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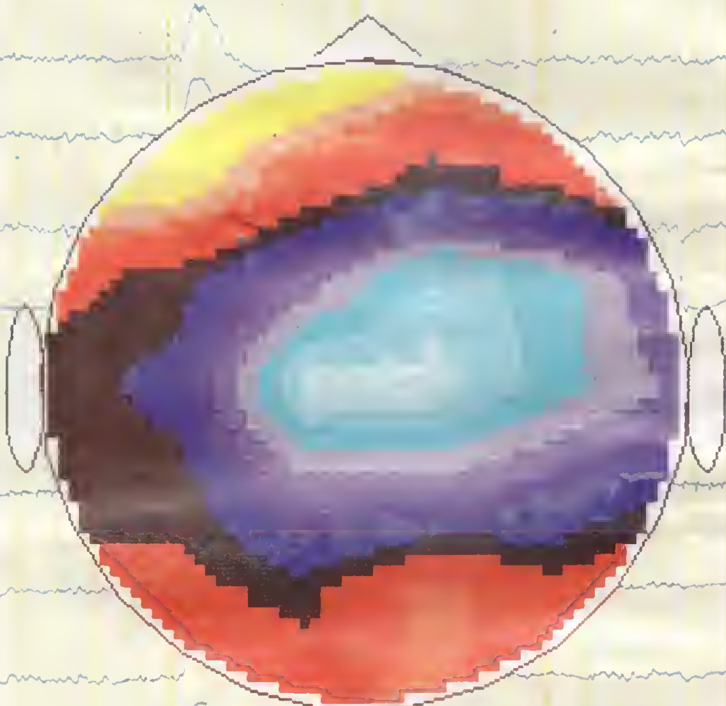

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Spot sine wave generator
Decoding satellite TV signals

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BURSTING THE BUBBLE MYTH

by Keiron Conway*

Bubble memory devices are not new. Until now though, the technology has been haunted by a reputation for unreliability — a leftover from the problems encountered in its early development stages. But, according to one UK company, now is the time for a radical reappraisal of bubble memory and its benefits. The Computer Systems Division of Vistec Business Systems has proved the advantages of this technology over its traditional mass-storage counterparts. Two years after recommending and installing bubble memory devices as part of a contract associated with an oil exploration project, Vistec has no regrets.

The technology itself has been around for over 16 years. Developed initially by Bell Labs-USA, it has always been acknowledged as a potentially excellent alternative to more traditional mass-storage media—magnetic tape or disk. Access times are at least comparable with floppy disk systems, if not faster. But it is the technology's rugged quality in comparison with rotating surface memories which has given it its major appeal. Simply because it has no moving parts, it can be used in portable applications or where levels of vibration would cause head crashes or unwanted tape movement in traditional storage devices.

Although Bubble Memories contain no moving mechanical parts, bubbles do actually move. Binary ones and zeros are stored in 'bubble loops', which act as large shift registers within a chip.

In the Intel 7110 chip, for example, a single loop can store up to 4096 bubbles or bits. The loop is physically manufactured such that it contains 4096 discrete, fixed locations, or sites. Each location can support the presence or 'absence' of a tiny magnetic field — a bubble. The presence of a bubble at a location represents a '1'; its absence indicates a '0'. The bubbles are preserved even when no power is supplied to the chip. Bubbles are created or 'erased', using localised magnetic fields, activated over the site of the location to be modified.

The 4096 discrete locations are arranged in a physical loop. Bubbles are made to rotate round the loop, from one location to another by switching on and off a magnetic field, affecting the whole loop. The changing external magnetic field, coupled with the physical shape and composition of the elements that make up a location, cause a bubble present in one location to 'move' across to the next adjacent site. The geometry and composition of the site are such that varying magnetic polarities are set up whereby 'attraction' across the gap between the two locations occurs and a bubble can be 'pulled' across.

The overall effect is identical to that of a 4096 gate shift register, set up such that the last bit is shifted into the first, forming a rotating loop configuratien. Propagation of bubbles round the loop is only initiated when it is desired to read from, or write into, the loop. The loop thus acts in a similar manner to a track of rotating magnetic disk but only needs to be rotated when access is required.

An Intel 7110 chip contains 320 storage loops, each containing 4096 potential bubble storage sites. Each loop operates as an individual self contained storage entity. These are referred to as 'minor' loops although 'storage' loop is a more appropriate description. All minor loops are rotated together, not individually. At the ends of each minor loop the bubbles pass another loop arranged as shown in the diagram.

One is the read loop and the other is the write loop. These 'major' loops are structured so that their locations lie adjacent to the end sites on each minor loop. Between the two sites is a transfer gate.

Only one bit at a time can be read from each minor loop, by rotating all minor loops until the desired bits are adjacent to the locations on the empty read loop.

When the correct bit is present on all minor loops, the transfer gate is opened and the bubble 'splits', i.e. it is replicated on to the read loop location, remaining intact on the minor loop. In this way 320 bits (one from each minor loop) have been read out of the storage loops and transferred onto the read loop.

The read loop itself is then rotated such that all bubbles (or absence of bubbles) eventually pass a magnetic detector. This detector converts the data pattern stored on the read loop into electronic data.

Synchronisation of minor loop propagation is achieved using a special loop which contains permanently recorded patterns. These allow the position of the required bit within all loops to be determined so that the correct number of rotations may be achieved to align the required bits with the transfer gates.

The write operation is the exact opposite of the read. First the full 320 bits to be written into the minor loops are generated, one bubble (or absence of bubble) at a time, onto the write loop. This is rotated until all bits have been transferred and the position of the bubbles have been aligned with the write gates on the ends of the minor loops. The minor loops are then rotated until the correct bits to be overwritten appear at their ends. The write gate is then opened and data from the write loop passes across to the minor loops, destroying all previous contents.

One read or write operation to a bubble chip involves one bit from each minor loop and this collection of bits is referred to as a page of data.

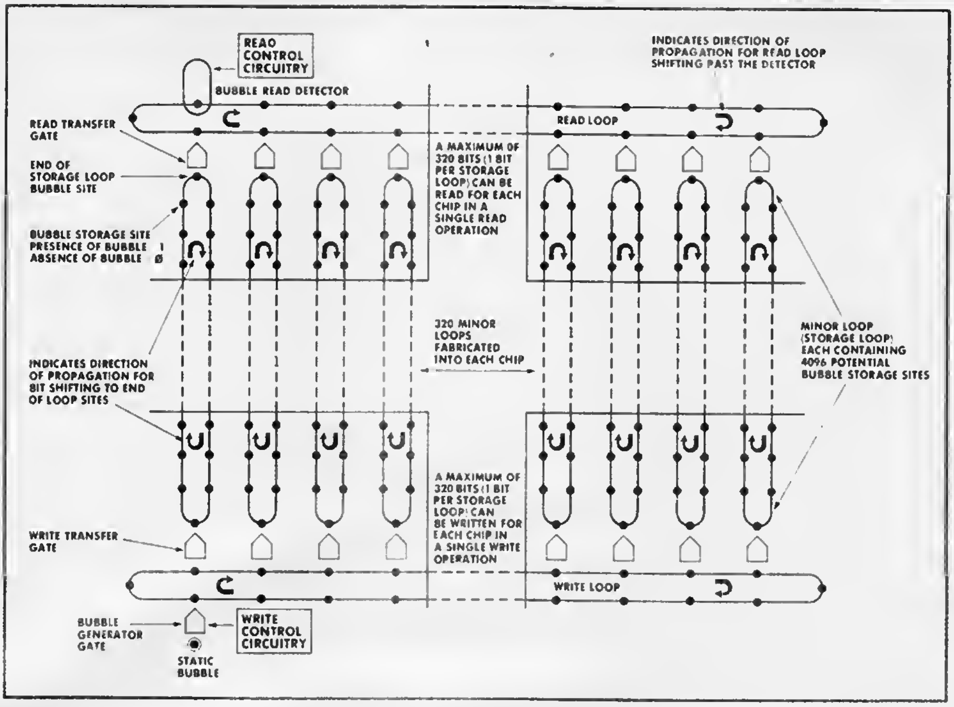
Bubble-tec Corporation of California, manufacture a bubble memory system that emulates a DEC RX02. This consists of a controller and one or more memory storage boards, each one containing four of the Intel 7011 chips. One memory board supports up to 512K bytes of storage, equivalent to a single sided, double density RX02 floppy disk.

A read operation is executed in parallel on all four chips of the bubble board. Thus a total of 4 × 320 bits can be read in one operation. In actual fact, 2 read loops and 2 write loops are constructed within each chip, to double the number of bits that can be read in one operation. This now gives a total capacity of 2560 bits for a single read or write operation.

An RX02 allows 256 bytes to be read from disc and then transferred to the QBUS memory per single read request. The bubble board needs to be capable of reading or writing 64 bytes per chip in one operation to emulate the RX02 single sector read or write.

Sixty-four bytes consist of 512 bits, a single bubble chip can provide 640 bits per read, bearing in mind that there are two read loops operated in parallel.

To manufacture error free loops in each chip would raise manufacturing costs unacceptably. Up to 48 defective minor loops may be allowed per chip, thus cutting down the total number of minor loops to 272. This now provides 544 bits, still



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allowing the required 64 bytes to be read or written per chip.

The manufacturer provides a map of all defective minor loops in the chip. These are recorded into another special loop called the 'boot loop' which also contains the codes to synchronise minor loop propagation.

Upon power up, firmware on the bubble boards reads the defective loop information from the boot loop and can then ensure that only complete loops are utilised.

If the boot loop becomes corrupted for any reason, then the bad loop map can be written back into the boot loop under a diagnostic program supplied with the boards.

The firmware used to access the bubble memory also performs error detection and correction. A 14 bit error correction code is stored for each page of data in the system. Correctable errors cause the offending page to be re-generated into the memory system.

The bubble board controller emulates the full RX02 control protocol. Firmware on the controller translates track and sector addresses to a page address to rotate all minor loops in all 4 chips to emulate a single sector read. Once this has been fed into the controller's internal data buffer, then it can be transferred into main memory in a series of DMA transfers in a similar manner to that employed by the RX02 controller.

The coil drivers that set up the minor loop propogation drive field generate an oscillating magnetic field at 50 kHz, providing one rotation per cycle. It takes approximately 370 rotations of a major loop to pass all bubbles across the detector (or generator).

Each page of data contains 512 bits, excluding any redundant bits and error correction bits. There are four chips operated in parallel, allowing a total of 2048 bits to be accessed in one operation.

The maximum throughput for each bubble chip access is thus 512 bits times 50,000 rotations divided by 370, approximately 69,000 bits per second. This figure assumes minimal minor loop propogation is required. As all four chips on an RX02 emulation board are operated in parallel, a full 256 byte 'sector' read can be transferred to main memory in a single bubble page access on each chip, taking less than 9 milliseconds.

DEC RX02 drivers are normally requested to read a full block or series of blocks, where a block is 512 bytes of data contained in two sectors. To maximise throughput on a rotating diskette, the driver interleaves sectors and skews them across the disk as well. The purpose behind this is to attempt to ensure that once the DMA transfer for the last sector has ended, the read/write heads have still not passed over the next sector to be accessed.

The bubble memory always has the next page available within one rotation and thus the firmware re-maps interleaved and skewed sector requests to contiguous page addresses to allow maximum throughput despite the interleaving algorithm of the RX02 driver.

It was two years ago that Vistec rediscovered the practical benefits of bubble memory technology. Working on a drilling monitoring system, the environment proved simply too hostile for floppy disks and Winchesters.

As an alternative, Vistec opted to use the Bubble-tec QBUS RX02 bubble memory system, a considerable advantage being that the unit is driven by standard software. The controller and memory card each consist of a dual height board and both can be housed in the QBUS backplane of the system. By simply adding more boards, up to 8 megabytes of storage can be included. Indeed the actual bubble boards do not need to be installed in the backplane as all they require is power. A single cable connects the controller, which must reside in the backplane, to all bubble memory cards.

In this kind of hostile environment, Vistec has successfully run RT11 and RSX11S from 11/23, 11/23+ and 11/73 systems, containing either one or two memory boards acting as single, or double, drive RX02 configurations.

This set up has proved reliable and offers a very compact configuration for delicate and quite complex real-time systems. In its portability, resistance to hostility and reliability, bubble memories, believe Vistec, are here to stay.

A final benefit, already being utilised in military applications, is the facility of one pulse erasure, providing complete security for unwanted, but sensitive, data.

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* Keiron Conway is Technical Manager of Vistec Computer Systems Division.

Since this article was commissioned, Intel has sold its bubble memory operations to Memtech Technology Corporation. Terms provide for the transfer of manufacturing equipment, inventory, design, and personnel. Bubble-tec, in the mean time, has already appointed an alternative supplier-Hitachi-to ensure continuity of production. (Ed)

DESIGN ABSTRACTS

The contents of this column are based on information obtained from manufacturers in the electronics industry, or their representatives, and do not imply practical experience by *Elektor Electronics* or its consultants.

LOW-NOISE AMPLIFIER TYPE TDA7232

The TDA7232 was developed by SGS-Ates in co-operation with American car audio specialists Bose for use in car hi-fi installations, but it can also be used in domestic hi-fi systems.

In car hi-fi units, the IC is used as a pre-amplifier in conjunction with SGS-Ates' digital amplifier IC Type TDA7260. The on-board limiter then has the task of preventing the output amplifier being overdriven. The three internal opamps are used mainly to form an equalizer to flatten the frequency response of the output signal.

When the chip is used in general-purpose amplifiers, mixer units, or active cross-over filters, its symmetrical input is a particularly valuable asset. Furthermore, it requires only a simple, unregulated power supply. The on-board opamps enable the TDA7232 to take care of the complete signal processing (filtering and power limiting) in an active subwoofer system.

The block schematic of the IC together with the external components required in its primary application is shown in Fig. 1. The positive supply voltage at pin 20 should be not less than 12 V nor more than 30 V (unregulated). In view of the noise present in any car's electrical system, the TDA2732 is provided with an internal voltage regulator that delivers regulated outputs of 10 V and 5 V. The 5-volt supply is brought out at pin 19 and used to power the opamps. The remainder of the stages are powered by the 10-volt output. The 5-volt line can deliver up to 10 mA and is protected against short-circuits: it is decoupled by the 10 μF electrolytic capacitor at pin 19.

The input stage consists of an inverting differential amplifier that serves as a symmetrical-asymmetrical converter. Its inputs are protected against transients by diodes. The input resistors are carefully matched to ensure a high in-phase rejection. The noise voltage at the output of the stage is not greater than 2.8 μV for a 20 kHz bandwidth so that a signal-to-noise ratio of more than 100 dB can be achieved.

The limiter following the input stage is an inverting opamp that uses an operational transconductance amplifier (OTA) in its

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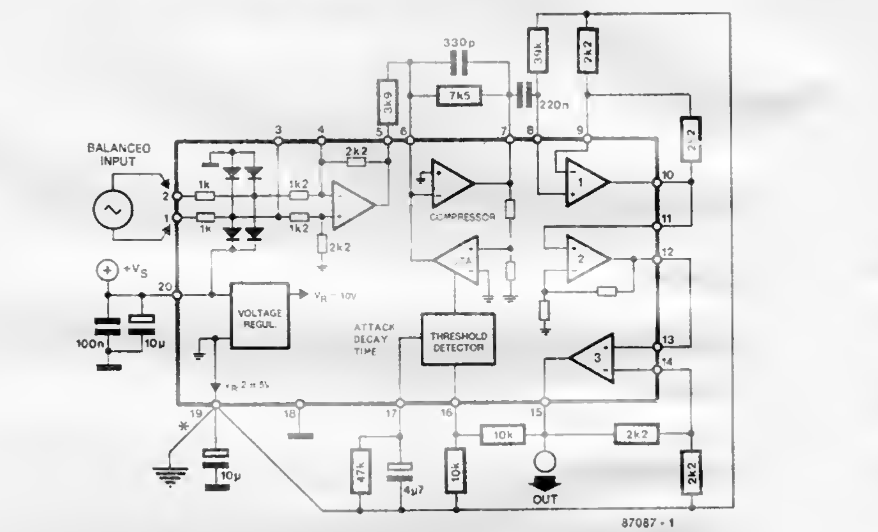

Fig. 1. Block schematic of the TDA7232 with external components for use as a pre-amplifier in a car hi-fi system.

Table 1

Technical specification

Maximum ratings	
Supply voltage U_b	≮12 V ≯30 V
[illegible]	≯U_b
Operating temperature	25 °C to +85 °C
Dissipation at T_a = 60 °C	≯800 mW
Electrical characteristics	
(U_b = 14.4 V; T_a = 25 °C; A = 30 dB)	
Supply current, I_b	typ. 10 mA
	max. 15 mA
Gain (no limiting)	typ. 30 dB
Distortion at 1 kHz	
no limiting, u_i = 70 mV	0,03%
limiting, u_i = 220 mV r.m.s.	0.3%
u_i = 700 mV r.m.s.	1%
R.M.S. output voltage, u_o	max. 2.8 V
Noise output voltage	
(B = 22 Hz to 22 kHz)	typ. 150 μV
Supply voltage ripple suppression	typ. 110 dB

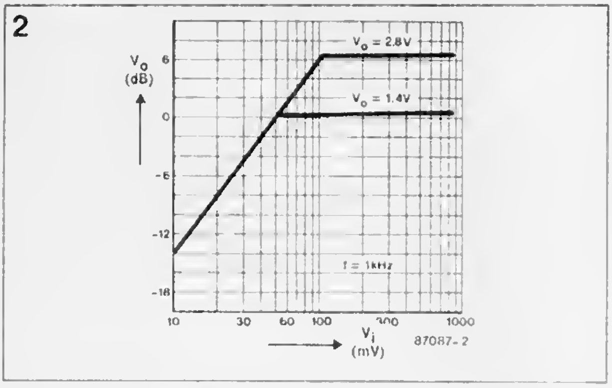

Fig. 2. Limiting characteristics of the TDA7232.

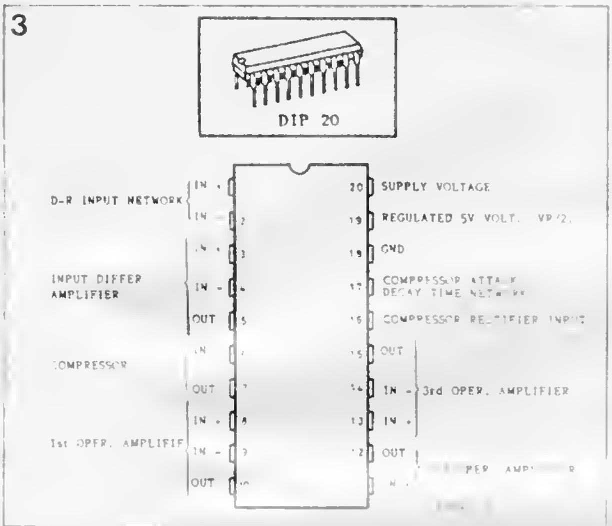

Fig. 3 Pinout of the TDA7232.

feedback loop as the control element. In contrast to usually encountered OTAs, the one used here provides a high output current, so that the feedback and input resistances have a low value to ensure minimal noise generation.

The OTA is driven by a window comparator (threshold detector) that monitors the level of the output signal on pin 15. As soon as this level exceeds a predetermined value, the OTA reduces the gain and so limits the output voltage to a fixed maximum value (see Fig. 2).

To obviate the generation of noise at the onset of limiting, an RC network at pin 17 ensures suitable attack and release times. Furthermore, the OTA is dimensioned for particularly low input off-set voltages.

In Fig. 1, the three available low-noise opamps are simply cascaded: numbers 1 and 3 are here connected as non-inverting amplifiers with unity gain, whereas number 2 is a 12 dB non-inverting amplifier.

Both the symmetrical input pins and the output pin carry DC and must, therefore, be isolated from equipment connected to them by suitable coupling capacitors.

The input impedance of the circuit (pins 1 and 2) amounts to about 4 kΩ.

The outputs of the opamps must be terminated into not less than 2 kΩ. The second opamp has an input impedance of 500 kΩ; the other two, having input currents of typically 100 nA, can similarly be arranged with high-impedance inputs. Their no-load gain (when terminated into 2 kΩ) is typically 100 dB.

Sources:

TDA7232 Product Preview. SGS-Ates May 1985.

A high-performance, high-efficiency audio subsystem for car radios by Casini, *et al*, IEEE Transactions on consumer electronics, Vol. CE-31, No. 3, August 1985.

SGS-Ates (UK) Ltd
Planar House
Walton Street
AYLESBURY HP21 7QJ

NEWS • NEWS • NEWS • NEWS • NEWS

70 MHz WIDEBAND FM DEMODULATOR

The Space Applications Centre of the Indian Space Research Organisation at Ahmedabad has developed a 70 MHz wideband FM Demodulator for satellite or ground based FM communication systems

The Demodulator consists of 70 ± 36 MHz Wideband limiter, Driver, Discriminator and post detection Amplifier With the change of input filter, this versatile demodulator can be used for Video and Telephony in Satellite Communications, Line of Sight microwave links or other applications involving frequency modulation

TYPICAL SPECIFICATIONS

Input IF Frequency
: 70 MHz
Input Frequency deviation
± 18 MHz Max.
Input Level (IF)
-10 dBm nominal
IF input, BB output,
BB Monitor Impedance
75 Ohm
Input Return Loss
20 dB [illegible]
Dynamic Range
-5 to -15 dBm
Linearity
5% (± 18 MHz BW)

Group delay
Linear
25 nsec MHz
Parabolic
0 05 nsec MHz
Ripple
1 nsec P-P
BB output level
1 Vpp nominal
BB response
. 1 dB (25 Hz to 5 MHz)
BB output return loss
20 dB
Operating temperature
0° to + 50°C
Humidity
: 95% RH at + 40°C
Power supply
: ± 24V DC
Length
: 31 cm
Width
18 5 cm
Height
[illegible]

ISRO offers to transfer technology of the 70 MHz Wideband FM Demodulator to industries in India with adequate experience and facilities Enterprises interested in obtaining the know-how may write giving details of their present activities, infrastructure and facilities, to

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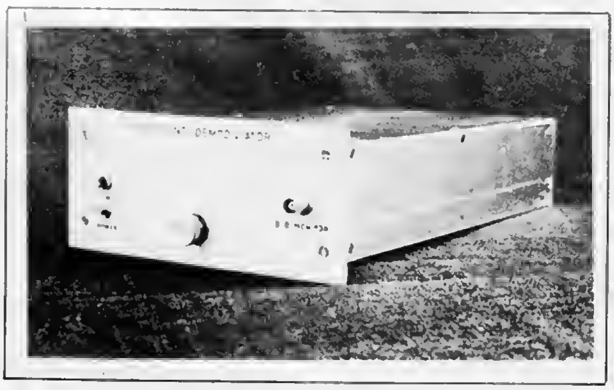
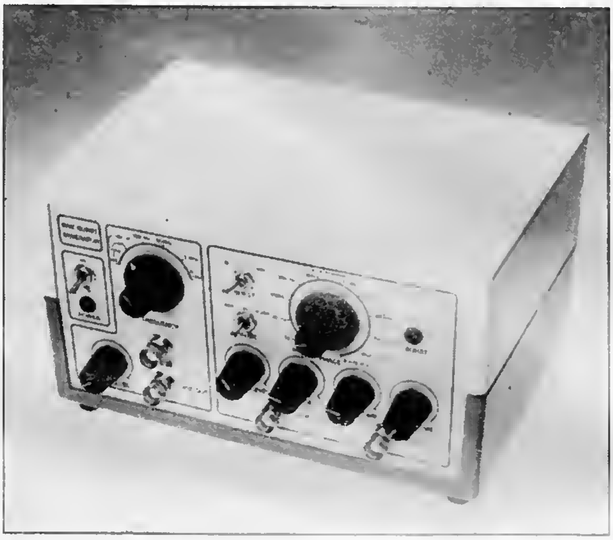


SPOT SINE WAVE GENERATOR — 1

by M G Weigl

This ultra-low distortion, 4-frequency, sine wave generator is a laboratory-grade instrument for testing and aligning AF circuits of almost any kind.

A spot frequency generator is primarily used for distortion measurements. It derives its name from the fact that it delivers one or more *fixed* output frequencies (*spots*), rather than a continuous range. The use of fixed frequencies makes it possible to tailor the generator such that it outputs each "spot" as a pure sine wave with significantly less distortion than would be attainable with a continuously variable instrument. The spot sine wave generator described in this two-part article has technical features that make it suitable for a wide variety of applications having to do with the analysing, testing, and setting up of high-end audio equipment. Its excellent performance is the more surprising in view of its simplicity, relatively low cost, and the use of standard, off-the-shelf components.



Spot sine wave generator
Technical specification:

Output frequencies:	5 kHz 1 kHz 500 Hz 100 Hz
Output voltage	1.5 V_{rms} (variable)
Frequency stability:	depends on quartz crystal.
Distortion:	0.008% (third harmonic).
Additional feature:	built-in tuning fork circuit, f = 440 Hz; V_{out} = 2 V_{rms} (variable).

Design principles

Figure 1 shows the functional blocks that make up the spot sine wave generator. In essence, the sine wave is obtained by first generating a square wave, integrating this to make a triangular waveform, and feeding this in turn to a high-order low-pass filter, which then outputs the sine wave signal. This approach is based on Fourier's theory of signal synthesis and analysis, which proposes that a rectangular wave is composed of an infinite number of harmonically related sinusoidal constituents.

The 4 MHz clock oscillator in the spot sine wave generator is crystal-controlled, and drives a :16 divider to obtain a 250 kHz signal. After subsequent division by 25 and 2, a 5 kHz rectangular wave is available for integrating in an R-C network. The other three frequencies of the generator are obtained by dividing 10 kHz by 10 (1 kHz), 1 kHz by 2 (500 Hz) and 1 kHz by 10 (100 Hz).

The four rectangular waves are integrated with the aid of R-C combinations to obtain triangular waveforms. Each of these is passed through a low-pass filter to make the sine wave signals available for the driving of the burst-adaptor circuit via rotary switch S_4.

A useful boon of the spot sine wave generator is the built-in tuning fork circuit, which outputs a very pure and stable 440 Hz note.

Circuit description

The circuit diagram of the spot sine wave generator appears in Fig. 2. The central clock oscillator, IC_1, is controlled by quartz crystal X_1, whose operating frequency can be set to 4.000 MHz precisely by aligning trimmer C_5.

The Q_4 and Q_7 outputs of the ripple counter in IC_1 supply the 250 kHz clock for the spot

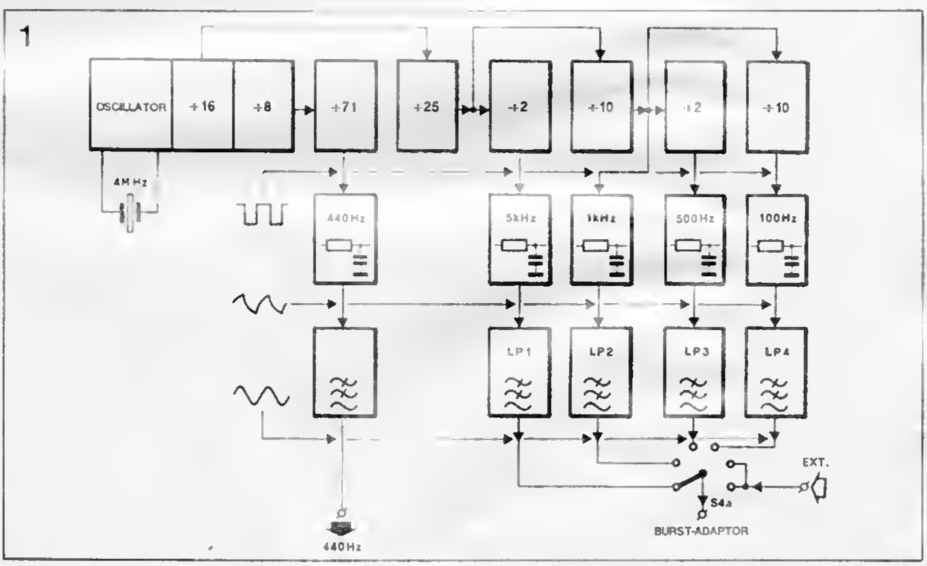


Fig. 1. Block schematic diagram of the spot sine wave generator.

