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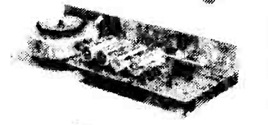

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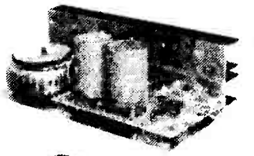
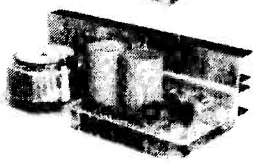


OMP/MF200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 250, Slew Rate 50V/uS, T.H.D. Typical 0.001%, Input Sensitivity 500mV, S.N.R. —130dB, Size 300 × 150 × 100mm. PRICE
PRICE £62.99 + £3.50 P&P.



OMP/MF300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz —3dB, Damping Factor 350, Slew Rate 60V/uS, T.H.D. Typical 0.0008%, Input Sensitivity 500mV, S.N.R. —130dB, Size 330 × 147 × 102mm. PRICE
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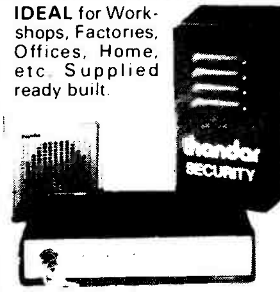

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8" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.
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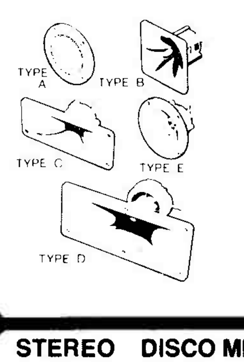

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3 watt FM Transmitter

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STEREO DISCO MIXER with 2 × 5 band L & R graphic equalisers and twin 10 segment L.E.D. Vu Meters. **Many outstanding features** 5 Inputs with individual faders providing a useful combination of the following:—
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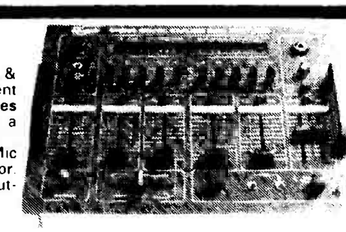

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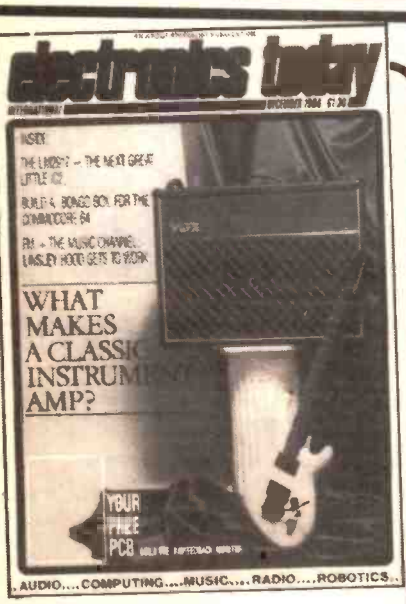

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FEATURES

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DIGEST

Stereo Standard Approved

A further step has been taken towards the introduction of a stereo television sound system with the granting of Government approval to a joint BBC/IBA specification for a new transmission system.

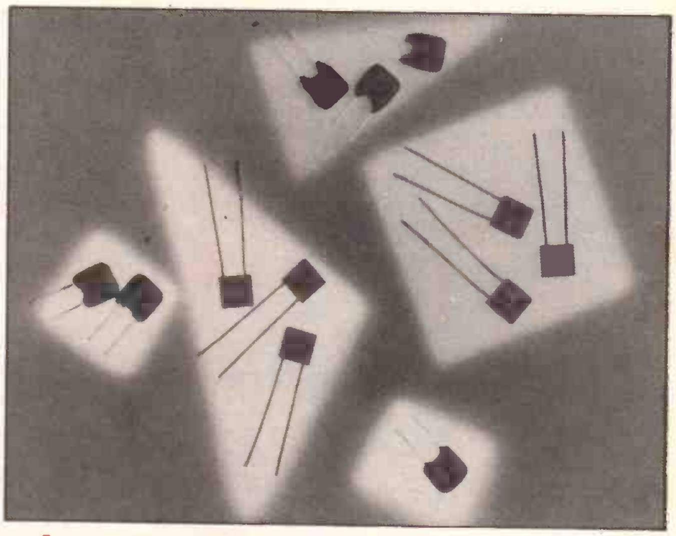
The adoption of the system follows a series of experiments which began on the 18th of July this year using the BBC2 transmitter at Crystal Palace. The first programme to be broadcast in this way was the first night of the Proms, live from the Albert Hall.

The system is quite independent of the existing television sound channel and uses a digitally-modulated carrier placed 6.552MHz above the vision carrier. The sampling frequency of the digital signal is 32kHz at an initial resolution before companding of 14 bits, and the bandwidth occupied by the digital signal is approximately 728kHz.

There are no plans to introduce a full stereo service at present but the tests at Crystal Palace will be extended over the next few months to include both BBC1 and BBC2 transmissions. The tests are intended to provide operational experience of the system for BBC staff and also to allow manufacturers to develop and test suitable decoders.

The BBC and the IBA have also announced that they are changing the vision-to-sound power ratio of their broadcast signals. At present the ratio is 5:1, but tests have shown that reception is not affected by changing the ratio to 10:1. As well as preparing for the transmission of a stereo sound carrier, this move will also save electrical power and increase transmitter efficiency.

Further information can be obtained from The Engineering Information Department, BBC, Broadcasting House, London W1A 1AA, tel 01 - 927 5432.



Ultra Precision Resistors

A new range of etched metal foil resistors from TDK offers high stability and reliability with tolerances of as little as ±0.0025%.

In addition to their small size and ease of handling for PCB mounting, the resistors have better inductance characteristics than wirewound types and better stability and reliability under harsh conditions than metal film types.

The values available cover the range from 10R to 120k in 0.25W ratings and some ranges are also available in 0.5 and 0.6W ratings. The operating temperature range is from −55 to +125°C with a temperature coefficient of 5 PPM/°C and loading and shelf-life stability of approximately 1 PPM/°C.

The resistors are available from the CGS Resistance Company Ltd, Marsh Lane, Lymington, Hampshire SO41 9YQ, tel 0590 - 75461.

● DONT is the off-putting acronym by which the Directory of Opportunities in New Technology is known. The 152-page book is aimed at school-leavers, graduates and post-graduates looking for jobs in electronics, physics, information technology and related fields. It costs £7.95 and is available from Kogan Page Ltd, 120 Pentonville Road, London N1 9JN, tel 01 - 278 0433.

● **The October 1986 Electrovalue catalogue is now available and can be obtained from them free-of-charge. Its 56 A5 pages list the usual extensive range of electronic components, including a comprehensive selection of Siemens inductors and capacitors. Contact Electrovalue Ltd, 28 St. Jude's Road, Englefield Green, Egham, Surrey TW20 0HB, tel 0782 - 33603.**

● Another new catalogue, this one from Rapid Electronics. Its 112, A4 pages list over 4000 product lines and same-day despatch is guaranteed for all orders received before 5.00 pm. The catalogue is valid until the 31st March 1987 and all prices remain fixed for that period. Rapid Electronics Ltd, Hill Farm Industrial Estate, Boxted, Colchester, Essex CO4 5RD, tel 0206 - 272 730.

● *The final entry in the catalogue stakes is from Greenweld. Their 1987 catalogue will be available from early November and will cost £1.00 including postage. In return, you get 80 pages describing electronic components and test gear plus a £1.50 discount voucher. Greenweld Electronic Components Ltd, 443 Mill Brook Road, Southampton SO1 0HX, tel 0703 - 772 501.*

Easy-PC Circuit Design

If you've just bought an Amstrad PC-clone and are wondering what to do with it, you may be interested to hear about two new software packages from Number One Systems.

Known as Analyser I and II, the packages are similar to those which the company markets for use on the BBC Micro and allow users to design and evaluate analogue electronic circuits entirely on-screen. Circuit elements can be selected from a library of standard components, configured into circuits and then analysed at various frequencies to determine gain, phase, input and output impedances and group delay.

The packages are both fully menu-driven and the manufacturers say they are very easy to use. The components held in the standard library include bipolar transistors, FETs, op-amps and transformers as well as passive components, and they can be configured into circuits with up to 60 nodes and 180 components using the larger of the two packages. The results can be presented in tabular form on the screen or output to a printer and the Analyser II package can also present results in graphical form.

Number One Systems say that Analyser can be used in the design of a wide range of circuits including audio amplifiers, tuned and wideband RF amplifiers, active and passive filters, loudspeaker cross-over networks, aerial matching networks and so on. As an indication of the system's speed, they say that Analyser II can evaluate a wideband circuit containing five transistors, an op-amp and 12 other components at 25 frequencies between 10Hz and 100MHz in about 40 seconds.

Analyser I costs £65.00 and Analyser II costs £195.00, both prices inclusive of VAT, etc.

Number One Systems Ltd, 9A Crown Street, St. Ives, Huntingdon, Cambridgeshire PE17 4EB, tel 0480 - 61778.

Better Red Than Dead

General Information Systems is the latest brainchild of Chris Curry, co-founder of Acorn and former colleague of the indefatigable Clive Sinclair.

Curry may not have Sinclair's high profile, but his ideas are sometimes just as zany. GIS have come up with 'Red Boxes' — the first of many planned 'systems that receive and process data', in the words of fellow director and Acorn leaver, Ramanuj Banerjee.

The first three Red Boxes (which are coloured red, naturally) are designed to control household lighting and appliances (Red One) and to provide basic security (Red Two is an intruder alarm) from a 'command terminal' (Red Leader) programmed using a home micro.

The BBC, Commodore 64 and Spectrum 48K and 128K machines are all suitable and are used as terminals for Red Leader — a micro in its own right supplied with a control BASIC. Once programmed, the boxes are stand-alone devices using a mains borne carrier for data transmission.

Starter kits consisting of the Leader, One and Two boxes are available for £133 including VAT and p&p, and the system is expandable, with additional boxes costing £36.95 inclusive. Contact: Electronic Fulfilment Services Ltd., Chesterton Mill, French's Road, Cambridge CB4 3NP.

PCB Tribulations

All those readers who've stuck with us through the long and painful troubles with the ETI PCB Service will be pleased to hear that there is light at the end of the tunnel. Our hard-pressed but ever-helpful Readers' Services department has recently completed an agreement with a new supplier whom we know to be both experienced and reliable.

Our aim is to create a service with no more than a 14-day waiting period which, given the range of PCBs we hold in stock, will be no mean feat. To avoid the build-up of a backlog of orders while we change suppliers, we are asking readers to refrain from ordering PCBs for one month. We have, therefore, omitted the order form from this month's issue.

What A Bind

Readers might like to know that binders are available for their treasured copies of ETI. They cost £5.20 each inclusive of post, packing and VAT. Each binder holds 12 issues of the magazine and is supplied with self-adhesive labels to indicate the year. All binders are printed with the magazine logo on the spine and are are simple but positive to use.

Cheques should be made payable to ASP Ltd. Access and Barclaycard are accepted. Send to ASP Ltd., PO Box 35, Wolsey House, Wolsey Road, Hemel Hempstead, Herts HP2 4SS (telephone: 0442 211882).

KIA Offer

Regular ETI advertiser, KIA of Ilkley, have become well-known to readers for their remarkable value special offers. Their latest comes just in time to build that Christmas tree light flasher you've always meant to make and consists of a generous bag of assorted capacitors. The sample pack we've seen certainly commends itself to our readers. To see for yourself, send a 50p coin to cover post and packing to KIA, 8 Cunliffe Road, Ilkley, West Yorkshire, LS29 9DZ. Only one request per household, please, and make sure to enclose this item.

Fast Frame

Siemens, the German electronics giant, claims to have developed a technique for the transmission of TV images at the remarkably low rate of 2 Mbits/second 'without any noticeable impairment of quality'. This rate is 70 times slower than normal TV transmission rates and represents a significant breakthrough in the serach for low bandwidth video transmission — one of the central technical problems underlying the relatively slow growth of cable and satellite TV into areas like video-conferencing.

Siemens' research has been supported by the Federal German Ministry for Research and Technology — which has no real equivalent in the UK. The company claim that the technique they are using will be capable, eventually, of achieving data transmission rates as low as 65 Kbits/second.

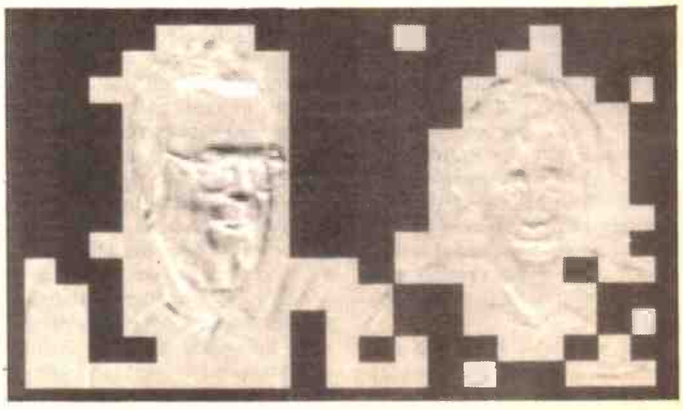
The technique involves dividing a picture frame into blocks of 16x16 pixels, each of which is subject to a mathematical procedure known as discrete cosine transformation (DCT). This results in a numerical representation of each block.

Once one image has been transmitted, the DCT for each block is compared with each frame. Small changes are transmitted complete, while substantial changes — such as those resulting from sudden movement — are transmitted piece-by-piece, most significant differences first. Each image change, therefore, may only be completed over the course of several frames — the result being a slight lack of definition.

The technique is similar to more familiar compression techniques which transmit only the changes to an image, except that it allows even the changes to be 'compressed'. Siemens claim that the results are at least seven times better than those achieved with conventional data rate reduction procedures.

