COURSE AND'
117 PRINT 'TARGET, AND BELOW THE CRITICAL ALTITUDE, THE COMBAT COMPUTER'
118 PRINT 'WILL RELEASE YOUR TORPEDO FOR YOU.'
119 PRINT '     NOTE:  THE LONGER YOU STAY IN THE TRENCH, THE LOWER'
120 PRINT 'THE CRITICAL ALTITUDE BECOMES.  THIS STARTS AT 200'
121 PRINT 'METRES, SO GET LOW, FAST.  TO ASSIST YOU, YOUR POSITION'
122 PRINT 'ON THE X-Y GRID, HEADING, AIRSPEED, RANGE AND BEARING TO '
123 PRINT 'TARGET (TO THE CENTRE OF THE CALIBRATION RECTANGLE) ARE GIVEN.'
124 PRINT 'AT THIS POINT YOU MUST BE BELOW 200 METRES, HEADING ON A'
125 PRINT 'COURSE OF NOT MORE THAN +- 5 DEGREES.'
126 PRINT '     YOU CONTROL YAW AND PITCH RATES AND THROTTLE SETTINGS.'
127 PRINT 'THROTTLE>0.5 WILL ACCELLERATE YOUR SHIP.  <0.5, AND THE'
128 PRINT 'DEATHSTAR DEFENSE SCREENS WILL SLOW YOU DOWN.'
129 PRINT '     YOU ARE FLYING ON A HEADING OF 0 DEGREES AT POSITION'
130 PRINT 'X=200, Y=-15000.  YOUR VELOCITY IS 1000 AND YOUR ALTITUDE IS'
    PRINT '10000 METRES.' \ PRINT
      WARNING:  THE DEATHSTAR WILL LAUNCH THE FIGHTERS AGAINST
      YOUR ONBOARD HIT PREDICTOR WILL WARN YOU OF LASER
      YOUR SHIP.' \ PRINT
      MAY THE FORCE BE WITH YOU.' \ PRINT \ PRINT
      PILOT, YES OR NO'; \ INPUT R$
      THE DEFENDING
      ATTACKS'
```

Fig. 1. An extract from Robin Hill's Star Wars program (this talented lad was also responsible for the cartoon). The full BASIC program is available from ETI.

The game program simulates the final bust up that involves a pilot (you) taking his (space) ship down a narrow channel at a (critical) high speed the aim being to release a bomb at the end of the channel at the precise moment in time that will cause it to enter a narrow shaft. While trying this manouvre you can expect to be shot at.

We have only room to show a brief extract from the program, if you want the whole lot please send 25p in negotiable currency, stamps, POs, cheques (payable to ETI not me)—no live animals please.

Send your monies to:
ETI
Womp Rat Shoot
25/27 Oxford Street
London
W1R 1RF

ETI

electronics tomorrow......

by John Miller-Kirkpatrick

SIT up its the COPS

Regular readers will be able to cast their minds back to the MM57109 calculator chip mentioned a few months ago. This was a programmable calculator chip which could be interfaced to PROM, RAM, LEDs and Flags as well as to an MPU. Well, the MM57109 was part of the Calculator Oriented Processor System (COPS) from National Semiconductor. Two new COPS based chips have now been announced which use calculator style logic to give complex timing applications a new simplicity.

STAC (Standard Timer And Controller) is a 28 pin IC which uses a calculator style keyboard and LED readout to perform the functions of a digital clock and appliance timer. Typically STAC is connected to a 10 position keypad and a four digit LED display. The chip will run from 50 or 60 Hz and in 7 or 8 day cycles. The keys allow fast and slow setting of time and day and alarm times, manual over-ride, test mode and data entry mode.

Alarming Facilities

STAC is basically a four digit mains driven clock which operates from a low power supply of about 9 volts. The first obvious additional feature of STAC is that it has four alarm times and four alarm outputs, but that's not all. At each alarm time each of the four alarm outputs may be switched on , off or left as it is. One of the problems of a central heating system is that at the end of an ON cycle the main tank is full of hot water which will not get circulated as the pump is turned off with the water heating system. With STAC you could program the boiler to turn off at 10.00 but the pump to continue circulating the heated water until 11.00. In this application the boiler could be connected to STAC output 1 and the pump to STAC output 2, your anti-burglar lights are controlled by STAC output 3 and your morning 'wake-up' alarm by STAC output 4.