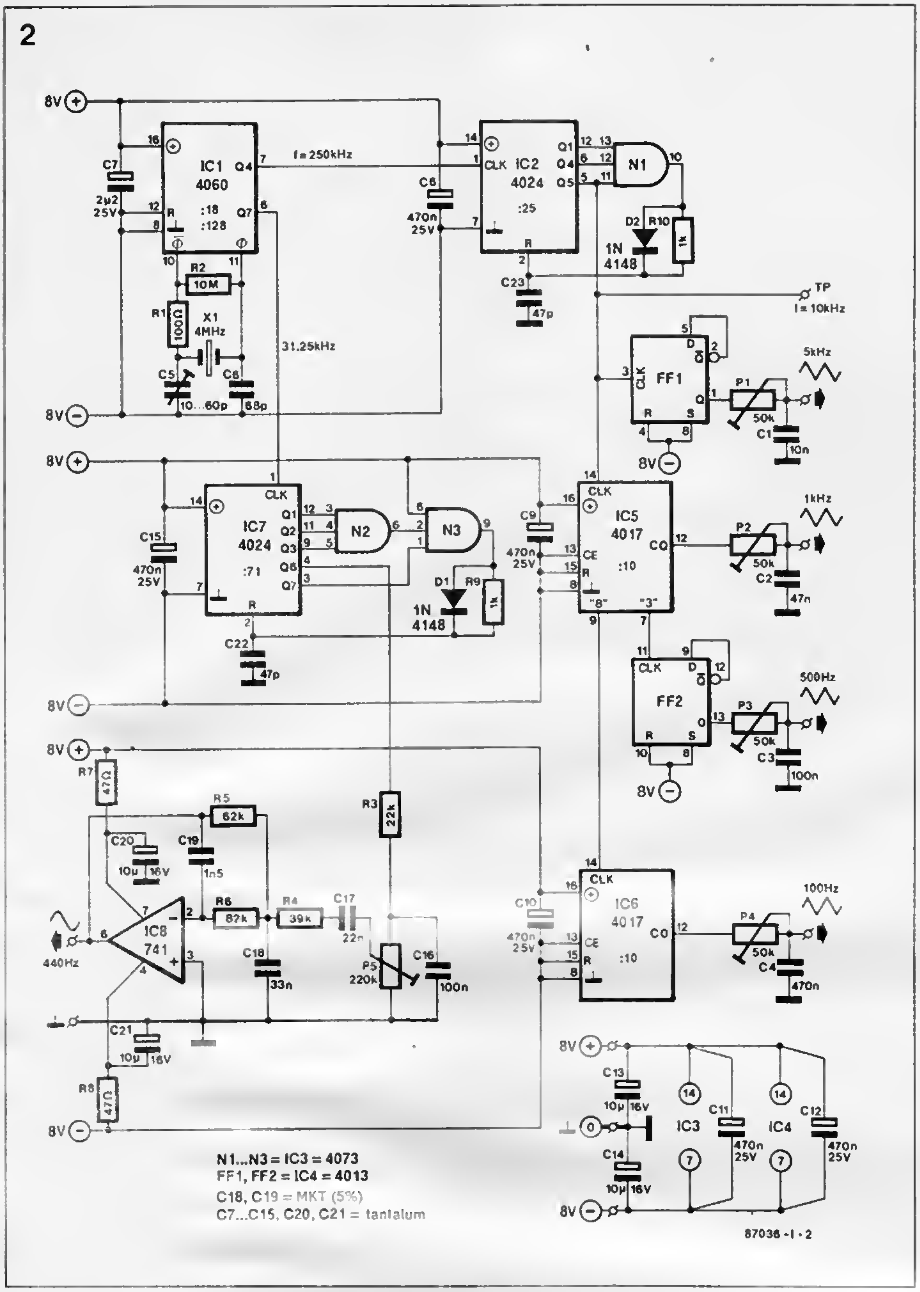


Fig. 2. Circuit diagram of the spot sine wave generator without output filters.

dividers, and the 31.25 kHz clock for the tuning fork, respectively. The 250 kHz signal is divided by 25 in IC_2. The slightly unusual divisor is obtained with the aid of a three-bit AND function, N_1, which resets the counter when Q_5 goes high. The 10 kHz signal at the Q_5 output is an asymmetrical rectangular wave which is made available at test point TP, and applied to the CLK inputs of FF_1 and IC_5. The bistable divides by two, and the 5 kHz triangular wave is obtained after integration in P_1-C_1. The counter divides by ten, and drives integrating network P_2-C_2 to provide the 1 kHz triangular signal. Bistable FF_2 and counter IC_6 likewise serve to deliver the 500 Hz and 100 Hz signals, respectively. The resistive part of each of the four integrating filters is a preset to enable setting the period to that of the incoming square wave. Example: P_1-C_1 should be aligned to give a period of $1/5000 = 200\ \mu s$. At this setting, the amplitude of the triangular signal is 63% of that of the input square wave. Therefore, the presets are readily adjusted by measuring the peak amplitude of both signals.

Counter IC_7 is set up to divide the 31.25 kHz signal by 71 with the aid of AND gates N_2 and N_3. Ripple output Q_6 drives integrating network R_3-C_{16}. Preset P_5 is used to adjust the level of the 440 Hz triangular wave fed to the active low-pass filter set up around IC_8. This filter is a second-order Butterworth low-pass section with multiple feedback, dimensioned for a cut-off frequency of 440 Hz. The output is left DC-coupled, and may require a series capacitor to drive an amplifier.

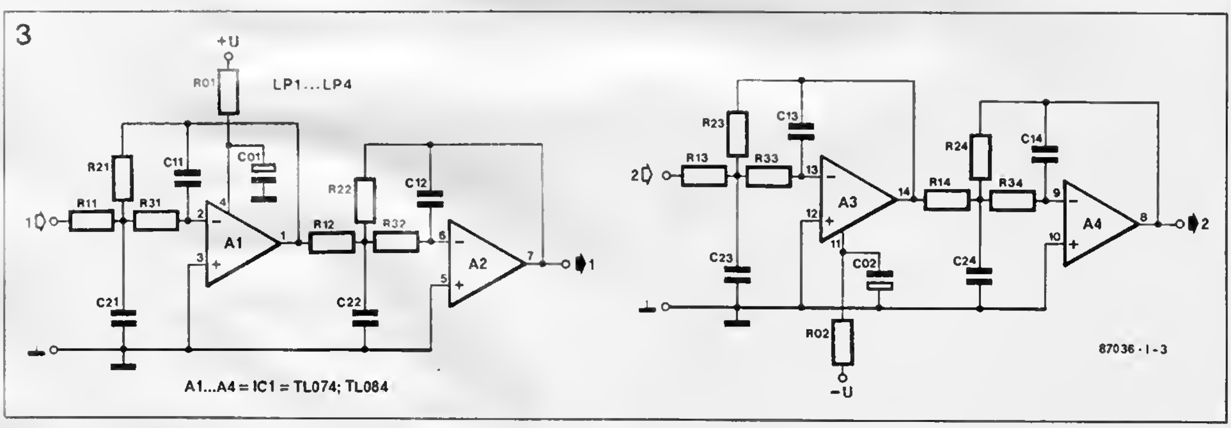


Fig. 3. Basic circuit diagram of the 8th order Butterworth filter. Output 1 goes to input 2.

Table 1

Technical data $LP_1 \dots LP_4$.

Filter type:	Butterworth low-pass; 8th-order with multiple feedback.
Cut-off frequency (f_c):	5 kHz (LP_1) 1 kHz (LP_2) 500 Hz (LP_3) 100 Hz (LP_4)
Filter coefficients:	$A1 = 1.9616$ $A2 = 1.6629$ $A3 = 1.1111$ $A4 = 0.3902$ $B1 \dots B4 = 1$
Overall amplification:	$A_t = \prod_{i=1}^{4} A_0 = (A_0)^4 = 1 \; (f_{test} << f_c)$
Amplification of individual filter sections:	$A_0 = -1 \; (f_{test} << f_c)$

Calculation of component values in a filter section (see also the parts list to Fig. 5):

$$R_{1i} = R_{2i} / -A_{oi}$$

$$R_{2i} = \frac{A_i C_{2i} - \sqrt{A_i^2 C_{2i}^2 - 4 C_{1i} C_{2i} B_i (1 - A_{oi})}}{4 \pi f_c C_{1i} C_{2i}}$$

$$R_{3i} = B_i / (4 \pi^2 f_c^2 C_{1i} C_{2i} R_{2i})$$

$$C_{2i} / C_{1i} \geq 4 B_i (1 - A_{oi}) / A_i^2$$

Subscript i denotes filter section number (1 . . . 4).

The low-pass filters

To make pure sine waves from the four available triangular signals, an equal number of active low-pass filters is required. Fig. 3 shows the basic circuit diagram of the four-section, 8th-order Butterworth filter used in the spot sine wave generator. Note that the individual opamp sections are identical to the previously mentioned 440 Hz filter. Each of the low-pass filters LP_1-LP_4 is dimensioned as set out in Table 1. The calculations for the component values are based on those set out in *Halbleiterschalttechnik*, a standard reference work by Tietze & Schenk.

The capacitors in the filter sections have been taken as the starting point for the calculation of the precision resistors to arrive at the correct cut-off frequency. This is so arranged because high-stability (1%) resistors are generally more easily available than precision capacitors. The theoretical values of the resistors can be approximated to a reasonable extent by using series-connected 1% metal film types, as stated in the parts lists for the low-pass filters.

Construction

Figures 4 and 5 show the track layout and component mounting plan for the main generator board and one of four identical filter boards, respectively. The fitting of the various parts should not present serious difficulty when the overlay and the parts list are to hand. Make sure that the four filter boards are completed with the correct components, and use adhesives marked LP_1, LP_2, LP_3 and LP_4 with each filter to avoid connecting them to the wrong outputs on the main board.

Next month's concluding part of this article will detail the burst-adaptor extension and the constructional completion of the spot sine wave generator.

Sv

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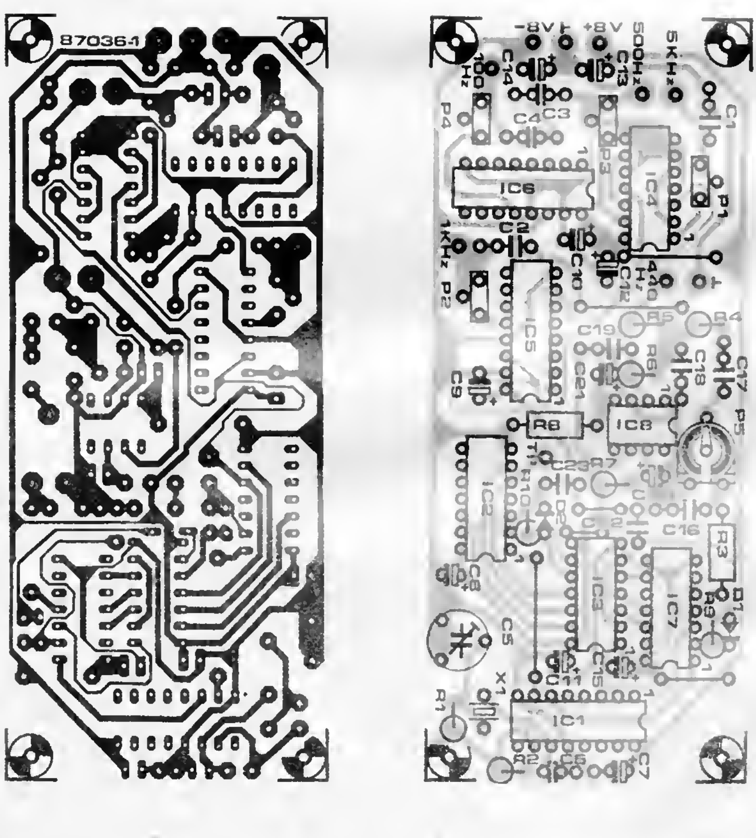

Fig. 4. The printed circuit board for the spot sine wave generator.

Parts list
(main board; see Fig. 4)

Resistors (± 5%):

R_1 = 100R
R_2 = 10M
R_3 = 22K
R_4 = 39K
R_5,R_6 = 62K
R_7,R_8 = 47R
R_9,R_{10} = 1K0
P_1 … P_4 incl. = 50K preset for vertical mounting
P_5 = 220K preset

Capacitors:

C_1 = 10n
C_2 = 47n
C_3;[illegible] = 100n
C_4 = 470n
C_5 = 60p trimmer
C_6 = 68p
C_7 = 2μ2; 25 V; tantalum
C_8 … C_{15} = 0μ47; 25 V tantalum
C_{13};C_{14};C_{20};C_{21} = 10μ; 16 V tantalum
[illegible] = 22n
C_{18} = 33n MKT 5%
C_{19} = 1n5 MKT 5%
C_{22};C_{23} = 47p

Semiconductors:

D_1,D_2 = 1N4148
IC_1 = 4060
IC_2;IC_7 = 4024
IC_3 = 4073
IC_4 = 4013
IC_5;IC_6 = 4017
IC_8 = 741

Miscellaneous:

X_1 = 4.000 MHz quartz crystal
PCB Type 87036-1 (not available through the Readers Services).

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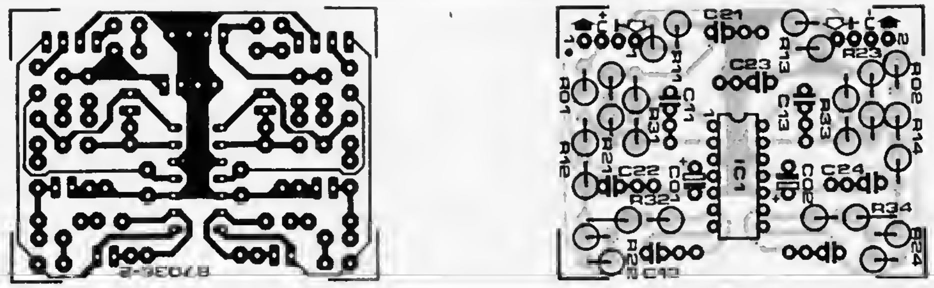


Fig. 5. The active filters are each constructed on a separate board of the type shown here.

Parts list

(low-pass filter boards LP_1 .. LP_4; see Fig 5).

LP_1:

Resistors ($\pm$ 1%):
R_{01};R_{02} = 10RJ
R_{11};R_{21} = 118K7 (110K + 9K1)
R_{12};R_{22} = 89K86 (47K + 43K)
R_{13};R_{23} = 138K5 (130K + 8K2)
R_{14};R_{24} = 22K35 (22K + 360R)
R_{31} = 82K57 (82K)
R_{32} = 75K37 (75K.
R_{33} = 107K6 (100K + 7K5)
R_{34} = 30K23 (30K)

Capacitors ($\pm$ 5%):
C_{01};C_{02} = 22μ; 16 V; 20%; tantalum
C_{11};C_{12} = 220p
C_{13} = 100p
C_{14} = 150p
C_{21} = 470p
C_{22};C_{23} = 680p
C_{24} = 10n

Semiconductor:
IC_1 = TL074 or TL084

LP_2:

Resistors ($\pm$ 1%):
R_{01};R_{02} = 10RJ
R_{11};R_{12} = 119K5 (120K)
R_{12};R_{22} = 63K79 (62K + 1K8)
R_{13};R_{23} = 69K24 (68K + 1K2)
R_{14};R_{24} = 50K78 (51K)
R_{31} = 96K35 (91K + 5K1)
R_{32} = 56K32 (56K)
R_{33} = 53K8 (47K + 6K8)
R_{34} = 68K7 (68K + 680R)

Capacitors ($\pm$ 5%):
C_{01};C_{02} = 22μ; 16 V; 20%; tantalum
C_{11};C_{13} = 1n0
C_{12} = 1n5
C_{14} = 330p
C_{21} = 2n2
C_{22} = 4n7
C_{23} = 6n8
C_{24} = 22n

Semiconductor:
IC_1 = TL074 or TL084

LP_3:

Resistors ($\pm$ 1%):
R_{01};R_{02} = 10RJ
R_{11};R_{21} = 118K7 (110K + 9K1)
R_{12};R_{22} = 127K6 (120K + 7K5)
R_{13};R_{23} = 138K5 (130K + 8K2)
R_{14},R_{24} = 46K6 (47K)
R_{31} = 82K57 (82K)
R_{32} = 112K6 (110K + 2K7)
R_{33} = 107K6 (100K + 7K5)
R_{34} = 68K02 (68K)

Capacitors ($\pm$ 5%):
C_{01};C_{02} = 22μ; 16 V; 20%; tantalum
C_{11} = 2n2
C_{12} = 1n5
C_{13} = 1n0
C_{14} = 680p
C_{21};C_{22} = 4n7
C_{23} = 6n8
C_{24} = 47n

Semiconductor:
IC_1 = TL074 or TL084

LP_4:

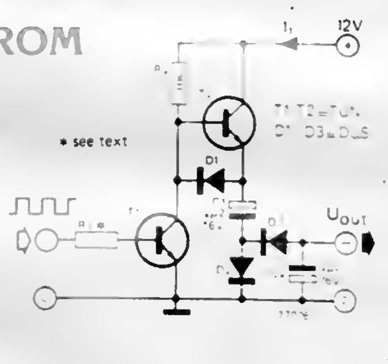
Resistors ($\pm$ 1%).
R_{01};R_{02} = 10RJ
R_{11};R_{21} = 119K5 (120K)
R_{12};R_{22} = 63K79 (62K + 1K8)
R_{13};R_{23} = 97K53 (91K + 6K8)
R_{14};R_{24} = 50K78 (51K)
R_{31} = 96K35 (91K + 5K1)
R_{32} = 56K32 (56K)
R_{33} = 81K26 (82K)
R_{34} = 68K7 (68K + 680R)

Capacitors ($\pm$ 5%):
C_{01},C_{02} = 22μ; 16 V; 20%; tantalum
C_{11} = 10n
C_{12} = 15n
C_{13} = 6n8
C_{14} = 3n3
C_{21} = 22n
C_{22},C_{23} = 47n
C_{24} = 220n

Semiconductor:
IC_1 = TL074 or TL084

Note: each low-pass filter is constructed on its own PCB Type 87036-2 (four pieces required).

NEGATIVE SUPPLY FROM POSITIVE SUPPLY



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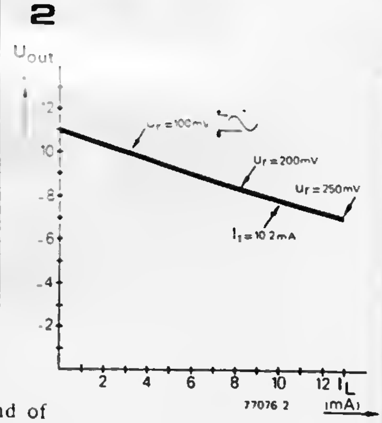


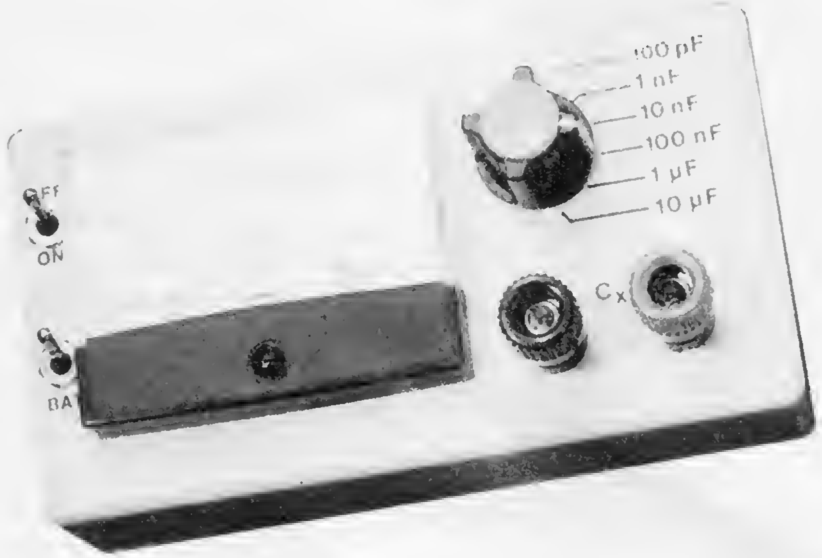
It is sometimes necessary to provide a negative supply voltage in a circuit that otherwise uses all positive supply voltages, for example to provide a symmetrical supply for an op-amp in a circuit that is otherwise all logic ICs. Providing such a supply can be a problem, especially in battery operated equipment.

In the circuit shown here T1 is turned on and off by a squarewave signal of 50% duty-cycle at approximately 10 kHz. In logic circuits it is quite conceivable that such a signal may already be available as clock pulses. Otherwise an oscillator using two NAND gates may be constructed to provide it.

When T1 is turned off, T2 is turned on and C1 charges through T2 and D2 to about 11 V. When T1 turns on, T2 turns off and the positive end of C1 is pulled down to about +0.8 V via D1. The negative end of C1 is now about 10.2 V negative so C1 discharges through D3 into C2, thus charging it. If no current is drawn from C2 it will eventually charge to around −10 V. Of course, if a significant amount of current is drawn, the voltage across C2 will drop as shown in the graph and a 10 kHz ripple will appear on the output.

CAPACITANCE METER

by J Peltz



A smartly designed, inexpensive, yet accurate, analogue capacitance meter.

The capacitance meter described here is intended to meet the need for an accurate, battery-operated, and low-cost instrument, which has no more features than strictly necessary for the testing and measuring of a wide range of capacitors. Considering that a capacitance meter is not the most frequently used of test instruments in the electronics workshop, a relatively simple design can have all the necessary features, and yet be accurate and reliable. The digital capacitance meter described in [1] is, of course, the ultimate as far as ease of readout and operation are concerned, but the cost of this instrument may be considered rather high in relation to the number of occasions when the instrument is called for.

The present instrument can operate in conjunction with almost any multimeter that has a 1 mA DC current range with sufficient accuracy. However, it is also possible to build a moving-coil meter into the capacitance meter's enclosure, as shown on the above photograph, to make for an autonomously operating instrument at very little extra expense.

The operation of the proposed meter is based on measuring the time to charge the capacitor under test to a certain voltage. The measured time is converted into a voltage that is directly related to the value of the capacitance.

The measuring principle

The functional diagram of the capacitance meter is shown in Fig. 1. Since a single charge and voltage measurement cycle poses practical problems—the charge voltage drops the instant the meter circuit is connected—this meter uses the principle of alternately charging and discharging the capacitor under test.

Figure 1 shows that capacitor Cx is charged with the aid of a regulated voltage and a series resistor R. Capacitor Cx is shunted by a switch, which is opened and closed by the pulses from a clock oscillator. Therefore, Cx is quickly discharged during the on-time of the clock signal, and charged again during the pulse pauses.

The Cx—R junction carries a periodic ramp-like signal, which is converted into a rectangular wave with the aid of a Schmitt-trigger circuit. As the duty factor of the Schmitt-trigger's output signal is directly proportional to the capacitance of Cx, an integrator suffices to actuate a meter, whose indication corresponds to the capacitance of Cx.

The operation of the Schmitt-trigger section in the circuit is crucial to the operation of the circuit. Since the capacitance meter is fed from a regulated 5 V line, the trigger level can be established fairly accurately at ⅔ of 5 V.

The voltage, Uc, on a capacitor C charging through a resistor R from a supply voltage, U, is given by

$$U_c = U(1 - e^{-t/\tau}) \quad \text{volts}$$

where e is the base of natural logarithms (=2.71828) and $\tau = RC$ (and is called the time constant). With this formula, it can be calculated that if $t = \tau \log_e 3$, $U_c = 0.667U$. Since Uc is inversely proportional to C ($U_c = Q/C$, where Q is the charge of the capacitance), and also inversely proportional to t, it may be concluded that the capacitance is directly proportional to the time t, and it is on this that the present circuit is based.

Circuit description

The circuit diagram of the capacitance meter appears in

1

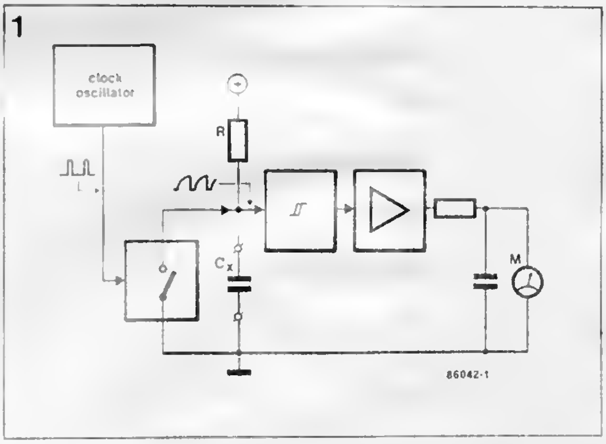


Fig. 1. Functional diagram of the capacitance meter.

Fig. 2. It is not very difficult to recognize the previously introduced functional blocks. The clock signal for the electronic switch across Cx, and the value of the charge resistor, R, can be selected with the aid of 6-position range selector S_1. The circuit around T_2 and N_3 was added to provide compensation for parasitic capacitances, and the measurement error which inevitably occurs as a result of the leakage discharge of Cx.

The operation of the practical circuit is essentially as follows. The clock signal is generated by oscillator N_1. Four clock frequencies are available at the outputs of decimal counters IC_2-IC_5. Each of these outputs a switching signal with a duty factor of 10% (t_h=0.1T; t_l=0.9T). During the logic high time of the selected pulse, T_1 short-circuits Cx and dissipates its charge, and during the logic low time of the pulse Cx is charged via the relevant resistor, R_2, R_3 or R_4. As already noted, the switch clock frequency and the charge resistor are selected as required for a particular measurement range. Gate N_2 is an inverting Schmitt-trigger for the voltage across Cx, and drives buffer N_5-N_7 via XOR gate N_4. The integration of the proportional voltage is effected with R_7-C_4. Preset P_2 serves to calibrate the meter, and push button S_3 to check the condition of the battery. If this contains the nominal charge of 9 V, the current through R_6 is nearly the fsd current of the meter.

2

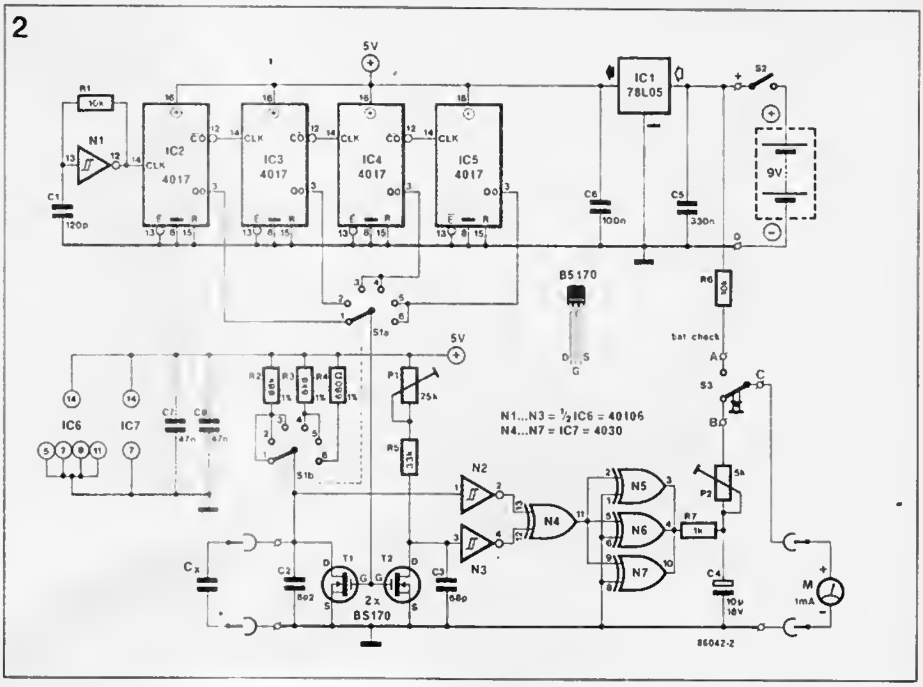


Fig. 2. Circuit diagram of the low-cost capacitance meter.

The previously mentioned compensation function is realized by connecting an additional network P_1-R_5-C_3 in parallel with the measuring network R_2/R_3/R_4-Cx, and using T_2 as an electronic switch. Capacitor C_3 is switched simultaneously with Cx, and its charge ramp is subtracted from that of Cx by means of XOR gate N_4. The purpose of this arrangement is twofold. Firstly, the relatively low value of C_3 will cause the output signal of N_3 to be very similar to the clock signal when S_1 is set to the higher ranges. A near perfect compensation for the 10% discharge time of Cx can thus be achieved by subtracting this signal from the instantaneous voltage across Cx. Secondly, the value of C_3 can not be neglected when measuring relatively small capacitors. The pulses from N_3 are then relatively wide, which effectively compensates for any parasitic capacitances introduced by, for instance, a set of test leads. The timing diagram in Fig. 3 further illustrates the above compensation method.

Construction and alignment

The circuit board for this easy to build project is available ready-made from our Readers Services, and its completion should not present any problems. Simply fit all the parts as per Fig. 4 and the accompanying parts list. The capacitance meter is housed in a suitable ABS enclosure that has room for the meter, if used, and the PP3 battery. The introductory photograph to this article should give some idea of the drilling and lettering of the instrument's front panel.

Setting up the capacitance meter is extremely straightforward. Do not yet connect a test capacitor, set the meter to its 100 pF range, and null the moving coil meter by adjusting P_1. Proceed with connecting a precision capacitor of 10 nF (use the best you can get, an 5% MKT or polystyrene type is the absolute minimum), switch the meter to the third range (10 nF), and adjust P_2 for full scale deflection of the meter (1 mA).

Accuracy

The extraordinary precision of the present meter is best illustrated by Table 1, in which a

3

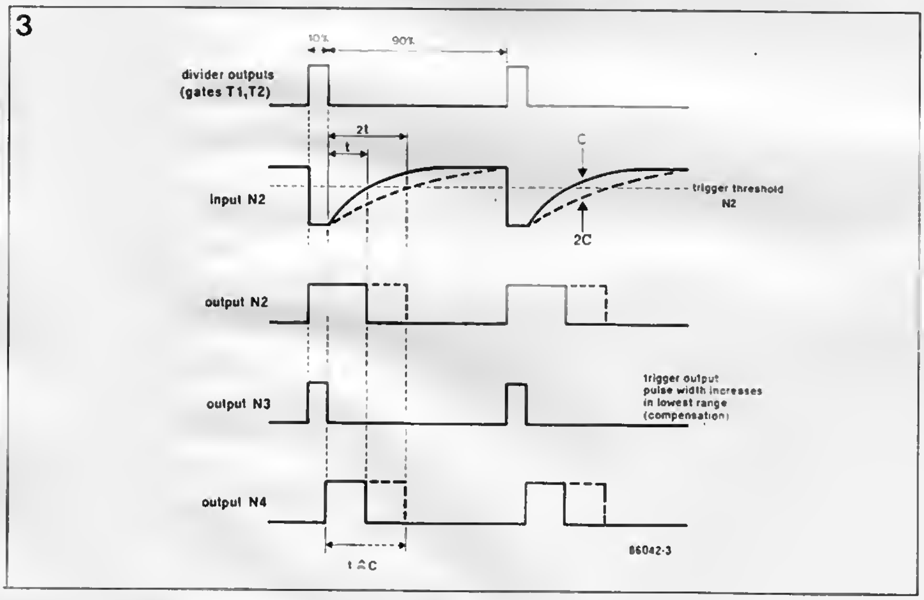


Fig. 3. Pulse diagram illustrating the operation of the compensation circuit.