Reducing the data rate below 2 Mbits/second involves a reduction in resolution and transmission rates. Siemens are exprimenting with a picture resolution of 360x288 pixels (as against 540x575) and a frame transmission rate of 8.33 per second (as against 25). A computer algorithm is used to interpolate images in order to synthesize a normal transmission rate from the slow one which would otherwise result in jerky movements.

The picture shows the information transmitted by a 2 Mbits/second video conferencing system when two people move their heads. The 16x16 block structure should be apparent.



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NEW AMSTRAD 1512 SERIES

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AMSTRAD PCW 8256	399.00	7.00
AMSTRAD PCW 8512	499.00	7.00

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MEMOTECH MTX 512 80K MICRO	60.00	5.00
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12" HI–RES MONITOR IN MATCHING CABINET	75.00	5.00
500K OR 1MB DISC DRIVE WITH SYSTEM DISC	115.00	3.00
3.5" 1MB DISC DRIVE WITH SYSTEM DISC	95.00	3.00
DISC INTERFACE (STATE BASIC OR CP/M)	48.00	2.00
KRAFT JOYSTICK	8.25	1.00
80 COL CP/M UPGRADE KIT	132.50	2.00
RS232 TWIN I/F	30.00	2.00
32K MEMORY EXPANSION	26.00	2.00
64K MEMORY EXPANSION	32.50	2.00
128K MEMORY EXPANSION	57.50	2.00
NEWWORD ON ROM (MTX 512 ONLY)	26.00	2.00
PASCAL ON ROM (MTX 512 ONLY)	26.00	2.00
SPECULATOR (MTX 512 ONLY)	26.00	2.00

SEND FOR PRICE DETAILS ON MODEMS

BBC DISC DRIVES All Drives Supplied With Leads, Manual & Utilities Disc.

5.25" DRIVES, WITHOUT POWER SUPPLY

	Price (Ex VAT)
Single 100K drive, 40 Track	£60.00
Single 200K drive, 40 Track D/S	£87.00
Single 400K drive, 40/80 Switchable	£99.00

5.25" DRIVES, WITH POWER SUPPLY

Single 100K drive, 40 Track	£99.00
Single 200K drive, 40 Track D/S	£106.00
Single 400K drive, 40/80 Switchable	£110.00
Dual 400K drive, 40/80 switchable, horizontally mounted in monitor stand (Master Version)	£237.00

3.50" DRIVES, WITHOUT POWER SUPPLY

Single 400K drive, supplied in dual case, with blanking plate to allow easy upgrade to dual drive.	£90.00
Dual 400K drive	£160.00

3.50" DRIVE, WITH POWER SUPPLY

Single 400K drive, as above	£105.00
Dual 400K drive, as above	£175.00

NB: Please add £3.00 P & P per Single Drive,

and £5.00 P & P per DualDrive

CASED/UNCASED FLOPPY DISC DRIVES

5.25" FLOPPY DISC DRIVES	Price(Ex VAT)	P&P
500K 48 TPI D/S DD	£90.00	£2.00
1MB 96 TPI D/S DD	£90.00	£2.00
500K 40 Track 48 TPI Cased with, PSU & Leads*	£110.00	£3.00
1MB 80 Track 96 TPI Cased with, PSU & Leads*	£110.00	£3.00
3.50" FLOPPY DISC DRIVES		
250K SS/DD 40T	£35.00	£1.50
1MB 135 TPID/S Slimline	£75.00	£1.50
1MB 80 Track 135 TPI Cased with, PSU & Leads*	£90.00	£3.00
Twin 1 MB 80 Track 135 TPI Cased with PSU & Leads*	£165.00	£5.00

*Also available in 110V & 220V Versions

DISC DRIVE ACCESSORIES

DISKETTES

5.25" Double Sided/Double Density	£0.90	
3.50" Double Sided/Double Density	£2.50	
Amstrad 3" CF2	£3.99	£1.00
Amstrad 3" CF2DD	£5.00	£1.00
Regulated PSU (state 5.25" or 3.25")	£8.50	£1.50
5.25" Drive Case–Takes 1 5.25" H/Height Drive	£9.00	£2.00
3.50" Drive Cased–Takes 2 3.50" Drives	£15.00	£2.00
Drive Interface Cable–Single	£5.00	£0.50
Drive Interface Cable–Double	£7.00	£0.50
5.25" Drive Case and PSU assembled–Takes 1 H/H Drive*	£20.00	£3.00
3.50" Drive Case and PSU assembled–Takes 2 Drives*	£20.00	£3.00

MONOCHROME/COLOUR MONITORS

PHILIPS	Price (Ex VAT)
High-res Green screen monitor. Model No:BM7502	£72.5
High-res Amber screen monitor. Model No:BM7522	£77.50
IBM compatible (Green) with Leads. Model No:BM7513	95.00
Dark glass, White screen monitor. Model No:BM7542	£77.50
Medium-res (640x200) Composite RGB linear (for Atari 520St) RGB-TTL	
RGBI-TTL (for IBM and Compatibles). New product compatible with almost all computers. Model No:CM8533	£260.00
14" Colour TV with RGB-TTL and Composite video input. Model No:CF1114	£225 00
MICROVITEC	
14" RGB Standard Res colour monitor. Model No: 1431MS	£185.00
14" RGB Medium Res colour monitor. Model No: 1451DS	£225.00
14" RGB High Res colour monitor. Model No 1441MS	£365.00
HANTAREX	
Boxer-12 High-Res Green screen monitor (Matt Black or White cabinet)	£75.00
MODEMS	
Nightingale plus Comstar software	£120.00
Answercall mini modem MD101,V21	£73.00
Miracle Technology WS2000 V21,V23	£95.00
Miracle Technology WS3000 V21,V23 AA AD	£275.00
Miracle Technology WS3000 V22,V21,V22 AA AD	£471.00
Miracle Technology WS3000 V22BIS,V22,V21,V23 AA AD	£595.00

* Please add £7.00 delivery on Monitors, £3.00 on Modems

SPECIAL OFFER
MEMOTECH MTX 512 plus Twin RS232 and Twin 500K CP/M FDX - This includes NewWord, Supercalc, System Utilities and MTX BASIC - only £399.00 Inc Vat and P and P.

IDC CONNECTORS

	SKT	PCB Plug	R/A Plug	CARD EDGE Plug
10way	0.61	0.72	0.72	
16way	0.75	1.00	1.00	
20way	0.88	1.24	1.24	
26way	0.98	1.34	1.34	
34way	1.40	1.69	1 69	2 27
40way	1.62	1.88	1.88	
50way	2.08	2.93	2.93	

RIBBON CABLE per metre

	Grey	Colour
10 way	0.40	0.70
16 way	0.65	1.10
20 way	0.80	1.30
26 way	1.00	1.70
34 way	1.35	2.30
40 way	1.65	2.60
50 way	1.95	3.30
64 way	2.80	4.20

LA4420	2.25
LA4422	2.80
LA4461	3.50
LC7120	3.00
LC7130	3.00
LC7131	3.00
LM18891	2.50
M51513L	2.00
M51515L	3.00
MB3712	1.80
MC1315P	2.90
MC1330P	1.90
MC1349P	1.50
MC1460G	2.90
MC1643R	4.80
MC1469R	3.00
MFC6040	0.70
ML237B	2.50
ML238B	4.50
NE535T	1.10
NE5501N	0.90
NE5543N	1.00
SAB3020	3.75
SN78008N	2.25
SN76110N	1.20
SN76115AN	1.60
SN76131N	1.70
SN76396N	1.65
SN76600P	1.40
SN76680N	0.80
SN76707N	2.10
SN76708N	3.00
TA7204	1.30
TA7205AP	0.85
TA7208P	1.30
TA7222P Q	1.30
TA7310P	1.15
CA3020	1.50
HA1388	2.50
LM1357P	1.95
LM301AN	0.30
LM310N	2.40
LM311	0.40
LM319	1.50
LM324N	0.35
LM339N	0.35
LM348N	0.55
LM358N	0.45
LM380N–14	0.80
LM381	1.70
LM3900	0.70
LM558	1.50
LM710CN	0.90
LM711CN	0.90
LM741	0.50
LM747CN	0.80
MB3756	3.50
NE555	0.20
NE558	0.55
NE566	1.30
TBA120S	0.60
TBA920	1.75
TDA1011	2.00
TDA1022	3.75
TDA2006	2.75
TDA2190	2.40
TDA2591	2.75
TDA2670	1.50
TLO71CP	0.40
TLO72CP	0.60
TLO74CN	1.00
TLO81CP	0.30
TLO82CP	0.50
TLO84CN	0.90
TBA990Q	2.75
TC9100	7.50
TC910QP	7.50
TCA270SB	3.00
TCA850	3.50
TCA660B	3.50
TCA740	2.50
TCA900	1.90
TCA910	1.90
TDA1003A	1.90
TDA1035A	3.50
TDA2002	2.75
TDA2030	1.80
TDA222	2.50
UPC1025H	3.25
UPC1156H	2.50
UPC1182H3	3.25
UPC1366C	1.75
ZN425EB	3.50
ZN426EB	3.50
ZN427E	6.00
ZN427ES	4.50
ZN447E	8.75
ZN449E	2.90
ZN435E	5.00

DIL SWITCHES

4 way	0.64
6 way	0.80
8 way	0.85
10 way	1.25

HEADER PLUGS–DIL IDC

14 PIN	0.72
16 PIN	0.78
24 PIN	1.04
28 PIN	1.43
40 PIN	1.63

MODULATORS

UM1286	2.00
UM1233	3.00

COMPUTER ICs

AM822PC	5.50
D8755AD	15.00
HD6802P	2.60
MCBT28P	1.65
MCBBT8P	1.15
M5L8035LP	3.00
M5L8085AP	2.70
M58155P	3.00
M5L8158P	3.20
M5L8212P	1.45
ML5L8216P	1.45
M5L8251AP–5	2.96
M5L8253P–5	2.70
M5L8255AP–5	2.55
M5L8279P–5	3.50
UPD8284AD	4.00
UPD8243C	2.30
UPD8748HD	16.00
6621P	1.40
6850P	1.15
808G	17.00
8088	9.50
8228	3.00
8748D	13.00
Z80ACTC	1.50
Z80ACPU	1.50
TMS9929	5.00
TMS9928	5.00
76489AN	2.50
MC6845SP	5.00
Z80ADART	6.50
Z80ADMA	7.00
Z80AP10	2.40
Z80AS10–0/1/2	7.00
VL450QA	13.00
8272	9.00
8272A	11.0
6551A	4.50
6800	2.50
6809P	12.00
68000 PS	20.00
1793	12.00
1691	12.00
9216	12.00
1770	15.00
1772	15.00
8271	30.00
2793	20.00
2797	20.00
MC1488	0.58
MC1489	0.58
SN75108	0.90
SN75189	0.70
SN75450	0.70
SN7580	0.99
SN76013	2.70
SN76023	2.80
SN76110	0.90
SN76228	0.90
SN76530	0.70
SN76660	0.70
SN76666	1.00
SN76686N	1.00
ULN2001	0.70
ULN2 002	0.70
ULN2002AN	1.10
ULN2003	0.70
ULN2004	0.70
6522A	3.50
6502A	4.25

MEMORIES

2016AP12	2.95
2114–2	2.25
2716–350 N/S	2.50
2735–450 N/S	2.50
2732A–250	2.75
2764–200 N/S	2.50
2764–250	2.00
27C6425	6.00
27128–200	3.00
27128–250	2.25
27256–25	4.50
4116–3	0.50
27512–25	15.00
4164P–15	1.50
41256–15	3.00
4864P–2150N/S	0.90
50256–15	3.00
6118LP3150N/S	1.50
50256–15	3.00
T HN6264LP12	3.40
HN6264LP15	3.00
TC5514AP3	2.95
TC5515APL2	2.90
TC5517BP	2.95
C5565PL1	3.00
UPD41464C15	8.00

74HC & 74HCT

HC00	0.26
HC02	0.26
HC03	0.26
HC04	0.28
HC08	0.28
HC107	0.35
HC108	0.40
HC10	0.28
HC112	0.40
HC113	0.40
HC11	0.28
HC125	0.40
HC126	0.40
HC132	0.70
THC133	0.70
HC137	0.70
HC138	0.70
HC139	0.70
HC14	0.70
HC15	0.70
HC153	0.50
HC158	0.50
HC160	0.80
HC161	0.80
HC162	0.80
HC165	0.85
HC173	0.80
HC174	0.80
HC175	0.80
HC194	0.80
HC195	0.80
HC240	1.00
HC241	1.00
HC242	1.00
HC244	1.00
HC245	1.00
HC257	0.80
HC266	0.70
HC273	1.00
HC32	0.35
HC39 0	1.00
HC393	1.00
HC42	0.50
HC51	0.25
HC534	1.00
HC540	2.00
HC541	2.00
HC74	0.50
HC75	0.50
HC85	1.00
HCT240	1.75
HCT	1.75
HCT244	1.50
HCT245	2.00
HCT640	2.40

CRYSTALS

32.768KHz	0.95
100.0KHz	4.00
1MHz	2.85
1.8432MHz	1.75
2.0MHz	2.00
2.4576MHz	1.75
42.5MHz	1.80
3.0MHz	1.20
3.2768MHz	3.00
3.5795.45MHz	1.25
3.6864MHz	1.70
4.00MHz	1.20
4.19430MHz	1.50
4.433619MHz	0.75
4.9152MHz	1.20
6.0MHz	1.20
6.144MHz	1.30
6.4MHz	1.30
6.5536MHz	1.50
7.159MHz	1.30
7.3728MHz	1.50
8.0MHz	1.20
10.0MHz	1.50
12.0MHz	1.30
15MHz	1.80
16MHz	1.50
18.432MHz	1.30
20.00mhZ	1.30
32.00mhZ	1.30
36.00mhZ	1.30
48.00mhZ	1.30

DIL SOCKETS

TP – Turned Pin LP = Low Profile

	LP	TP
8 PIN I C SOCKET	0.05	0 20
14 PIN I C SOCKET	0 07	0 35
16 PIN I C SOCKET	0 08	0 38
18 PIN I C SOCKET	0.09	0 43
20 PIN I C SOCKET	0 10	0.48
24 PIN I C SOCKET	0 13	0.52
28 PIN I C SOCKET	0 14	0 55
40 PIN I C SOCKET	0.18	0 85
24 PIN ZIF	4 16	
28 PIN ZIF	4 87	
40 PIN ZIF	7 02	