So far STAC seems to be quite a nice home timing system except that you may not want the anti-burglar lights on every night, perhaps only on Fridays and Saturdays when you are usually out. Similarly you do not want the alarm to wake you on Saturdays and Sundays. No problem for STAC, it has a day counter (1-7 or 1-8) and the facility to switch as per program each day or to ignore switching and simply perform as a clock. This facility opens up applications which should be familiar to many schools and Open University students. Now you can go away for the weekend and program STAC to record your TV or Radio lessons at 10.30 on Friday night and 6.30 on Sunday morning (especially if one is radio and the other TV). STAC will turn on the radio at 10.25 on Friday, the tape at 10.29, TV 6.25 Sunday and TV recorder at 6.29.

Standard Interval Timer (SIT)

The second COPS based chip is called SIT and like STAC uses the mains frequency, simple power supply, keyboard and display. With SIT the features include 99 hr, 59min, 59.9 secs timing range; count up or down; metronome and relay driver outputs; sequential cycling and 4 event stopwatch mode.

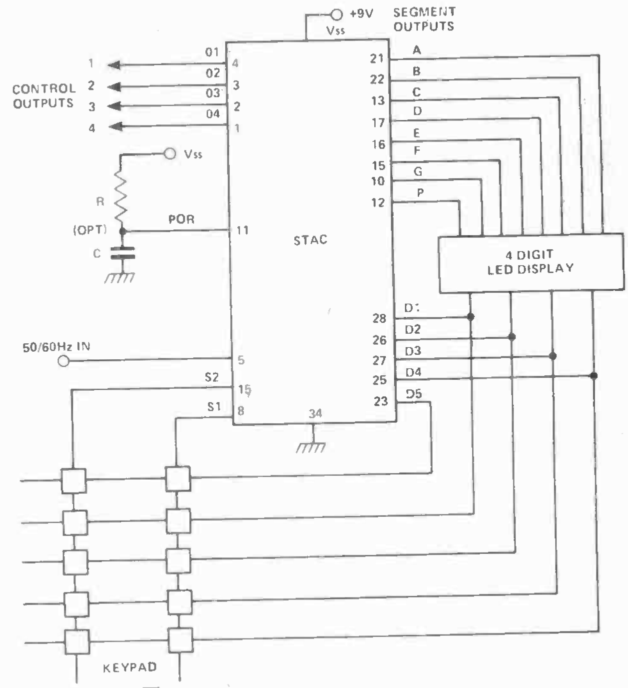


Fig. 1. Typical STAC circuit

The timing period data is entered from a numeric keyboard which is also used to enter commands to indicate up/down counting, stopwatch or timer mode, RUN, CLEAR and HOLD commands.

Keying 'RUN' places the working register on the top of the four entry stack and then rolls the stack to the next entry and the count continues. Thus the last four times at which RUN was enabled ar stored for viewing.

'SEQ' is similar to RUN except when pressed the working register is cleared at each enable time. Thus the stack contains the last four times between SEQ enables.

'HOLD' operates in one of two ways depending on whether RUN or SEQ initiated the operation. In either mode it does whatever is required by RUN or SEQ and then stops the count after rolling the stack and clearing the working register if required. The unit will now wait for the next operation of RUN or SEQ.

Four indicator lines are available to show when the stack is at entry a, b, c, or d, each of these lines can directly control an LED lamp. These outputs are also useful in the timing sequence mode to provide activation signals to external equipment.