Table 1			
range	test C	analogue C meter	digital C meter
1	10 pF 33 pF 68 pF	10.8 pF 37.0 pF 77.5 pF	9.2 pF 31.2 pF 64.5 pF
2	100 pF 330 pF 680 pF 1 nF	110 pF 350 pF 660 pF 0.98 nF	94.5 pF 330 pF 640 pF 0.95 nF
3	3.3 nF 6.8 nF 10 nF	3.25 nF 6.80 nF 10.0 nF	3.20 nF 6.65 nF 9.83 nF
4	33 nF 68 nF 100 nF	30.2 nF 69.2 nF 102 nF	31 nF 69 nF 102 nF
5	330 nF 680 nF 1 μF	338 nF 685 nF 1.01 μF	336 nF 674 nF 0.993 μF
6	1 μF* 4.7 μF 10 μF	1.10 μF 5.80 μF overflow	1.09 μF 5.90 μF 11.3 μF

* Electrolytic capacitor.

A comparison between the performance of the present capacitance meter and that published in reference [1].

4

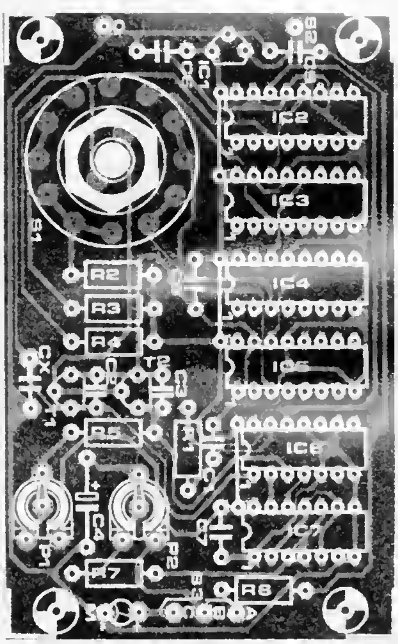
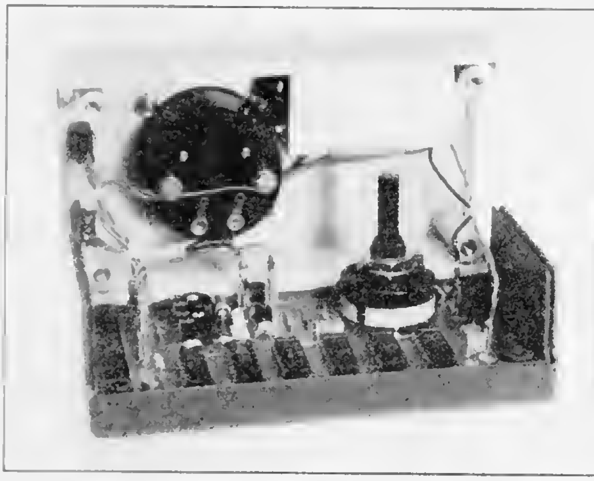


Fig. 4. The circuit board for the capacitance meter. Rotary switch S_1 is fitted direct onto it.



A look inside the completed capacitance meter.

Parts list

Resistors (±5%)
R_1;R_6 = 10K
R_2 = 68KF
R_3 = 6K8F
R_4 = 680RF
R_5 = 33K
R_7 = 1K0
P_1 = 25K preset
P_2 = 5K0 preset

Capacitors
C [illegible]
C_2 = 8p2
C_3 = 68p
C_4 = 10μ; 16 V axial
C_5 = 330n
C_6 [illegible]
[illegible]

Semiconductors.
T_1;T_2 = BS170 *
IC_1 = 78L05
IC_2 ... IC_5 incl. = 4017
IC_6 = 40106
IC_7 = 4030

* [illegible] m STC Electronic Services. Telephone: (0279) 26777.

Miscellaneous:
S_1 [illegible] 6 way rotary switch [illegible] PCB [illegible]
[illegible]
[illegible] re SPDT push-button.
M [illegible] 1 mA fsd meter.
Suitable ABS enclosure.
PCB Type 86042 (see Readers Services).
1 red and 1 black insu[illegible] terminal post.
PP3 batt[illegible]ry p[illegible]s h[illegible]lder and clip-on conn[illegible]tor.

comparison is made with the capacitance meter detailed in [1]. The performance of the low-cost meter described here is the more surprising in view of its simplicity and ease of calibration. Its maximum deviation occurs in the lowest range, where the indication is typically too high. It is seen, however, that the digital capacitance meter gives too low readings with the same test capacitors.

A final remark concerning the current consumption of the capacitance meter: this is no more than about 6 mA, so that the built-in battery will last for many tests and measurements.

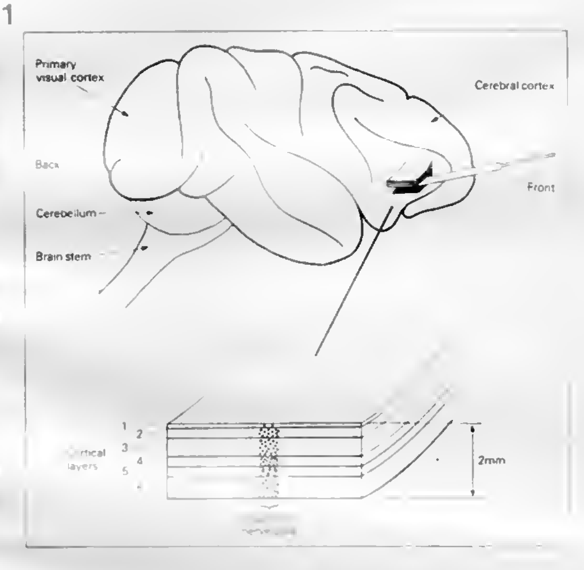
TW

HOW DOES THE HUMAN COMPUTER WORK?

by Dr Kevan Martin, UK Medical Research Council Anatomical Neuropharmacology Unit, Department of Pharmacology, Oxford University

The human brain is a triumph of miniaturisation, the most remarkable computer in the world. Yet its nerve cells process only 100 or so instructions per second in contrast to the half-a-million that a microcomputer may handle. This makes the speed at which we perform very complex operations all the more astonishing. One of the most complicated tasks we are capable of is visual perception, which goes on in the cerebral cortex. Scientists are now steadily gaining information about how the cortical 'microchip' works: technically formidable operations such as injecting a recognisable 'label' into single nerve cells through a glass tube only one-half a micrometre in diameter are producing detailed information that is extremely valuable, not only in understanding our visual processes but in building the parallel processing systems that so-called fifth generation computers will use.

1



The brain of a monkey seen from the side. Its cerebral cortex covers all the other regions apart from portions of the cerebellum and the brain stem. Much of the cortex lies buried in deep folds. If a piece of cortex is dissected away from the underlying fibre connections, its laminated structure can be clearly seen. The width of a column of cells with similar functional properties varies from about 0 05 to 0 5 mm, depending on the property.

Computers are now part of our daily lives. We see them at work in shops at the checkout till, they dispense money to us outside banks, they produce our utility bills and they are coming to replace typewriters for tasks such as writing this article. They tackle complex arithmetic with an accuracy and speed that no ordinary human can hope to match. The rate at wich they have proliferated to occupy almost every niche of our existence, in the home and workplace, is a tribute to their flexibility of operation. The silicon 'chip' which is the basis of modern computers has indeed produced a revolution in the 30 years of its existence.

In our admiration for the electronic marvel we perhaps forget that the most powerful computers in the world are not built of silicon, but are carbon-based. Each of us, in fact, owns one of these computers; they come 'built-in' at birth and operate unceasingly, often for well over 70 years. It is, of course, the human brain.

Unlike the silicon chip, our brain has evolved over millions of years and, because it is always with us, we often forget how powerful it really is. It is only recently that attempts to simulate human behaviour using computers have revealed how difficult many of the tasks are that we perform with ease. The speed at which we can carry out very complex operations is all the more astonishing when we consider that a microcomputer can process about half-a-million instructions per second, against 100 per second or fewer for the average nerve cell.

Processing Visual Information

One of the most complex tasks we perform is that of visual perception, and this has been a major area of investigation over the last 25 years. We now know that the main processing of visual information goes on within an areao of brain called the cerebral cortex. In within an area of brain called the cerebral cortex. In primates, including humans, the cerebral cortex is so well developed that it covers the rest of the brain and, with its connections, forms over 80 per cent of the brain's volume.

The cortex consists of a sheet of nerve cells 2 mm thick and about one-seventh of a square metre in area. It forms a great deal of the grey matter of the brain, and the nerve fibres that connect different areas of the brain form the white matter. In humans the cortical sheet has to be folded many times to fit inside the skull: this produces the very convoluted surface of the human brain.

The design of the brain is a triumph of miniaturisation; no present-day computer even approaches the computing power contained within its 1.5-litre volume.

The primary visual processing areas of the cerebral cortex lie at the back of the brain, but the positions of the many ohter visual areas that undoubtedly exist in humans have yet to be found. In other primates, such as monkeys, these other visual areas have been mapped and it turns out that about 40 to 50 per cent of their cerebral cortex carries out visual processing. That so much of the brain is occupied with visual processing is perhaps not surprising, when we consider how much we depend on our eyes for normal living.

The first stage in visual processing takes place in the eye, where the retinal receptors sample the visual world and transmit the information to the visual cortex via an intermediate structure called the thalamus. Each receptor in the retina 'looks' at a small piece of the visual world and signals changes in contrast, such as the difference between the black letters and the white page of this article. In many vertebrates, including ourselves, the retina contains a mix of receptors, all of which are selectively responsive to light of a different wavelength. The information they provide is used for the interpretation of colour.

While almost any visual stimulus activates the retinal receptors, the nerve cells in the cortex are much more selective in their responses. Intensive study by the Nobel-Prizewinning scientists Professor David Hubel and Professor Torsten Wiesel of Harvard Medical School showed that most of the cells are selective for the orientation, shape, size and direction of movement of the visual stimulus. Cells with similar preferences are grouped together in columns extending through the full thickness of the cortex. Clearly this sort of functional organisation must reflect an underlying organisation of the cortical circuitry. However, analysis at this level is unable to tell us very much about how the cortex is put togehter and programmed, any more than we can understand a computer by exploring its word-processing capacities. Nevertheless, in the same way that the circuitry and logic of the computer determines its capabilities, so our understanding of how the visual cortex performs its tasks depends on how much we can find out about the contents of the cortical 'black box'. Several groups, including ourselves, have now begun long-term programmes of research to find out the structural basis of cortical function.

One of the main problems we face is the sheer number of components involved. Each square millimetre of cortex covers about 100 000 nerve cells. In primates, the primary visual cortex alone probably contains about 320 million nerve cells. As if this is not enough, there are many different types of nerve cells and the cortex is further divided into six basic layers containing different densities of these types. Nevertheless, there appears to be one important simplifying principle in the design of the cortex: it is a modular system. This means that, at least at its most basic level, particular structural patterns are repeated again and again, in effect adding together more of the same kind of 'microchip'. From the massive expansion of the cerebral hemispheres seen in the fossil record, we surmise that the design of the cortical microchip was succesful, efficient, and flexible enough to accommodate the new processing tasks that arose during our evolutionary history.

Our task, then is to discover what the structure of the cortical microchip is, and how it works. The way we do this involves a combination of many different techniques, all of which press against the limits of our present expertise. There are two strategies that we are using to find out how the nerve cells interconnect to form the circuits they do. The first is to watch how they form, unit by unit, by studying the development of the nerve connections during early life. The second strategy is to take the complete adult circuit, select one element, for example a single nerve cell, and find out its position in the circuit and what it does.

The experimental work involved in both these strategies is similar. The activity of a single nerve cell in the visual cortex of an animal is recorded, using a glass tube of microscopic dimensions filled with a salt solution containing the enzyme peroxidase, which is made from horseradish. After the physiological properties of the cell have been recorded, the enzyme is injected into the cell, which it fills entirely. The size of the cell body is about 20 μm and the diameter of the glass tube is about 0.5 μm, so the operation of injecting a single cell is technically formidable. Nevertheless, the effort has produced detailed information about the connections made by single cells, which could not be obtained in any other way. The first point in the circuit that we have examined is the input to the cortex from the thalamus. Each nerve cell in the thalamus sends a single fibre to the cortex, and the fibres travel to the cortex in tracts known as the white matter. We have recorded from these fibres as they enter the cortex and have filled them by injecting them with horseradish peroxidase. As the fibre from a thalamic nerve cell enters the cortex, it breaks up into a great many branches, which are beaded. The beads, called boutons, are the points of connection between the nerve fibres and the cells in the cortex. The connection is made by a structure called a synapse, a specialisation of the membrane of the bouton that can only be seen using the very high magnifications of an electron microscope. The bouton itself contains many small packets of chemicals known as neurotransmitters, which are the means of communication between cells, as opposed to the electrical impulse that is the signal sent out from the nerve cell body down the nerve fibre. When this electrical signal arrives in a bouton, the neurotransmitter is released and crosses the synapse.

The nature of the neurotransmitter is critical in determining what happens next, because some neurotransmitters activate, or 'excite' their target cells to produce an electrical impulse, while other neurotransmitters act to prevent impulses being produced and so 'inhibit' their targets. So we have not only to discover what connections are made between the different nerve cell types, but we have to find out which neurotransmitters they contain. This is done by using the powerful techniques of immunology. Antibodies can be made that recognise particular neurochemicals, and different specific antibodies can be used to test which neurotransmitter is used by a particular nerve cell.

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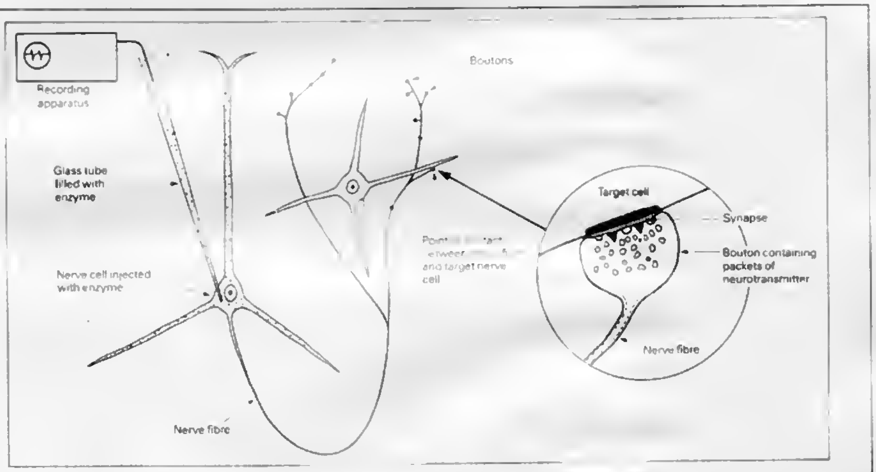


Schematic view of some of the experimental techniques used to uncover the cortical circuits. Electrical activity of the cell can be recorded through the glass tube, which is then also used to inject the cell with the enzyme. The enzyme remains only within the injected cell and fills all the processes of the cell. The point of contact between two nerve cells, the synapse, appears as shown in the inset when viewed under the electron microscope. All boutons make synaptic contacts. Only one of the many target cells is illustrated here.

Extensive Branches

The nerve fibres from the thalamus excite their target cells. Previously it was thought that only a few nerve cells were contacted by each thalamic fibre. Our research has shown that the branching of these fibres is far more extensive than was supposed, and that as many as 5000 cells can be contacted by the branches of a single fibre from a thalamic cell. However, each fibre contributes no more than a few synapses to any single cell, whereas we know that each nerve cell in the cortex receives at least 3000 synapses.

Not only is the contribution anatomically small but, we believe, it is also functionally small. The activity of each synapse produces only a small potential change in the cell to which it connects, and because each cell has a threshold to be reached before it produces an electrical impulse, the activity of hundreds of excitatory synapses has to be added together before the cell sends the electrical signal down its nerve fibre. This is a critical observation, for it gives us the first hint of how the cortex might be working.

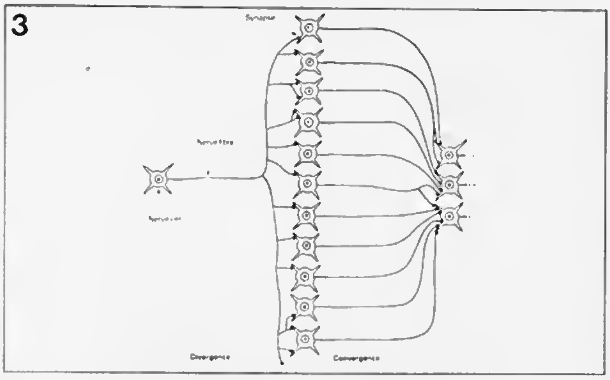
The high degree of convergent excitation that is required to activate a single cell makes it very different from the computers with which we have been comparing it. Unlike the computer, which is organised in a very hierarchical way, the cortex seems to be operating here as a democratic society. Only when enough cells agree that an event has taken place do they act together to produce an electrical impulse in the cells on which they converge. This circuitry is in sharp contrast to that found at earlier stages in the visual pathways, where the linkage between one nerve cell and the next is very much more secure because there is much less convergence and divergence.

These experiments indicate that the principle on which the cortex is designed is one where each nerve cell talks to many other nerve cells and, in turn, receives communication from a great many nerve cells. There are a number of good reasons why this should be so. One big problem that needs to be dealt with by the brain is that the transmission time along the nerve fibres and across the synaptic junctions is very slow. If these conduction times were transposed to a computer, the processing time just to read a single line of text would be intolerably long. The situation is made worse by the fact that most of the problems the cortex has to deal with are complex and, naturally, the time taken to arrive at a solution increases with the complexity of the problem. Yet we can arrive at solutions to complex tasks with remarkable speed.

Parallel Processing

The paradox of how rapid solutions are achieved using circuitry that operates slowly is explained by a technique known as parallel processing. This is a means of breaking up a single complex task into a number of sub-tasks that can then be solved simultaneously instead of sequentially. The result is that the overall processing time is reduced. It is the high degree of divergence in the input of single nerve cells to the cortex, and of nerve cells within the cortex itself, that provides the structural basis to make this parallel processing possible. In this way, the severe physiological limitations of the speed at which individual nerve cells can operate are offset by having a great many working at the same time on the same problem.

The converse aspect of the circuitry, a single nerve cell receiving a convergence input from many other nerve cells, also has important functional implications. Many nerve cells particularly at the sensory surfaces such as the skin or retina, are spontaneously active. This could be a source of confusion if every nerve impulse arriving at the cortex was interpreted as an indication that something had been seen or felt. We would be living much of the time in a land of illusions. The design of the cortex ensures that this random activity is filtered out, because only the simultaneous action of hundreds of cells produces an electrical impulse in the cell or cells on which they all converge. Simultaneous activity in all these cells is most unlikely to occur through random spontaneous activity, so only real events produce the required simultaneous activation of large numbers of nerve cells.



The cortex is built on the principles of divergence and convergence. One nerve cell diverges to contact many other cells, and each cell in turn receives a convergent input from many other nerve cells.

However, even in normal vision the cortex has to create illusions in order to sidestep some of the inherent limitations of the system. For example, the visual field of each eye contains a blind spot that corresponds to the region of the retina where the optic nerve leaves the eye. We have no conscious awareness that there is any gap in our field of view, because the brain is able to fill gaps in our visual space. Similar filling-in can occur in time, too. This is well demonstrated by our experience of cinema films, where 24 'stills' are presented successively every second, yet our experience is of continuous, smooth motion. These illusions of continuity in our visual experience are clearly preferable to a disjointed and incomplete view of the world. A great deal of what the cortex as a whole does may be to provide the most complete view it can of the world around us. When not enough information is present, we make the best guess, which unfortunately (and sometimes embarrassingly) is not always the correct one, as when we greet the long lost friend who turns out to be a complete stranger.

Highly Ordered

A crucial factor in our interpretation of a visual scene is that the stimulation must be such that the cortical circuits are activated in a highly ordered way in space and time. When this essential requirement is not met, the brain cannot usefully interpret the input. A simple illustration of this is the common experience of 'seeing stars' after receiving a knock on the back of the head. The mechanical stimulation activates large numbers of cortical neurones directly and we have the experience of moving points of lights, called phosphenes. This experience does not correspond to any normal visual perception because the knock on the head does not activate the cortical circuits in the appropriate pattern.

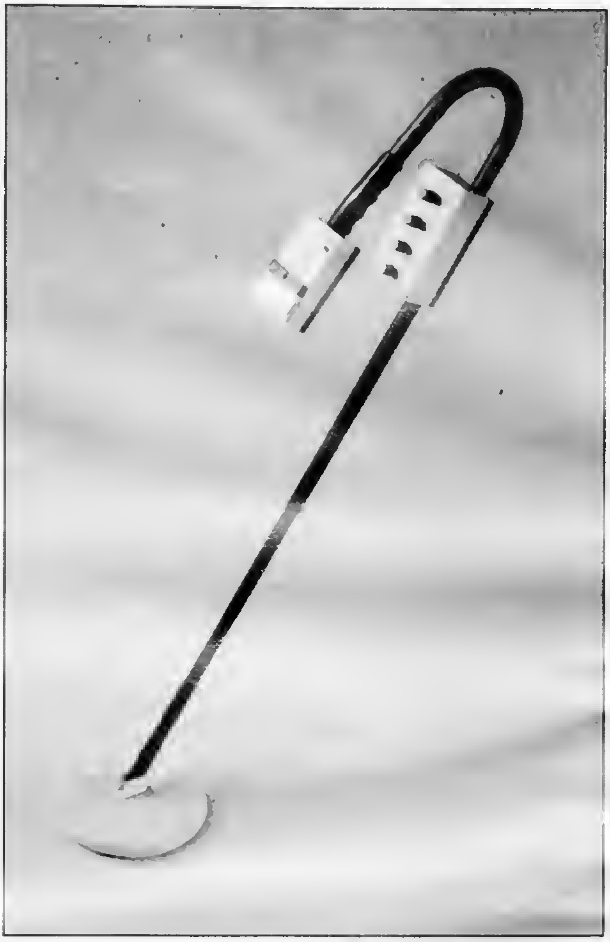
It is only through a knowledge of the circuitry and function of the cortical modules that we will be able to understand the nature of the processing that the cortex is doing. At present we are still grappling with very basic aspects of this problem. Even when these are solved many big issues will remain, such as how our memories are used in cortical processing to solve problems of recognition, and how we are able to direct our attention to particular tasks and ignore extraneous distracting stimuli, and understanding why we are 'conscious'. Solving these problems is still one of the most formidable tasks in biological research, but the rate of progress, and the development of new ways of unlocking the secrets of the cortical microchip, make this one of the most exciting and promising areas of new research.

A great deal of the work described here was done in collaboration with members and associates of the UK Medical Research Council's Anatomical Pharmacology Unit, whose contribution I gratefully acknowledge.

0219/6B

METAL DETECTOR

Attention, treasure hunters! Here is a simple, inexpensive, and highly sensitive metal detector.



Metal detectors generally operate on the basis of one of the following technical principles:

BFO (beat frequency oscillator).

In this system, the inductor in the search head is part of an oscillator, whose variable output frequency is mixed with another, fixed, frequency obtained from a second oscillator. The difference (beat) frequency falls within the audible range. When the search head is brought near a metal object, the variable oscillator causes an audible or otherwise detectable change in the beat frequency. BFO-based metal detectors are relatively inexpensive and easy to operate.

TR/IB (transmit-receive/induction-balance).

This system is based on the mutual-inductance coupling between a transmit coil and a receive coil. When a metal object is introduced in the vicinity of the inductors, the degree of coupling changes, and the resultant variation in the oscillator output level is detected.

PI (pulse induction).

A continuous pulse train is transmitted, and the received echoes thereof are examined in respect of their shape and strength. This enables reporting the presence of metal objects in the area covered by the transmitter.

Each of the above methods for detecting netals has its particular advantages. The ideal metal detector is, therefore, based on the most advantageous aspects of all three principles discussed. Such a detector would be very sensitive, and capable of providing an indication of the type of metal the buried object is composed of. It will be understood that the ideal detector does not exist, as it is extremely difficult to rule out some of the disadvantages inevitably associated with any of the previously mentioned measuring methods.

The metal detector described here is based on the TR/IB principle, and therefore has two inductors in the search head. As will be seen further on in this article, the design is essentially a combination of a variable-L oscillator, and a detector.

Magnetic properties

A metal object can cause a variation in a coil's self-inductance, and, therefore, in the degree of coupling between inductors. The effect can be positive or negative, depending on the relative permeability, μ_r, of the relevant metal. In this context, it is useful to know that materials and substances are classified as *paramagnetic* ($\mu_r > 1$), *diamagnetic* ($\mu_r < 1$), or *ferromagnetic* ($\mu_r >> 1$)—see Table 1.

Determining an object's substance on the basis of μ_r measurement is generally rather difficult. However, the difference between paramagnetic and diamagnetic materials on the one hand, and ferromagnetic ones on the other, is readily detectable thanks to the appreciable difference in the magnitude of μ_r.

Eddy currents are induced in a conductive object when this is subject to a varying magnetic field. The strength of the eddy currents depends on the shape and the size of the metal object, and the resisivity of the substance(s) it is composed of Strong eddy currents can be induced in, for instance, a metal sheet if this is flat and fairly large. The eddy currents are considerably weakened, however, if slots are cut into this sheet. Referring in particular to the use of a metal detector, further factors that determine the strength of eddy currents in a metal object include its pos-

Table 1

Magnetic properties of various substances.

diamagnetic ($\mu_r < 1$)	paramagnetic ($\mu_r > 1$)	ferromagnetic ($\mu_r >> 1$)
Bismuth	Aluminium	Cobalt
Glass	Silicon	Nickel
Copper	Air	Iron
Water	Platinum	Ferroxcube
Silver	Palladium	Steel

ition in the magnetic field (i.e., the number of lines of force that intersect it), and the effect brought about by the composition of the earth's surface.
The foregoing considerations may serve to account for the technical difficulties involved in determining the substance of a buried object on the basis of a single measuring method.

Circuit description

The circuit diagram of the metal detector appears in Fig. 1. Transistor T_1 functions as a self-quenching oscillator. This means that it simultaneously produces a low and a high frequency signal that together form an AM-like waveform as illustrated in Fig. 2. Notice that the rising slope of the composite signal is steeper than the falling slope. The oscillator is switched on and off by means of D_1, C_1, and R_1. During the oscillation, C_1 is charged via D_1, up to a voltage that is high enough to turn off T_1. The oscillation stops, and C_1 is discharged via R_1, until the voltage is low enough for T_1 to start oscillating again.
The transmitter inductors, L_1, L_2, and L_3 are connected between the base and the collector of T_1. In practice, the transmitter inductor set is arranged such that stray capacitance is counteracted to ensure the stability of the oscillator. Capacitor C_5 is fitted in the search head, together with the inductors, to preclude stability problems owing to the capacitance of the cables between the search head and the detector circuit. Inductors L_4 and L_5 together form the coupling loop, also built into the search head, and partly covering the transmitter's set of inductors. The residual (background) signal from L_4-L_5 can be compensated with the aid of tuning capacitor C_6, which serves to null the detector when the position of the transmitter and receiver inductor has been aligned, and the construction of the search head has been completed successfully.
The sensitivity of the metal detector can be adjusted with potentiometers P_1 (fine) and P_2 (coarse). Diode D_2 is a positive rectifier that ensures the absence of negative levels on the inverting input of IC_1. The operation of the detector circuit is fairly simple: when the rectified input signal exceeds the threshold voltage at the comparator's non-inverting input, the IC toggles, pulling its open-collector output low, and turning on loudspeaker driver T_2. The pitch of the note sounded by the loudspeaker on the detector depends on the level of the signal from the receiver inductor, L_4-L_5. This is illustrated by the dashed horizontal line in Fig. 2. Variations in the received signal strength give rise to a corresponding variation in the duty factor of the part of the burst that exceeds the threshold. The effect thus obtained is a clearly audible pitch shift when a metal object is detected.
Components D_3-R_7-C_{12} convert the output signal from T_2 into a negative feedback voltage for the comparator. This set-up provides an automatic gain control facility that counteracts strong input level variations. Moving coil meter M_1 provides a visual indication of the signal strength. Push-button S_2 makes it possible to check the battery condition before or during the search for metal objects in the ground.