VOLTAGE REGS

7805	0.36
7805	0.38
7808CK	0.56
7812	0.36
7815	0.35
7815CK	0.56
7818	0.36
7824	0.35
78L05	0.20
78L06	0.20
78L12	0.30
78L24	0.30
7905	0.40
7912	0.40
7915	0.40
7918	0.40
7924	0.40
79L04	0.33
79L06	0.40
79L12	0.33
79L15	0.40
79L24	0.60

CMOS

4000	0.18
4001	0.18
4002	0.18
4006	0.50
4007	0.18
4008	0.50
4009	0.25
40103	3.00
40104	0.75
40105	1.50
40107	0.40
40108	2.35
40109	0.87
4010	0.25
40110	1.85
4011	0.18
40114	2.10
4012	0.18
4013	0.25
40147	0.85
4014	0.40
4015	0.40
40160	1.25
40161	1.25
40162	0.50
40263	0.50
4016	0.25
40174	0.50
40175	0.50
4017	0.40
40181	1.80
4018	0.40
40192	0.50
40193	0.60
40194	0.60
4019	0.30
40106	0.35
4020	0.50
4021	0.50
4022	0.50
4023	0.15
4024	0.30
40257	1.50
4025	0.15
4026	0.80
4027	0.25
4028	0.32
4029	0.50
4030	0.15
4031	1.00
4033	1.00
4034	1.10
4035	0.50
4038	0.80
4040	0.45
4043	0.40
4044	0.45
4045	1.00
4046	0.50
4047	0.50
4048	0.30
4049	0.25
4050	0.25
4051	0.50
4052	0.45
4053	0.45
4054	0.60
4055	0.60
4056	0.60
4060	0.50
4063	0.70
4066	0.25
4067	2.00
4068	0.18
4071	0.18
4072	0.18
4073	0.18
4075	0.18
4076	0.50
4077	0.18
4078	0.18
4081	0.18
4082	0.18
4086	0.45
4089	0.95
4093	0.25
4094	0.60
4095	0.75
4096	0.75
4097	2.25
4099	0.75
4502	0.50
4503	0.33
4508	0.90
4510	0.40
4511	0.40
4512	0.40
4514	1.00
4515	1.00
4516	0.40
4517	2.25
4518	0.40
4520	0.40
4522	1.10
4526	0.45
4527	0.50
4532	0.50
4536	2.00
4538	0.60
4543	0.55
4555	
4556	0.45
4584	0.40
4585	1.00

ACCESS AND BARCLAYCARD WELCOME VISA **All prices subject to change without notice**

74LS & 74

74LS00	0.17	74LS151	0.30	74LS241	0.55	74LS352	1.00	74LS673	5.00
74LS02	0.18	74LS153	0.50	74LS242	0.55	74LS353	0.80	74LS674	5.00
74LS03	0.18	74LS155	0.40	74LS243	0.70	74LS365	0.35	74LS682	2.10
74LS04	0.17	74LS156	0.40	74LS244	0.50	74LS366	0.35	74LS684	2.75
74LS08	0.18	74LS157	0.30	74LS245	0.50	74LS367	0.35	74LS685	2.75
74LS09	0.18	74LS158	0.30	74LS247	0.55	74LS368	0.35	74LS686	5.00
74LS10	0.18	74LS160	0.50	74LS248	0.90	74LS37	0.18	74LS687	2.75
74LS107	0.30	74LS161	0.50	74LS249	0.90	74LS373	0.5	74LS689	2.75
74LS109	0.30	74LS162	0.55	74LS251	0.40	74LS374	0.50	74LS73	0.30
74LS1	0.18	74LS163	0.50	74LS253	0.60	74LS378	0.75	74LS74AN	0.22
74LS112	0.30	74LS164	0.50	74LS256	0.60	74LS38	0.18	74LS75	0.27
74LS113	0.30	74LS165	0.75	74LS257	0.40	74LS390	0.50	73LS76	0.27
74LS114	0.30	74LS166	0.75	74LS258	0.50	74LS393	0.50	74LS78	0.27
74LS12	0.35	74LS168	1.10	74LS259	0.65	74LS395A	0.90	74LS83	0.40
74LS123	0.40	74LS169	0.80	74LS26	0.18	74LS40	0.18	74LS85	0.45
74LS125	0.30	74LS170	0.90	74LS260	0.65	74LS42	0.40	74LS86	0.20
74LS126	0.30	74LS173	0.40	74LS266	0.30	74LS47	0.50	74LS90	0.22
74LS12	0.18	74LS174	0.35	74LS27	0.18	74LS48	0.60	74LS92	0.30
74LS132	0.35	74LS175	0.40	74LS273	0.50	74LS49	0.80	74LS93	0.27
74LS133	0.35	74LS181	1.80	74LS279	0.50	74LS51	0.20	74LS95B	0.45
74LS136	0.28	74LS182	2.00	74LS280	1.50	74LS54	0.20	74LS96	0.65
74LS137	0.70	74LS183	1.50	74LS283	0.50	74LS541	0.90		
74LS138	0.30	74LS190	0.55	74LS290	0.70	74LS55	0.20		
74LS139	0.30	74LS192	0.50	74LS293	0.70	74LS640	1.20		
74LS13	0.30	74LS193	0.50	74LS295	1.00	74LS641	1.20		
74LS14	0.30	74LS194A	0.60	74LS298	0.95	74LS642	1.20		
74LS145	0.80	74LS196	0.60	74LS299	2.00	74LS643	1.20		
74LS147	1.10	74LS197	0.60	74LS30	0.18	74LS644	1.20		
74LS148	1.00	74LS20	0.18	74LS32	0.18	74LS645	1.20		
74LS15	0.18	74LS21	0.18	74LS322	3.00	74LS668	0.80		
		74LS22	0.18	74LS323	2.50	74LS669	0.80		
		74LS240	0.60	74LS33	0.25	74LS670	1.00		

LINEAR ICs

710	0.40
748	0.30
AY–3–1014A	2.75
AY–3–1015D	2.75
AY–3–8470	2.00
AY–3–8475	3.00
AY–3–9710	3.15
AY–3–9725	4.00

CA3011	1.10
CA3018	0.75
CA3028A	1.00
CA3046	0.60
CA3052	1.90
CA3054	1.00
CA3065	2.00
CA30804A	2.00
CA3080E	0.55
CA3085	1.30
CA3086	0.50
CA3088	2.00
CA3089Q	2.30
CA3090AQ	2.30
CA3100S	2.00
CA3130E	0.75
CA3140	0.70
CA3161E	1.80
CA3162E	5.00
CA3189E	1.70
CA3193E	1.50
CA3240E	0.90
CA3280E	2.5)
CA3290E	1.10
HA1366W	1.70
ICL7660	2.00
LA3300	1.90
LA4032P	2.45
LA4400	3.00

SPECIAL OFFERS

UM1286 Modulator colour/sound	only 2.00
Z80A CPU Incredible!	only 1.50
Z80A CTC Amazing!	only 1.50

4116-3 200n/s 16K DRAM			0.50
4864-2 150n/s 64K DRAM			0.90
5×20mm Inline Fuseholders			0.10
2764-25	1.75	PAL 14L4	1.00
27128-25	2.25	6264LP-15	3.00

D type CONNECTORS

PLUGS	9 way	15 way	25 way	37 way
SOLDER	0 42	0.57	0.81	1 15
PCB	0.44	0.60	0.85	
PCB R/A	0 85	1 27	2.01	
SOCKETS				
SOLDER	0 63	0.86	1 14	1 94
PCB	0 71	1 07	1 60	
PCB R/A	1 20	1 88	2 94	
COVERS	0 58	0 61	0 68	0 78
IDC				
PLUG	3.05	3 77	4 94	
SOCKET	3 25	3 90	5 27	

MAIL ORDER ONLY

FULL PRICE LIST AVAILABLE ON COMPETITIVELY PRICED TRANSISTORS, THYRISTORS, TRIACS, BRIDGE RECTIFIERS, FUSES, FUSEHOLDERS AND 74S SERIES

Please add **£1.00 P&P** to all orders unless otherwise stated
All prices are **EXCLUSIVE OF VAT** – please add VAT to total cost including P&P

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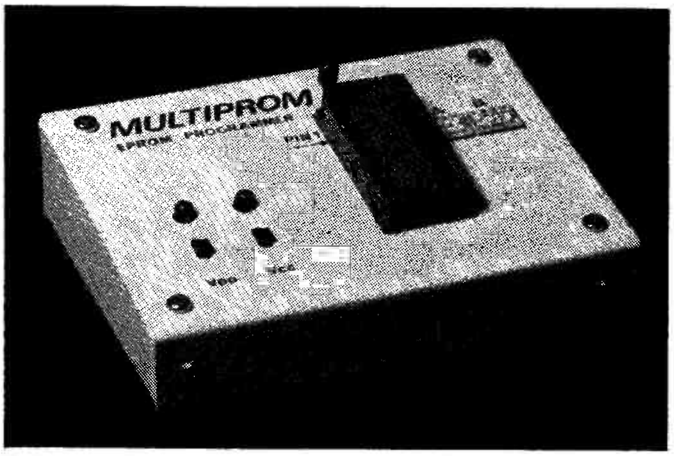


New Programs On The Beeb

The MultiPROM EPROM Programmer from Ground Control is designed for use with the BBC range of micros. It accepts all 27 type EPROMs from the 2732 up to and including 27512, 27513 and 27011 types (including 'A' versions), and is compatible with all BBC micros from the 'B' to the Master.

Software is supplied on a ROM or can be downloaded into sideways RAM. It allows an EPROM to be programmed from any file on disk. The MultiPROM plugs into the user port and is powered from the computer. An internal converter provides the 21V and 12.5V needed for programming, but each type of EPROM has to be set manually using front-panel switches. All the same, the MultiPROM is good value at £44.95 for the hardware and £5 for the ROM-based software (inclusive of VAT and post and packing).

Further details from: Ground Control, 4 Alfreda Avenue, Hullbridge, Hockley, Essex SS5 6LT (telephone: 0702-230 324).

Vinyl Lives On

A sophisticated tracking system allows conventional vinyl discs to be played by a laser 'stylus', according to Finial Technology, a Silicon Valley company who recently unveiled the wear-free turntable for old-style records. Finial are keeping the secret of their tracking system close to their corporate chest. If their claim is true, they will have undermined one of the chief arguments in favour of compact disc. The system should prolong the life of vinyl discs indefinitely.

Sceptics say that no weightless device can track a vinyl groove with sufficient stability to ensure listenable results. But with the aid of a microprocessor it may be possible to correct for errors. Accurate positioning is not the problem — keeping the laser beam to a twisting track is.

The Finial deck will be expensive, if it works, because the technology is probably more complex than that required for CD. It is scheduled to arrive in the UK in 1987 and, if it lives up to expectations, may bring a smile back to the face of many a despondent hi-fi fan, despairing at the apparently irresistible march of CD.

Useful Add-ons

Electronic and Computer Workshop are busily supplying useful add-ons for a range of home micros. Currently available is the K2629 real-time clock for the Commodore 64 — a battery-backed unit providing calendar, daily alarm and accurate time-keeping as well as 50 bytes of static RAM useable for storing information during power-down (for example, set-up data). E&CW are also supplying the K2640 motherboard for Amstrad CPC464 and 664 computers which will give Amstrad users access to a wide range of add-ons including A-to-D and D-to-A converters, a Centronics printer port, I/O boards and a real-time clock.

Both these products come from the Velleman range. The K2629 costs £36.11 inclusive as a kit or £50.45 ready built, while the K2640 motherboard is £42.20 inclusive in kit form. They are available mail-order from E&CW, 171 Broomfield Road, Chelmsford, Essex CM1 1RY (telephone: 0245 262149).

DIARY

3D Television — A Solid Future? — November 4th
The IEE, London, 6.00pm. Lecture by Dr. R. Borner of the Heinrich Hertz Institute, Berlin. Contact the IEE at the address below.

Electron & BBC Micro User Show — November 7-9th
Royal Horticultural Halls, London. Contact Database Exhibitions at the address below.

Compec '86 — November 11-14th
Olympia, London. See November '86 ETI or contact Reed Exhibitions on 01-643 8040.

High Definition Television: The Technical Challenge — November 12th
The IEE, London, 6.00pm. Lecture by T.S. Robinson of the IBA. Contact the IEE at the address below.

Audio Fair — November 12-16th
Olympia 2, London. Major industry audio exhibition organised by the Federation of British Audio. Contact them on 01-930 3206.

The History Of Television — November 13-15th
The IEE, London. See November '86 ETI or contact the IEE at the address below.

Commodore Horizons Show — November 15/16th
Novotel, London. Contact Database Exhibitions at the address below.

Electromagnetic Interference: Practical Design And Construction Techniques — November 17th
City Conference Centre, London, 9.30 am. One-day symposium organised by the IEE. Contact them at the address below.

Optical Disc Recording — November 18th
The IEE, London, 6.30 pm. Lecture by Dr. S. Miyaoka of Sony. Contact the IEE at the address below.

ISDN Seminar — November 19–21st
Tara Hotel, London. Contact Online at the address below.

Atari Christmas Show — November 28–30th
Royal Horticultural Hall, Westminster, London. Exhibition of Atari add-ons and software plus another opportunity to examine the newly-launched 2080STF and 4160STF micros. Contact Database at the address below.

CIMAP — December 1–5th
NEC, Birmingham. An event aimed at potential users and manufacturers of Management Automation Protocol (MAP) technology with special programmes for design engineers, production engineers and managers. Contact Independent Exhibitions on 01-891 3426.

Satellite Communications — December 2–4th
Wembley Conference Centre, London. Conference. Contact Online at the address below.