For further details of STAC, SIT or other COPS chips contact National Semiconductor at 19 Goldington Rd, Bedford. The chips should cost under £10 each and may be available from National outlets. ETI

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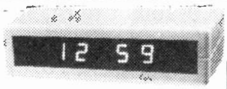

RED DIGIT DESK CLOCK

	CODE	PRICE
6 Red Digit **ALARM CLOCK** w 205mm h 40mm d 140mm	ACK	£28.80
4 Red Digit **DESK CLOCK** w 154mm h 40mm d 85mm	111-222	£15.50
4 Green Digit **DESK CLOCK** w 154mm h 40mm d 85mm	GCK	£12.95
6 Red Digit **CAR CLOCK WITH TIMER** w 205mm h 40mm d 140mm	CCK	£41.90
4 Red Digit **CAR CLOCK** w 154mm h 40mm d 85mm	AUT-CK	£18.85
50Hz **CRYSTAL TIMEBASE KIT**	XTK	£6.45

CMOS

Mainly RCA

		CD4020	1.28	CD4040	1.11	CD4066	0.63	CD4096	1.08
		CD4021	1.04	CD4041	0.86	CD4067	3.85	CD4097	3.85
		CD4022	0.94	CD4042	0.86	CD4068	0.23	CD4098	1.13
CD4000	0.17	CD4023	0.23	CD4043	1.01	CD4069	0.23	CD4099	1.90
CD4001	0.18	CD4024	0.80	CD4044	0.96	CD4070	0.51	CD4502	1.24
CD4002	0.17	CD4025	0.23	CD4045	1.45	CD4D71	0.23	CD4510	1.41
CD4D06	1.20	CD4026	1.78	CD4046	1.37	CD4072	0.23	CD4511	1.72
CD4007	0.18	CD4027	0.58	CD4047	1.04	CD4073	0.23	CD4514	2.84
CD4008	1.00	CD4028	0.92	CD4048	0.58	CD4075	0.23	CD4515	3.24
CD4009	0.58	CD4029	1.18	CD4049	0.58	CD4076	1.34	CD4516	1.40
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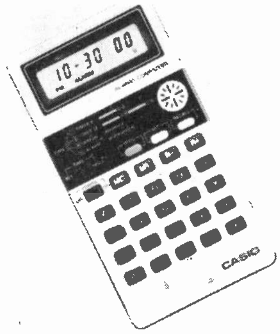

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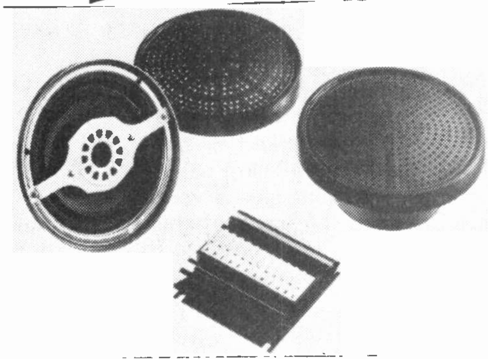

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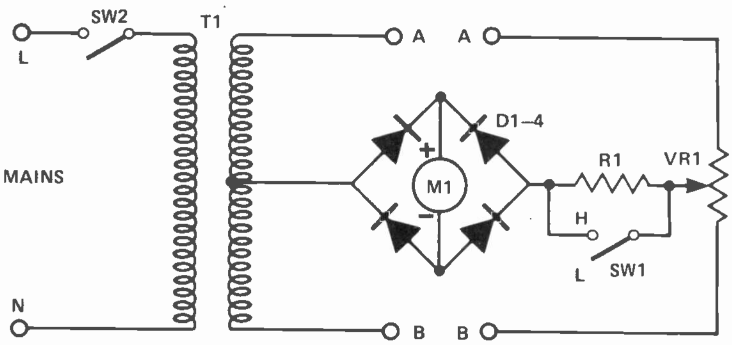
Capacity checker

D. Chivers.

This bridge was originally designed to find values for odd, unmarked or undecipherable capacitors. While not being of great accuracy, it does give a very good indication as to the value of the capacitor.

A known value component is placed across terminals A–A, polarity is not important, but polarised capacitors must not be used, and cannot be tested. The capacitor under test is inserted in B–B, the unit is switched on and VR1 rotated until a maximum value reading is obtained on meter M1. At this point, a reading is taken from the calibration scale on the pot which initially must be calibrated in ratios, ie: 1000:1, 100:1, 10:1, 1:1, 1:10, 1:100 etc. The unknown value is then calculated from this reading. Original calibration is from known values.