Construction

The final performance of the metal detector largely depends on the precision used in constructing the inductor assembly in the search head. Figure 3 shows the shape and size of the formers that hold the inductors. The formers should be made of perspex, which is reasonably easily obtainable in sheet form. Do not use wood, as the resultant susceptibility of the formers to ambient humidity variations gives rise to difficulty in nulling the detector. Cut, rabbet or file a 5 mm wide, 10 mm deep slot into the entire edge of both plates, then use 30SWG (0.3 mm) enamelled copper wire to make the inductors as follows:
commence with glueing the start of the first winding onto plate 1 at point A. Wind L_1 as 22 clockwise turns in the slot around the side of the plate. Stop at point A and create a tap by twisting the wire over a length of roughly 10 cm, which is glued onto the plate surface. Leave the remainder of the wire unused for the moment, and connect the start of L_3 to the tap. Then wind L_3 as 4 counter-clockwise turns onto L_1. Start and stop at point A and glue the

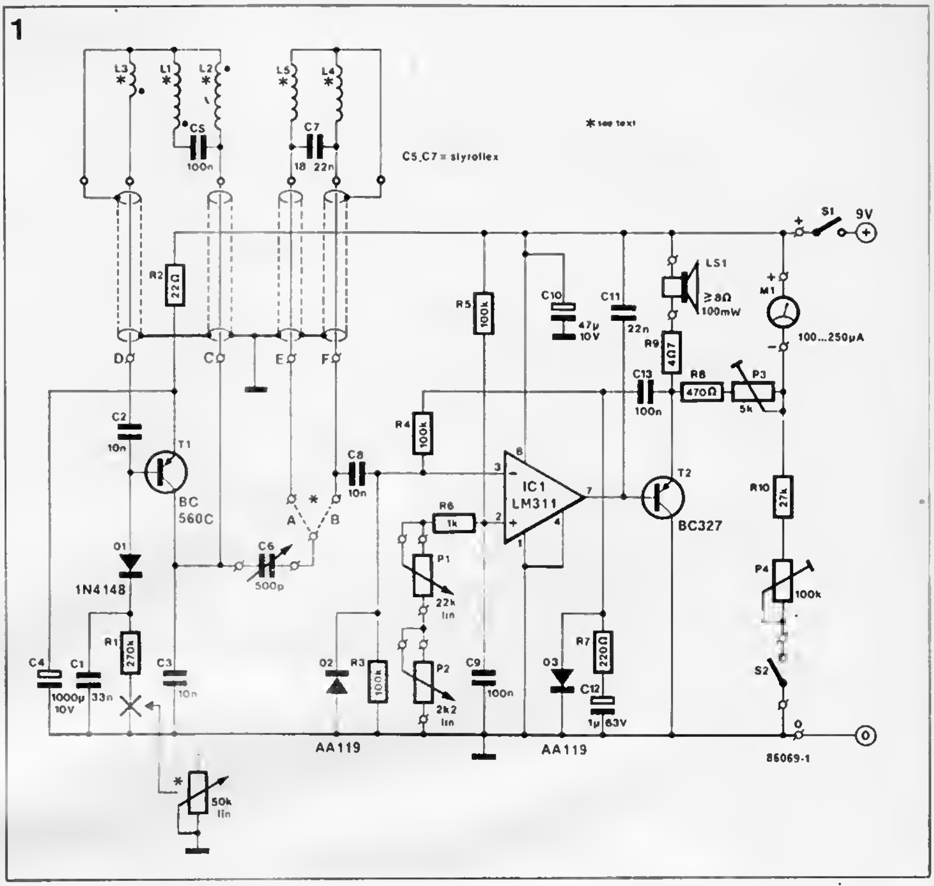
1


Fig. 1. Circuit diagram of the metal detector.

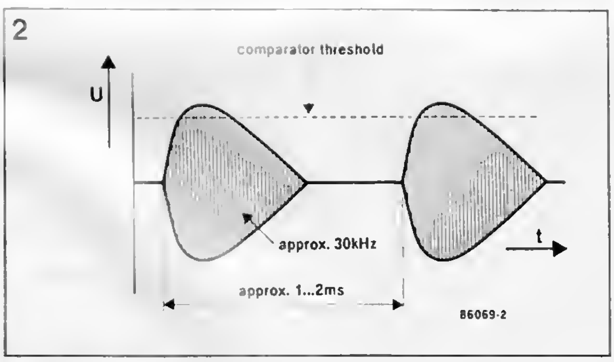
2


Fig. 2. The output signal of the self-quenching oscillator.

free end of L_3 onto the plate. Proceed with winding L_2 from the wire that was left flying after winding L_1. Wind 22 clockwise turns into the slot, starting and ending at point A. Secure the wire end by glueing it onto the plate.

The receiver inductors on plate 2 are made as follows: wind L_4 as 36 clockwise turns, starting and ending at point B. Create a tap as for L_1 and glue this and the start of the winding onto the surface of plate 2.

Proceed with this length of wire and wind L_5 as another 36 clockwise turns. Stop at point B and glue the last wire end onto the plate. Now identify all wire ends and inductor junctions, check for correct continuity, secure capacitors C_5 and C_7 onto the plates, and connect them to the relevant wires.

Cut a slot into plate 2 at the location shown in Fig. 3, and drill holes in both plates to enable asembling and aligning these with the aid of nylon bolts and nuts.

The remaining mechanical parts of the metal detector can be made to individual liking. The search head and the enclosure for the detector electronics can be fitted onto a wooden stick or a length of PVC tubing. The latter construction is preferable because of its lower weight and the possibility to hide the wiring between the search head and the detector circuit from sight.

The construction of the detector's electronics is a matter of fitting all components in accordance with the PCB overlay and the parts list—see Fig. 4. There are five controls on the enclosure front panel: S_1, S_2, C_6, P_1 and P_2. A sixth may be added as set out in the next section. The connections between the tuned circuits in the search head and the detector PCB are made in screened wire.

A suggested enclosure for the inductor assembly is composed of two plastic, dispensable, plates, which leave sufficient room inside when the rims are glued together. The completed search head can be made sufficiently sturdy by filling it with polyurethane potting compound or epoxy resin.

Before fitting the perspex plates inside the search head, however, make sure that the inductor assembly is thorougly tested and correctly aligned.

3

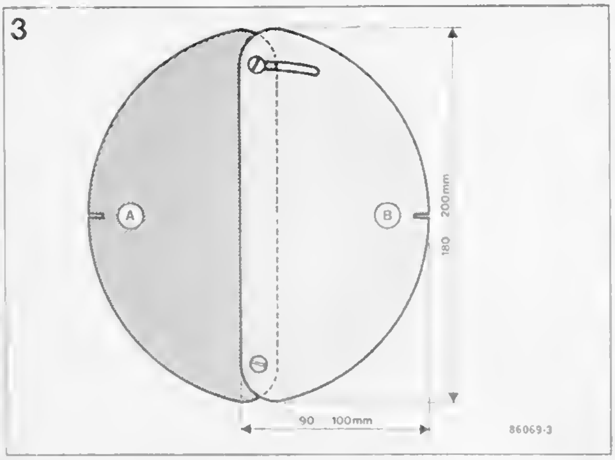


Fig. 3. The coil halves can be aligned for optimum balance.

4

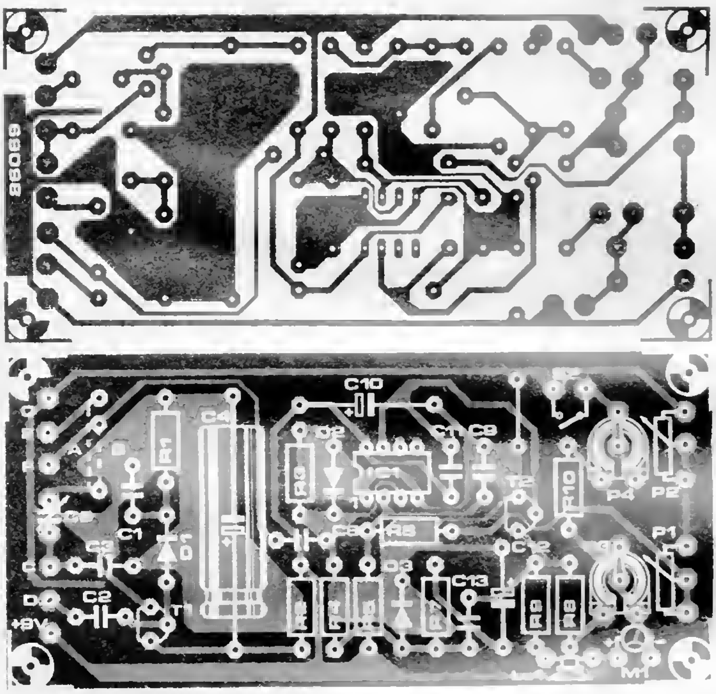


Fig. 4. The printed circuit board for constructing the metal detector.

Parts list

Resistors (±5%):
R_1 = 270K
R_2 = 22R
R_3;R_4;R_5 = 100K
R_6 = 1K0
R_7 = 220R
R_8 = 470R
R_9 = 4R7
R_{10} = 27K
P_1 = 22K linear potentiometer
P_2 = 2K2 linear potentiometer
P_3 = 5K0 preset
P_4 = 100K preset

Capacitors:
C_1 = 33n
C_2;C_3;C_8 = 10n
C_4 = 1000μ; 10 V axial
C_5 = 100n styroflex *
C_6 = 500p tuning capacitor ^
C_7 = 18-22n styroflex *
C_9;C_{13} = 100n
C_{10} = 47μ; 10 V axial
C_{11} = 22n
C_{12} = 1μ; 63 V axial electrolytic

Semiconductors:
D_1 = 1N4148
D_2;D_3 = AA119
T_1 = BC560C
T_2 = BC327
IC_1 = LM311

[illegible]
L... s incl. ... *
S_1 = miniature SPST switch.
S_2 = push-to-make button.
LS_1 = 100 mW; 8R.
M_1 = 100 ... 250 μA moving coil meter.
PCB Type 86069 see Readers Services
* See text
* May be made by parallel connection of smaller styroflex capacitors.
^ Available from Cirkit PLC • Telephone: (0992) 444111. Stock no.: 06-50006.

Setting up

Initially, the perspex plates are spaced to the maximum extent allowed by the nylon adjustment bolt. Neither link A nor B must be fitted on the circuit board, and all controls are set to mid-travel. Switch on the detector, and check whether it can produce an audible note at a particular setting of P_1-P_2. Make sure that this test is carried out in the absence of metal objects in the direct vicinity of the search head. Carefully align the position of the plates until a point is reached where the loudspeaker volume is minimal; it may be necessary to redo the adjustment of the sensitivity controls. Increase the distance between the plates by about 0.5 mm, and secure the bolt and nut to retain the position. The inductor assembly can now be fitted into the search head, which is then sealed and filled with a suitable compound. Fit wire link A and check whether C_6 can be adjusted for a dip in the detector's output volume. If this does not work, fit link B. If the adjustment is still incorrect, the inductor assembly is probably unbalanced by it being fitted into the search head enclosure. The final attempt you can make is to fit a 470p capacitor in parallel with C_6. If that does not remedy the problem, there is no other solution than to make a new search head.

Feed the circuit from a regulated 9 V supply, and adjust the sensitivity controls such that the detector produces no sound. Press S_2, and adjust P_4 for full-scale deflection of M_1. Reduce the supply voltage to 7 V, and mark the resulting needle position in red. Preset P_3 makes it possible to adjust the meter sensitivity to individual preference.

A final remark about the oscillator: a hum-like 100...150 Hz beat note may be audible as a result of interference between the two output frequencies. This effect can be obviated by fitting a 50K SYNC potentiometer in series with R_1 (see the cross in the circuit diagram, Fig. 1).

The detector in practice

First-time users of this metal detector are advised to try out the effects of various settings of C_6. A number of field experiments have shown that the detector's sensitivity is greatest when the note from the loudspeaker is just about audible. Turning C_6 to the left and the right of its null position is a means of determining whether an object in the ground is composed of a ferromagnetic or a dia paramagnetic substance.

Practice is doubtlessly the best way of gaining experience in the operation of this metal detector and the interpretation of its output signal. It will soon become apparent that the overlapping part of the plates is the most sensitive area of the search head. When this is slowly swept over the ground, it enables detection of a coin the size of a shilling buried some 15 cm deep. *B*

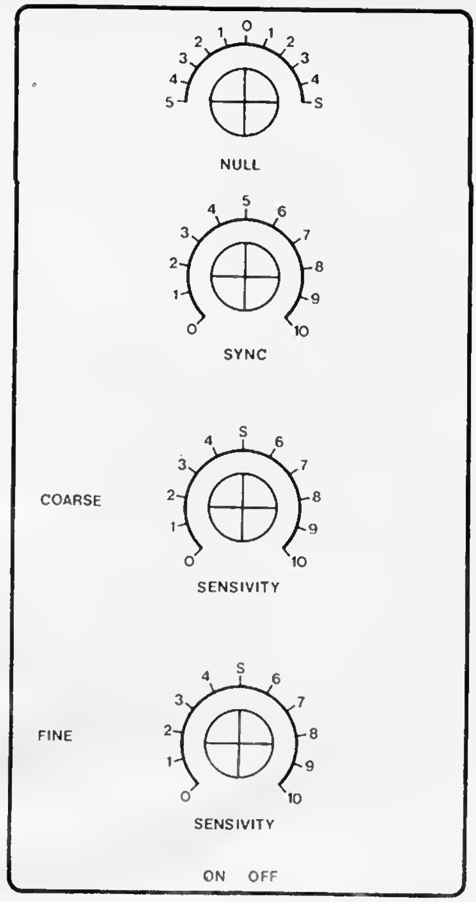


Fig. 5. Suggested lay-out of a front panel for the metal detector.

NEWS • NEWS • NEWS • NEWS • NEWS

IN THE FOOTSTEPS OF MARY SHELLEY?

Computers are now so much part of our daily lives that we tend to forget that the most powerful computers are not built of silicon devices, but are carbon-based. They are, in fact, human brains.

The Science and Engineering Research Council—SERC—has recently announced a multi-million pound research project which has as its ultimate aim the development of a chemical computer that will operate in the same way as the human brain.

A number of electronics companies and universities will collaborate under the project, called MERI—Molecular Electronics Research Initiative. MERI is intended to keep Britain in the forefront of advanced computer technology although the Japanese are also known to be working on the development of an organic computer.

The idea of a molecular computer was first suggested by Forest Carter an American scientist as a means of overcoming heat dissipation problems in electronic computers.

Living organisms are made up of carbon-based compounds, better known as organic compounds, that interreact to make possible, among many other things, such functions as thinking. Under the MERI, biologists and electronics experts will work side by side to engineer carbon-based chemicals that can replace electronic components now made from silicon. These chemicals will be able to interact at molecular level and will, therefore provide enormous computing power in a very small space.

Since molecules are interconnected in three dimensions, the computer based on them would be able to use parallel processing making it very fast. It would also be better at pattern recognition than conventional computers.

ofcourse, a working model of the molecular computer will probably not be ready until the turn of the century, but there will undoubtedly be many important spin-offs during its development in the form of improved electronic components.

It remains to be seen how the chemical computer will compare with the photonic computer, now also under development both in Britain and in the USA. It is, however, interesting to note that the Science and Engineering Research Council has decided to fund the former to a very much larger extent than the latter.

It is thought-provoking to speculate on what the chemical computer will eventually consist of. After all, once molecular electronics has proved successful, the way will be clear for a legitimate marriage between physics and biology. May we then look forward to a truly biological computer made by a modern Prometheus?

SPEECH RECOGNITION SYSTEM

A breakthrough and the prospect of a radical advance in the way man relates to machine has been achieved by Marconi Speech Systems, a GEC company, with its MACROSPEAK Speech Recognizer.

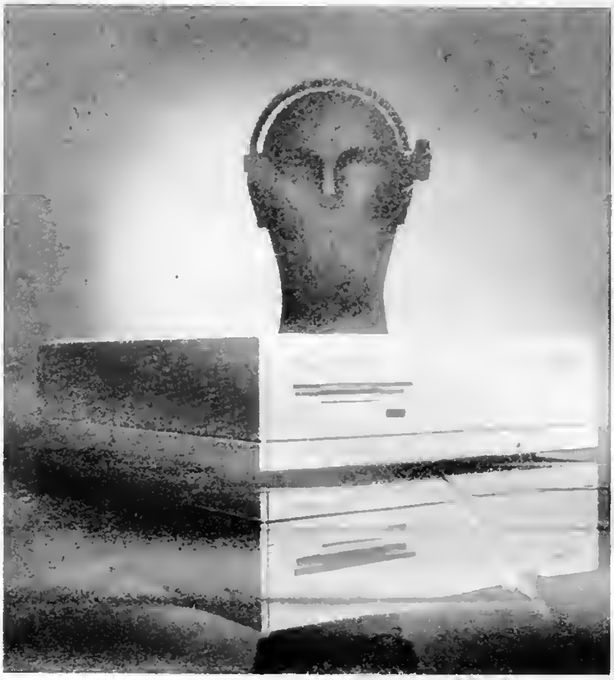
The most rapid, universal and simplest form of human communications is speech. Speaking rates of 180 words per minute are quite typical, yet even a relatively slow rate of 100 words per minute is still much faster than an average typist. Speech recognition however involves solving many complex problems. For example:—

- A speaker says the same word differently every time. We naturally accept these variations when listening.
- Words spoken in isolation are often very different from the same words in normal speech. We say 'to', and we write 'twenty to two', but in the latter case most of us actually say 'twenty 't' two'.
- IFTEXTWASWRITTENINTHE SAMEWAYASWESPEAKITW OULDLOOKLIKETHIS. Another problem for a recognizer is therefore to distinguish each word from a spoken phrase or sentence.

Human speech recognition starts in the ear where the cochlea provides a detailed analysis of the acoustic signal which is then processed by millions of interconnecting nerves. We then naturally use a combination of:—

- *Phonetic knowledge*, that is, knowledge of the spectrum and time information of sounds.
- *Syntactic knowledge*, that is knowledge of word order rules of our language.
- and *semantic knowledge*, or knowledge of what words mean, to achieve correct recognition.

In the past speech recognizers have rarely been able to solve the complex problems or incorporate human recognition processes. Speech recognition systems have often been large, expensive, inflexible and cumbersome to use. MACROSPEAK, however, is a high performance, compact device that is commercially cost effective, flexible and simple to operate.



It can recognize up to 640 words in real time with a very high percentage of certainty, and what's more you speak naturally and not in an isolated 'dalek' type manner.

MACROSPEAK is the product of eighteen months intensive development conducted at Portsmouth-based Marconi Speech Systems. It successfully blends leading-edge know-how with low-cost micro-electronics and surmounts many of the problems that have, to date, limited the widespread use of commercial speech recognizers.

The spoken word has long been [illegible]d as the ultimate replacement for the computer keyboard in man-machine operations. Indeed, a number of such man-machine interfaces have appeared in recent years, aimed at the professional and consumer markets. And one recent US survey* forecasts a $1 billion domestic market for professional speech recognition products by the end of the decade.

Yet, the human voice has been notoriously difficult to recognize. The nature of speech is a poorly-understood process, a problem compounded by the voice pattern that is unique to each and every individual. For this reason — and despite the hype adopted by some manufacturers — speech recognizers of the past have suffered severe practical limitations. For example:

- Limited vocabularies.
- Lengthy and tedious first-time sampling routines whereby users 'teach' the recognizer to respond to their individual voice patterns.
- Slow, error-prone recognition.
- An inability to respond in real time to naturally delivered speech, i e spoken in connected groupings such as phrases.
- Expensive hardware or software modifications needed for the system integration.

When high unit cost is added to these failings, such products have generally tended to offer doubtful value for money.

A proven pedigree

Marconi has overcome these limitations with MACROSPEAK by capitalizing on its twenty years of work in speech processing. Since 1981, this work has focused on the company's SR-128 equipment, the world's first stand-alone connected speech recognizer. It has proved to be a product that retains user

Table 1

Technical Specification

	Standard Model	Enhanced Model
Maximum number of words	160	640
Maximum duration of stored speech	51 seconds	205 seconds
Maximum number of syntax nodes	50	200
Maximum number of macros	200	800
Maximum number of macro characters	2000	8000
Maximum number of training text characters	1600	6400

Interfaces:

Dual RS232C Ports, full Duplex
Baud rate — user programmable up to 9600 Baud
Parity — user programmable
8 Bits Data word
Stop Bits — user programmable

Speech Input — local at microphone level, remote at line level
Power Supply — 230/115 Vac mains, 20W
Office Model Dimensions — Width 310mm, Depth 386mm, Height 93mm

* Probe Research Inc., Morristown, NJ.

credibility in demanding civil and military applications, British Telecom, Smiths Industries, Plessey, Ferranti, British Airports Authority, The Post Office and the London International Financial Futures Exchange are some representative users of this high performance equipment.

Perhaps the SR-128's greatest success has been achieved in flight trials conducted by the Royal Aircraft Establishments at Bedford and Farnborough. These have clearly established the benefits of speech recognition in the cockpit, principally as a means of reducing aircrew workload. These trials, and their highly promising results, culminated last year in the award of a Ministry of Defence contract, following competitive tender, under which Marconi Defence Systems and GEC Avionics are pioneering the UK's first dedicated 1000-word airborne speech recognizer.

A powerful new voice

MACROSPEAK builds on the reputation of the SR-128 by incorporating new lost cost technology, a refined algorithm and easy-use features. The result extends practical, effective and affordable speech recognition to a host of every-day professional computer-related activities.

Built for the world of work

MACROSPEAK has been built to appeal to first-time users who may be totally unfamiliar with a speech recognizer. Its modern, uncluttered looks result from a design precept that gave high priority to simplified operation and suitability for the workplace.

The unit is connected to the RS-232 interface of any VDU supported computer or system using the supplied lead. The application text is typed in: the system trained with one's voice, and all the information saved to disk. This initial set-up is a once-only process which does not have to be repeated in day-to-day use. MACROSPEAK is now ready for future operation, a simple procedure which involves switching on MACROSPEAK, loading the applications disk, and speaking into the microphone.

Using the supplied microphone, key words and phrases are spoken into the unit (up to 160 words for the standard model, and up to 640 words for the upgraded unit). Words are accepted instantly, verified on the VDU and the voice pattern is stored on the disk ready for future use.

Any number of users can programme their voice patterns using separate disks, and a single utterance of each key word or phrase is all that is required during each teaching session.

Being 'transparent' in operation means that MACROSPEAK gives its operator the choice of voice and/or keyboard entry. Its small size — just 310×386×93 mm — makes it a practical desk-top peripheral, and the unit can operate in a vertical position where space is at a premium.

Industrial users may well wish to site MACROSPEAK in areas subject to high levels of ambient noise. Marconi has significant experience in the successful application of speech recognition in high-noise environments and MACROSPEAK includes as standard a noise masking facility to retain recognition performance in such conditions.

3-D voice template

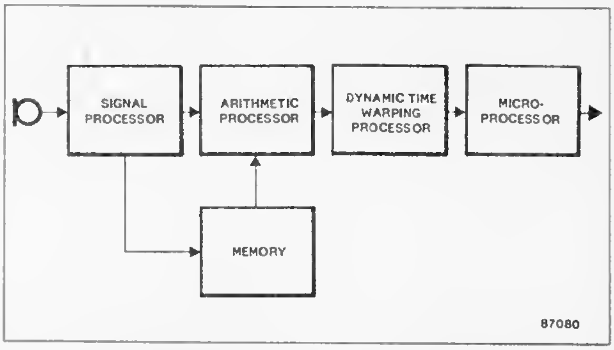
MACROSPEAK uses a spectral technique known as 'whole word dynamic time warping pattern matching' to compare spoken with stored words. The algorithm is implemented on two custom 3-micron Silicon-on-Sapphire LSIs designed by the Marconi Speech Systems and produced by Marconi Electronic Devices Limited.

The first is an arithmetic processor which calculates the distance between the acoustic input and the stored spectral patterns on a frame-by-frame basis. The second contains the algorithm which undertakes the pattern matching process. A 68000 32-bit processor completes the heart of the system.

In simplified terms, the recognition process compares the spoken words against the spectrogram, or three-dimensional voice template, compiled during the initial teaching session. Inputs are matched against time, frequency and energy parameters that have been loaded into memory from the disk. Recognized words are passed to the internal macro processor which converts them into output characters. The entire process is performed in real time, even in the continuous speech mode.

Say less, do more

Although MACROSPEAK responds directly to a large vocabulary of user-defined words, its capability can be further enhanced by using the built-in macro facility. This Marconi-patented feature can be programmed by the user who initially types in each macro command against menu-driven prompts. These



Block schematic of the MACROSPEAK Speech Recognition System

Principal MACROSPEAK features include the following:

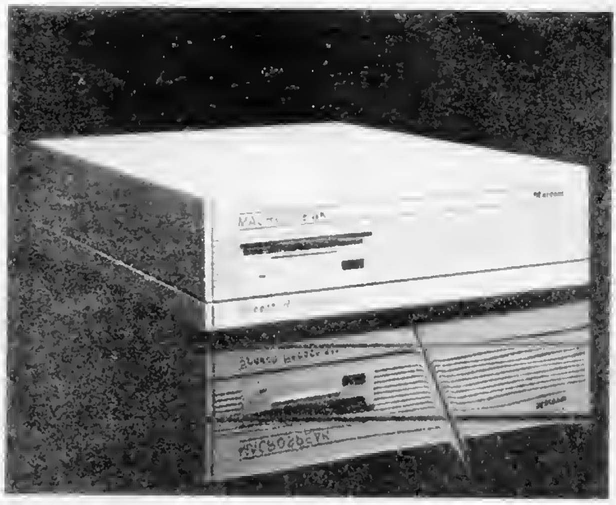
- Accurate and reliable recognition performance
- Simple Interfacing
- Low cost
- Large vocabulary — 160 words or 640 word capacity
- Easy installation
- Single Pass training
- No host software or hardware modifications necessary
- Macro command facility
- Continuous recognition
- Rapid response time
- Local storage of applications on 3.5 inch disc
- Syntax option to enhance performance
- Accepts any language or dialect
- Special purpose LSI devices designed-in
- Provision of 'score' information of recognized words
- Single board design
- Voice switching capability
- Menu driven set up
- Choice of office or industrial models
- Compact size

are then stored in memory and may be saved and loaded from the disk. Macro capacities for the 160 word standard and 640 word upgrade models are 200 and 800 commands respectively. An idea of the practical advantages of this facility can be gained from the following simple examples.

1. A MACROSPEAK user requires the recognizer to respond to a series of spoken inputs as follows:—
"twenty"........to be output as '20'
"two"...........to be output as '2'
So far, so good. But the recognizer, acting on the above rules, will interpret the input "twenty two" as '202'. A macro command will automatically suppress the '0' and output the desired '22'.
2. Marconi believes that the powerful macro facility will allow System Houses to produce elegant customized solutions for specific application areas thus extending the potential for MACROSPEAK.
3. One simple spoken phrase "Run Default Parameters", for example, can be interpreted into a whole sequence of host interactions in order to access or set up a user system. In fact, standard letter formats could be called up and created with a few words!

User-defined syntax

Another standard feature of MACROSPEAK is its user-definable syntax. This imposes a set of grammatical rules, important with the size of vocabulary being handled. Consider a database containing, in total, several hundred words representing menu options. In use, perhaps only a handful of these are immediately available. Syntax rules ensure that only a limited number of words need to be active at any one time. This improves recognition performance and can be employed to reduce the size of the active vocabulary. As with the macro feature, the operator can define these rules by typing in against menu-driven prompts in MACROSPEAK set-up mode.



Applications

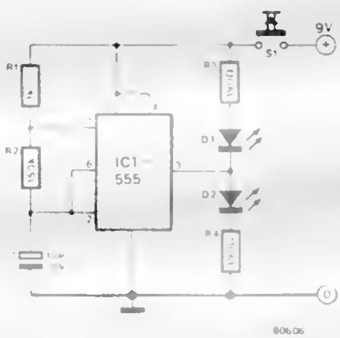
Some of the many applications include:

- Data base enquiry
- Quality control
- Banking and insurance — dealer rooms
- Baggage handling (sorting)
- CAD/CAM
- Research and development departments
- Simulator control
- Computer systems (immediate data entry)
- Medical data input
- Spreadsheets
- Process control
- Map plotting (digitizing)
- Aviation and Air Traffic control
- Stock control
- Military command and control
- Education (speech therapy)

Pre-production quantities of the MACROSPEAK Speech Recognizer have already been undergoing trials and evaluation with a number of organizations.
An interesting use of MACROSPEAK is in China, where an important element in the current Five Year Plan is a long-sought simplification of its commonly-spoken yet highly-complex written language.
Sindex Speech Technology Ltd of London has been using MACROSPEAK for voice control of their Chinese text editor for over a year.
Like many other organizations, Sindex is finding that one successful application leads to another. The company is so satisfied with the overall performance of MACROSPEAK that it will be using the system in development work it is carrying out under the Alvey Directorate's Speech Recognition Research Programme.

SIMPLE 555 TESTER

The versatile 555 timer IC has the habit of turning up in wide variety of circuits. As it is such a useful little device it has become very popular over recent years. Although the 555 is generally very reliable, there are occasions when malfunction does occur. The circuit shown here will provide a simple and effective method of testing suspect devices.
The timer to be tested, IC1, is connected as an astable (free-running) multivibrator. When the 'push to test' button (S1) is closed capacitor C1 will start to charge up via resistors R1 and R2. As soon as the voltage level on this capacitor reaches the trigger point of the timer the internal flip-flop is activated and pin 7 is taken low to discharge C1. The flip-flop is reset when the voltage on C1 reaches the threshold level of the IC. This takes pin 7 high and the charge cycle starts once more.
The output of the timer (pin 3) is connected to a pair of light-emitting diodes. When the output is high LED D2 will be on and D1 will be off.



Conversely, when the output is low D1 will be on and D2 will be off. The LEDs will flash on and off alternately — provided, of course, that the IC under test is a good one.
For readers who may have other applications for the circuit and who wish to alter the frequency, the rate at which the LEDs flash is determined by the values of R1, R2 and C1. The frequency of oscillation can be calculated from the formula

$$f = \frac{1.44}{(R1 + 2R2) \times C1}$$

If, as in this case, the value of R2 is much greater than the value of R1, the frequency can be approximated from the following:

$$f \approx \frac{0.72}{R2 \times C1}$$

For the values shown in the circuit diagram the frequency works out to be around 0.5 Hz.
The tester can be made very compact by soldering all the components directly to the IC test socket, which is first mounted through a hole in the upper surface of the box or container to be used. Alternatively, the components can be mounted on a small piece of Vero-board or similar. Current consumption is minimal and the unit can be powered from a single 9 V battery

DECODING SATELLITE TV SIGNALS

by J & R v Terborgh

Unravelling the mysteries of the two encoded TV channels on ECS-1 merely requires an oscilloscope, some insight into the composition of a video signal, and. . .a handful of standard parts from the junkbox.