Television Sound Seminar — December 5th–7th
University of Warwick. Weekend seminar covering the design and operation of TV sound equipment and aimed at newcomers as well as experienced engineers. Contact the Royal Television Society on 01-387 1970.

Addresses

Database Exhibitions, Europa House, 68 Chester Road, Hazel Grove, Stockport SK7 5NY, tel 061-456 8835.

Institution of Electrical Engineers, Savoy Place, London WC2 0BL, tel 01-240 1871.

Online International, Pinner Green House, Ash Hill Drive, Pinner, Middlesex HA5 2AE, tel 01-868 4466.

ETI

READ/WRITE

A Further Exchange

Dear Sir,

I was sorry that the reply to my letter on Exchange Resources (August issue) degenerated into personal abuse, as my comments reflected genuine routine efforts by a member of my staff to establish the capabilities of a business entity for future recruitment purposes. For the benefit of any reader who may think my comment was racist (a word unknown in the 1930s), I did move my education from the 1930s by having to fight in a war that would never have happened if we had not reduced our defence expenditure in earlier years. In addition, as an RAF pilot I have spent thousands of hours operating on 'mercy missions' into Eritrea and other areas of Africa. I can show readers places where maximum operating temperatures of electronic components are exceeded shortly after sunrise, which accounts for the failure of crystal sets and the misuse of variometers. Surely this is not racist by any stretch of the imagination.

Some 20 miles to the east of Exchange Resources at RAF Lyneham many highly skilled and brave young men and women risk their lives daily to do something positive with our defence expenditure, by flying supplies that are saving thousands of lives to destinations in Ethiopia, Somalia and Sudan. What a nice gesture it would be if your readers wrote to thank them, or invited them to write an article for ETI about the experiences and the electronics problems of operating in the front line of the 'real world'.

Yours sincerely,
A.H.E. Welch DFC. TD,
Corsham,
Wiltshire.

An Unexplored Field

Dear Sir,

I was interested to read the article by Jeff Macaulay on the design of a valve amplifier in your August issue.

One of my cherished bits of apparatus is a Williamson amplifier, built to his exact specifications around 1949/50. This I still use to compare the sound of modern audio amplifiers.

About two years ago I 'discovered' FETs. These appeared to offer a promising compromise between valve and bipolar transistor performance. I consulted most of the standard text books and they all covered the behaviour and characteristics of FETs in detail — often with pages and pages of higher mathematics. Most provided single-stage FET circuits, but that was all.

I read most of the monthly radio and audio publications and am appalled at the paucity of information on the practical application of FETs. Singe-stage FETs followed by bipolar transistors are there by the gross, but no-one seems to want to couple two or more FETs together.

I do think that this is an unexplored field which you might encourage some of your contributors to investigate. It should produce some interesting articles for your magazine.

Yours truly,
D.C. Ayres,
Walsall.

AUNTIE STATIC'S PROBLEM CORNER

Dear Auntie,

I am a regular subscriber to ETI, and was very interested in the Digital Panel Meter article in the August issue. I have assembled a circuit with four strain guages for an experimental weighing system, but this has not been too successful. I wonder if you could recommend a practical book or reference on how to build load cells with strain guages for accurate weighing applications.

In the same article, reference was made to a 136PC15GI pressure transducer. Where can I obtain one, and roughly how much will it cost?

Mr. M. Williams,
Rustington,
West Sussex.

Most books on transducers will give a diagram of a 'typical' load cell, but I suspect that you are looking for more detailed information than this. I must admit that I haven't come across a book on the relative merits of various materials and geometries, nor a design for a 'do it yourself' load cell. If anybody has, and would like to let me know, I'll pass the information on to you. As it's rather a specialised area, your best bet is to try a good technical library.

You haven't given any details of the difficulties you are experiencing with your weighing machine, but I wonder if you are absolutely certain that it is the construction of the load cell that is to blame? Most metals will expand or contract in proportion to an applied load over a limited range, so very simple arrangements and commonly available materials can give good results as long as the distortions are small. If the readings you get are consistent and repeatable, but not proportional to the load, you can be fairly sure it is the load cell geometry or material to blame. On the other hand, if the readings jump about, or drift over a period of time, it is almost certainly the electronics causing the problem.

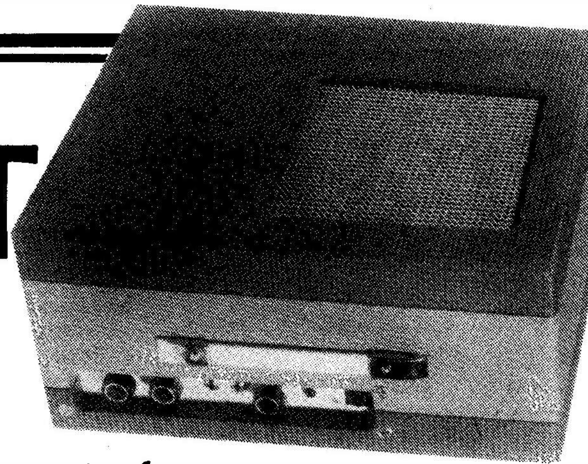
Amplifiers for strain gauge based quipment have to be designed with care, since their inputs will consist of a few mV of wanted signal sitting on a common mode voltage of several volts. The circuit given in the digital meter project was about as simple as it could possibly be and still achieve useable results. Generally speaking, a chopper stabilised amplifier or a very low drift instrumentation amplifier would be used. Since the output from the bridge will be proportional to the applied voltage, this must be very well regulated or, much better, can be sensed by separate wires from the bridge and used to scale the amplifier's output. Low pass filtering would be used to reduce noise, and so on.... The techniques are well known, and can be found in any good book on instrumentation.

The pressure transducer mentioned in the project is available from RS Components, stock no. 303-343, and costs £43.37 + VAT. (Ouch!) To pre-empt a possible future question, no — I'm afraid I don't know of any books on how to make your own pressure transducers!

— Auntie.

ETI

THE RIGHT SOUND



The WEM Westminster 10 watt tremolo guitar amplifier.

David Peterson looks at the development of musical instrument amplifiers and explains why and how they sound the way they do.

The popularisation of the guitar as a dance-band instrument in the 1940s led players to demand equality in audible level with the naturally louder instruments like drums, trumpets, and saxophones. The magneto-dynamic pickup was developed in the late '40s and immediately solved most of the problems presented by this demand.

At about the same time, electronic keyboards like the organs produced by Hammond, Lowrey and Thomas spread through homes in the US and became basic equipment in cinemas and churches everywhere. Soon after, the electric bass was developed and the first 'all-electric' groups appeared. They multiplied and assumed some national and commercial importance in the mid '60s with the 'beat boom' that followed the success of the Beatles and the Rolling Stones. With minor changes due to technical advance, the three-to-six person amplified group has remained the single most popular form of live entertainment.

Louder Still And Louder

The most immediate need for any electric instrument is audibility. In public performance alongside other instruments, this demands an average sound-level of over 105dBA at one metre — as loud as an average drum-kit without microphones. A peak capability of at least 112dBA is necessary for solo parity with brass instruments. Some performers use very high levels (over 120dB) in order to generate harmonic distortion or extra sustain and harmonics from the instrument. This is usually matched by more power by the other members of the group, in order to retain musical balance.

Where only one instrument is in use, the amplification requirements alter slightly. There has to be enough volume to enable the performance to be clearly audible over crowd levels if in public, or over whatever ambient noises may be present in the home or studio. This can be as low as 60dBA at one metre or as much as 110dBA. The frequency range must be adequate for the instrument which, in the case of an organ, can mean 80 to 12,000Hz. The ear demands a greater extension of frequency response from single instruments to supply the same harmonic complexity provided by a combo or band.

Commercial design has always been based on volume requirement, and takes as its point of departure the sensitivity rating of a loudspeaker or speaker system with reference to its maximum power handling ability.

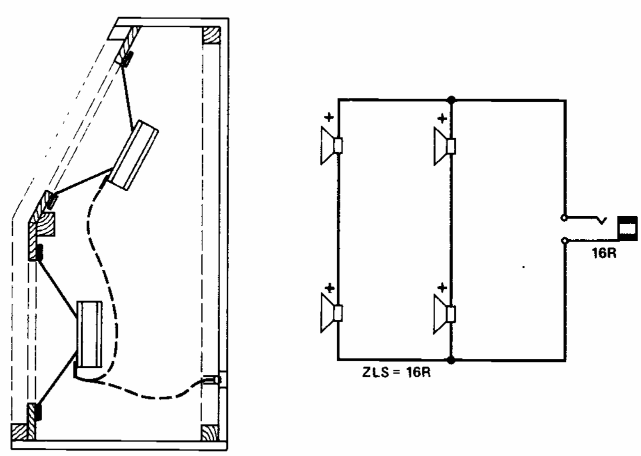


Fig. 1 Electrical and mechanical arrangement of a typical 4 x 12" angle-fronted guitar loudspeaker cabinet. The drive units would normally be rated at 30W each, giving 100W total safe handling and an efficiency of around 98dB/W at one metre.

The choice of speaker system rests on the required frequency response parameters.

For bass instruments it is normal to use 80 to 3,000Hz as the –3 dB point. This indicates the use of 12" or 15" drivers, as the normal 112dB requirement at 80Hz can only be met by a large cone without excessive excursion and power dissipation. Large amounts of power supplying only adequate volume means poor reliability. A voice-coil will become excessively hot under conditions of high mechanical stress leading to early failure of the adhesive bond between the coil and coil-former.

For lead-guitars the speaker-type is decided by the efficiency in the frequency band from 3 to 6kHz, as this is the pass-band for the higher harmonics which give the instrument its character. It is desirable to have a rise in the speaker response at this point, but a flat response is usually sufficient. A high-gauss magnet with a medium-size voice coil is commonly used with cones of either 10" or 12" in diameter. Smaller speakers are favoured for extra pressure but the 12" units are generally preferred for a smooth response and high power-handling.

Drive units are often used in twos or fours to reduce axial beaming effects (high frequency roll-off outside a narrow beam to the front of the speaker) and to lessen reactance at the resonant-frequency. Each speaker is also at a more efficient working point in a multi-speaker system and the effect is so marked that some manufacturers prefer to use four low-cost speakers to two of good quality. The most successful manufacturers always use highly efficient drive units with an adequate margin of power-handling in appropriate arrays.

It is rare for a guitar amplifier to use a two-way speaker system because such systems are often affected by the 90° shift in current/voltage vector that occurs at the crossover point, producing an audible cancellation at the frequency where the system should be at its most efficient.

The Vox Supreme of 1966 used Goodmans Midax horns to achieve the type of highly trebled sound popular at the time. This was to prove too analytic for the overdriven sound made famous by Marshall users (such as Hendrix and the Cream) which superceded it as the sought-after rock guitar sound.

The third main type of speaker system is that designed for keyboard use. These must be wide-band with less emphasis on the mid-range than a lead-guitar. Two-way systems are frequently found.

The classic keyboard system is the Leslie cabinet, with a 15" bass speaker in a reflex cabinet and a mid and treble horn system in a separate compartment on top of this, all included in one large cabinet. The horns rotate to

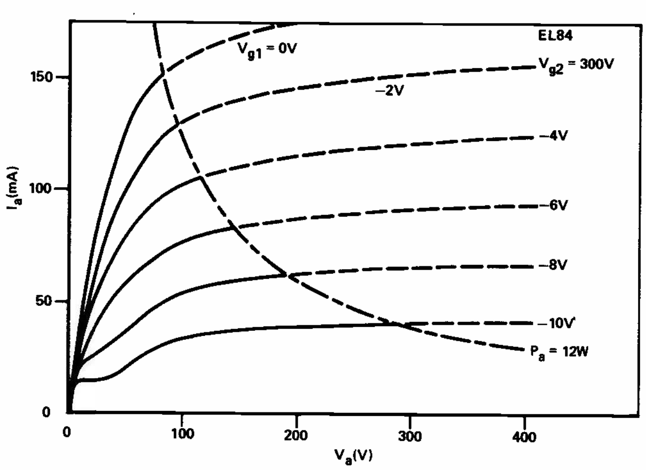


Fig. 2 The Ia/Vg of an EL84 output pentode showing the characteristic non-linearity.

produce a frequency modulation in the HF by the Doppler effect. Electrical contact is maintained by sliding leaf-springs on a conductive annular track. Electronic vibrato circuits can produce a short-term modulated delay like the Leslie sound at far less cost.

Amplifying Somewhat

The emphasis on speakers is because amplifier design has usually been subject to current speaker technology.

In the late '50s, speakers would only handle some 15 to 20 watts. So a single-speaker combo would only need 12 to 15 watts, a twin 30 to 40 watts and so on. In the early '60s, Amercian speaker-makers began to make 30 to 40 watt drivers and the Fender Twin Reverb was introduced as a 60 watt twin 12" combination, formidable for the time. Shortly afterwards Jim Marshall introduced his

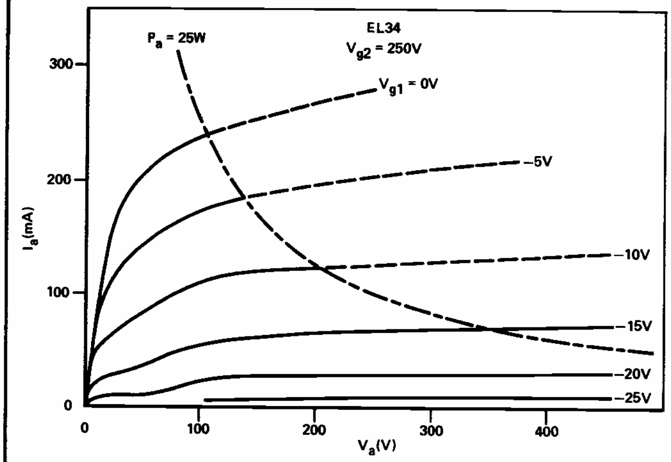


Fig. 3 The Ia/Vg curves of an EL34 output pentode which are far more linear than those of the smaller EL84.

4x12" cabinet, and a stacked pair of these would accept the output of a 200-watt amplifier.