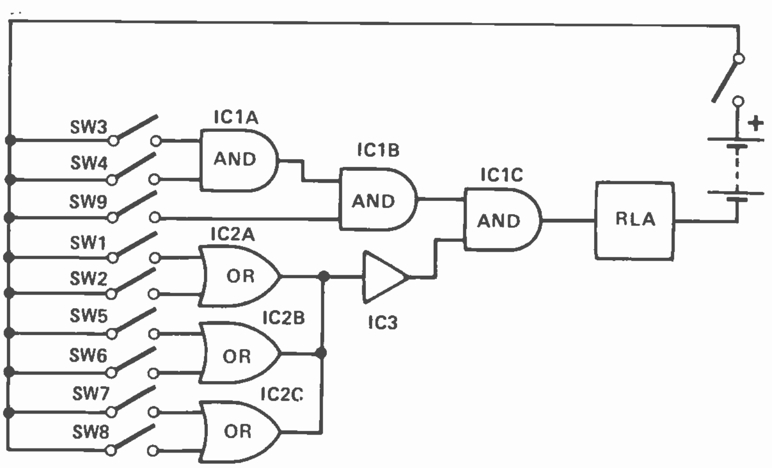
	H	L
10n	X	
100n	X	X
1u		X

M1 = 100uA
D1–4 = 1N4001
R1 = 25k
VR1 = 10k Lin
T1=240V/3V–0–3V

To increase the range of the circuit switch SW1 has been included to bypass R1. Since the frequency used is 50 Hz from the mains, ranges are limited; if another source were used, driving an audio output transformer, the versatility of the unit would then be further increased.

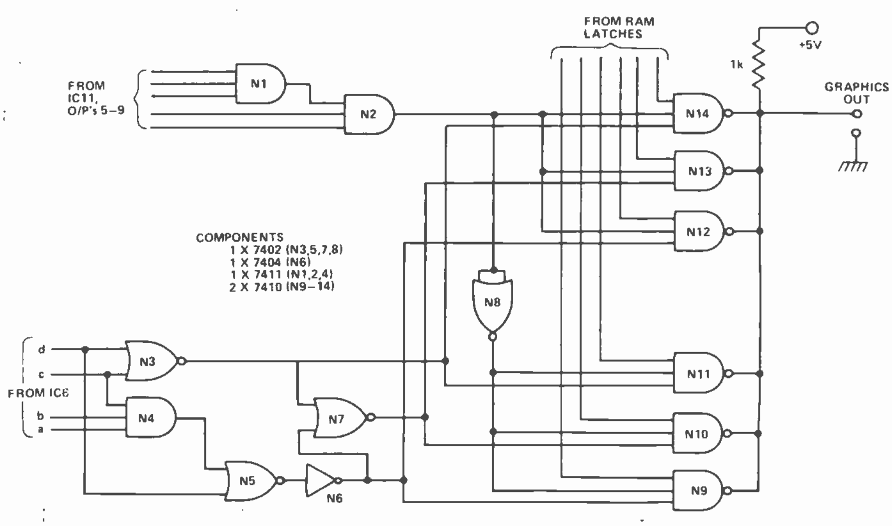
Selective alarm controller

S. Butler.



This circuit provides greater versatility than the simple "in-series" switches mode of alarm, but is still cheap and easy to build.

When SW3 and 4 are closed, the output of the AND gate goes high. This high is fed to the second AND gate only when SW9 is pressed. The output of this gate goes high and providing no other switches are pressed, it will operate the relay: if any other switches are pressed, the OR gives an output to the inverter and cuts off the power to the AND gate, preventing the coil being energised.

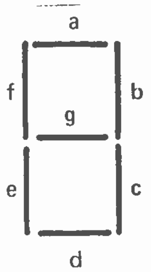


Seven to binary with a special bit!

T. Nash.

This circuit, which uses only four TTL or CMOS ICs, converts a seven segment digit to binary, with indication of the 'special' characters: minus, E (exponent or overflow), and optionally blank. Both types of 6, 7 & 9 can be handled, and for ease of manipulation blank is encoded as binary zero.