Broadly speaking, satellite TV transmissions are encoded to ensure the income of transponder leaseholders. Ideally, the decoding of the relevant channel is so intricate as to require the use of a special decoder unit, which cable authorities, and sometimes individual viewers, purchase or lease from the satellite broadcaster's viewers registration department. In this way, these (commercially operating) broadcasting stations can keep an account of the number of viewers of their satellite service, and are thus in a position to raise a fee for authorized reception of the programme.

In the case of Sky Channel, the first all-commercial European satellite TV service to come into existence, the underlying reasons for encoding their popular programme were in principle not aimed at regulating the programme penetration. Since the Eutelsat 1-F1 (ECS-1, OP 13° E) was—and still is—a *communication service satellite*, international regulations initially prohibited the transmission of a standard PAL TV service via satellite. A compromise was then found by arranging for the Sky Channel signal to be beamed down in encoded form, so that it could no longer be considered PAL compatible, i.e., it was to become a communication rather than a TV signal. The encoding system was supplied by OAK-ORION, and this has been in service ever since the first test transmissions.

The purpose of the present article is to show how encoded satellite TV signals can be restored for normal viewing. As a practical example of how to go about doing this, it will be demonstrated how an experimental Sky Channel decoder was developed from an analysis of the encrypted vision signal with the aid of an oscilloscope, and how a simple circuit was designed that largely eliminates the effects of the encoding procedure. From the onset, however, it must be made quite clear that the analysis of the encoded Sky Channel vision signal refers to that as transmitted from ECS-1, transponder 6WH. This is *not necessarily* the same signal as that available on a radio & TV cable network, because additional encoding components often originate from the head-end station.

Sky Channel: an analysis

Constructors of the Elektor Indoor Unit for Satellite TV Reception[1] will no doubt have noticed the unintelligible pictures from Sky Channel. In most cases, the screen shows but a confused mess of B&W areas, and the TV set refuses to synchronize. Sometimes the picture is in colour, then reverts to monochrome again, and it seems to wobble and tear at random. The only facts that can be established are that the picture is inverted, and that the main sound channel is, fortunately, left uncoded.

Initially, the IDU was tuned for highest S-meter deflection on Sky Channel, and an oscilloscope was brought into action to observe the CVBS signal. The essential conclusions of the measurements are shown schematically in Fig. 1. As could be expected from the inability of the TV set to produce at least a synchronized image, the line and raster blanking intervals in the signal have a rather peculiar content. There is no proper sync pulse during the line blanking, but instead a 6-period burst of 2.5 MHz (0.4 μs), followed by a SIS (sound-in-sync) block. On some TV sets, these signals are visible to the right of the picture as a set of 6 vertical white lines, and an adjacent bar containing what looks very much like AM picture noise. Returning to the upper waveform presentation in Fig. 1, it is seen that the colour burst is left uncoded and located in accordance with the PAL standard. As to the raster blanking, there is a rather longer 2.5 MHz burst, followed by the usual VIT lines and the Teletext block. It must be pointed out that the illustrations in Fig. 1 are purposely simplified. Not shown, for instance, are the variable length of the raster sync burst, and the effect of interlacing in the line blanking period. There is much more to the composition of the OAK-ORION signal, but a detailed description of its technical characterists would be beyond the scope of this article. The above observations readily lead to formulating the function of a design for a decoder as follows: the 2.5 MHz bursts must be detected and used to control a circuit that arranges for the generation of standard PAL line and raster blanking periods, complete with stable sync pulses.

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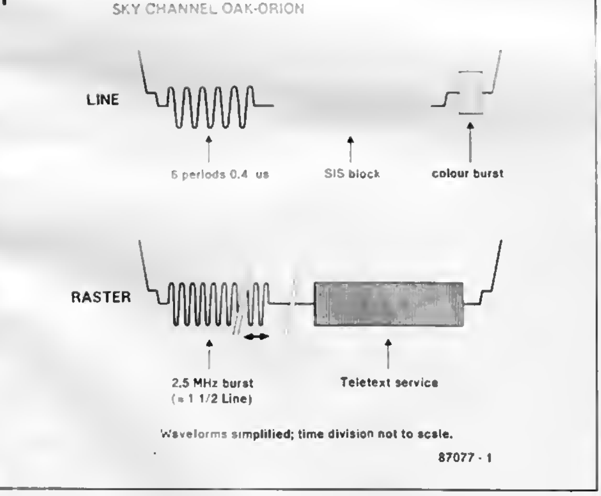


Fig. 1. Essential characteristics of the OAK-ORION picture scrambling method.

A practical circuit

The proposed, experimental, Sky Channel decoder is composed of standard components only, and its circuit diagram appears in Fig. 2a.

The inverted composite video signal (denotation: $\overline{\text{VIDEO}}$) from Sky Channel is taken from the NE592 differential amplifier on the vision/sound/PSU board in the Elektor IDU (see reference [1]). The 2.5 MHz compo-

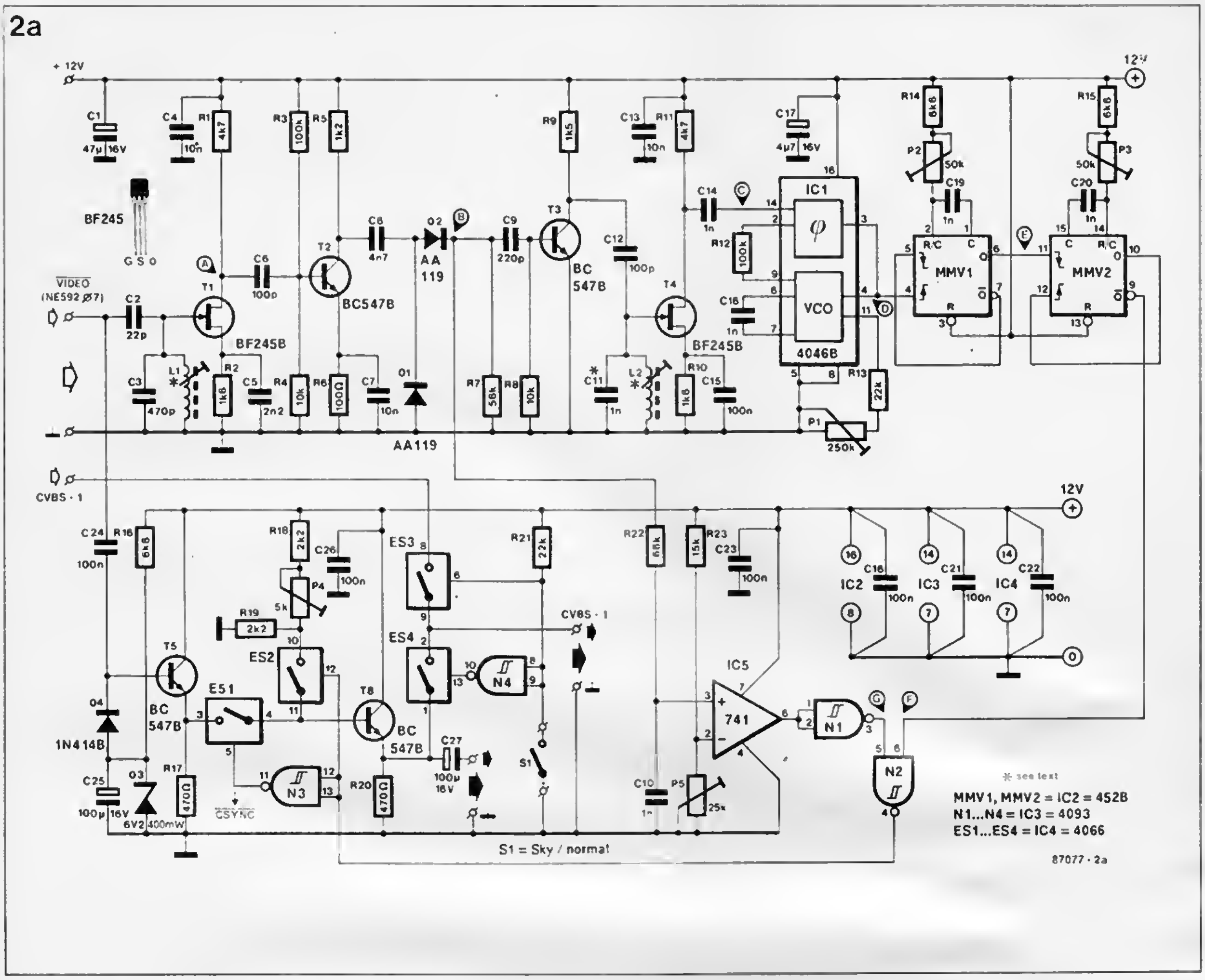
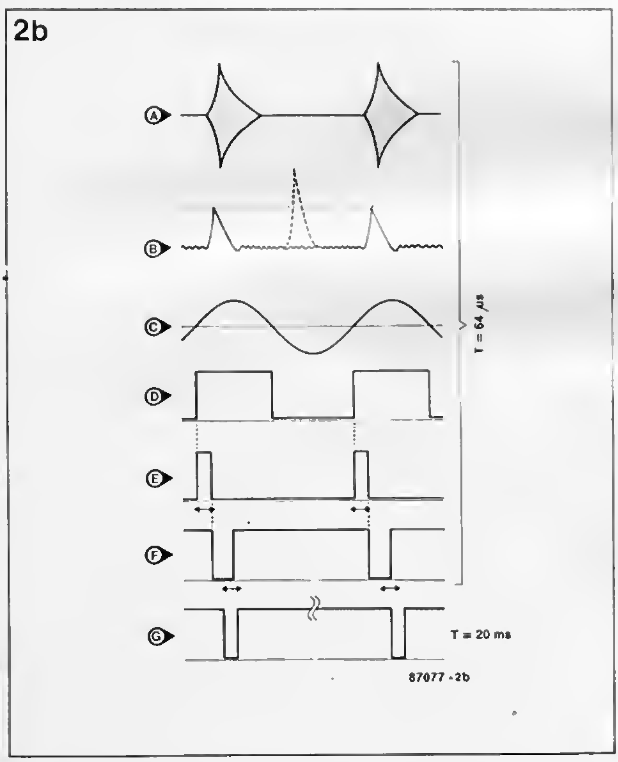


Fig. 2. An experimental Sky Channel decoder for incorporation in the Elektor Electronics Indoor Unit.



nent is extracted from this signal with the aid of tuned circuit L_1-C_3, and amplified by FET T_1, whose high gate impedance ensures the required Q factor and hence the selectivity of the L-C combination. The still relatively weak 2.5 MHz bursts are amplified in T_2 and then recified with D_1-D_2 and the parasitic capacitance of the base of T_3 and its R-C input network. With reference to the pulse legend shown in Fig. 2b, it is seen that point B carries the raw form of the line and raster pulses, obtained by rectifying the 2.5 MHz bursts. The raster pulses are readily obtained separately by attenuating the line pulses in low-pass R_{22}-C_{10} and then using a comparator, IC_5, to ensure that noise and spurious low-frequency pulses are adequately suppressed. Schmitt-trigger gate N_1 inverts the raster pulses, and feeds them to sync combiner N_2.

The generation of usable line sync pulses from the 6-cycle 2.5 MHz bursts requires a more elaborate circuit than that for the raster pulses. the negative-going line pulses at the collector of T_3 are capacitively fed to phase control tuned circuit L_2-C_{11}, which is dimensioned for resonance at 15,625 Hz precisely. Since inductors for this frequency are fairly cumbersome to make with pot cores and long lengths of thin enamelled wire, it was considered convenient to use the relevant L-C combination salvaged from a line oscillator on an old TV chassis. The line frequency signal at the drain of T_4 is a fairly clean sine wave with sufficient amplitude to drive phase locked loop (PLL) IC_1, whose centre VCO frequency is determined with C_{16} and R_{13}-P_1. The PLL functions as a flywheel circuit to stabilize the frequency and the phase of the line sync pulses. Its 15,625 Hz output signal at pins 3 & 4 is a rectangular wave with a duty factor of 50%. The position and the width of the line sync pulse is set with P_2 and P_3, respectively. Monostable MMV_1 triggers on the leading edge of the incoming signal, provides a delay set with P_2-C_{19}, and in turn triggers MMV_2 with its output signal Q. As MMV_2 is connected to trigger on the trailing edge of the needle pulse from MMV_1, preset P_3 can be adjusted to give the correct line sync duration. Note that both monostable multivibrators in the 4528 are set up in the non-retriggerable mode. NAND gate N_2 combines the raster and line sync pulses into a composite sync signal, CSYNC, while inverter N_3 provides $\overline{CSYNC}$.

It was already stated that Sky Channel transmits inverted video. This is readily remedied by using the $\overline{VIDEO}$ output of the NE592, as set out above. The circuit around T_5 and D_3 is a clamping anti-dispersion buffer, whose operation was discussed in [1]. It will be understood that the sync pulses obtained with the previously described circuit sections must replace the encryption signal shown in Fig. 1. This is effected with the aid of inversely controlled electronic switches ES_1 & ES_2, and biasing network R_{18}-P_4-R_{19}. When $\overline{CSYNC}$ is inactive, i.e., the output of N_3 is logic high, ES_1 is closed, and ES_2 is consequently open, so that the video signal from T_5 is passed to emitter follower T_6, which outputs it via C_{27} and ES_3. When $\overline{CSYNC}$ is active, ES_1 is open, and ES_2 is closed, so that the base of T_6 is pulled down by the potential at junction P_4-R_{19}. Preset P_4 therefore determines the potential of the bottom of the sync pulses. Note that the blanking level of the signal is left unaltered; the decoded sync pulse simply takes the place of the 2.5 MHz burst and a certain portion of the SIS block. Provision has been made to pass the decoded Sky Channel programme to the remodulator in the IDU. This is done with the aid of ES_3, ES_4, inverter N_4, and switch S_1. The function of this circuit is so simple as to obviate the need for a detailed discussion.

Construction and setting up

Experienced constructors will have little difficulty in building the circuit on a piece of prototyping (vero) board. The $\overline{VIDEO}$ and CVBS-1 connections to and from the decoder should preferably be made in thin, 50-75 Ω coaxial wire, and the decoupling capacitors in various locations must not be omitted if the circuit is to work optimally. Do not be tempted into using a ready-made choke and a trimmer capacitor for the 2.5 MHz tuned circuit, as this must have the highest possible Q factor to preclude erroneous operation of the circuit owing to the detection of the colour burst and other high-frequency components in the composite video. If you have a GDO, it is probably not very difficult to make an L-C combination that yields a strong dip at 2.5 MHz. For the prototype decoder, 50 turns of SWG30 enamelled wire were wound as a double layer on a Type 10K1 former from Neosid.

Before fitting the tuned circuit for the line frequency, L_2-C_{11}, make absolutely sure that this can be tuned to 15 625 Hz. Even if you have an existing L-C combination from a TV set, it is still necessary to find its optimum resonance frequency with the aid of a function generator and an oscilloscope. Practice has shown that most line oscillator coils have such a high inductance as to require a capacitor from a very limited range for resonance at the line frequency. Do not wonder, therefore, when it is found that, for instance, both a 1n0 and a 1n2 close tolerance capacitor fail to produce resonance when the core in L_2 is set to mid-travel. In this case, the value of the capacitor must be determined by trial and error connection of small capacitors in parallel with the 1n0 type. The resonance frequency of the L-C combination can only be found if the generator signal is applied via a small (47p) capacitor, and if the scope probe is set to 10:1 attenuation.

An oscilloscope is indispensable for aligning the completed circuit. The pulse legend shown along with the circuit diagram should help in locating constructional errors and incorrectly aligned circuit sections. Initially, all presets should be set to the centre of their travel. Commence with peaking L_1 at 2.5 MHz. This is readily done by adjusting the core for maximum amplitude of the bursts that appear at point A. Carefully reduce the amplitude of $\overline{VIDEO}$ (P_1 in the IDU) if spurious signals remains visible at A when the Q factor of L_1-C_3 is known to be sufficiently high. Set P_5 such that IC_5 outputs raster pulses only. In most cases, a satisfactory adjustment is reached when the voltage at pin 2 is about half the peak voltage of the raw raster pulses at test point B. Clean raster sync pulses should now be present at the output of N_1.

Tune L_2 for resonance, i.e., for maximum amplitude of the sine wave at point C. Connect a high-impedance DVM to IC_1 pin 9, which is temporarily decoupled to ground with a 1n0 capacitor. Adjust P_1 such that pin is at half the supply potential.

Observe the negative-going signal at point F to see whether P_3 can be used to adjust the pulse width. It is then time to monitor the composite video output and make sure that the generated line sync pulse occurs at the right instant during the blanking period. Redo the adjustment of P_2 (sync pulse position) and P_3 (sync pulse width) until the TV produces a synchronized image. The setting up procedure is concluded with the adjustment of phase control L_2, which enables the picture to be shifted horizontally until the SIS block is no longer visible to the right of the screen.

It must be reiterated that the proposed Sky Channel decoder is an experimental design aimed at the experienced electronics enthusiast, who is willing to examine the basic operartion of the various building blocks in further detail, with an aim to find and use more sophisticated variants for flawless picture decoding of the OAK-ORION signal.

It stands to reason that a simple circuit as shown here is unable to output a stable picture in the absence of a sufficiently strong satellite signal; the operation of the PLL obviously improves with an increase in the C/N ratio obtained from the outdoor unit.

The picture from Sky Channel before (left) and after (right) decoding with the circuit described here.

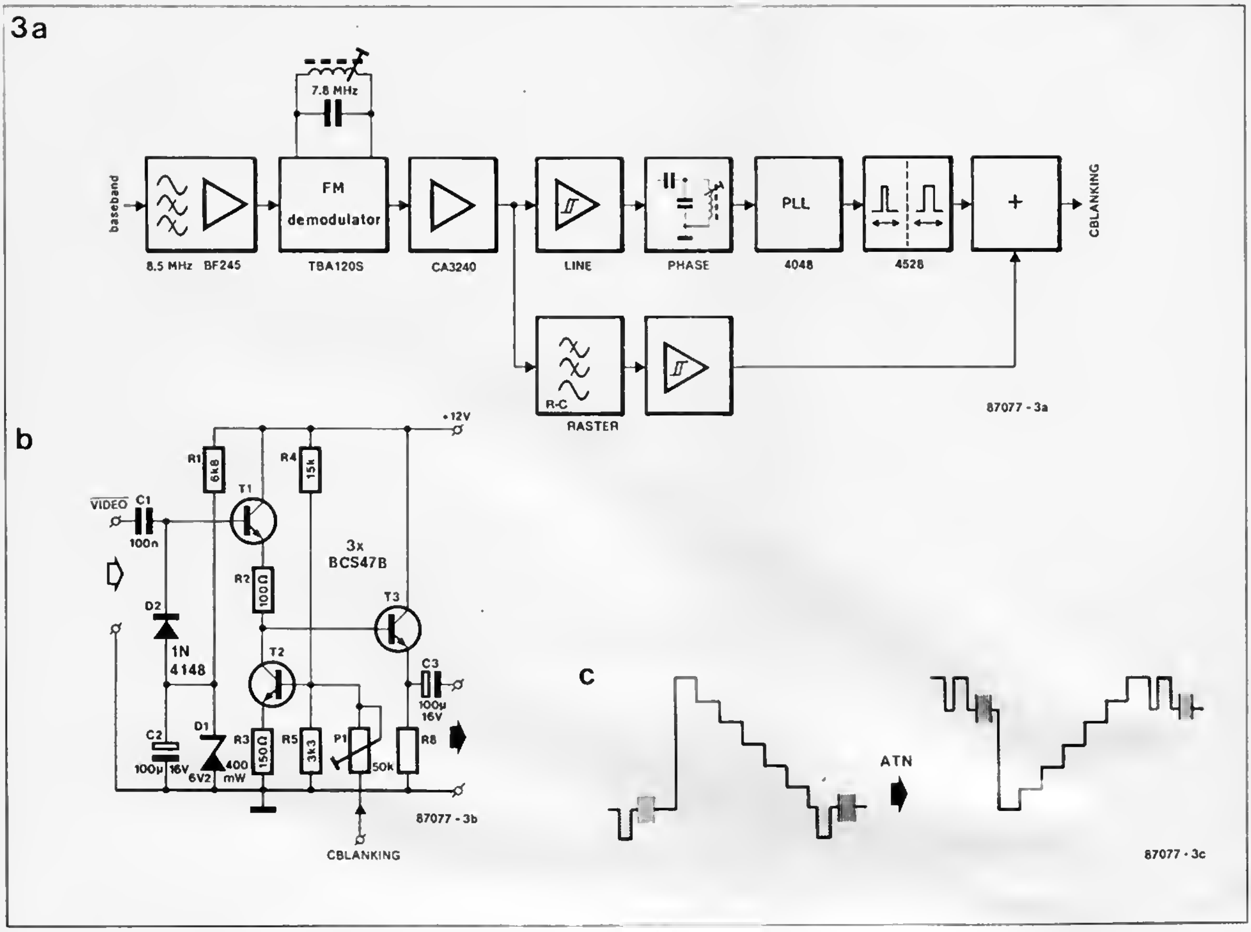


Fig. 3. Design idea for an ATN Filmnet decoder.

The slight horizontal instability of the decoded picture is probably caused by the phase shift of the line sync pulse after the writing of the first 312.5 lines in the interlaced frame. The PLL then briefly loses lock and its VCO runs free, which may result in a slightly unstable line sync pulse. The counteracting of this effect may well require the use of an externally synchronized TV pulse processor, such as the Type S178 from Siemens.

Over to you: ATN Filmnet

ATN Filmnet is a pay-TV channel on the 9VW transponder of ECS-1. Since September 1st of last year, this station transmits its programmes in encoded form, but remains interesting for its pick of English-spoken films, which are mostly subtitled in Dutch. Subscribers to this channel have a choice of three programme levels, for which they pay the appropriate fee. The decoders are remote controlled, i.e., enabled and disabled in accordance with the particular "viewing level" of the subscriber. This is done with the aid of a digital signal in the upper region of the transponder's baseband spectrum. Unlike that from Sky Channel, the signal from ATN Filmnet does contain properly dimensioned sync pulses that occur at the right instant during the blanking period. The signal is still encoded, however, since the video signal and the sync pulses are inverted—see the waveform illustration in Fig. 3c. This means that the TV set is unable to discern a proper blanking period. The sound signal from ATN is left uncoded at about 6.5 MHz in the baseband. The fact that the blanking level is the same as that of certain portions of the video signal makes it impossible to operate a decoder on the basis of level detection.

The solution to the decoding mystery of ATN Filmnet can be found in the versatility of the Elektor IDU, which features a continuously tunable sound receiver. Apart from its main audio intercarrier, compressed stereo signal, and subscribers control data, ATN Filmnet also transmits the composite blanking signal at about 7.6 MHz. This signal is clearly audible as a deep rattle when the sound receiver is tuned across its range.

In conclusion of this section, Fig. 3a shows the block diagram of a suggested ATN decoder, based on building blocks described in this article and in [1]. Remember to limit the bandwidth of the input signal to 100 kHz or so, and make sure the de-emphasis capacitor for the TBA120S FM demodulator is kept relatively small to avoid suppression of the line sync pulses. As the shifting down of the blanking level is probably the crucial point in your experiments, a detailed circuit of this section of the decoder is included in Fig. 3b. During the CBLANKING periods, T_2 acts as a current source in the emitter line of T_1, and hence lowers the base voltage of T_3 when the blanking period is due. This results in a picture that is of remarkable quality considering the simplicity of the proposed design.

As the decoders for Sky Channel and ATN Filmnet have certain circuit sections in common, the construction of a two-standard decoder extension for incorporation in the IDU is relatively straightforward. Simply use and combine the previously detailed circuits: the FM demodulator in the ATN decoder, for instance, can be a virtual copy of the one on the vision/sound/PSU board in the IDU (use a quadrature coil for 7.6 MHz instead of 10.7 MHz (L_{17}), and use a 2n2 capacitor for C_{87}).

Digital encryption

The two previously discussed satellite TV channels operate on the basis of substitution of the sync and/or blanking pulses by signals or DC levels that upset the operation of the synchronization separation circuit in the TV set, and so make it impossible to obtain a stable picture in the absence of a decoder-interface. These encoding methods are generally classified as analogue, and can not be made more complex in view of the limitation on the bandwidth available for the particular channel. Digital encoding offers a far higher security level for satellite broadcasters, but suitable systems are complex and expensive. Some programmes on Northern American satellites (4 GHz band) are transmitted with a very hard to discover algorithm for the picture line order, while others can not be seen in colour, because the 3.58 MHz burst (NTSC system) is phase-shifted in a particular manner. But the toughest task for even the most skilled of satellite "hackers" is yet to come. The MAC system (Multiplexed Analogue Components) that will be used on the future DBS services has a built-in provision for a very secure, all-digital, picture scrambling method, which is far more difficult to decode than any of the European or American systems hitherto used on satellites.

In a D2-MAC signal, the scrambling sequence is generated by a pseudo-random binary sequence generator (PRBS), which operates at a clock speed of 10.125 MHz. A block of 61,677 bits is scrambled by modulo-2 addition of the PRBS sequence. The PRBS generator is initialized every 625 lines, such that the first bit of the sequence is added to bit 7 of line 1. The last bit which is scrambled is no. 105 in line 623 in the same frame.

This is not to say that the introduction of D2-MAC means the end of private reception of satellite TV programmes, since that implication would conflict with broadcasters' intentions to reach the largest possible audience with the best techniques available for high-quality reception. The first satellite TV services that will be operated on the basis of the new D2-MAC standard are foreseeably the German and French DBS projects, and these are unlikely to be encrypted, as this would make it impossible for individual owners of receiving systems to benefit from the availability of additional, interesting programmes. For the so-called *pay as you view* system, however, the encryption system offered by D2-MAC would appear highly suitable.

RGK:Bu

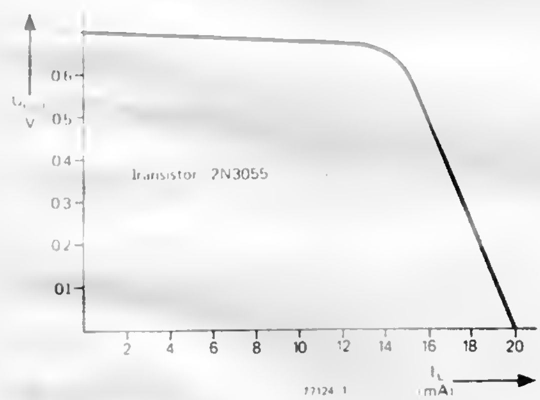
Functional and technical aspects of the MAC video standard will be discussed in a forthcoming issue of this magazine.

Literature reference:

[1] Indoor Unit for Satellite TV Reception, *Elektor India*, October, November, December 1986 & February 1987.

TRANSISTOR SOLAR CELL

1



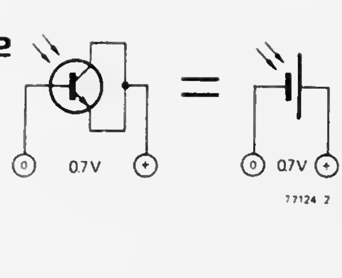
Most amateur constructors will have one or two burnt out power transistors lying about in their junk box. If at least one of the junctions is still intact, the transistor can be converted to a solar cell by filing or sawing off the top of the case to expose the chip.

In strong sunlight a 2N3055, for example, will generate about 0.7 V at currents of up to 20 mA. The graph shows output voltage plotted against load current. As the area of the silicon chip is small compared to a normal solar cell a magnifying glass may be used to focus light onto the junction and so increase the output current. However, this is not to be recommended in very strong sunlight or the junction may be destroyed!

If a good transistor is used then the output current may be doubled by connecting the collector-base and emitter-base junction in parallel, as shown in the diagram. This should not be done with faulty transistors, however, since if the faulty junction is short-circuit it would short the output of the solar cell.

Warning: It is not advisable to use old Germanium power transistors, since these may contain highly poisonous substances. However, a major semiconductor manufacturer has assured us that the more modern silicon devices, such as the 2N3055, are completely safe.

2



AN INTRODUCTION TO D.C. POWER SUPPLIES

by Peter Bardos*

In this article, Peter Bardos explains the basic workings of power supplies and also considers why they do what they do, and why they behave differently from any other piece of electronic equipment.

D.c. power supplies are used in just about every piece of electronic equipment and yet they are taken very much for granted and usually ignored. Nevertheless the modern direct-off-line stabilised switch mode power supply (SMPS) is a highly sophisticated and specialist piece of equipment on which the whole equipment will rely for its safety, stability and long term performance. To explain what a direct off-line SMPS is, this article will first discuss what a power supply is.

Power

Power is defined as the rate of doing work and, in electrical terms, it is given by the voltage multiplied by the current. Energy, which is the related factor, is the capacity to do work and is defined, in electrical terms, as the voltage × the current × the time for which the voltage and the current are present.

The usual source of power is the mains supply. A simple circuit diagram (Fig. 1) of how this works shows a generator (supply) which generates a voltage which is distributed to many different places where different loads are put on the system. For the system to work, the supply of voltage has to be standard and the load current will vary with different loads (resistance). A higher power load will take more current than a low power load, but they will both be rated and operate off the same voltage level which is a standard supply voltage (240 V for the UK domestic supply).

A.c. or d.c.

Having defined the voltage, it is then necessary to decide whether it is d.c. (direct current) or a.c. (alternating current).

Direct voltage is unchanging with time and one terminal of the supply is positive with respect to the other terminal at all times. Examples of direct voltage uses are battery toys (1.5 V), torches (3 V), cars and other vehicles (12 V), telephone system (48 V).