So power requirements have tended to follow the development of speaker systems and arrays which would reliably accept ever-increasing amounts of power. Although extremely loud systems are now feasible, design trends favour a reduction in size and weight of equipment rather than an increase in volume for its own sake.

The first amplifiers for musical use developed some 10 to 15 watts. Among these were the WEM Westminster (1954) and the Vox AC10 (1958), both using a push-pull pair of EL84 valves in the output.

Lots Of Bottle

This valve was notable for its efficiency in terms of power requirement versus watts-output, but had an unusually non-linear transfer characteristic (also known as Ia/Vg curve, that is, the anode current drawn for a given control-grid voltage potential), which produced an audible ringing harmonic in any amplifier that used it without the benefit of negative feedback. This was utilised by the designers and builders of the time and it is rare to find an amplifier of this era with a feedback arrangement.

Vox developed a larger amplifier, a double up version of their AC15 (in turn, a development of the AC10) — the AC30, which became one of the classic guitar amplifiers and is still produced today and used in large numbers. This has four EL84s driving two 12" speakers. Its power has actually increased over the years, starting at 32 watts and now at about 40 watts, but the overall sound output of 115 dB is still rated as exceptional for an amplifier of its size and vintage. The individual sound of the EL84s is much in evidence.

The introduction of the EL34 pentode by Mullard in 1956 generated a new wave of amplifiers. Like the EL84, this new valve was easily driven and very efficient. A push-pull pair could produce up to 50 watts. The EL34 did not have the knee in the slope characteristic of its smaller cousin, so that amplifiers which used it, such as Selmer's Treble-and-Bass, Vox's AC50 and the Marshall 50, tended to sound smoother and less ringing.

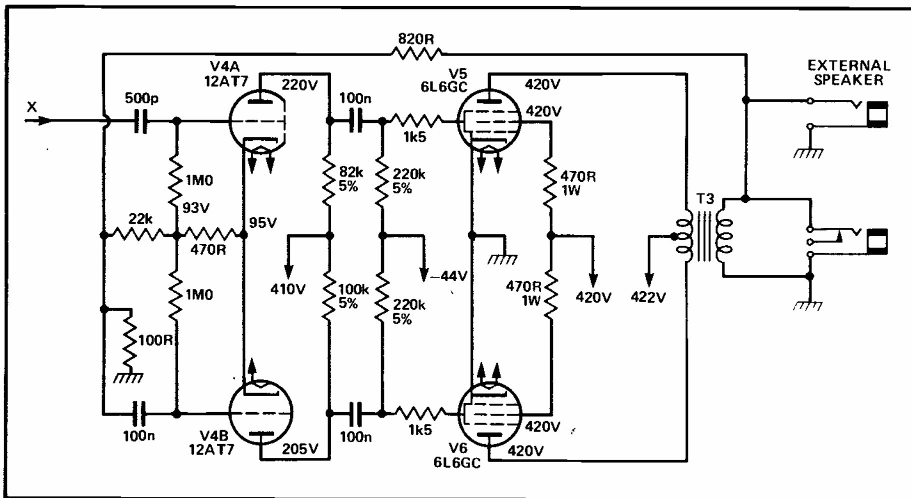


Fig. 4 The power amplifier stages of the Fender model AA-864 Bassman amplifier. Note the use of a cathode-coupled phase splitter (V4a and V4b) and the feedback loop from the output transformer secondary to the phase-splitter cathode circuit.

It was, consequently, widely used in bass-guitar amplifiers, of which the above are all classic examples. When used in fours, it could produce 100 watts of power, and this became a music industry standard, with the Vox Super-Beatle and the Marshall 100-Super-Lead both appearing within a year of each other. These had a certain edge to their sound, probably due to haphazard choice of valves in manufacture and a small amount of imbalance in the output-transformer windings. Sufficient sectionalization to avoid this latter problem was not considered cost-effective.

A look at some of the power-stage circuits of the time reveals a similarity to that of the Fender power stage of 1963. A cathode-coupled phase-splitter is common to most designs. This gave adequate drive and enough gain to incorporate a feedback loop from the output-transformer secondary to the cathode circuit of the driver. In higher-powered amplifiers, this was necessary to keep some sort of damping control over the multiple-speaker arrays and to overcome the often inadequate frequency-response of the large output transformers fitted.

A four valve push-pull pentode circuit is capable of producing 10% of 2nd and 3rd harmonic at 90% power, which can produce intermodulation between low notes and high notes played simultaneously. The feedback reduced this to some 2 or 3%, retaining enough colouration to make the sound satisfying but removing excessive intermodulation.

A Gross Distortion

A common sales-pitch in advertisments during the EL34 era was to boast 'clean, undistorted power'. But when the transistor began to be incorporated into instrument amplifiers, some idea began to emerge as to what a really clean amplifier could sound like.

The transistor was not, however, accepted by musicians. Mystified engineers would say, 'You can't make a bad enough amplifier using transistors to give the same sound as a valve amp.' But recent research has shown that some of the early transistor amplifiers were actually very bad indeed, confirming the uninformed ear's immediate impression. It was not until the emergence of the constant-current source (for example, in the 741 op-amp) that solid-state circuitry begin to gain credibility among musicians.

This gives a clue to the preference for valves, as these have their own in-built constant-current source by virtue of high anode resistance. The first transistor amplifier to gain widespread acceptance by musicians was the HH IC100, whose principal amplifying element is the 747 op-amp, a good example of the practical application of the constant-current source. Valves have another advantage in enormous headroom. Their gain does not make it easy to drive them anywhere near their signal-handling

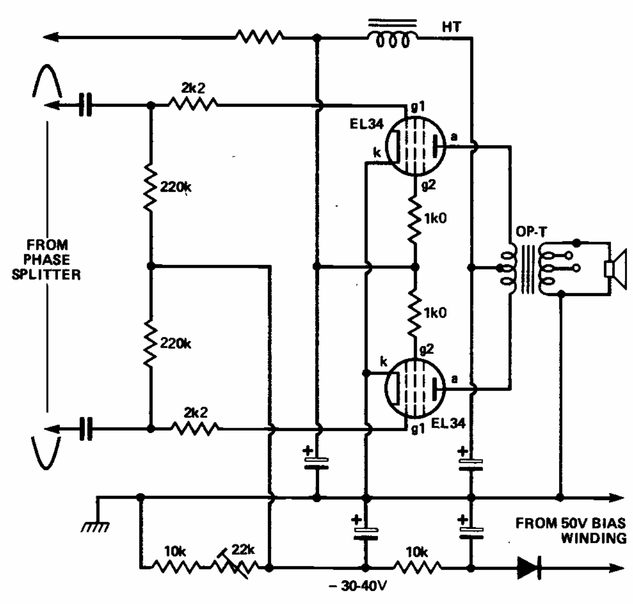


Fig. 5 A typical 45–50W valve output stage in which a fixed bias voltage is tapped off of the HT chain or derived from a separate bias winding. The advantages include a low output impedance and hence high damping factor but the distortion figures suffer.

limit, while transistors or ICs operate for most of the time at around a third of their total signal capacity.

Many opinions exist regarding the essential differences between valves and transistors. The 'constant-current theory' seems coherent, especially since a class A valve amplifier actually sounds different to a class AB valve amplifier even when they use the same output devices. The class A valve amplifier is a near perfect constant-current power-amplifier, due to intrinsically high anode resistance combined with class A biasing.

The relatively high output-impedance of such a circuit gives a low damping factor which is said to result in a certain warmth of tone. A transistor power amplifier may have a higher-than-normal output-impedance and be worked in class A. It then begins to sound increasingly valve-like, but the output-impedance reduces efficiency below the 48% characteristic of class A working. The power-stage and power supply become so costly that it is more practical to use valves and arrive directly at the desired result.

There are also differences in the types of distortion generated by valves and transistors. The most obvious to an engineer doing A-B tests of valves against transistors are in the realm of dynamics, which are difficult to evaluate using continuous signals and measurement systems. It is clear, though, that the lower-order harmonics generated by valve-amplifiers are more pleasant to the ear when used with music than the virtual absence of self-generated harmonics in transistor equipment.

Of late, much research has been done into the generation of 2nd harmonic distortion in solid-state circuits without loss of their inherent advantages (low noise and wide frequency response, in particular). Solid-state circuitry is being developed which sounds confusingly similar to valves. In the final analysis, a thing sounds like what it is and the gap may never be finally closed.

The Good Transistor

This does not mean that good music equipment cannot be produced with transistors. In some applications —notably, keyboard and bass guitar amps — the differences between valves and transistors are not obvious. The HH IC100 range is an example of good solid-state design practice, both electronically and structurally. The sound relies on the accentuation of harmonics already present in the signal rather than generated by the circuitry. The excellent dynamic performance of the power-amplifier makes the most of this technique and the result is pleasing in most applications.

A recent trend in solid-state preamp design is the use of bi-fet op-amps such as TL071. These devices benefit from excellent input linearity and low noise. They give good AC performance, and can be regarded as a net improvement on the 741 device as far as instrument amplifiers are concerned. They are used in such successful designs as Roland's Cube series and the UK-built

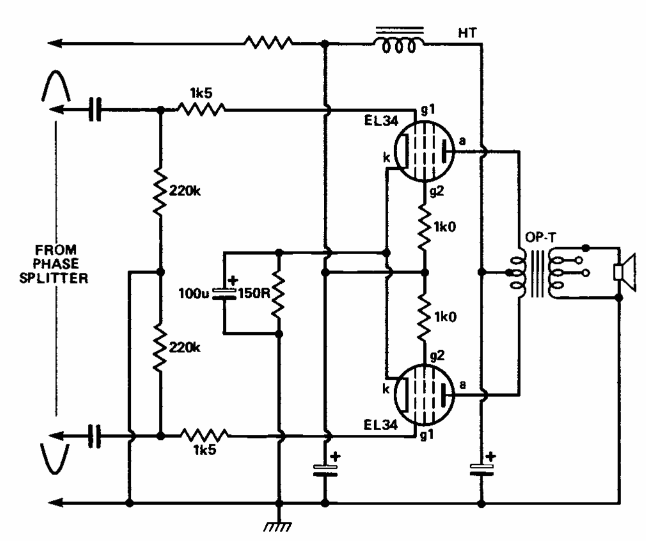


Fig. 6 A valve output stage employing the less commonly used auto-biasing system. This offers less power than a fixed bias arrangement but produces less distortion and has a warmer sound because of the low damping factor.

Session range, which owe their transparency and fast AC performance in large measure to these devices.

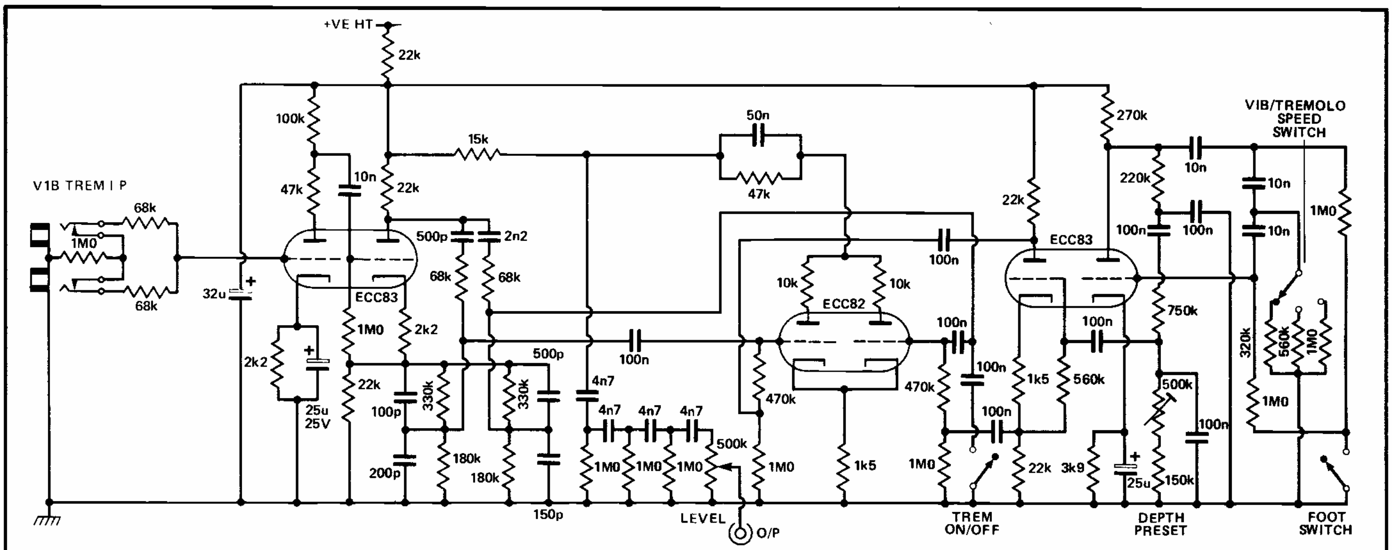
Early transistor designs were commercially disappointing but technically interesting, and will repay close attention. No less interesting is the hybrid technique used in Peavey's Classic and Deuce amplifiers, with solid-state driving-circuitry coupled to a push-pull power-valve output. In all cases, design approaches are aimed at a satisfying richness of tone, and volume without noise or unpleasant distortion. But distortion remains.

A Little Echo

The other area in which instrument amplifiers differ markedly from other types of amplifier is in the facilities for processing the signal before it drives the power-stage. The gain requirement is apparently simple: an input sensitivity of 10mV to produce a signal of between 500mV and 2V, adequate to drive the power amplifier. Less apparent is the headroom requirement.

The signal whose mean value is 10mV can have a transient maximum value of up to 500mV. This can apply equally to guitars and keyboards with touch-sensitivity (most recent synths, Fender Rhodes pianos, and so on).

The Marshall Artist 3203, a 30W amplifier which has a valve output stage and an IC preamplifier. Note the 'standby' switch, a common feature on valve amplifiers. The 3203 has only one input channel but two tone control networks. This allows the user to set both a 'backing' sound and a brighter 'solo' sound and to select between the two in performance using a footswitch.