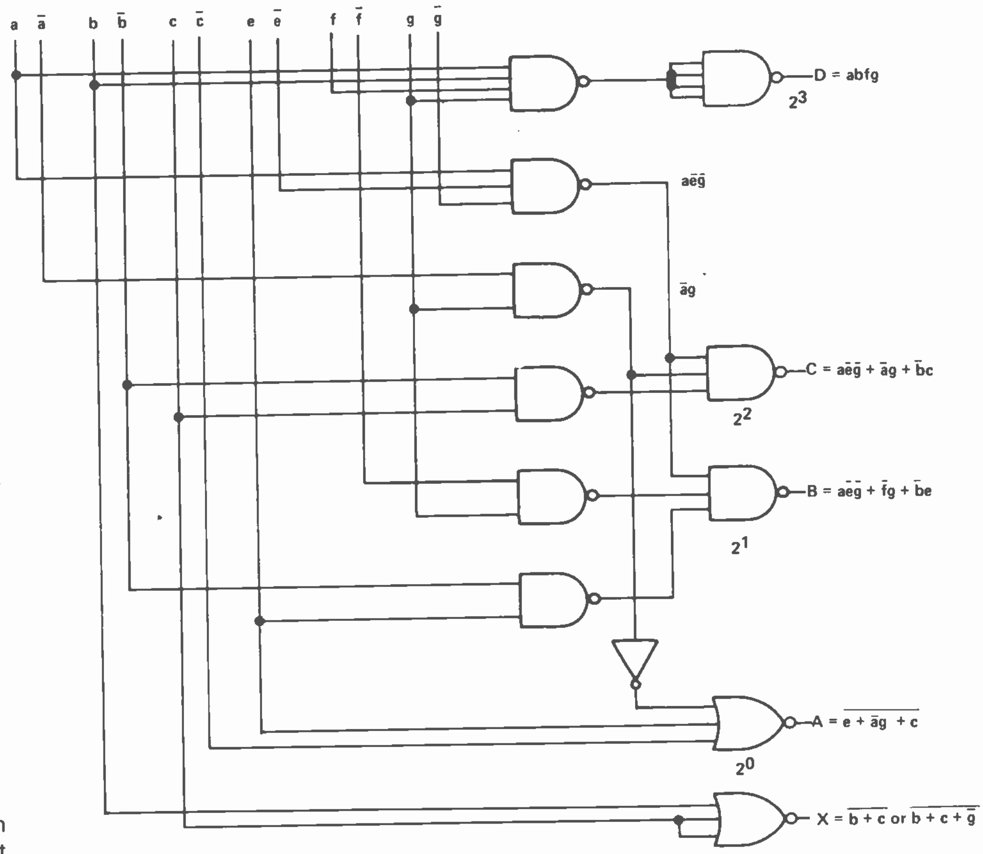
For a calculator — microprocessor interface the 'X' output should be fed to the sign position for ease of testing: this method is more economical in time and memory space than testing for a specific binary value. The extra bits needed for the equivalent ASCII character could also be added at the interface.



The segment identification shown above is the standard seven segment lettering system and so should be familiar to most constructors.

The letters also refer in this case to the circuit diagram and the truth table given below on the right hand side of the page.

No power supply connections are shown for the circuit as this depends on which version, TTL or CMOS is constructed.



COMPONENTS:

1 x 7400/4011
1 x 7410/4023
1 x 7420/4012
1 x 7427/4025/4000 (4000 SHOWN)

FIRST VARIATION SETS X FOR BLANK, SECOND DOES NOT.

* FOR TTL AND 4025 VERSIONS, use 3 input nor.

SEE DIAGRAM

TRUTH TABLE

7–SEG	a	b	c	d	e	f	g	D	C	B	A	X
BLANK	0	0	0	0	0	0	0	0	0	0	0	*
0	1	1	1	1	1	1	0	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0	0	1	0
2	1	1	0	1	1	0	1	0	0	1	0	0
3	1	1	1	1	0	0	1	0	0	1	1	0
4	0	1	1	0	0	1	1	0	1	0	0	0
5	1	0	1	1	0	1	1	0	1	0	1	0
6	0	0	1	1	1	1	1	0	1	1	0	0
6	1	0	1	1	1	1	1	0	1	1	0	0
7	1	1	1	0	0	0	0	0	1	1	1	0
7	1	1	1	0	0	1	0	0	1	1	1	0
8	1	1	1	1	1	1	1	1	0	0	0	0
9	1	1	1	0	0	1	1	1	0	0	1	0
9	1	1	1	1	0	1	1	1	0	0	1	0
–	0	0	0	0	0	0	1	0	1	1	1	1
E	1	0	0	1	1	1	1	0	0	1	1	1

Graphics for the 560 VDU

M. Jackson

This circuit can be added to the 560 VDU published in ETI in September 1976 to allow the display of simple graphics. The rows and columns of each character position are gated by, N1 to N8 to make up the graphic character sections. This information is ANDed with the RAM data to determine whether ot not a particular section is on or off.

The graphics/character selection may be controlled by the spare bit in RAM after it has been latched.