Alternating voltage means that the polarity and magnitude of the voltage of one terminal with respect to the other changes with time. The frequency with which an alternating voltage alternates is called the frequency, and the number indicates the number of times that the voltage goes through a complete cycle of changes in a second. The unit of frequency is Hertz (abbreviated Hz), so a 240 V 50 Hz supply means that the effective value of the voltage is 240 V and in one second it goes through a complete cycle of changes fifty times. The effective value is defined as an alternating voltage which will supply the same power in a resistive load as a direct voltage of the same value. Examples of alternating voltage systems are, domestic mains (240 V, 50 Hz), industrial mains (380 V, 50 Hz), National Grid (11,000 V, 50 Hz).

There are many reasons for choosing 50 Hz as the right frequency, but for the moment it will suffice to consider that this is 3,000 r.p.m., which is a convenient speed to run machinery.

The next obvious question is why bother with two radically different systems, namely, a.c. and d.c.? As Fig. 1 shows electricity has to be generated in one place and then distributed through some distance to different loads in another place. Although there are very many different loads they normally fall into one of three categories: (1) heaters, (2) motors, and (3) electronics. Electronics in this instance covers everything whose primary purpose is not to heat something or move something. As such it includes computers, television, radios, instrumentation of all kinds, and control equipment—to name but a few examples.

So the ease with which electricity can be generated, distributed and used by heaters, motors and electronics needs to be considered. In addition,

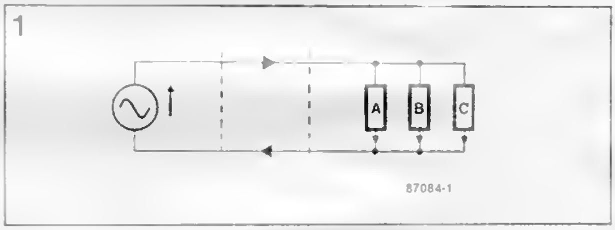


Fig. 1. Basic power supply system.

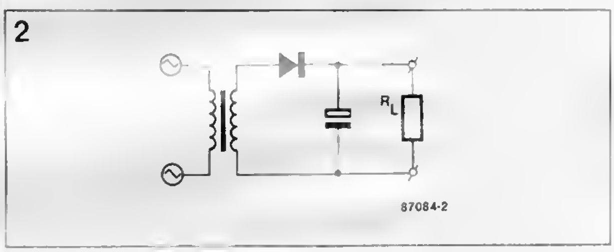


Fig. 2. Basic circuit diagram of a power supply.

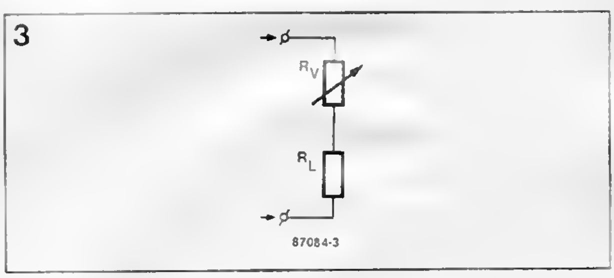


Fig. 3. Stabilisation.

* Peter Bardos is with Advance Power Supplies

electricity may need to be stored, for example, for use with portable equipment. A.c. is much easier to generate and distribute than d.c. but d.c. is required by almost all electronic equipment and is much easier to store. A.c. electricity is more suitable for motors. Heaters are the only sort of equipment that is equally suitable for a.c. and d.c. use.

Power supply

Consequently, the obvious step is to generate and distribute a.c. and then convert it into d.c. for electronics. This is, in fact, one of the functions of a power supply. Other things that a power supply has to do include isolation, changing of the voltage level, and storing energy. Each of these will be considered in greater detail.

The mains supply is "live" and thus has a potential with respect to earth and will give a severe shock to any operator who happens to touch it. Therefore, for the safety of the operator, the power supply has to provide isolation from the mains. The component which does this is a transformer and this will only operate on a.c.

The power supply then has to change the level of the supply since 240 V may be suitable for motors and heaters but electronics like to operate off a much lower voltage, which is normally 5 V-12 V. The component which changes the voltage level is, again, a transformer and, as mentioned previously, will only operate off a.c.

The power supply must also convert the a.c. supply into d.c. as demanded by the electronics load. This action is called 'rectification' and is performed by the rectifier diode which converts a.c. into d.c. with a lot of ripple on it.

Finally, the power supply must be able to store energy. This is needed for two reasons. First, since the a.c. supply alternates continuously it will actually go through zero (i.e. disappear completely) twice every cycle. During these times, when instantaneously there is no input voltage, power to the load will have to be supplied by some other means, i.e., from a store of energy. Second, energy storage is also required to decrease the ripple level that is present after rectification to a low level acceptable by the load. The component which stores the energy is called a "reservoir capacitor" which operates off d.c.

Table 1

LOAD WANTS 5 V
INPUT 5 V WORST CASE, BUT
VARIES UP TO 10 V

INPUT	REGULATOR	OUTPUT	O.K.?
10 V	5 V	5 V	
9 V	4 V	5 V	
8 V	3 V	5 V	
7 V	2 V	5 V	
6 V	1 V	5 V	
5 V	0 V	5 V	
4 V	0 V	4 V	·
3 V	0 V	3 V	·
2 V	0 V	2 V	[illegible]
1 V	0 V	1 V	[illegible]

Having established that to supply an electronics load off an a.c. supply a transformer, a rectifier and a capacitor are required, and bearing in mind that some operate off a.c. and some off d.c., the only way these can be fitted together is shown in Fig. 2, which is a circuit diagram of a power supply.

Stabilisation

For most electronic loads, stabilisation is necessary because the supply is subject to variation in voltage due to input changes and changes in loads. Any power supply is also subject to changes in its output voltage because of variations in temperature and component ageing. In other words, the output voltage of the power supply in Fig. 2 is subject to random changes. With changes of voltages, changes of the performance of the load will occur.

Loads are normally quite sophisticated pieces of equipment (maybe a computer or a TV receiver, or some telecommunication equipment) and so it will be well worthwhile to stabilise the voltage in order to maintain the performance of the load irrespective of the changes mentioned.

The most obvious way to stabilise is to derive from the source more power than needed by the load even under worst case conditions, and then throw away the surplus power when conditions are not worst case. The electronic circuit which does this is illustrated in Fig. 3 and its action is shown in the table. As an example, the table shows what happens when the input to this stabiliser varies from 0 to 10 V when the load actually demands 5 V. Clearly, if the input is less than 5 V, there is not much the regulator can do about it and the load will not operate correctly. Should the input be 6 V however, the regulator will take 1 V leaving the output with 5 V which is what the load demands. Should the input be 10 V, the regulator will take 5 V, still leaving the output with 5 V, and so the regulator will maintain the correct voltage on the load for any input voltage between 5 V and 10 V.

4

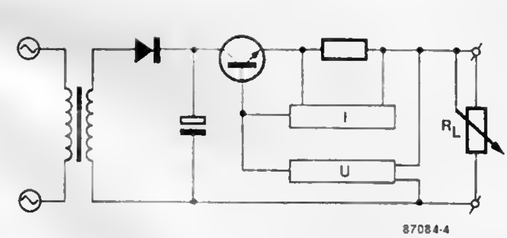


Fig. 4. A linear stabilised power supply unit.

Energy conversion

It all looks very easy but the problem is what to do with the energy which is now put in the regulator. To return to basic physics, energy cannot be created or destroyed but only converted from one form to another. Therefore, the power put into the regulator needs to be converted into mechanical, chemical, potential, kinetic or some other form of energy.

Most users do not like the power supply moving about (mechanical energy), or exploding (chemical), and therefore this energy is converted into thermal energy (heat). In addition, in most processes the conversion of energy from one form into the desired form is inefficient. This inefficiency manifests itself as an unwanted energy conversion into some form other than the desired form (usually heat), which leads to additional increase in temperature. The total increase in temperature is kept to an acceptable level by dissipating the heat. Examples of this imperfect conversion are, for example, converting electrical energy into light (a light bulb) where the unwanted conversion gives rise to heat. Or, for example, in a car where the conversion of chemical energy into kinetic energy gives rise to an unwanted conversion into heat which heats up the engine.

Heat and temperature

The quantity of heat does not equate with temperature. For example, a drawing pin glowing red hot is at an extremely high temperature, but if it is dropped into a bath of water it would not increase the water temperature by a noticeable amount because the quantity of heat in the pin is very small despite its high temperature. In fact, the temperature rise above ambient temperature of a piece of equipment is proportional to the power dissipated by it divided by the surface area.

Heat can be dissipated in three ways: radiation, conduction and convection. Radiation, the method by which the sun warms the earth, warms up the

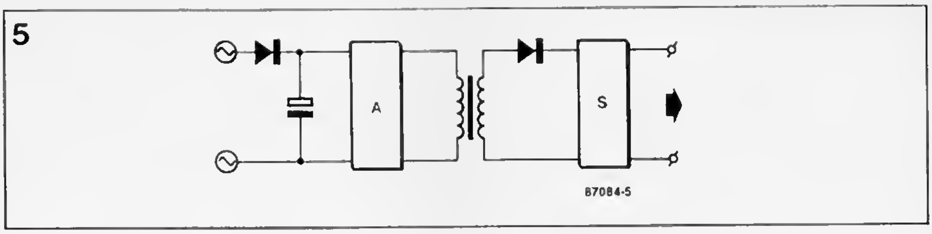


Fig. 5. Direct-off-line switched mode stabilised power supply.

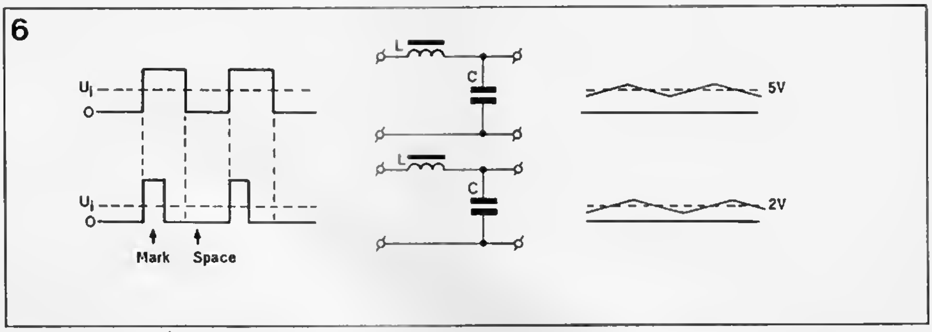


Fig. 6. Lossless regulator: changes in mark/space ratio.

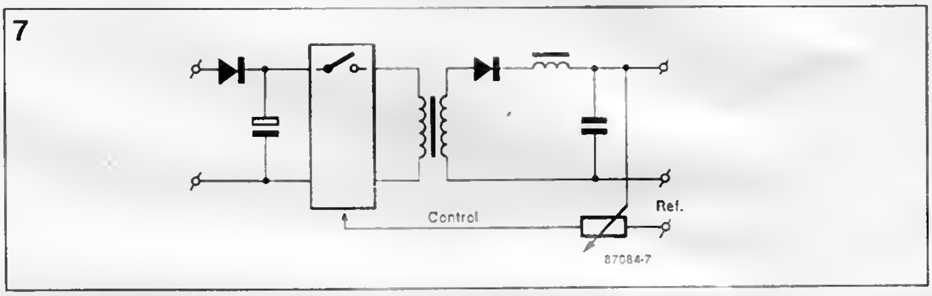


Fig. 7. Direct-off-line switched-mode stabilised power supply incorporating a switching device.

recipient direct without warming up the intermediate material. Such a method is only effective at very high temperatures.

The next method is conduction where heat is conducted to the recipient from the source through a thermally conductive material. This is what happens when you burn your finger on the teaspoon, having left it in the cup. The heat is conducted to your finger through the spoon.

The last method, and that which is most applicable to power supplies, is convection, which operates through the movement of some medium, usually air. Central heating operates in the same way but, unfortunately, the heater is called, popularly, a "radiator", although what it actually does is to convect the heat rather than radiate. Such convection takes place by the source heating the air and the air warming the recipient through circulating from the source.

Efficiency

To return to the regulator in Fig. 3 when the input voltage is 10 V and the output is 5 V the power in the regulator is actually equal to the power in the load. (They both have 5 V across them and they both have the same current through them). Hence, the efficiency of this regulator is 50%. In other words, the power supplied to the system is twice as much as the power required by the load. The implications of this, regarding temperature rise and electricity bills, are quite horrendous.

Taking a closer look at the stabiliser in order to stabilise, three elements are required.

(a) A control element which does the stabilising,

(b) a reference which does not alter at all, and

(c) a comparator which compares the quantity to be stabilised with the reference and then derives a signal which tells the control element what to do to keep the quantity to be stabilised as constant as the reference.

So, in order to stabilise the output *voltage* a *voltage* control element, a *voltage* reference, and a *voltage* comparator are required.

The signal derived from the comparator is normally quite small and insufficient to operate the control element and, hence, the need for a final item, an amplifier.

Linear stabiliser

The circuit diagram of such a system is illustrated in Fig. 5. However, there are some problems with this stabiliser. Bearing in mind that the stabiliser will try to maintain a constant output voltage under any conditions. should an overload condition occur, such as a short circuit, the stabiliser will destroy itself. In addition, as the stabiliser's input power is a lot higher than that demanded by the load, should there be a fault condition in the stabiliser it will destroy the load.

One other problem which needs to be considered is the problem of oscillation which, typically, manifests itself as a howl in a public address system.

To avoid self-destruction of the stabiliser. it is necessary to detect when the overload condition occurs and override the original control signal. This function is called a current limit circuit in power supplies.

The solution to the problem of load destruction is to detect the effect of a fault condition and control the output completely independently. In power supplies this is known as an over-voltage circuit.

The instability problem is solved by correct design but this is more difficult than it sounds as any design necessarily involves a compromise between the achievement of good performance and good stability. Fig. 4 shows Fig. 2 modified with current limit and over-voltage functions, which represents a linear stabilised power supply.

Having designed a particularly good linear power supply with current limit and over-voltage, how could it be improved?

The performance of the linear stabilised power supply is perfectly adequate. In fact it is probably better than is required in a large number of applications. However, the power supply is rather large, heavy and inefficient.

The power supply has a large transformer operating at the mains frequency at 50 Hz. According to theory, the size of a transformer for a given power level is inversely proportional to frequency. Hence, to make the transformer smaller we need to operate it at a high frequency.

The size of the capacitor used in a power supply is determined by the amount of energy that needs to be stored. For the sort of electrolytic capacitors normally used for energy storage, the size of the capacitor is proportional to its CV product. But the energy stored is equal to half CV^2, so the capacitor size for a given amount of energy is inversely proportional to the square root of the voltage. Therefore, to decrease the size of the capacitors the capacitor needs to be operated at a high voltage. Heatsinks are used to dissipate the power lost due to the stabilising process and other ineffeciencies. So, to decrease the size of the heatsinks a way has to be found of stabilising without losing power. This is much more difficult than it sounds, but it is interesting to think that if such a method of stabilising existed the size of the capacitors and transformer would decrease even further because the total amount of power handled by the system would decrease anyway.

The ideal power supply

To make the ideal power supply it is necessary to store the energy at a high voltage, to operate the transformer at a high frequency and to use a lossless stabiliser. Fig. 5 shows such a power supply which operates this way, i.e. a direct-off-line switch mode stabilised type.

The easiest way to operate the energy storage capacitors at a high voltage is to rectify the mains direct, giving a rectified d.c. voltage of some 250-300 V across the capacitor. To operate the transformer at a high frequency the capacitor needs to be followed with a d.c. to high frequency a.c. converter.

The high frequency in this instance is normally between 20,000 to 100,000 Hz, or about 1,000 times faster than the 50 Hz mains supply.

Using the transformer the voltage level can be adjusted and isolation achieved as before. To stabilise the output, the lossless stabiliser is then required.

There are now two new components on the block diagram—a d.c. to a.c. converter and a lossless stabiliser. The simplest form of d.c. to a.c. converter is a switch which is opened and closed regularly. This is, in fact, exactly what is used in a lot of power supplies except that a transistor is substituted for a switch which is being turned on and off regularly.

Switching regulator

Regarding the lossless stabiliser, it is important to remember where this loss comes from. In electrical terms, the power dissipated is given by the product of the voltage and the current that is present across the component. In a linear stabiliser a lot of current and a lot of voltage is present at the same time, by definition, since the way this circuit operates is to dissipate surplus power to achieve stabilisation.

However, if a switch is substituted for the linear stabiliser it can have two different conditions. When the switch is open there are a lot of volts across it, but no current flowing through it, so the power dissipated is zero. In the other condition, when the switch is closed there is a lot of current flowing through it but no voltage across it, so the power dissipated is again zero.

There is a slight problem with this method of stabilisation: the output is either identical to the input (switch closed) or is zero (switch open). What is required is a stable voltage somewhere between these two extremes.

However, if the switch is opened and closed regularly, the average value of the output can be changed by altering the proportion of the time that the switch is closed. All that is required is to add a filter to average and smooth this output waveform. This, then, is a lossless stabiliser. In such a system the output voltage equals the input voltage times the mark to space ratio, and this is illustrated in Fig. 6.

In principle, there is no power lost at all in this system. In an actual power supply a transistor or a SCR or mag-amp, or some such other switching device would normally be substituted for an actual switch.

The two extra blocks added both use the switch and, in fact, it is possible to combine them such that there is only one switching stage, but in this case, the mark to space ratio of this switch needs to be controlled as well as its frequency. This configuration gives rise to the circuit diagram of Fig. 7 which is, in some respects, an even better power supply.

Conclusion

The advantages of switched mode power supplies over the linear types include:

(a) much lighter and smaller,
(b) lower cost (over a few hundred watts), and
(c) better efficiency (less heat generated, less electricity used).

On the other hand, SMPS do provide some problems, namely, that the circuit is: more complex, more noisy (both on the input and output) and more difficult and critical to design.

The difference between the next generation of power supplies and the last generation will NOT be due to the availability of some brand new software or the availability of the latest and greatest VLSI chip. Progress will be made due to some advance in the fundamental physics of either the component or the circuitry such that less power is dissipated or power is converted more efficiently.

Indeed, the design and development of power supplies has come a long way since the selenium rectifier was added to a transformer and called a power supply.

EW PRODUCTS • NEW PRODUCTS • NEW

Extensive range of membrane switches

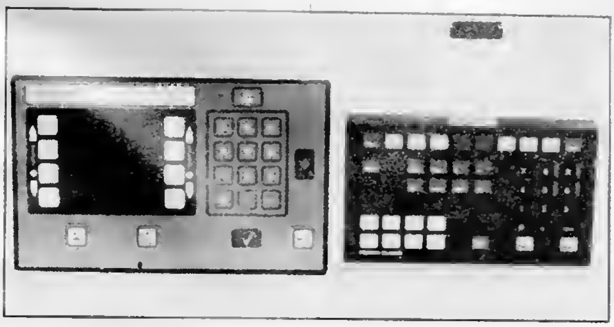
Based in Winchester, RH Technical Industries designs and manufactures an extensive range of sealed membrane switch panels for the computer and electronics industries.

The company specialises in custom designs for OEMs, and each panel is designed in close co-operation with the customer's engineering staff. There are four switch mechanism options: perimeter, recessed, bubble tactile ("snap action") and grid.

Because the panels are completely sealed they are suitable for use in hazardous environments or situations where it is important to be able to clean or disinfect the panel. They have been used in hospitals, mines and garages.

The lack of freely-moving parts in the switch mechanism confers robustness, and the polymer overlays used for the front panel surface are resistant to most acids, oils and solvents. The insulation employed in the switches themselves is safe to 500 volts RMS at 50 Hz.

The precious metal contact materials are intended for long service life; the company claims a typical life expectancy of 10 million operations per switching element for flat panel switch arrays, or 2 million operations for tactile panels.



RH has its own high-quality printing facility which can print any design of front panel in the customer's choice of colours. If the panel is to be illuminated, a solid-state electroluminescent layer is included which provides even lighting of all the panel inscriptions.

RH Technical Industries Ltd
Easton Lane
Winchester
Hants SO23 7RR.
Telephone: (0962) 61707

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ROBOT ARMS WITH VERSATILITY OF HUMANS

by Arthur Fryatt, CEng, MIProdE

Robots are now accepted as the best technology for efficient production, but nevertheless, as independent units they will not provide a solution to manufacturing problems. Although recent developments are providing robots with senses such as vision, touch and even a degree of smell, their most important attributes are still effective and precise work or tool handling in terms of arm and manipulator design. British manufacturers and research establishments concerned with design are extremely active in the development of robotic hands and arms. By being provided with controlled shoulder, elbow, and wrist movements, robots are tackling increasing work envelopes in more confined spaces and even "over the shoulder" movements are now being accomplished.

In the field of manipulator design, perhaps the most interesting work is being carried out by professor Jim Nightingale and his team at the University of Southampton[1]. For almost 20 years he has been nurturing an idea, suggested to him by a student, to produce a prosthesis that would be the most advanced artificial hand in the world.

Although the expense of such a development would be extremely high even for a government health service, its industrial application with robotics could be viable and some development investment has now been granted by The Ministry of Defence.

Nuclear reactors

Most of the work has been devoted to building a mechanism to replace the human hand, which is capable of being controlled by the body's nervous system. Since most hand movements are unconsciously actuated by the central nervous system and not by calculated brain power, the technical specification is for a structure with the dexterity of a real hand. Only low level control of drives is needed but with very high precision of movement. The problem is therefore one of mechanical design rather than complicated control programming.

There is a growing need for such high precision, automated manipulation in industrial placement and assembly robots and Professor Nightingale's work has already put the University of Southampton among the world leaders in the field.

Developed to operate within the molten sodium coolant of a fast breeder nuclear reactor and also now being applied to the packaging of pharmaceutical products in a clean room, the Taylor Hitec[2] advanced work performing manipulator can carry a 35 kg payload and manoeuvre it in any attitude with continuous path position and velocity control.

Operated by a 16-bit microprocessor, the manipulator can function in a number of modes ranging from the simplest joint-to-joint manual joystick operation to a fully automatic control including resolved tip motion software developed especially for the nuclear reactor application.

Continuous path mode

The machine is fully contained within its diameter of 205 mm. It may be mounted in any attitude and could be deployed from a moving vehicle if required. In principle, the control console can be mounted several hundred metres from the actual manipulator.

The RDP anthropomorphic robot with trunk, shoulder, elbow and wrist joints, enables loads up to 35 kg to be manoeuvred "over the shoulder".

The six servo drives for the joints are based on dc torque motors driving through harmonic speed reducers. Resolvers record the joint angles and a high-gain velocity loop provides accurate motor speed control. The joints may be back-driven for recovering the machine from a restricted access in the event of a drive malfunction. Shoulder pitch is from +90 degrees to −45 degrees and shoulder roll is from +180 degrees to −180 degrees. Elbow pitch is from +120 degrees to −60 degrees, wrist roll is from +90 degrees to −270 degrees, and wrist pitch is from zero to +90 degrees.

Anthropomorphic, that is to say resembling a human being (at least in its arm movement), is a justifiable use of the terminology for a five-axis robot developed by R.D. Projects[3]. Like the advanced work performing manipulator, the RDP robot is capable of moving loads up to 35 kg and its arm design provides a number of advantages over many other industrial robots.

Its anthropomorphic configuration of trunk, shoulder, elbow, wrist, and flip-over action, coupled with its sophisticated control system, enables the robot to operate in true continuous path mode even through complex requirements.

Extremely fast operation

The trunk rotation of 360 degrees is much greater than the range available on most industrial robots. This, together with the extremely large movements of shoulder and elbow axes, each with arcs of ±125 degrees, permits full over-the-shoulder operation with all round accessibility. Wrist pitch is ±120 degrees and wrist roll is ±180 degrees (or continuous 360 degrees). The reach capability is 3650 mm over the shoulder and front to back, from floor level up to 3125 mm and 1187 mm inner to outer radius.

These capabilities give the robot a very large working envelope. The swept volumes are 23.65 m³ at load point, 18.06 m³ at the gripper flange and 13.05 m³ at wrist centre. These are true swept volumes and include the inaccessible space occupied by the trunk and folded arms.

The robot can move very fast. With arm outstretched, a linear speed of 4.28 m/s is achievable by trunk rotation alone. The top combined axes speed is 2.51 m/s in the plane of the arms. Maximum shoulder and elbow speeds are 0.9 m/s and 1.08 m/s respectively.

Confined space working

With considerable experience in the design, manufacture, and use of robots in feeding, loading/unloading, inspection, spraying, and assembly, GEC Robot Systems[4] has long been aware of the limitations of reach of a single piece robot arm. Its development of the Comparm with a jointed elbow and shoulder as well as a fully articulated wrist provides movements that closely resemble those of the human arm.

In painting and coating applications, this gives an ability to spray into confined spaces and around complex objects while maintaining uniform quality.

The limited area in which the robot can operate has also resulted in a compactness of size that takes up far less space than a more conventional machine having similar abilities. This means that it is easier to fit Comparm into an existing spraying operation and will permit the automation of existing plants and avoid the need to build new ones. With additional axes to move the robot closer, higher, or along a horizontal track, the Comparm has a very high degree of flexibility.

The physical capability of the robot is complemented by a sophisticated computer control which, together with recognition and conveyor synchronization, gives a fully automated system. Programming is made easy by means of a lightweight teaching arm through which the computer control ensures that all movements are reproduced smoothly and precisely.

Pneumatic manipulator

A new development in pneumatically powered robot arm movement has recently been completed by Shrader Bellows[5]. Designated the 3D Manipulator, this system answers the problems arising out of using conventional pneumatic cylinders on automated assembly aids or pick and place units. Generally, it has been necessary to provide methods of guiding and supporting to overcome lack of rigidity, deflection, and turning of the piston rod.

The construction of the 3D Manipulator, however, obviates the need for the majority of guides, supports, and slides normally required.

In the new design, the piston and rod are fixed, allowing the cylinder tube to move within a tandem arrangement of recirculating bearings. Additionally, an internal travelling bridge prevents rotation of the rod. This bridge, together with the recirculating bearings, counteracts deflection due to increased cantilever loading. These features give a high degree of accuracy and mean that only final tooling is necessary.

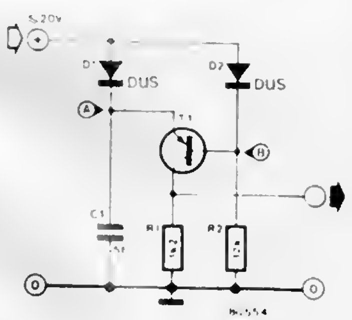
A dovetail slide is incorporated to mount the units to each other or directly on to the machine itself, using a suitable mounting kit. Linear units are available with bore sizes of 15 mm, 24 mm, 40 mm and 50 mm, giving stroke ranges of (respectively) 25 mm to 200 mm, 50 mm to 600 mm, 50 mm to 800 mm and 125 mm to 1200 mm. Vertical units are available with lift heights of 40 mm to 590 mm (40 mm bore) and 110 mm to 885 mm (50 mm bore).

The 3D Manipulator can also be fitted to a base rotating unit and accessories such as wrist rotate mechanisms and pincer grippers are also obtainable.

1. The University of Southampton, The University, Highfield, Southampton, Hampshire, SO9 5NH.
2. Taylor Hitec Ltd, 77 Lyons Lane, Chorley, Lancashire, PR6 0PB.
3. R.D. Projects Ltd, Unit 1C, Tideway Industrial Estate, Kirtling Street, Vauxhall, London SW8 5BP.
4. GEC Robot Systems Ltd, Boughton Road, Rugby, Warwickshire, CV21 1BU.
5. Schrader Bellows Ltd, Walkmill Lane, Bridgtown, Cannock, Staffordshire, WS11 3LR.

VOLTAGE DROP DETECTOR

This circuit will generate an output pulse whenever the input voltage drops by more than 0.6 volt. Operation of the circuit is very simple. As long as the input voltage remains constant or increases, the voltages at points A and B will be equal to the input voltage minus 0.6 V (due to the voltage drop across D1 and D2). In this condition transistor T1 will be turned off. If the input voltage drops, the voltage at point B will drop accordingly. The voltage at point A, however, will remain unchanged because C1 will be charged. When the difference in voltage between points A and B becomes greater than 0.6 V (in other words, the input voltage will have dropped by 0.6 V), T1 turns on causing C1 to discharge through R1 — generating an output pulse.



STRETCHABLE CONCAVE MIRRORS

by Dr Peter Waddell, Mechanical Engineering Group, University of Strathclyde, Glasgow

A possible alternative to heavy and expensive glass mirrors, especially for telescopes carried on board satellites, is to make them of thin, metallised plastics sheets stretched over circular frames. Such a mirror is not only cheap and light but, by regulating a gas to change the pressure across its face, it can be made to curve and give a controllable focal length. Its many possible applications also include large diameter mirrors for big telescopes in astronomy, small adjustable lenses for cameras, and use as a mould for making optically accurate radar and microwave radio dish antennas. Three trial mirrors have been built at Strathclyde University.

Reflecting telescopes, using mirrors, have grown from Sir Isaac Newton's 2.5-cm diameter model to to the Soviet Union's 236-inch diameter model, opened during 1976 in the Caucasus. The best known reflector is the Hale 200-inch diameter unit, at the top of Mount Palomar in southern California. It is regarded as the finest in the world. The final mirror took six years to grind from Pyrex glass: the first blank broke after eighteen months of grinding.

Why have astronomers opted for ever larger sizes of reflecting telecopes? The ability of a telescope to reveal fine details in an image depends on the mirror aperture and the wavelengths being examined. The mirror aperture may be less than the actual mirror diameter. All the main telescopes use parabolic concave primary mirrors, which have a maximum resolution that is limited by diffraction. Such a mirror images the collimated light rays from a star into a circular spot of light surrounded by circular diffraction rings, called Airey rings after a former British Astronomer Royal.