AC30 VIBRATO/TREMOLO CIRCUIT

Fig. 7 The vibrato/tremelo circuitry of the Vox AC30. The signal is first amplified and passed through two 90° phase shifts produced by the RC feedback networks around the second triode. The two signals are then combined in a modulator (the ECC82) with the outputs from an LF oscillator and phase splitter built around the second ECC83.

Consequently, the front-end stage must have either a low gain or a huge headroom capability.

In transistor circuits, the first course is usually adopted, most of the gain being 'post-fade' or subsequent to the volume control. In valve circuits the headroom is not a problem and a stage gain of 50 is common in a front-end. This implies 25V AC at the anode on peaks, but this is well within the capabilities of a typical triode. This is a practical reason why the theoretical noise advantages of transistors are seldom realised in practice — with 40dB of gain after the volume control, the perceptible noise is usually higher in the transistor amplifier.

Various special effects are found in instrument amplifiers. The most important of these is reverberation or reverb. This is normally provided by the excitation of a spring-type (electro-mechanical) delay-line and its subsequent amplification and re-mixing with the dry audio signal. The spring type seems to suit guitars better than bucket brigade or charge coupled circuits. The spring displays more randomly-distributed delay-times than solid state devices, which suit vocal and percussive material better. Reverb is found in most of the better-known guitar-combos.

Less common but once widely used is tremelo, the amplitude-modulation of the signal by a low-frequency oscillator. This was easily effected in valve amplifiers by the use of the secondary control-grids in output-valves known as screen-grids. In transistor amplifiers the effect is less easy to implement, as the LF oscillator has to generate a pure sine-wave of 1 to 5Hz and the modulating element must be square-law, to avoid lumpiness in the response or audible LF in the background. Coincidentally the effect became unfashionable in the mid-60s and few solid-state amplifiers ever featured it.

The last of the effects once commonly fitted to amplifiers is vibrato. Vibrato is the frequency-modulation of the signal, usually by the same LF oscillator used for the tremelo effect. The Vox AC30, which is the only production amplifier still featuring vibrato, uses an elaborate 90° phase-shift circuit operating in the 200-2,000Hz band built around two triodes with RC phase-shifting elements. The effect would now be more readily produced using a frequency-modulator based on a short-delay bucket brigade device. Demand, however, does not justify the additional expense of fitting such circuitry to solid-state amplifiers which usually have to fight their way through a tight budget in any case. Such built-in luxuries will have to wait for the next 'beat-boom'.

The present day equivalent is to fit a three-stage front end with a level-control between each so that, by suitable settings, any desired degree of overload distortion or sustain may be generated. This may be filtered by the tone-controls to produce soft or hard distortion. Unlike the other effects, this requires a certain skill in matching the settings to the way the instrument is played. But a wide range of expression is possible and this, finally, is what the builder of electric instrument amplifiers is there to facilitate.

The classic Vox AC30 combo amplifier, a valve design which uses four EL84s to drive some 30–40 watts into two 12" drive units.

ETI

FM FROM THE BEGINNING

John Linsley Hood begins a short series on FM transmission and reception with a look at propagation and stereo signal encoding.

The choice of the VHF part of the available radio spectrum (Band II, 87.5 — 108MHz) is dictated by the way in which radio signals are propagated, which depends on the influence of the ionosphere.

This is a group of three diffuse layers of ionized gases which surround the earth, and which bend the paths of radio signals (Fig. 1). The ionization occurs partly as a result of high intensity UV and X-rays emitted by the sun. The rays do not affect that part of the earth's atmosphere in shadow, during the hours of darkness.

A fair bit of ionization, especially in the upper layers, occurs as a result of the bombardment of the earth with energetic particles. These are also mainly due to the sun but do not penetrate the atmosphere very deeply and also have their paths bent by the earth's magnetic field, to follow the curvature of the earth. The onset of night doesn't affect them very much.

The three major layers in the ionosphere are known as the D, E and F layers (Fig. 2). Long wavelength (low frequency) radiation is bent or refracted back towards the earth's surface by the first layer it encounters (D). At these long wavelengths, the irregularities on the earth's surface, such as buildings, trees and gas-holders, are

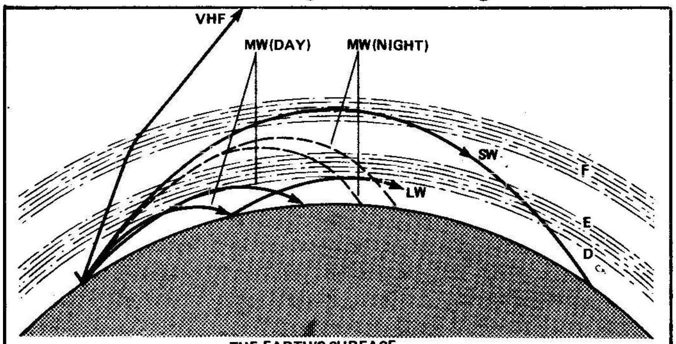


Fig. 1 Layers in the ionosphere affect radio propagation differently by day and night.

ignored. There is quite a good reflected wave from the ground, which acts as a mirror.

The combination of the reflected (ground) wave and the refracted (sky) wave adds up to what is known as the *space wave* and this can continue, gradually getting weaker, for a thousand miles or more.

Medium wave (shorter wavelength) transmissions are also bent back down to the earth by the lower layers of the ionosphere but are less strongly affected. But at these wavelengths the irregularities of the earth's surface impair the efficiency of ground reflections, and MW broadcasts have a smaller range in the daytime.

However, at night the D and E layers largely disappear, and the MW signal is able to reach the upper F layer. This bounces it back to earth at much greater distances.

During the day time, you can get perhaps a dozen MW radio stations on your 'tranny', but at night you may be able to get a hundred or more. This is all good fun, but a great nuisance in the pursuit of received signal quality.

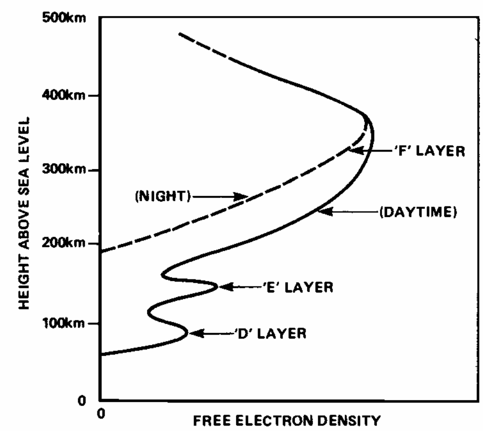


Fig. 2 Variations in electron density in the atmosphere by day and night.

At the last count, there were some 450 AM broadcasting stations on MW in the UK alone.

To try to avoid complete overcrowding, the European Broadcasting Convention has shared out the available frequency allocations at 9kHz intervals. This effectively limits the possible AF bandwidth broadcast by a MW tranmitter to 4.5kHz. (Broadcasting authorities tend to bend the rules a bit to give a bit more than this, but not a lot). Quite a lot of local low power stations share the same frequencies.

Fortunately, as the radio wavelength gets shorter, the extent to which the waves are refracted by the ionized layers gets less. Below 10 metres (30MHz) or so, the waves are seldom returned to the earth, but tend to continue on in to outer space.

In the Band II region, transmission is largely a line of sight affair, and you can mainly ignore the neighbours. As the transmission frequency goes up, available bandwidth increases, so that the restrictions of MW and LW need not apply. The result is less crowding and better sound quality.

Why FM?

Amplitude modulation is associated with the simplest kind of receivers to construct, which use familiar techniques. But AM signals are subject to fading and, at VHF, are very badly affected by motor vehicle ignition noise.

It is also difficult (though not impossible) to obtain low distortion in the demodulator (or detector) stage, and the linearity of the audio frequency response is affected both by the quality of the RF tuned circuits and by the accuracy of tuning.

The demodulator circuits needed for FM reception are a good bit more complex than those used in AM, but they can be very linear. For 100% modulation, THD will be in the range 0.01 - 0.5%, compared with 0.5 - 2% for the normal types of AM detector circuit.

An additional, and substantial, advantage of FM is that the signal will be amplitude limited in the RF stages prior to demodulation, so that the final RF output will always be constant. This greatly assists in getting rid of impulse-type interference, and this is assisted by the choice of demodulator circuits which have a low sensitivity to AM.

Since the loudness of an FM signal depends on frequency deviation, rather than actual signal strength, FM signals should not display the variation in strength familiar with AM signals. The available transmitter power is used more efficiently. This gives a wider 'service area' for the same receiver field strength than would be possible with AM.

Finally, modulation frequency controls the speed with which the carrier is swept up and down its band, rather than the size of the signal at any point. This makes it easy to achieve a flat audio frequency response —essential for hi-fi.

In Two Ears . . .

With the greatly increased transmission bandwidth available in the VHF region, it became practicable to offer a stereo signal. The Zenith-GE pilot tone system was adopted by international agreement (Fig. 3). This has the great advantage that you can receive a high quality mono signal without stereo decoder circuitry.

The agreed frequency deviation for 100% modulation on a mono signal is ±75kHz. With the stereo encoding employed, this is reduced to 67.5kHz because of the added components of the stereo signal.

The left-right information appears as a superimposed double sideband signal based on a 38kHz sub-carrier.

In order to avoid the inadvertent intrusion of this signal in to a mono receiver, the 38kHz sub-carrier is suppressed (to within a specified 1% of signal strength). A 19kHz sine wave, at 10% amplitude, is added to the broadcast signal to allow the missing 38kHz carrier to be regenerated, if the stereo components are to be decoded.

Signals to be transmitted are combined in a matrix circuit to give (L+R)/2 and (L-R)/2 outputs (Fig. 4). The mono L+R signal is filtered to remove any components above 19kHz and passed through to the output, while the L-R signal is taken to a balanced modulator and converted into a double-sideband suppressed signal, based on a crystal controlled 38kHz carrier frequency.

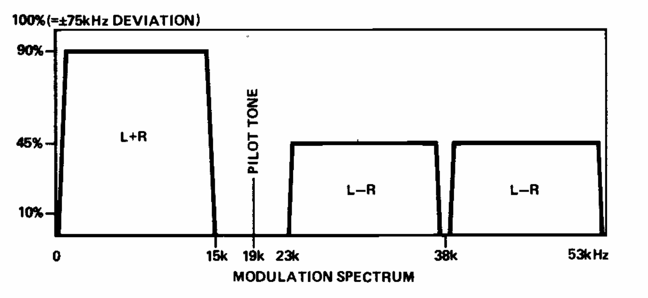


Fig. 3 The Zenith-GE 'pilot-tone' stereo system.

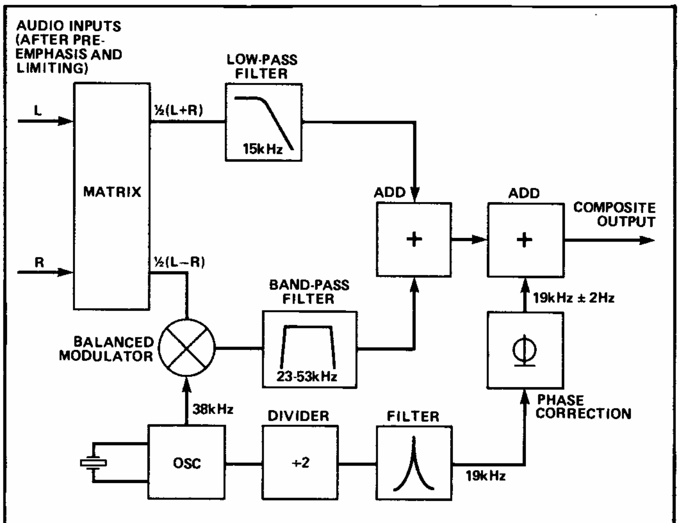


Fig. 4 A matrix-type stereo decoder circuit.

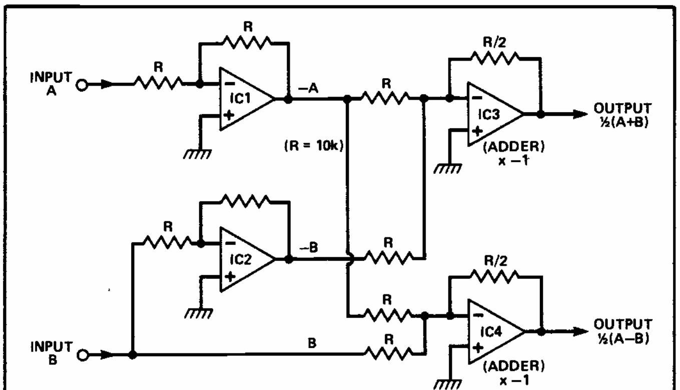


Fig. 5 A simple but highly effective method of signal pair conversion.

This is filtered to limit the bandwidth to 23-53kHz, and added to the mono L+R signal. Finally, the 38kHz carrier frequency is divided to give the 19kHz pilot tone. This is filtered to remove all harmonics, phase adjusted so that it has the right relationship to the 38kHz waveform and added to a composite 30Hz-53kHz signal.

A simple, high quality method of signal pair conversion is shown in Fig. 5. In this the incoming signals (labelled 'A' and 'B') are phase inverted by input buffers IC1 and IC2, and combined in the mixer stage IC3 to give the required (A+B)/2 signal. The B signal, without phase inversion, is added to the '—A' signal in the mixer stage, IC4, to give (A—B)/2 at the output. The *same* matrix could be used as the receiver adder stage (Fig. 6).

. . . And Out

There are two common methods of decoding the composite signal, once the 19kHz note has been extracted and a 38kHz waveform has been produced. In the matrix addition system, the recovered sub-carrier wave is used to demodulate the L—R portion of the signal in a synchronous mixer (or balanced modulator (Fig. 6)).

The L—R signal is taken to a circuit which will add it to the L+R, mono, signal and also phase invert it and then add it. The original L and R channels will result.

The second method (Fig. 7) is very much more complex in theory but much simpler in practice. In this, the 38kHz recovered waveform is used to operate some kind of synchronous switch, by which the composite signal is sampled and routed alternately to the L and R outputs.