Note: RCLK must be disconnected otherwise blank lines will appear in the graphics display.

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Channel splitter for radio control

G. Bathe.

This circuit is designed to replace the electromechanical reed units used as channel-splitters in radio controlled models.

The circuit is based on the MC 1310P integrated circuit, a chip that is primarily a stereo decoder for use in stereo radio tuners. When used as a stereo decoder, the MC 1310P automatically switches itself from the mono mode to the stereo mode whenever its input contains the 10 kHz subcarrier of a stereo multiplex signal at a sufficiently high level (16 mV), and switches back to the mono mode when the 19 kHz subcarrier ceases to be present. Pin 6 of the integrated circuit drives a stereo indicator lamp to give a visual indication of whether the circuit is operating in the stereo or mono mode.

It is this lamp driver facility of the MC 1310P that makes it an ideal chip to use as a channel-splitter. When used as a channel-splitter the circuit is not tuned to the 19 kHz of the stereo decoder but to the audio frequency that the circuit is required to detect, and the lamp driver output from pin 6 is used to drive a power transistor controlling a motor or other device.

The output from the detector of a radio receiver is amplified by the BC 108 and then fed into a series of MC 1030P channel-splitters (connected in parallel) each tuned to a different audio frequency.

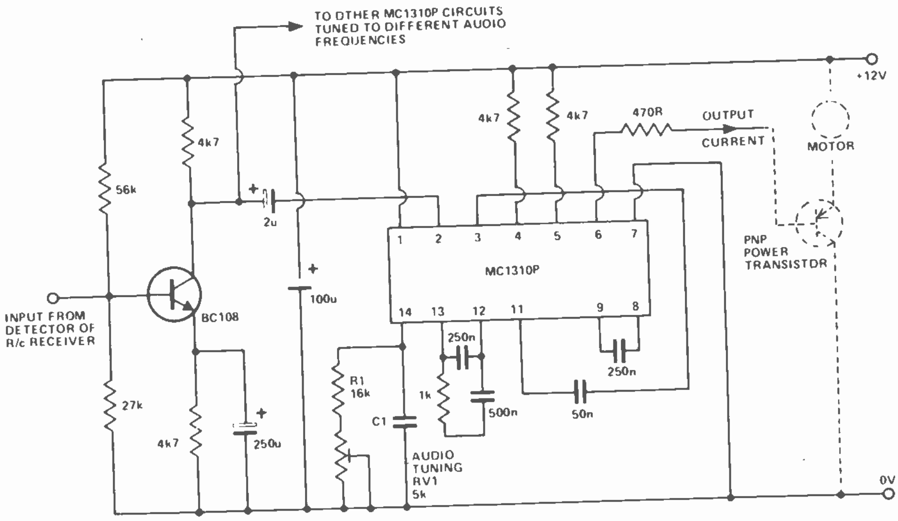
The audio frequency to which the channel-splitter responds is determined by the tuning circuit R1, VR1 and C1, and is given by the formula:-

$$f = \frac{1}{2\pi \ C1\ (R1 + RV1)} \text{ Hz}$$

The value of C1 is chosen to give the required tuning range for the preset RV1. For example, if C1 is 10,000 pF, then the tuning range is approximately 750 Hz to 1,000 Hz.

The output is a switched current output between Pin 6 of the chip and the positive supply rail. This current should not exceed 35 mA and so a 470 ohm resistor is inserted in the output connection from Pin 6 as short circuit protection. If a voltage output is required then a resistor can be connected from Pin 6 to the positive supply and the voltage output taken from Pin 6.

The MC 1310P is triggered when the input to Pin 2 contains its tuned frequency at a level greater than 16 mV. It can be triggered by noise if the noise level is greater than 16 mV. Some radio control transmitters tend to transmit noise when they are not transmitting a tone, and if this is the case the transmitter should be modified to prevent noise being transmitted. This could be done by making the transmitter transmit an extra unused tone whenever it is not transmitting one of the used audio tones.