Should there be two stars very close together, their focused image spots and rings might overlap. A minimum distance *d* is required between the centres of the two spots to be able to state definitely that two stars are really there and that one is not just examining the slightly distorted spot and rings from only one star. The smaller the value of *d* to resolve two stars, the greater is the resolving power of the telescope. Minimum distance *d* for diffraction limited mirrors is given by

$$d = 1.22 \frac{\lambda}{D}$$

where D is the mirror aperture and λ the wavelength of the light being examined. It can be seen that d decreases as D increases and λ decreases. Infra-red images of a scene, with their longer wavelengths than white light, produce a lower resolution image than that obtained with white light. It can be seen that the resolution increases as the mirror diameter or aperture increases. The maximum resolution of the Hale unit is 0.027 arc seconds. A feel for figures is required here: planets have angular sizes of a few arc minutes. In practice, varying turbulence in the Earth's atmosphere limits the best resolution to 0.3 arc seconds on a really good night and to around one arc second on an average night.

The large telescopes are not there for high resolution, that is, for seeing small objects in space, but are simply large area light collectors. Double the mirror diameter and you have four times the light-collecting area. It should be pointed out that a 15-inch diameter telescope can resolve to 0.3 arc second, equivalent to the Hale! The best way to increase image resolution is to place the telescope at high altitude, to be above a great deal of the atmosphere. Mauna Kea in Hawaii is a good example. The alternative is to send it into space, as is planned for the 2.4-metre Space Telescope.

Modern electronics has produced extremely sensitive light detectors such as the charge coupled device (CCD, see *Spectrum* 182) which can detect and register two photons of light energy in every three. Photographic plates of 1948 vintage, the inauguration year of the Hale telescope, recorded under one photon in a hundred. So modern detectors have improved the light-gathering efficiency of telescopes by over one hundred times. The Hale telescope with a CCD detector is equivalent to a 50-metre diameter telescope equipped with 1948 photographic plates. Detector sensitivity cannot go much further, which is why astronomers are looking once again for larger telescopes.

Economics

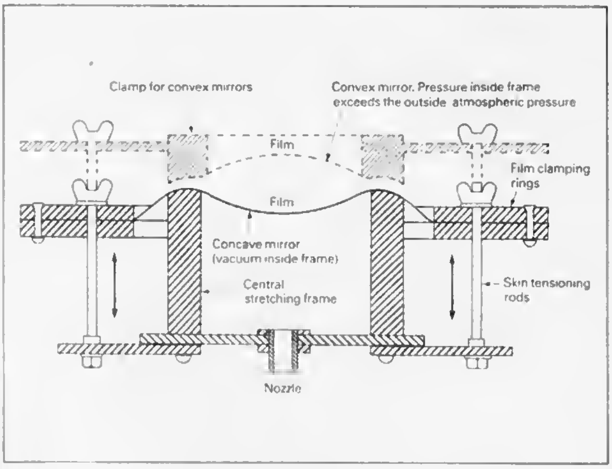
Big telescopes are expensive. The cost is proportional to the mirror diameter raised to the power of 2.6. A 25-metre telescope built by conventional practices would cost around three thousand million US dollars in 1985 prices. It would be better to build, for the same price, 70 five-metre telescopes, giving a light-collecting area a great deal bigger than that of one single 25-metre mirror. The dome cost increases as the cube of the telescope length and as the cube of the mirror diameter (for a fixed design). The dome for a 4-metre telescope costs as much as the telescope itself; for larger sizes it is more expensive than the telescope. One possible answer is to reduce the telescope length by using mirrors of shorter focal length. But the cost of highly curved parabolic mirrors can be as much as three times the cost of small, curved, longer focal length parabolic mirrors of the same diameter. Moreover, it costs a great deal more to grind the deeper, short focal length mirrors.

Large mirrors mean large weight, too, presenting severe stressing and deflection problems to the designer of the telescope mount. Most telescopes use an equatorial mount, which has one axis pointing at the pole of the sky, around which the stars rotate in concentric circles. The telescope is now rotated about this axis to follow any selected area of sky continuously. However, hundreds of tons of asymmetrically shaped metal being swung about an inclined axis, with constantly changing deflections and stresses, requires expensive and skilled engineering. The Soviet Union's six-metre telescope is the first large reflector to use the so-called altazimuth mount, with computer control to drive it simultaneously about the horizontal and vertical axes. Such a mount revolutionises the size and shape of the dome, which can be made smaller, square or oblong instead of circular as for the equatorial mount.

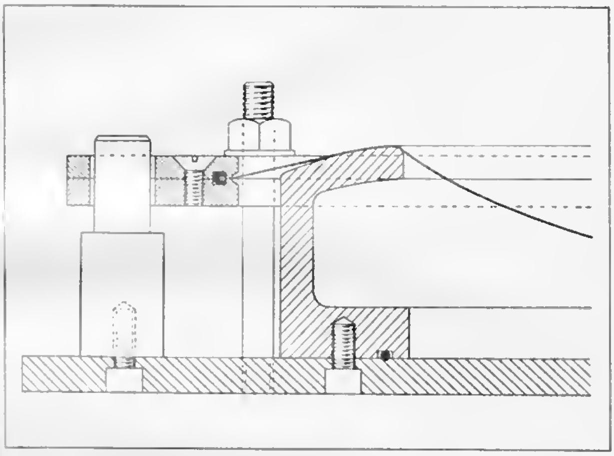
If cold air is allowed to circulate around a large warm mirror, air currents rise from the mirror by natural convection, blurring the image. This effect has been noticed on mirrors of more than 20 inches diameter. To overcome this problem, resort is made to honeycombing on the reverse face, allowing the cold air to penetrate the mirror interior and remove the heat faster. Unfortunately, the mirror is then no longer as rigid as a solid mirror and flexes more easily. No matter what diameter of mirror is used, the maximum deflection allowed is two micro-inches over the entire surface, so one can imagine the near-perfection required in designing and making the mirror mounts.

A possible revolution in large, lightweight, short focus parabolic mirror manufacture has been reported recently from the University of Arizona. By spinning molten glass at low speed (about 15 revolutions minute), a 1.8 metre f/1.0 mirror was created. The aim is to produce eight-metre f/1.0 mirrors (the f number is the mirror focal length divided by the diameter). Reports have circulated of building ovens for this in space, to spin large space mirrors. Such mirrors have of course one fixed curvature and focal length.

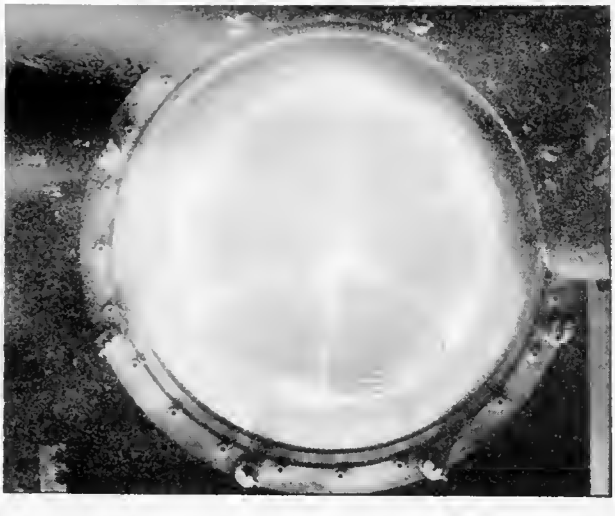
A big problem with parabolic mirrors is that they have a small field of view: to examine a large area of sky would mean scanning the telescope in different directions. The Schmidt telescope, with a hemispherical mirror, has greatly increased the fields of view. Fields of 15 degrees have been reported, but with reduced resolution; more usually the field is five to six degrees with superior resolution. Schmidts tend to have small f numbers, down to f/1.0, producing small, highly intensive light or heat images.



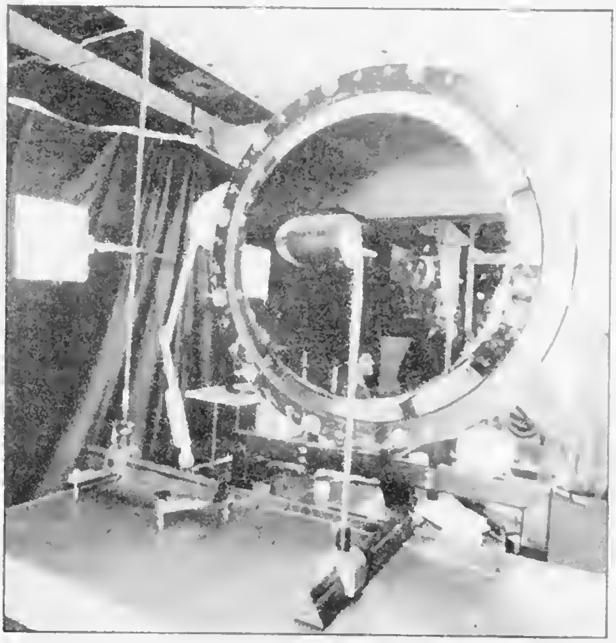
Principles of construction of mirror using a circular, ultrathin, metallised plastics film stretched over a specially shaped frame. The circumference of the skin is gripped between two flat clamping rings, which are then pulled down over a central stretching frame. By changing the pressure across the film it can be turned into a concave or convex mirror, with focal length remote-controlled at will



Alternative edge grip in which a rubber bead grips the film edge and is squeezed tightly over it.



Vibration pattern of extremely low amplitude at a frequency of 780 Hz, revealed by laser holography.



The 26-inch aperture mirror set up for experimental trials, in a Newtonian telescope arrangement with a secondary mirror in front to direct light rays at right angles to the mirror axis and create an image on the white card at left.

The Schmidt image plane is usually highly curved, so curved photographic plates have to be used. 'Spy-in-the sky' satellites use infra-red Schmidt telescopes to seek out intercontinental rocket exhaust plumes. Bigger fields of view are obtained by spinning the satellite to point the telescope in various directions. The ultimate spy satellite should have a very wide field of view for general surveillance, switching to a small field of view with a parabolic shape of mirror for target tracking. Varying the mirror curvature enables the telescope to 'zoom' in on a target.

Plastic mirrors

A possible alternative to ground, polished mirrors of one curvature is a stretchable, variable-focus, ultrathin plastics sheet mirror, such as I have devised. I created it to image the heat radiated from warm components on to flat sheets of cholosteric liquid crystals. Such crystals are relatively thermally insensitive, so each type needs a minimum amount of heat before it will display the coloured, focused image of the heat pattern from a warm object.

The crystals are illuminated with either white or monochromatic light. The heat in the image is proportional to the reciprocal of the *f*-number squared. Small *f*-number mirrors of high curvature are seen to produce much warmer images than large *f*-number, small-curvature mirrors. All you have to do is simply keep on increasing the mirror curvature until there is enough heat in the image to produce a visible image in the crystals.

Future patents, and military and commercial secrecy, restrict whot I om allowed to divulge at present.

A circular, ultra-thin, metallised plastics film with a unitorm thickness of 30 to 40 micrometres is stretched over a specially shaped frame, as in the first diagram. The circumterence of the skin is gripped between two flat clamping rings, which are then pulled down over a central stetching frame, thereby rapidly producing an optically flat mirror. The frame has to be radially broad and accurately shaped to maintain a satisfactory stress condition in the skin.

An alternative edge grip is shown in the second illustration: a rubber bead grips the film edge and is squeezed tightly over it. The general arrangement with the bead is seen in the third illustration. A very small vacuum is introduced behind the tilm, whereupon the pressure difference across the skin now causes it to be pushed back into a concave mirror. It can be shown that the pressure difference is proportional to the reciprocal of the fourth power of the mirror diameter. As the diameter increases, the pressure difference talls sharply.

Very large mirrors of many metres diameter require extremely small pressure differences to suck the mirror back into any curvature required. Such small pressure torces mean that remarkably light support rings and frames are needed. The supports could be made as arcs ot circles and then bolted together on site, or in space.

How can we operate such a mirror in space? The simplest way is to stretch a thin sheet of clear plastics over the tront of the mirror. A suitably pressurised gas introduced between the sheet and mirror pushes the mirror back into a concave shape. The cover sheet, of thicker plastics and suitably stretced, will barely bulge, so it does not attect the quality ot the image trom the mirror. Such sheets will transmit white light, infra-red, millimetric and centimetric waves.

Change of vacuum changes mirror curvature. It is not necessary to use a vacuum pump. A few strokes of a cylinder and piston with one-way valves (a bicycle pump in reverse) quickly pulls the skin back. Contact between the skin and the central trame seals in the vacuum.

We have held the mirrors sealed at the one curvature of *f*/1.0 tor over three weeks. At such small *f*-numbers the depth of image field is a few millimetres. The smallest change of this curvature and tocal length blurs a visible image on a thin, flat imaging plane. Over the three-week period, in spite of temperature and otmospheric pressure changes, the image was never found to blur.

Should the mirrors be required to maintain interterometric accuracy ot curvature, sensitive transducers can either sense change of vacuum or skin movement. Transducer signals are sent to restore the skin to its original position by changing the vacuum pressure.

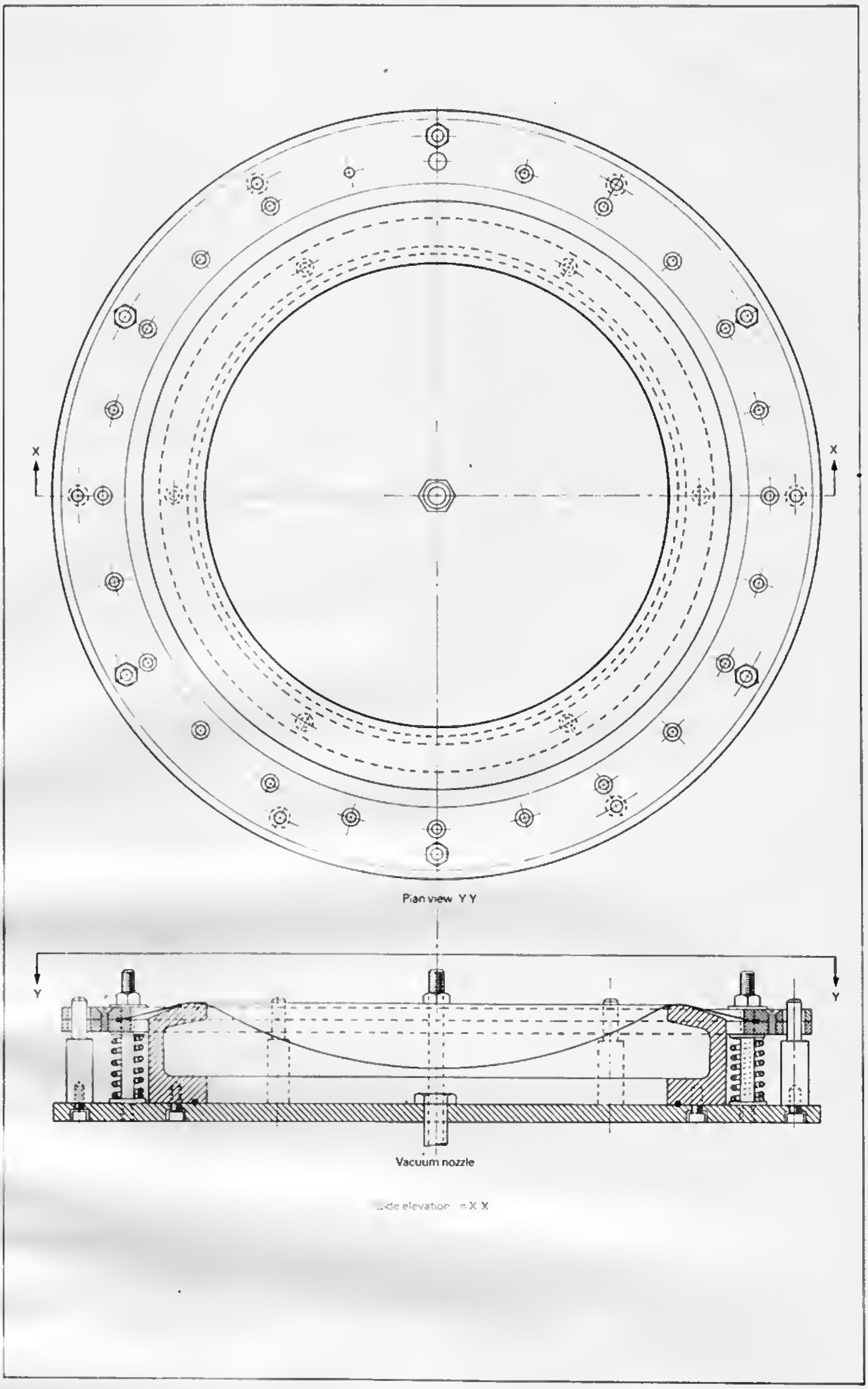
Because such thin skins have negligible thermal mass, they do not sutfer from convective air currents that adversely attect the resolution of images. The mirrors weigh extremely little and have small inertias, so they need only very small drive powers to tollow or track moving targets.

Very large diameter

There is a problem in creating plastics concave mirros with a very large diameter. Metallised sheets are available only up to about three metres wide, but the rolls are several hundred metres long. Unmetallised plastics sheets are available up to some 4.5 metres wide, and there is no technical reason why extremely wide sheets cannot be produced. It may be possible to tape numbers of small sheets together to create one large sheet, for the ultra-low pressures in the operation of large diameter mirrors make such a venture reasonably promising.

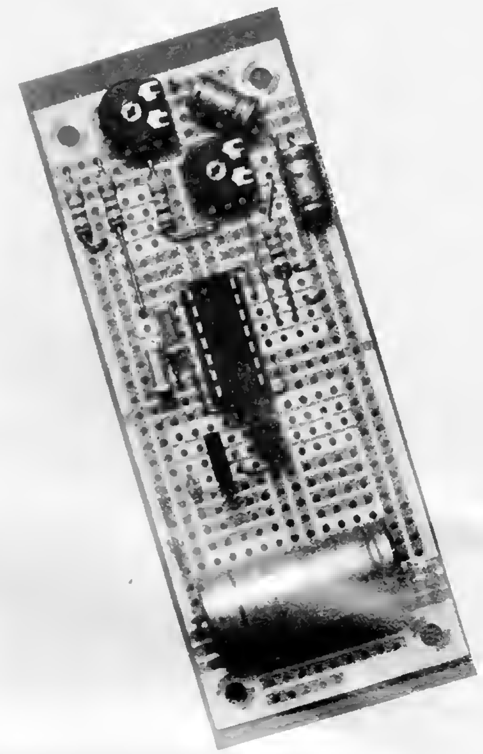
The mirrors appear to otter the perfect solution where variable focus and

switching from a parabolic narrow field to a non-parabolic very wide field of view are needed. Fields of view to about 32 degrees have been achieved in the laboratory, almost double that reported anywhere else. Resolution falls off over 25 degrees but with image correction techniques it may be possible to regain the full field and even exceed 32 degrees.
Three mirrors have been built. A four-inch aperture mirror is used in a Newtonian telescope with an equatorial mount and was recently observing details in the Moon's craters. A 12-inch aperture mirror has been shown in a BBC *Tomorrow's World* television programme. It has been used to study mirror skin vibrations. The skins are like microphone diaphragms and can resonate with airborne or frameborne noise and vibration. It has been found that the contact between the skin and the central frame acts as an excellent vibration damper. Radially varying skin stresses give rise to locally varying skin resonance frequencies. It is also found that the larger-amplitude, low-frequency patterns cannot be generated or sustained. Such large amplitudes could change the mirror curvature sufficiently to blur the images. The first photograph shows a vibration pattern of extremely small amplitude at a frequency of 780 Hz, recorded by laser holography. The second shows a 26-inch aperture mirror that has been built and used in a Newtonian arrangement to observe reflected and focused images from targets.
All kinds of uses are predicted for the mirrors. They could be used as master moulds for cold-setting compounds to produce optically accurate radar and telecommunications parabolic and off-axis parabolic dishes. Off-axis parabolics are easily produced by simply slackening off some of the clamping ring screws, whereupon the mirror pulls in off centre! Cheap, large diameter and extremely efficient solar concentrators are feasible.
In astronomy, the supply of large diameter, inexpensive, variable-focus, variable-shape mirrors could cause a revolution in techniques. It may also be possible to replace all camera lenses, including telephoto lenses, by using two small pieces of metallised plastic of variable curvature and vary the distance between them.
The future looks promising for stretchable mirrors. Though I have described only concave devices, the system lends itself just as easily to shaping convex mirrors.



General arrangement with the bead grip. A very small vacuum introduced behind the film causes it to be pushed into a concave mirror shape.

SIREN



The word SIREN is known to everybody mostly as the Police Siren, or a warning signal like the Air-raid Siren

However, it has an interesting origin. The name SIREN originates from the Greek name for the divine nymphs - SEIREN, said to sing with such sweetness that sailors were lured to death.

What we are going to describe here is the circuit for an electronic siren. It has nothing to do with divine beings or sweet singing! We shall rather associate the word siren with Police Siren, Fire Alarms or Rescue Vehicles.

The siren circuit works with a digital CMOS IC, a few resistors and capacitors. Two transistors are used to provide sufficient power output. The possibilities of sounds generated by the siren vary from the normal two-tone horn upto the excited howling of police vehicles.

The Circuit

Figure 1 shows the functional block diagram of the circuit. Block A produces a square wave, which is then converted into a saw-tooth wave by the RC combination. Block B produces a rectangular wave at a substantially high frequency (500 Hz to 1000 Hz). If this signal is given directly to the loudspeaker through the amplifier, it would generate a constant whistle, with no resemblance to a siren. The rectangular waveform must be modified to produce the siren sound as shown in figure 2(C).

Figure 2(A) shows the output from block A. Signal shown in 2(B) is formed by the RC Combination. This signal is used to modulate the frequency of the signal generated by block B. The frequency of the rectangular wave produced by block B is proportional to the voltage of the sawtooth wave. The frequency of the sawtooth wave decides the modulation pattern as can be seen in figure 2(C). This frequency is kept low, approximately 0.5 Hz to 2Hz, to get a good resemblance with the actual siren sounds.

The heart of the circuit is the 4093 CMOS IC (Quad NAND · Schmitt - Trigger with 2 inputs) One of the four NAND gates is used in the block A to form an oscillator as shown in figure 3.

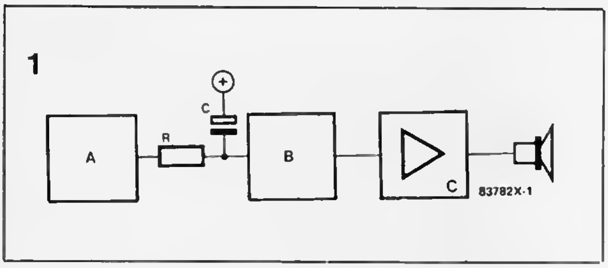
We are already familiar with the NAND gate symbol The stylised S shown inside the NAND gate symbol represents the Schmitt Trigger. The Schmitt Trigger NAND gate has better switching characteristics than the ordinary NAND gate. The operation of the oscillator circuit is very simple. If the output of the gate is "1", capacitor C starts charging through R. Once the capacitor C is charged, the inputs to the NAND gate are both on "1". This means that the output must switch to "O", As soon as output switches to "O". capacitor C starts discharging through R. When capacitor is discharged the inputs to the gate become "1" and "O". Now the output must switch to "1". This cycle keeps on repeating and a square wave is generated at the output of the NAND gate This output is fed to the AMV (Astable Multi Vibrator) in block B through an RC combination.

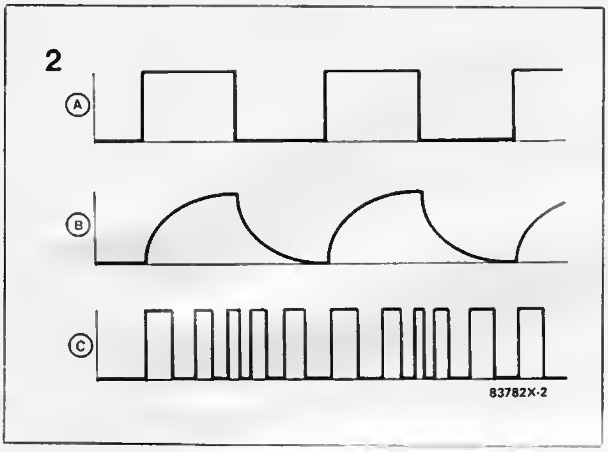
The circuit of block B is shown in figure 4. Both the NAND gates are connected as inverters R1, R2 and C1, C2 decide the frequency of the astable. If R1 = R2 and C1 = C2 then the output is a square wave. The Astable Multi-Vibrator (AMV) has two outputs which are always opposite to each other. This fact, however, has no relevance to the siren circuit The important fact for the siren circuit is that the basic frequency of this AMV can be modulated, if a small modification is done in the circuit as shown in figure 5.

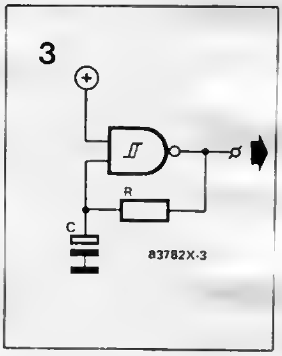
Figure 5, shows the complete circuit diagram of the siren. The resistors R1, R2 and capacitors C1, C2 of figure 4 are replaced by R3, R4 and C4, C5 in the circuit of figure 5. The change here is that the junction of R3, R4 is not grounded. It is supplied with the modulation Voltage coming from the sawtooth generator.

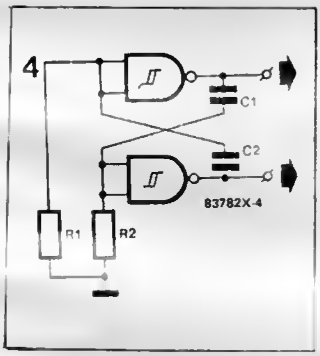
The modulation voltage affects the frequency of oscillation of the AMV as shown in figure 2 (c).

The AMV output is fed to the Darlington stage made of transistors T1 and T2. This stage amplifies the signal with an amplification factor which is the product of the two individual amplification factors of T1 and T2. This gain is substantially high and provides a loud siren output. The loudspeaker must have a power handling capacity of at least 5 Watts. Using a small capacity loudspeaker at the output may









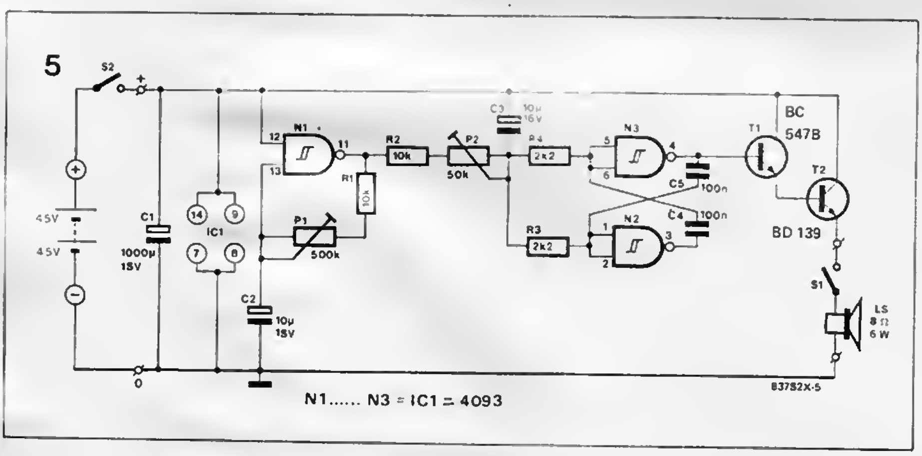


Figure 1:
Functional block diagram of siren circuit. The square wave produced by block A is transformed into a sewtooth weve by the RC network end fed to input of AMV block B. The howling sound is produced by modulating the output of AMV with the sawtooth wave. The modulated signal is amplified by block C and fed into the loudspeaker.

Figure 2:
Simplified diegram showing the different waveforms. A is the square wave genereted by block A. B is the sewtooth wave transformed by RC combination. C is the effective modulated output of AMV block B.

Figure 3:
Basic circuit of oscillator block A.

Figure 4:
Basic circuit of AMV block B.

Figure 5:
The complete circuit of the siren. The speed of howling is adjusted by P1 end the sound level is adjusted by P2. T1 and T2 form the Darlington pair to deliver sufficient power to the loudspeaker.

permanently damage the loudspeaker.

The first oscillator formed of N1 is not much different from the circuit of figure 3. The capacitor C is replaced by C2 and resistance R is replaced by (R1 + P1). P1 is introduced for providing a control over the modulation frequency. This can be varied between 0.5Hz to 10Hz. The higher the modulation frequency, the more rapidly the siren howls.

The RC combination made of (R2 + P2) and C3 provides the conversion from square wave to the sawtooth wave P2 is introduced for adjusting the amplitude of the modulation voltage. This decides the difference between the highest and lowest sound of the siren.

The power is supplied by two 4.5V battery packs, connected in series. The current drawn is about 1A, if an 8Ω speaker is used. This high current requires the buffer capacitor C1, so that the battery voltage remains quite stable.

Switch S2 is the normal ON/OFF switch, whose function is understandable. But why is S1 provided in series with the loudspeaker? This is essential to avoid the delay between switching S2 ON and the starting of the howling siren sound.

It takes about 2 seconds for the siren to start, after S2 is closed. If switch S2 is closed already, closing S1 gives immediate sound from the loudspeaker. S1 can be replaced by a push button switch, if is to be used as a bicycle siren.

Construction

One IC, two transistors and a few other components is all that is required for our siren circuit. It can be easily fitted on one small SELEX PCB.