This works because of the interesting circumstance

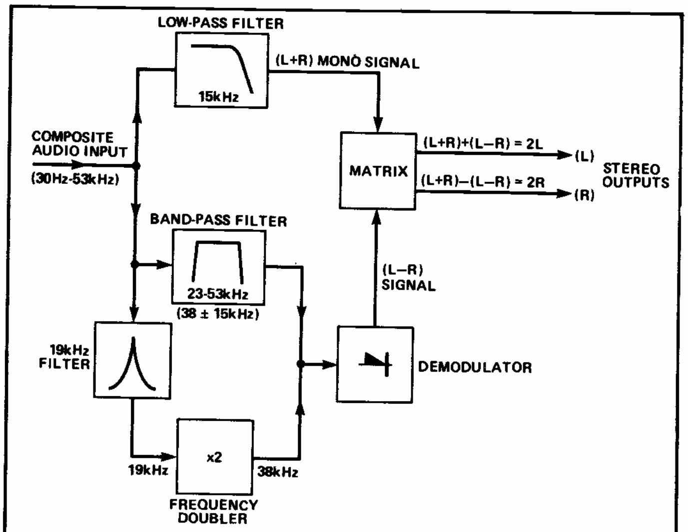


Fig. 6 the Zenith-GE stereo encoding system.

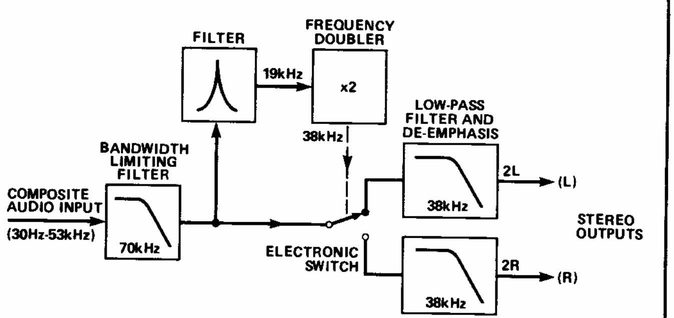


Fig. 7 A synchronous switch type of stereo decoder.

that an effective phase inversion of the L−R portion of the signal occurs 76,000 (2 x 38,000) times a second. Sampling at just the right point will capture either the L+R+L−R or the L+R−L+R components giving 2L and 2R outputs as before.

This kind of circuit lends itself well to incorporation in a single IC and has become a very popular technique, used in the vast majority of stereo FM tuners. It does mean that the signal is fed through some kind of digitally controlled sampling system at 38kHz, which imposes an absolute upper limit of 19kHz on the usable audio bandwidth. Because of aliasing, any signal above 19kHz would be indistinguishable from a signal occurring at the same frequency interval below.

The proponents of matrix addition say that it has a lower effective noise level than sampling. This can be true because harmonics of a 38kHz switching waveform (principally the 3rd) are equally capable of demodulating wideband noise signals occurring 19kHz on either side of the harmonic frequency, transposing them down in to the audio band. This defect of sampling decoders is known as *wide-band commutated noise.*

But if the incoming signal to the decoder is filtered, there will not be much unwanted bandwidth above 53kHz. The filtering should not lead to too much phase shift in the 38-53kHz band with reference to the 30Hz-15kHz one, which would impair stereo separation. A crafty answer to that problem is to adjust the relative phase of the 19kHz pilot tone, after extraction, to optimise the stereo image quality. Commercial systems often include a small phase shift network — often just a simple RC integrator network — ahead of the decoder IC, which serves the same function.

There will always be more noise on an FM stereo signal than on a mono one, because wide-band noise is proportional to the square root of the bandwidth. With mono bandwidth at 15kHz and stereo at 53kHz, minimum, the radio is 3.87:7.28, which is nearly 6dB.

Further Into Digital

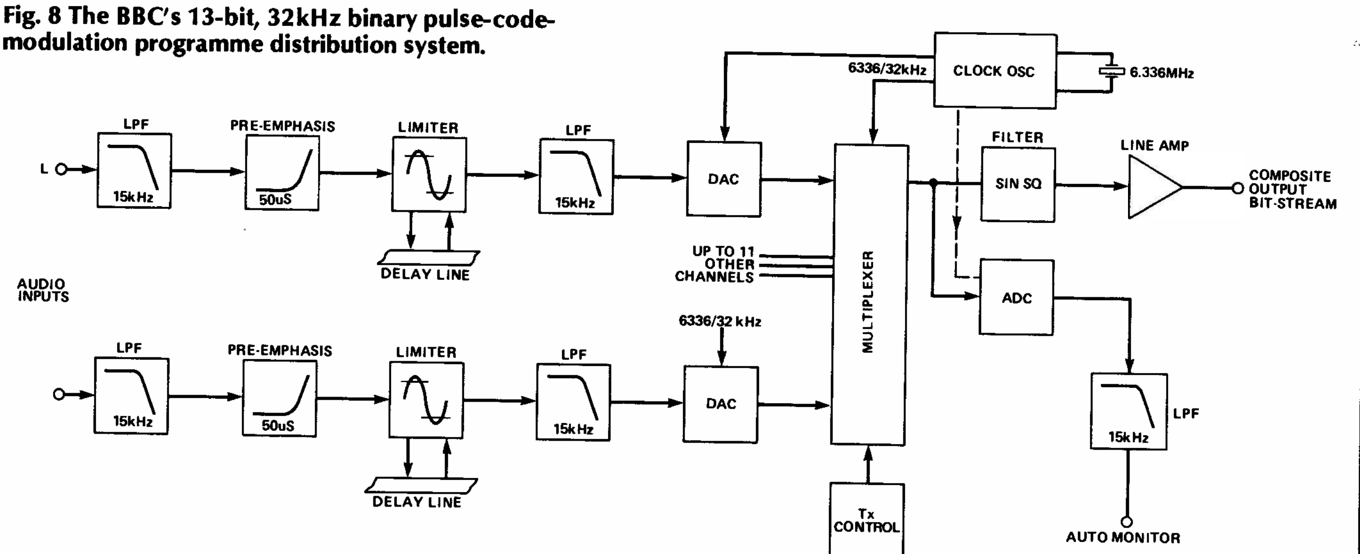
The second, and more important digital contribution to FM broadcast signals is the BBC's PCM signal transmission system, which is used to route programmes and control signals from the studio to the transmitter. (Actually, they also use it for AM transmissions).

This is cleverly designed to enable 13 high quality audio signals to be carried simultaneously over a 6.5MHz bandwidth transmission channel, of the kind which is used to carry the standard 625-line TV signal. It works by converting the incoming signal into digital form, using a 13-bit (8192 step), double ramp, linear binary code ADC at a 32kHz sampling rate.

This converts the signal into a 13-bit binary number, representing one of 8192 possible signal voltage levels. The binary code outputs from up to 13 ADCs are time sequentially multiplexed for transmission as a 6,336kHz bit-stream (Fig. 8).

An incoming audio signal is first passed through a steep cut low-pass filter to remove any audio components above 16kHz, which could lead to aliasing. The

Fig. 8 The BBC's 13-bit, 32kHz binary pulse-code-modulation programme distribution system.



appropriate broadcasting system pre-emphasis is then applied. (This is 50μs in the UK and Europe, corresponding to a frquency boost at 6dB/octave above 3.18kHz. In Japan and the USA, a 75μs pre-emphasis gives treble lift above 2.12kHz.)

The signal is then passed through a delay line limiter, in which there is an absolute ceiling at +12dB above nominal peak programme level. The delay line is used to hold back the signal until the measurement and channel gain reduction circuits have had a chance to operate. The output limit is essential to avoid overload and malfunction of the ADC.

An additional low pass filter is then included, prior to the ADC to remove any HF components produced by clipping. A crystal controlled 6.336MHz clock is used as the master pulse generator to operate the ADCs, through a frequency divider, and to generate a series of sequential shift pulses to transfer the binary code outputs into the multiplexer.

The output from this is passed through a filter which shapes the pulses into *sine squared* form, of 158ns half amplitude duration, and 158ns apart. This has a negligible energy content above 6.336MHz.

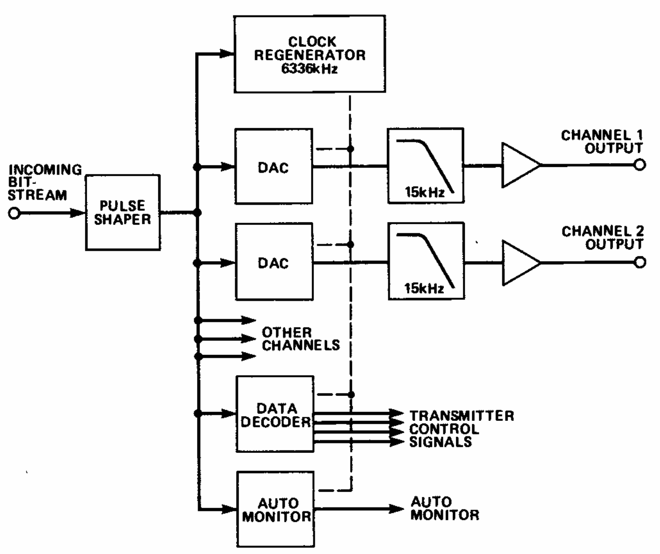


Fig. 9 The BBC's pulse code modulation decoder system.

In order to obtain a high degree of immunity from transmission circuit disturbances and noise, a single parity bit is added to each 13-bit word. This parity bit provides a check on the five most significant digits in the preceding 13-bit group. If an error is detected, the whole 13-bit word is discarded, and the word preceding it is used in its place. If too high a number of successive words are faulty, the system is muted until proper operation returns.

With a sampling rate of 32kHz, a bit rate of 6,336Kbits/second means a group of 198 bits/frame, which allows 13 channels carrying 14 bits (13 signal + 1 parity bit), plus 16 spare bits — 6.336MHz/320kHz = 198 and 198=13X14+16. Eleven of the 16 bits are used to provide a framing pattern, and five are used for transmitter control signals or possibly, in the future, for signal companding information.

The output of the multiplexer is sequentially sampled, with a time duration of 256ms for each input channel, in order to detect any malfunction.

At the input to the transmitter, the incoming bitstream is passed into a pulse shaper circuit to clean it up. It then goes to a circuit which regenerates the original 6,336kHz clock frequency (Fig. 9).

This is divided down to operate a sequence of 32kHz sampling rate DACs, timed by a further sequence of shift pulses so that they can extract and route the decoded signal amplitude information.

The output from the DACs is a staircase wave and must be filtered to remove all components above half the sampling frequency. It is surprising to see how good a sine wave can be extracted from a staircase having only eight possible sample levels, if adequate filtering is employed.

Problems, Problems

Any system in which a continuous signal is forced in to a discontinuous form must suffer from some kind of defect as a result. The defect is known as *quantisation noise*. Although the sampling rate in this case is well above the limits of human hearing and its effects should be filtered out, there is a good chance that a sequence of sampling intervals will give consistently wrong results when the value of each step level allocated by the circuit is too high or too low.

Such randomly occurring groups of errors contribute noise proportional to the ratio of step size to signal peak size.

The other major problem associated with digital signals concerns the steep cut (*brick wall*) filters which are used to remove the sampling steps and prevent aliasing. Such steep cut filters distort transients, and lead to coloration, and the steeper the slope the worse the problem becomes. Fortunately, the filtration frequencies used are either well above the audio range, or at the extreme upper end of it where the ear is not very sensitive.

That said, it is not often that one hears criticism of the quality of the BBC FM transmissions: In spite of the fact that they are first of all digitally encoded, in 13-bit form, at a 32kHz sampling rate for distribution to the transmitters, where they are then reconstructed, only to be cut about once more to give componsite stereo signal, part of which exists as a time sequential sample based on a 38kHz sampling rate.

To put the frequently maligned compact disc system in perspective, this also uses a PCM encoding system, but with a sampling rate of 44.1kHz, a bandwidth of 20Hz-20kHz±0.5dB, and a 16-bit (65,536 step) encoding matrix, which offers a final THD less than 0.02%, and a channel separation better than 60dB.

VHF/FM transmitted signal performance standards:	(These figures relate to the anticipated broadcast signal, including all parts of the programme chain. — Information by courtesy of the BBC).
Bandwidth:	30Hz - 15kHz, ±0.5dB.
Distortion:	THD = <0.5% at max. modulation. (That due to the transmitters and distribution chain is typically 0.1% at 1kHz).
Stereo channel separation:	>46dB.
S/N ratio:	Up to 64dB, ref. 100% modulation, using the CCIR/rec. 468 weighting pattern.

Next month, I propose to take a look at some of the sources of distortion in the FM receiver itself. **ETI**

NEXT MONTH

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MIDI Madness

This feature is, we hope, the start of a mini-MIDI bonanza. We've got teams of researchers, writers and designers working on MIDI projects and a complete anaylsis of this accepted standard for Musical Instrument Digital Interfacing. Begin here with a look at the general principles behind the hardware.

The Flanger

This project is a development of an earlier ETI Chorus Unit, but none the worse for that. Flanging is a less subtle effect than chorus, but this neatly packaged and professionally designed unit performs the trick with taste and gives control over rate, width and regeneration as well as incorporating a manual/auto facility, and sockets for a remote switch and an external power supply.

The LEDScope

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THE JANUARY ISSUE OF ETI —ON SALE 5th DECEMBER

All the articles listed above are at an advanced stage of preparation, but circumstances beyond our control may prevent publication.

HARDWARE DESIGN CONCEPTS

Mike Barwise finds out what's between the data sheets.

An ability to interpret IC data sheets is crucial to the design process if the end product is to prove reliable. To help readers acquire this ability, I have chosen the Rockwell R65C00 processor series as an example.

Maximum Ratings

It is frequently assumed that so long as your power rail is nominally legal at the power supply, maximum ratings can be ignored.

Wrong!

It is a mistake to consider the system as static, rather on the lines of domestic wiring. The realistic view of microsystems must take into account their dynamic characteristics, and allow for resonances, parasitic effects and so on, in what is, after all, a radio frequency system.