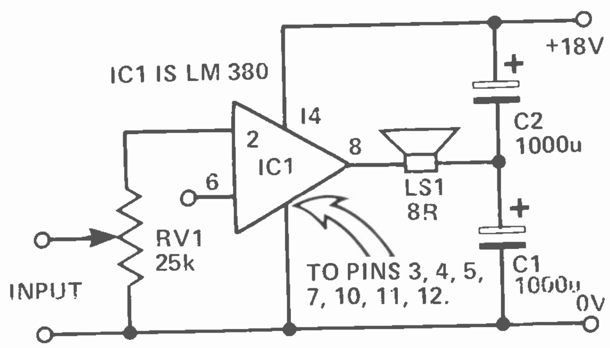
Novel loudspeaker coupling circuit

P. Mills.

In most amplifier designs the speaker is fed by a high value capacitor to provide DC blocking, but this may result in a heavy switch-on surge, as the capacitor charges up.

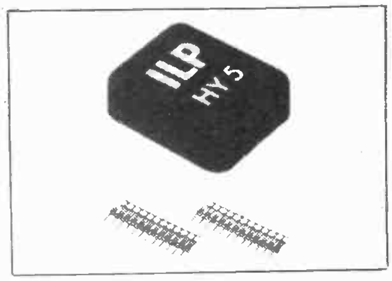
An alternative approach, which is worthy of experiment, is shown in the diagram below. Here the ground side of the speaker is connected to the junction of two equal high value capacitors (1000 uF is typical), across the supply.

The amplifier output voltage will be at $V_s/2$, and so will the voltage across C_1 (if C_1 and C_2 are equal); so as the supply voltage builds up, the DC voltage across the speaker will remain zero, eliminating the switch-on surge. C_1 and C_2 will also provide supply smoothing. The circuit is shown with the LM380, but could be applied to any amplifier circuit, providing that the DC voltage at the output is half the supply voltage.



15—240 Watts!

HY5
Preamplifier



The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc.) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropriate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.

FEATURES: Complete pre-amplifier in single pack — Multi-function equalization — Low noise — Low distortion — High overload — two simply combined for stereo.
APPLICATIONS: Hi-Fi — Mixers — Disco — Guitar and Organ — Public address
SPECIFICATIONS:
INPUTS Magnetic Pick-up 3mV. Ceramic Pick-up 30mV. Tuner 100mV. Microphone 10mV. Auxiliary 3-100mV; input impedance 47kΩ at 1kHz
OUTPUTS Tape 100mV. Main output 500mV R.M.S.
ACTIVE TONE CONTROLS Treble ± 12dB at 10kHz; Bass ± at 100Hz
DISTORTION 0.1% at 1kHz; Signal/Noise Ratio 68dB
OVERLOAD 38dB on Magnetic Pick-up; SUPPLY VOLTAGE ± 16-50V
Price £5.22 + 65p VAT P&P free
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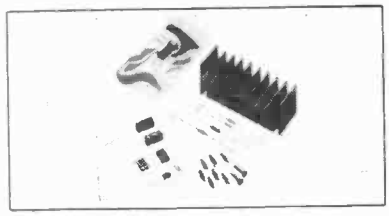
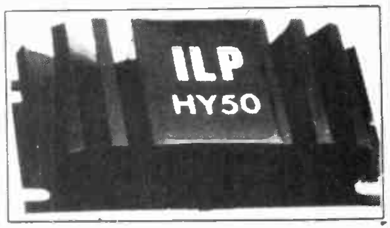
HY30
15 Watts into 8Ω



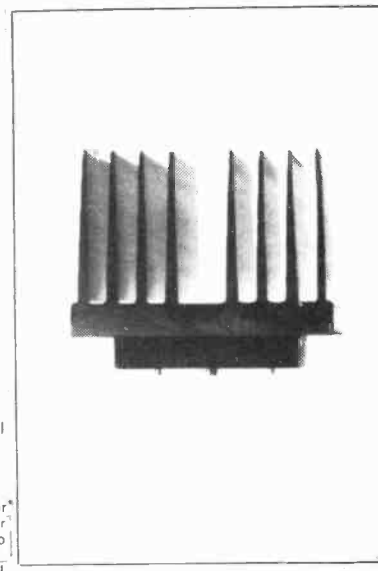
The HY30 is an exciting New kit from I.L.P. It features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.
FEATURES: Complete kit — Low Distortion — Short, Open and Thermal Protection — Easy to Build.
APPLICATIONS: Updating audio equipment — Guitar practice amplifier — Test amplifier — Audio oscillator.