The component layout of the PCB is shown in figure 6, to show exactly where each component fits onto the PCB. Capacitors C1, C2 and C3 must be soldered with proper polarity.

Transistor T1 is the general purpose BC 547B, but T2 is a heavy duty BD 139 transistor in plastic package with a cooling fin. The cooling fin is indicated by a solid thick black line in the layout diagram. The metalic cooling fin is internally connected to the collector of T2 and should not be shorted with any other conne ction externally. The heat dissipation allowed for T2 is 'W and does not need additional heat sink to be connected.
IC1 is mounted on a socket and care should be taken while inserting it to match pin 1 as shown in the layout. The pin 1 should come towards the two potentiometers P1 & P2.
After assembling the PCB, switch S1 and loudspeaker LS can be connected externally. Power supply can now be connected through switch S2. S2 and S1 must be open

P1 and P2 must be kept in the central position, before closing S2.

Now close switch S2, wait for a few seconds and then close S1. If everything has been assembled correctly, the siren must immediately start howling. The sound level and frequency of howling can be adjusted using P2 and P1.

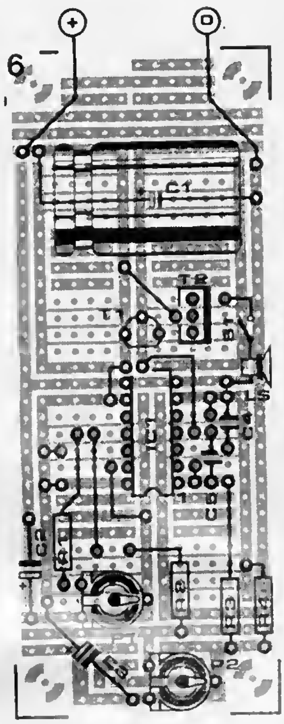
If there is no sound at all, check the soldering and component layout thoroughly. Check all the jumper wire connections and power supply connections.

Figure 6.
Components layout of the siren circuit, switch S1, S2 and the loudspeaker are external to the PCB.

Part List

R1, R2 = 10 KΩ
R3, R4 2.2 KΩ
P1 500 K ΩPreset Pot.
P2 SO K Ω'Preset pot
C1 1000 μF/16V
C2, C3 - 10μF/16V
C3, C4 = 100 nF
T1 BC547B
T2 - BD 139
IC1 4093
S1, S2 Toggle Switches

Other Perts :
1 SELEX PCB 40mm x 100mm
4 Soldering pins
2 Flat batteries 4.5V eech
1 Loudspeaker 8Ω/5W
1 IC Socket
Suieble enclosure etc.



RADIO WAVES

"... What do radio waves really look like?"

"Radio Waves are not to be seen, they are invisible!"

"Yes, I know that much, I want to know more about them."

"They are quite simple to understand,they are called electromagnetic waves. Do you still remember electro-magnetism?"

"That is magnetism generated by an electric current flowing through a wire"

"Right, the physicist says, magnetic field exists around a current carrying conductor."

"Are these the radio waves?"

"No, but imagine, you have a stretched wire and allow a current through it."

"Then magnetic field will be formed around the wire"

"When you suddenly reverse the current, so that now it flows in the opposite direction, magnetic field is obtained once again"

"In the reverse direction."

"Exactly! And because the old and the new magnetism cannot tolerate each other now because of their oppsotie polarities..."

there is a fight between them?

You can say that way. The old magnetic field is repelled away by the new field of opposite polarity!"

"It runs away from the conductor, and that is a radio wave?"

"When the direction of current in the wire is continuously changed,the new magnetic fields are formed with each reversal and old ones keep being pushed outwards. The condition for this is that the current reversal must take place at an extremely high frequency.

"This means an AC current must flow in the Wire."

"AC current of a very high frequency."

"How high is this frequency?"

"The is shown on the radio dial. On the medium wave it is a few hundred thousand Hertz. In the short wave ranges, it can go upto around hundred million Hertz."

"How does one produce such a fast alternating AC current? The gnerators must rotate ata mad speed!"

"These high frequency currents are not produced by rotating machines, they are produced by electronic oscillators in the radio transmitters using a number of electronic components. The music is superimposed on these high frequency currents and then transmitted."

"By current carrying wires?"

"No simple wires are not enough for this. Complicated antenna structures are used for transmission."

"Antennas? I thought they are used only in radio receivers."

"Antennas are of two types — transmitting antennas and receiving antennas. Transmitter antenna creates a radio wave from the high frequency AC voltage and the receiving antenna transforms the electro magnetic field reaching it, into electrical voltage."

"You mean there is an AC voltage on the radio antenna?"

"Yes however it is very weak because the radio wave has passed over a long distance from the transmitting antenna. The voltage on the receiving antenna is a few millionth of a Volt. The sensitive electronic circuit in the radio than amplifies that voltage".

"And then this voltage comes out of the loudspeaker"

"No, the high frequency voltage cannot directly be given to the loud speaker because the human ear cannot hear anything at that frequency. The radio circuit takes only the music or speech from the incoming signal and delivers it to the loudspeaker. The high frequency part is not used further in the radio, once it is received and sufficiently amplified. The audible part of the signal is further amplified before feeding it to the loudspeaker."

"So the whole high frequency part serves only to carry the music with it?"

"Yes, and it is indeed called the carrier wave"

"A lot of efforts for the small radio!"

SIMPLE LUXMETER

Amateur photographers can now have their own light intensity meter at a low cost. It is also very sensitive. The Luxmeter circuit can be of two types, based on LDR (Light Dependend Resistor) or a Photo-diode. Some instruments are also based on Photo-voltaic Cells.

A simple LDR based circuit is shown in figure 2. Since the LDR resistance depends on intensity of light falling on it, the current in the circuit also changes with light intensity. Additional switches and potentiometers are provided for calibration and adjustments.

The circuit described here uses a Photo-diode instead of LDR. Similar to zener diodes, the photo diodes are also connected in reverse direction as shown in figure 3. The photo-diode blocks the current only in complete darkness. When any light falls on it, it can allow a current to pass in the reverse direction which is proportional to the intensity of light falling on it. If a resistance is connected in series with the diode, a voltage proportional to the light intensity will be available across the resistance. The electronic circuit of the Luxmeter shown in figure 4 serves to measure this voltage

1

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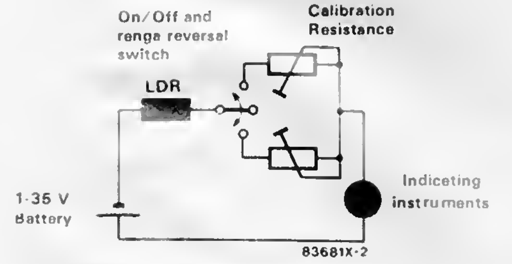

Figure 1:
Enclosure and front penel design.

Figure 2:
Simple Lux meter with LDR

Figure 3:
Photo dide BPW 34 used as the measuring element in Luxmeter.

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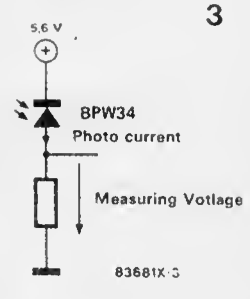

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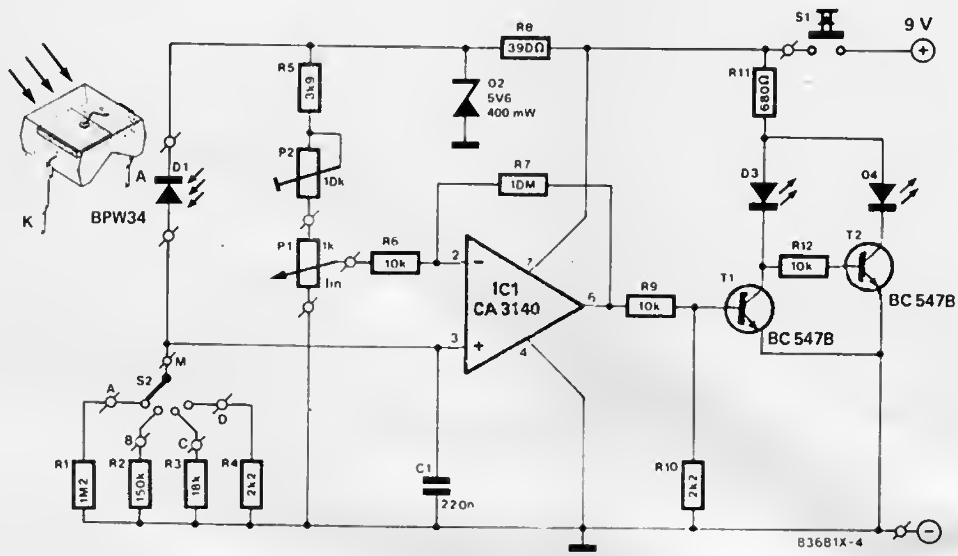

The Circuit

The circuit of the light intensity meter is shown in figure 4. You will immediately notice the photo diode and the selectable series resistances on the left side of the circuit. 4 resistances are available for selection through the switch S2.

With R1 (1.2MΩ), the meter has the highest sensitivity, because even with a small current, it produces a large voltage.

Parallel to the combination of photo diode and the resistors, there is a series combination of P1, P2 and R5. This can adjust the reference voltage to be given to IC 1 at pin 2. The IC then compares the voltage across the measuring resistance with this reference voltage. Both the series circuits effectively form a bridge circuit. The two LEDs D3 andD4 indicate whether the voltages at the two inputs of the IC 1 are equal. They become equal when the bridge is balanced.

Potentiometer P1 is used to adjust the voltage required for balancing the bridge. Setting of P1 is thus directly related to the light intensity. The settings of P1 can be marked on the panel with light intensity values.

IC1 is an operational amplifier, and its amplification factor is decided by the values of R6 and R7. In this case the values are 10K and 10M, giving an amplification of 1000. (The amplification factor is equal to the ratio of R7 to R6) The difference between the voltages on the two inputs of IC 1 is thus amplified 1000 times.

As the voltage on measuring resistance increases (+ input) the output voltage increases. When the voltage fed by P1 increases, the output voltage falls because P1 feeds the -input. The output deviation is very large due to the amolification factor of 1000, and the circuit can react to minute changes in the input voltages. A difference voltage of 1 mV can give 1V at the output of IC1.

A voltage divider consisting of R9 and R10 follows IC1. (see figure 6). This reduces the output voltage to about 1/5, because the subsequent transistor has a threshold voltage of 0.6V. Whenever this value is exceeded T1 starts conducting and a

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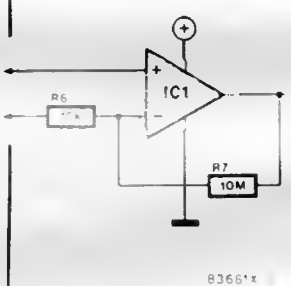

Figure 4
Complete circuit diagram of the Lux metar

Figure 5
The difference voltage is emplified by the Op amp IC1

Figure 6
LED D3 glows if light intensity is more than tha setting on front panel.

Figure 7:
LED D4 glows if light intensity is less than the front panel setting

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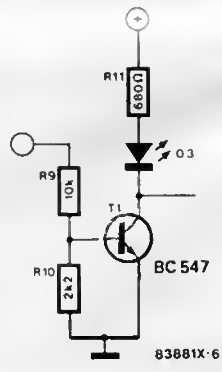

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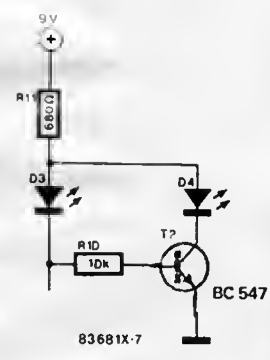

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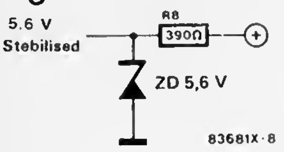
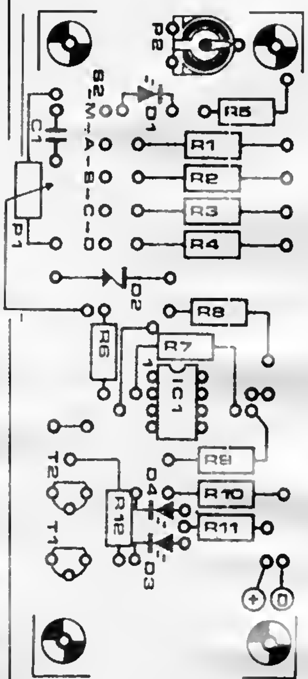




current flows through R11 and LED D3. Thus LED D3 glows whenever the light is brighter than the setting adjusted with P1. Conversely, if the light is weaker than the setting of P1, T1 is turned off. But now the base of T2 gets sufficient voltage through R11, D3 and R12 to turn it on. When T2 conducts, a current passes through R11 and D4. Thus D4 glows whenever the light is weaker than the P1 setting.

The 680Ω resistance R11 is the current limiting resistance, common for both LEDs. A common resistance can be used because both LEDs glow only alternately and never at the same time. However, with a balanced bridge, both the LEDs glow very dimly. The current limiting resistance is enough for both LEDs as the glow is very dim during bridge balance.

C1 is used to smoothen the voltage fluctuations at the + input which are created if we are measuring artificial light generated by AC current

R8 and the zener diode are used for stabilising the supply voltage to the bridge. This eliminates measuring error due to low battery voltage.

Part List
R1 = 1.2 MΩ
R2 = 150 KΩ
R3 = 18 KΩ
R4, R10 2.2 KΩ
R5 3.9 KΩ
R6, R9, R12 10 KΩ
R7 10 MΩ
R8 = 390 Ω
R11 680Ω
P1 = 1 K Ω Linear Potentiometer
P2 = 10 K Ω Preset Pot.
C1 = 220 ηF
D1 BPW 34 (or BPW 21) or equivalent
D2 5.6V 400 mW zener
D3, D4 = LED
T1, T2 = BC 547 B
IC1 = CA 3140

Other Parts
S1 Pushbutton key switch
S2 1 x 4 rotary switch or 2 x 5 rotary switch (S1 - S2)
1 9V Battery pack
1 Battery connector
1 IC socket.

Figure 8:
Zener diode stabilises the supply voltage of the measuring bridge and eliminetes possibility of measuring error due to low battery voltage.

Figure 9
Component layout on SELEX PCB.

Construction

The complete circuit fits on a small SELEX PCB (40 x 100 mm). Figure 9 shows the component layout of the circuit. Assembly of the circuit must be carried out in the usual sequence.

The polarities of the diodes must be properly checked. Figure 4 shows the illustration of the photodiode BPW34 and the cathode and anode connections. If you are using an equivalent photo diode, get the necessary data sheet or at least the correct pin connection details

As the photodiode must be open to light, it cannot be directly soldered on the main PCB. It can be soldered on a small PCB and mounted on the enclosure wall from inside such that it can receive light through a window or hole in the casing. The connections to the photodiode must be made with flexible wires from the main PCB.

IC1 is inserted into the socket, with correct orientation. Pin 1 must be towards R6.

The two LEDs D3 and D4 also must be mounted directly on the casing. They can be mounted on the front as shown in the photograph of the completed instrument at the end of the article. The user should be able to observe these LEDs while measuring the light intensity.

Also the potentiometer P1 and switches S1 and S2 must be mounted on the front side. For convenience, S1 can be combined with S2 as shown in figure 11 by using a 2 x 5 rotary switch instead of a 1 x 4 rotary switch for S2. The wiring is such that the S1 part of the switch remains ON as long as we are doing the measurement. The switch S1 and S2 are combined in the prototype shown in the photograph, and the push button key is absent from the front panel.

One point to remember about the photodiode BPW34 is that it is also sensitive to infrared light and can give misleading reading at Sunset. This must be taken into account when taking photographs at Sunset/Sunrise. Another photo diode BPW 21 can be used instead of BPW 34, which has an infrared filter. Cost of BPW21 is quite high compared to BPW34, and its sensitivity is also lower. As a consequence, R1, R2 R3,R4 must be increased by a factor of 10.

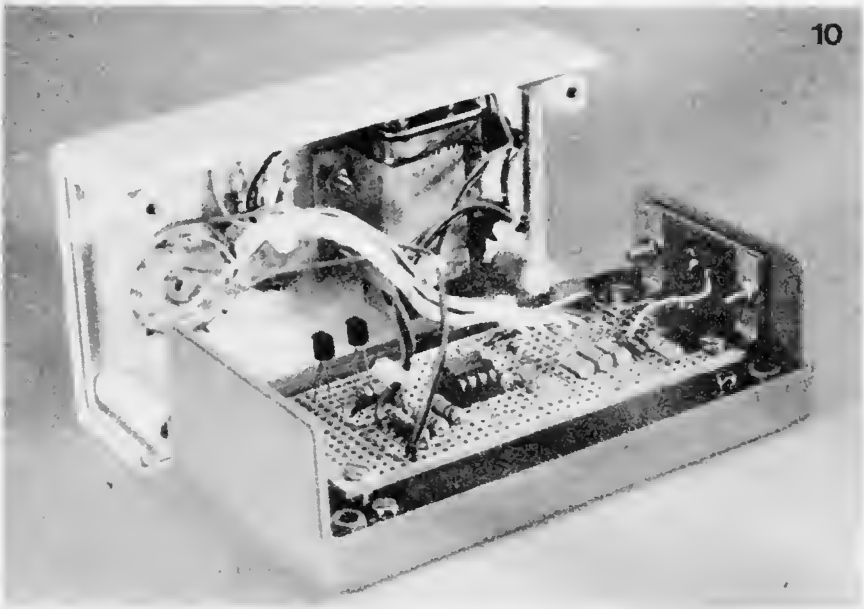
Calibration

For calibration, we must have a good analog light intensity meter.

Through comparison of measurements, P2 is so adjusted that the setting of P1 over the entire scale covers four values 0, 1, 2, 3. The measurement is done by taking the readings of positions from both P1 and S2.

Positions of S2 are marked with basic light values as A=3, B=6, C=9 and D=12, as shown in figure 4 and 11.

The operating is quite simple. S2 and P1 are so adjusted that both the LEDs



glow dimly. The effective light value is calculated by adding the basic light value indicated by S2 and the reading of P1. If only one LED glows continuously over the entire range of P1, S2 must be adjusted to the next setting and P1 must be adjusted again.

The combination of S2 and P1 readings thus provide us with readings of the light intensity.

The table shows the interrelationship between the light value and the apperture setting of the camera as well as the Lux reading. The table is prepared for a film speed of 21-DIN, and a shutter speed of 1/60 seconds.

If the shutter speed is modified, the light value also changes. For example, a shutter speed of 1/125 and apperture of 8 gives a light value of 13. The same value is valid even at shutter speed 1/60 and apperture 11.

For different film speeds, we must correct the light values in the table as follows :

15-DIN : LV-2
18-DIN : LV-1
21-DIN LV
24-DIN : LV+1
27-DIN LV+2

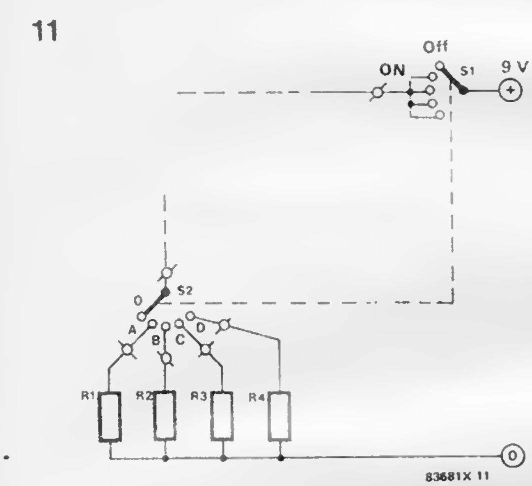


Figure 10
Suggested assembly of the Lux meter.

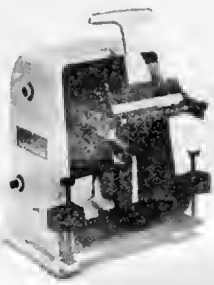
Figure 11:
To simplify the operation of the meter, S1 and S2 can be combined as shown here. S2 can be a 2x5 rotary switch, so that it also covers the function of S1

TABLE			
21-DIN Film, Shutter speed 1/60 seconds.			
Light Value	Apperture	Lux	Ambient light
9	2.8	1400	Winter day with clouded sky.
10	4	2800	
11	5.6	5500	Winter day with clear sky
12	8	11000	Summer day with clouded sky
13	11	22000	Summer day with clear sky
14	16	44000	
15	22	88000	Bright sunlight.

MARKEM 135-A PRINTER

This is a low cost, compact Printer for short run markings and is capable of marking flat, curved or irregularly shaped components.

Specifications:-
Imprint Area: 2" x 3" (50.8mm x 76.2mm) direct or offset.
Printing elements: Model 452 plates, rubber plates, etchings, masterplates with insertable type.
Mounting: Bench
Weight(Approx.): 44 lb (20 Kg)



For further details please contact:

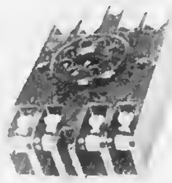
M/S KELLY CORPORATION
1413, Dalamal Tower
Nariman Point,
Bombay - 400 021.
Tel: 244286
Telex:11-5858 KELY IN

PLUG—IN BASE

"ELM" series SO E Plug-in sockets/bases are now available. Type SO E 102 is a 11 pin socket where as type SQ.E 103 is an 8 pin socket. Retaining clips are supplied with these sockets.

Front screw terminals offer (a) easy mounting and wiring; (b) avoid risk of dry solder joint, (c) dispense with necessity of relay mounting tray of hinged design, (d) ease of termination of the wires of 1.5 sq.mm for looping, etc.

Hylam cover at the bottom ensures electrical isolation of live portion. Electrical grade phosphor bronze tubular contacts of spring action are electro-plated and guarantee the reliable performance at high temperature. These main advantages make these sockets very ideal for use with plug-in relays, timers, Rapid stop units, Smoke detector and any other plug-in make instrument



For further details please contact:

M/S. SAI ELECTRONICS
(A Div. of Starch & Allied Industries)
Thakor Estate,
Kurla Kirol Road
Vidyavihar (West)
Bombay-400 086
Phone:51 31219/51 36601

SMD AID

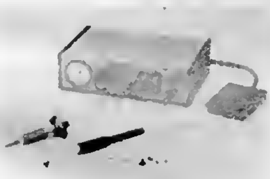
A new surface mount device paste and adhesive dispenser has been announced by I&J FISNAR INC.

The model SMD602 provides consistent dispensing of solder pastes and bonding adhesive

The SMD602 incorporates an adjustable vacuum transducer that operates a pick-up pencil for handling and positioning of micro components Five different size molded pads are included

The SMD602 requires plant air (5 to 7 BAR) and stanadard voltage, 90-115 vac, 50 60 Hz Current required is less than 10 watts. (220 vac models available.)

The SMD602 is shipped complete [illegible] fittings and input [illegible] stand and quantities of disposable dispensing components.



For further details please contact :
I&J FISNAR INC
2-07 Banta Place.
Fair Lawn,
NJ 07410,
USA.
Phone: (1) (201) 796-1477
Telex : 130252 DAVLE

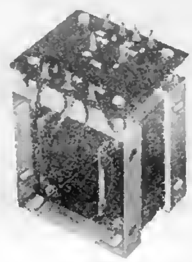
POWER TRANSFORMER

Mu—Netic range of Small Power Transformers (type SP - SL) are designed to handle power upto 1.6 KVA and voltage upto 2.0 KV.

The shell type construction is aimed at a compact, cost-efficient design and low leakage inductance.

Flying leads, moulded tag & pins on bobbins, solder terminals, terminal strips & brass bolts on bakelite tops terminations are available

These transformers are designed and manufactured to meet IS - 6297 (Part II) requirements.



For further details please contact:

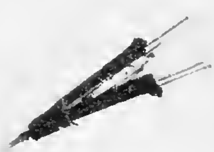
ELECTRO SERVICE (INDIA)
232, Russa Road South,
First Lane,
Calcutta 700 033.

WIRE STRIPPER

M/S. Efficient Engineering have developed a Thermal Wire Stripper,suitable for clean stripping of PVC and Mafcon [illegible] wires, flat cables and Teflon cables

It can strip wires of a wide range of sizes ranging from 1 to 75 mm diameter. Strip-stop slide is provided to adjust length of insulation to be stripped; this provision facilitates uniform stripping where desired.

Unit operates on 240V AC supply and thermal settings are provided.



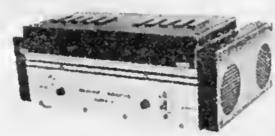
For further details please contact:

M/S. SAI ELECTRONICS
(A Div of Starch & Allied Industries)
Thakor Estate
Kurla-Kirol Road,
Vidyavihar (West)
Bombay-400 086
Phone: 5136601/5131219

LAMINATOR

This instant Laminator is an easy to operate table top machine which protects and makes your important documents tamperproof within seconds. The article to be laminated is placed in a specially treated polyester pouch and passed through the machine. Standard size pouches which are required for lamination, are readily available. This laminating machine can laminate articles upto 10" width.

Cost Basic Rs.8,000/- + 5% Excise Duty + 15% Sales Tax + L T. as applicable. For inter State Sales, CST @ 4% will be charged against 'C' Form

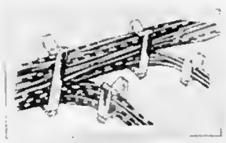


For further details please contact.

INDUSTRIAL ELECTRONICS & ALLIED PRODUCTS
34, Electronic Co-op. Estate,
Pune-Satara Road,
Pune 411 009
Tel 32538

WIRE HOLDER

Novaflex has developed a one piece construction Push Mount Wire Holder designed to channel a group of wire bundles. These Push Mount Wire Holders have a plug-in-fasting method They can be fixed in control panel cubicles, PCB, frame, chassis, sidewall of electrical/electronic equipment The main feature of there clips are that they can be installed easily and quickly by hand with no pin, screw or tool. Available in natural or black colour in 4 standard sizes.

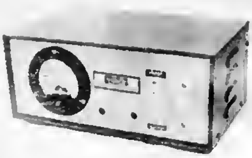


For more information please contact

NOVOFLEX CABLE CARE SYSTEMS
Post Box No. 9159
Calcutta 700 016

STABILIZER

GELCO' Automatic Voltage Stabilizer has been designed to provide corrected voltage to appliances like Refrigerators, Air Conditioners, Electric motor etc. against voltage fluctuations It gives cut off when voltage is beyond the range of Stabilizer It is available in 0 2 KVA in single phase and upto 60 KVA in three phase supply



For further details please contact

GUJARAT ELECTRONICS & CONTROLS
9 Advani Market
Outside Delhi Date
Ahmedabad 380 004

PUSH SWITCH

'IEC" have recently introduced a rugged Fully Insulated Push to On, Push to Off type switch which can be operated by foot or hand The switch has a rating of 10 Amperes, 250V AC. The body and knob are of black polycarbonate and the contacts are of pure silver

The switch has a very large mechanical and electrical expectancy and finds wide applications in various industries

For further information, contact
INDIAN ENGINEERING COMPANY
Post Box 16551
Worli Naka Bombay 400 018

PCB CHEMICALS

Modi offers a range of chemical products for the electronics industry

For further details please contact:

L N MODI & SONS
C 38 Pamp... E...
New Delhi 110 048

TRANSCONDUCTANCE AMP

Designed for use by calibration and test departments, this transconductance amplifier provides precise high accuracy current levels from DC to over 10 KHZ for calibrating Ammeters current transformers and shunts It provides output currents upto 100 Amperes and as such may also be used as a high curent power supply and as a power source in welding and bonding applications

Features include the following

1 Wide range 200uA to 100A and DC Voltage to current converter
2. Calibrates AC DC Ammeters, shunts and current transformers.
3. Basic accuracy ±0.02% of range DC,
3 Basic accuracy ±0 15% of range AC
4 Output current bandwidth DC to over 10 KHZ,
4 1 KHZ at 100A r.m.s
5 Programmable on IEEE-488-Instruments Bus.
6 Full overload protection.

For further details please contact
THE EASTERN ELECTRIC AND ENGINEERING COMPANY PRIVATE LIMITED Regd. Off
Gyan Ghar, Plot 434A, 14th Road, Khar, Bombay - 400 052
Tel 537210

ANTISTATIC DESOLDER PUMP

Diamond has introduced a new antistatic desoldering pump. Desoldering pumps are used in Electronic industry for removing multilegged components from printed circuit boards. The molten solder is sucked instantly. These desoldering pumps are guaranteed to be antistatic.

For further details please contact
INDUSTRIAL ELECTRONICS & ALLIED PRODUCTS
34, Electronic Co-op Estate
Pune-Satara Road,
Pune-411 009,
Tel 32538

AUTO RANGING DIGITAL MULTIMETER

MECO under technical assistance from M/S. SEIKO EPSON CORPN JAPAN has recently introduced their latest Model Auto ranging Digital Multimeter model 9A

This DMM measures AC/DC Currents upto 10A, AC Voltage upto 750V DC Voltage upto 1000V, Resistance upto 20 Megohms. Diode Test & Audible Continuity Test facilities are included

For further details please contact:
MECO INSTRUMENTS PRIVATE LTD
Bharat Industrial Estate
T.J. Road, Sewree
Bombay - 400 015
Tel. 4137423, 4132435, 4137253

L N A FOR TV

These two Low Noise Amplifiers are used for amplifying signals in Band I and Band III respectively with minimum noise. They come with an input/output impedance of 75 ohms, and have F connectors which are used for coaxial cable connections and hence are ideal for CATV installationas

COST Basic Rs.350 - + Excise Duty + Sales Tax + Local Taxes.

For further details please contact:
M/S. TRANSCOM
Plot No.33
Electronic Co op. Estate
Pune-Satara Road
Pune-411 009
Tel: 32438

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