SPECIFICATIONS:
OUTPUT POWER 15W R.M.S. into 8Ω. DISTORTION 0.1% at 15W
INPUT SENSITIVITY 500mV. FREQUENCY RESPONSE 10Hz-16kHz — 3dB
SUPPLY VOLTAGE ±18V
Price £5.22 + 65p VAT P&P free.

HY50
25 Watts into 8Ω



The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.
FEATURES: Low Distortion — Integral Heatsink — Only five connections — 7 Amp output transistors — No external components.
APPLICATIONS: Medium Power Hi-Fi systems — Low power disco — Guitar amplifier.
SPECIFICATIONS: INPUT SENSITIVITY 500mV
OUTPUT POWER 25W RMS in 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.04% at 25W at 1kHz
SIGNAL/NOISE RATIO 75dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB.
SUPPLY VOLTAGE ± 25V. SIZE 105.50.25mm
Price £6.82 + 85p VAT P&P free

HY120
60 Watts into 8Ω

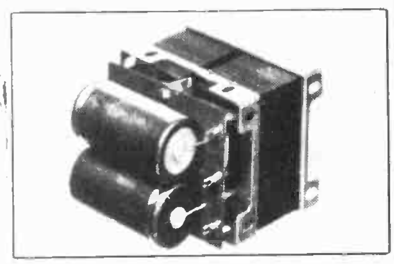


The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection, this amplifier sets a new standard in modular design.
FEATURES: Very low distortion — Integral Heatsink — Load line protection — Thermal protection — Five connections — No external components.
APPLICATIONS: Hi-Fi — High quality disco — Public address — Monitor amplifier — Guitar and organ.
SPECIFICATIONS:
INPUT SENSITIVITY 500mV
OUTPUT POWER 60W RMS into 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.04% at 60W at 1 kHz
SIGNAL/NOISE RATIO 90dB. FREQUENCY RESPONSE 10Hz-45kHz —3dB. SUPPLY VOLTAGE ±35V.
Size: 114 x 50 x 85mm.
Price £15.84 + £1.27 VAT P&P free.

HY200
120 Watts into 8Ω

The HY200, now improved to give an output of 120 Watts, has been designed to stand the most rugged conditions, such as disco or group while still retaining true Hi-Fi performance.
FEATURES: Thermal shutdown — Very low distortion — Load line protection — Integral Heatsink — No external components.
APPLICATIONS: Hi-Fi — Disco — Monitor — Power Slave — Industrial — Public address
SPECIFICATIONS:
INPUT SENSITIVITY 500mV
OUTPUT POWER 120W RMS into 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.05% at 100W at 1kHz
SIGNAL/NOISE RATIO 96dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB. SUPPLY VOLTAGE ±45V
SIZE 114 x 100 x 85mm
Price £23.32 + £1.87 VAT P&P free.

HY400
240 Watts into 4Ω



The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.
FEATURES: Thermal shutdown — Very low distortion — Load line protection — No external components.
APPLICATIONS: Public address — Disco — Power slave — Industrial.
SPECIFICATIONS:
OUTPUT POWER 240W RMS into 4Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.1% at 240W at 1 kHz
SIGNAL/NOISE RATIO 94dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB. SUPPLY VOLTAGE ±45V
INPUT SENSITIVITY 500mV. SIZE 114 x 100 x 85mm
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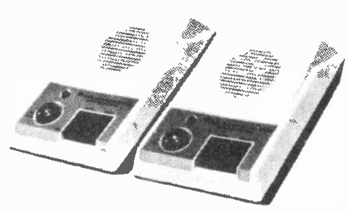

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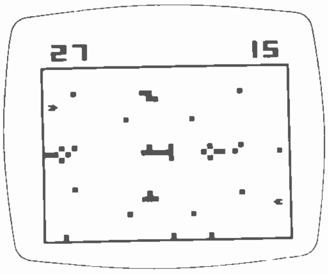

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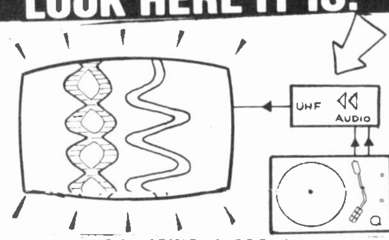

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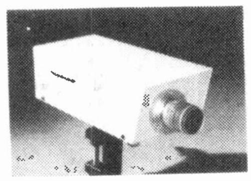

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