Working supply voltage for the R65C00 is listed as +5V±5% (*Fig. 1*) — which is between 4.75V and 5.25V. The absolute limits of –0.3V and +7V (with respect to ground or common) suggest that:

- the device must never be reverse connected,
- any supply protection device with a breakdown of about +6V to +6.5V will adequately protect the IC in event of deregulation, provided the protection disconnects power (blows the fuse, for example) within a reasonable period.

There is one other important factor: power supply noise voltage. This can be induced in an otherwise adequate power rail by the devices connected to it, and can assume critical proportions, particularly at high operating speeds. Its cause is frequently the extensive use of TTL chips with *totem pole* output stages.

The earliest TTL chips (and some today) have output stages effectively using a transistor switch to ground the bottom of a pull-up resistor. Conventional TTL has the resistor built in, whereas *open collector* TTL has the resistor omitted, allowing user selection (*Fig. 2*).

This type of output suffers from two problems:

- although the high to low (negative) transition is reasonably fast, the positive transition is compratively slow,
- the positive transition speed is very load-dependent, being sensitive to both resistive and capacitative loading.

To solve these problems, the *totem pole* output stage (Fig. 3) was designed. This uses a pair of transistors between the supply rails, the output being taken from their common point. The transistors are switched in anti-phase, so that the output is either actively pulled high or actively pulled low. This vastly improves both overall transition speed and loading susceptibility, and also makes rise and fall times almost equal.

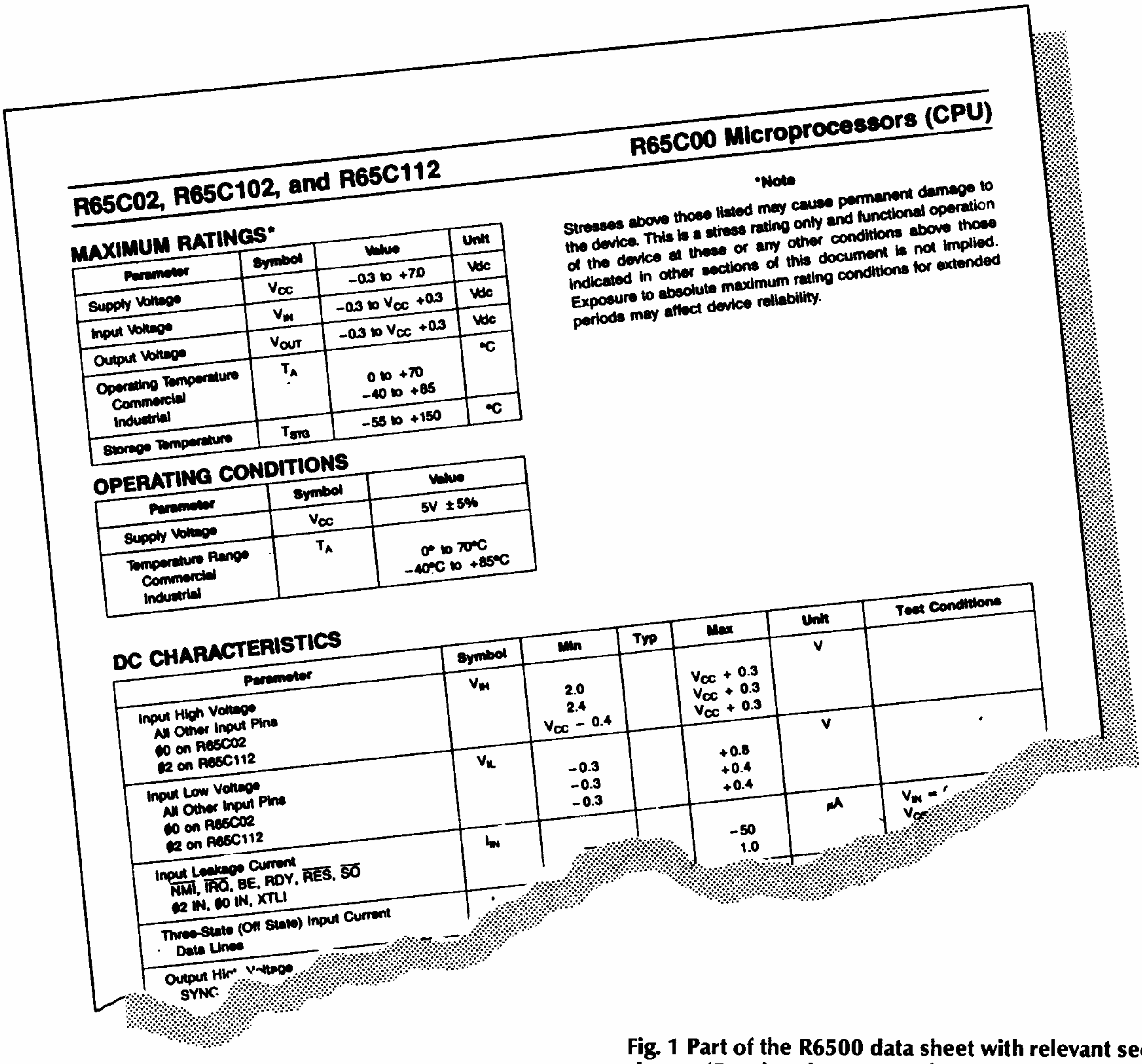
But totem pole outputs have their own troubles. Due to transistor characteristics, there is a brief moment during any output transition when *both* transistors are on simultaneously, thus *shorting the supply rail to ground* through a resistor no larger than about 50 ohms.

This moment is very short: maybe between 5 and 15 nanoseconds, but the dip in the supply voltage is quite detectable. For this instant, the current flow in the supply distribution wiring is a massive 100mA *per output*.

> *It is a mistake to consider the system as static, rather on the lines of domestic wiring...*

Then, quite suddenly, the current is blocked by the 'off' transistor turning off for real. The result is a nasty ringing: a series of voltage spikes and troughs superimposed on the mean supply rail, due to the inherent resonance of the wiring and tracking. Peaks are due to spike reflections appearing at any point in phase with previous spikes. Troughs are the result of them appearing in anti-phase with previous spikes. This is just the same problem as occurs on the mains when someone switches off a heavy electrical appliance in your house and your computer crashes.

Supply rail noise peaks induced by devices are very unlikely to exceed the maximum supply rating of 7V, so chip damage from this cause is improbable. However, practically no medium to large system can guarantee that all chips get their full 5V. A realistic figure is more like 4.8V. Taking into account the minimum operating voltage of 4.75V, there is very little margin to accommodate *dips* in the supply. There is also a significant risk that the noise (which can often be in the order of 100mV) will momentarily disrupt processor function by being erroneously recognised as logic signals through crosstalk to other signal lines.



R65C02, R65C102, and R65C112 — R65C00 Microprocessors (CPU)

MAXIMUM RATINGS*

Parameter	Symbol	Value	Unit
Supply Voltage	V_{CC}	-0.3 to +7.0	Vdc
Input Voltage	V_{IN}	-0.3 to V_{CC} +0.3	Vdc
Output Voltage	V_{OUT}	-0.3 to V_{CC} +0.3	Vdc
Operating Temperature Commercial Industrial	T_A	0 to +70 -40 to +85	°C
Storage Temperature	T_{STG}	-55 to +150	°C

*Note

Stresses above those listed may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in other sections of this document is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

OPERATING CONDITIONS

Parameter	Symbol	Value
Supply Voltage	V_{CC}	5V ±5%
Temperature Range Commercial Industrial	T_A	0° to 70°C -40°C to +85°C

DC CHARACTERISTICS

Parameter	Symbol	Min	Typ	Max	Unit	Test Conditions
Input High Voltage All Other Input Pins ϕ0 on R65C02 ϕ2 on R65C112	V_{IH}	2.0 2.4 V_{CC} − 0.4		V_{CC} + 0.3 V_{CC} + 0.3 V_{CC} + 0.3	V	
Input Low Voltage All Other Input Pins ϕ0 on R65C02 ϕ2 on R65C112	V_{IL}	−0.3 −0.3 −0.3		+0.8 +0.4 +0.4	V	
Input Leakage Current NMI, IRQ, BE, RDY, RES, SO ϕ2 IN, ϕ0 IN, XTLI	I_{IN}			-50 1.0	µA	V_{IN} = … V_{CC} …
Three-State (Off State) Input Current Data Lines						
Output High Voltage SYNC						

Fig. 1 Part of the R6500 data sheet with relevant sections shown. (Reprinted courtesy of Rockwell International).

Maximum input and output voltages are defined in terms of the supply voltage. It is crucial to realise that this means the supply voltage *you are really using*, not the nominal +5V!

The R65C00 processors cannot accept voltages more than 0.3V outside the supply rails without internal damage. This is common to practically all silicon gate CMOS. Beyond these levels awful things happen, like transistors reverse conducting and worse. The input voltage specification is obvious, but note that the maximum output voltage is not what the chip delivers: it's the voltage to which you are allowed to connect the output.

Fig. 2 Open collector output of TTL IC.

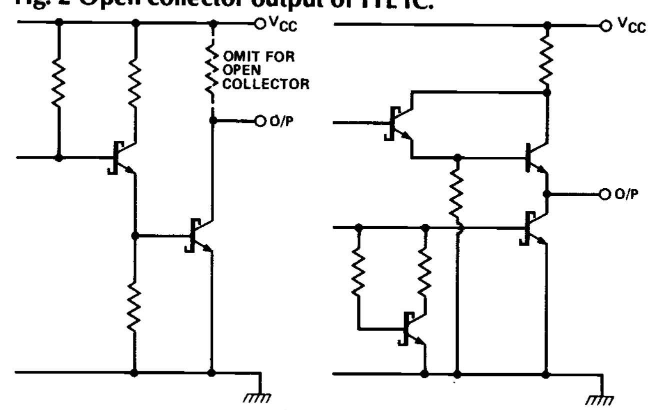


Fig. 3 Totem pole IC output stage.

Once again, the problem of spikes raises its ugly head. In signal terms, spikes are referred to as *undershoot* and *overshoot*. These usually cause more trouble than power rail noise, mainly due to the relatively high impedance and inherent lack of decoupling of the signal lines.

The two problems can combine to create totally unacceptable operating conditions. Consistent signal overshoot (excessively high voltage peaking), together with a generally low power rail voltage subject to dips can in the long run damage the IC if the maximum input voltage differential is exceeded, but long before this the microsystem will be constantly losing itself.

Prevention Is Better Than Cure

You are not likely to blow a chip instantly as a result of these faults — you'll need a good scope and lots of patience to find them. It is, luckily, possible to greatly minimise their effects at the design stage.

Keep power distribution short, tidy and low impedance (no unoccupied through-holes in PCB power tracks, for example). Use lots of distributed decoupling (not just a capacitor at the power inlet to the board), and make sure your power supply has plenty of spare capacity.

A good rule (particularly for PCBs) is this: design the power distribution first, allowing a decoupling capacitor for each chip plus one larger one for the power inlet, then connect everything else.

When it comes to signal lines, keep them short and direct. It also pays to use some consistent approach when connecting bus lines. If each line is laid out differently from all others, solving problems will be much more difficult.

If it proves impossible to keep some lines short or direct, there are ways of reducing otherwise unacceptable undershoot and overshoot. The two most common options are shown in Fig. 4.

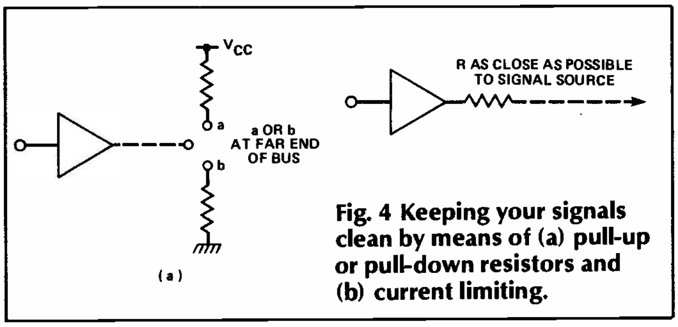


Fig. 4 Keeping your signals clean by means of (a) pull-up or pull-down resistors and (b) current limiting.

The most obvious (Fig. 4a) is the use of a pull up resistor in case of bad undershoot, or a pull down resistor in case of overshoot. These resistors should be as remote as possible from the signal source. A quite common practice is to install them on a carrier plugged into the most remote socket of a backplane.

Each line should be assessed individually for majority under- or overshoot, and the resistor connected accordinly. Note that *both* cannot be improved simultaneously to the same extent by this method. It is important to keep overall dissipation in the resistors low (which means using a highish resistor value) because power is wasted by them and they load the bus driver.

The alternative (Fig. 4b) is much better in these respects. It dissipates nothing and is invisible to the bus driver. On the other hand, it is trickier to set up and it slows the bus signals somewhat.

You can store most devices in boiling water if you like, but there's not much point...

In this second case, the system is run under observation and a resistor value chosen for each signal line to minimize over- and undershoot. The values normally pan out in the region of 30 to 300 ohms, and the transistion between adequate damping and excessive loss of signal edge speed can be dramatically sudden.

Typically, resistors should be selected from the E24 range, and be 1% components. A fast scope (50MHz) is essential for these tests, and care must be taken to eliminate artefact (the over- and undershoot contributed to the scope trace by the probes themselves).

The maximum and recommended operating temperatures will never be approached in normal use. Obviously it is a good idea to ventilate the system casing, but unless you are working in South America or the Sahara, you can normally ignore these parameters at the design stage.

You can store most devices in boiling water if you like, but there's not much point.

DC Characteristics

DC characteristics cover the voltages, capacitances and currents which should be presented to or originated by the IC. The specified test conditions should be very carefully studied. Not only do they demonstrate how representative the parameters are, but they provide a lot of supplementary parametric information.

A word of caution here: you will often find anomalies in characteristic tables. Most of these turn out to be printing errors, due to the speed with which the information is prepared, I suppose. If there's something that looks odd in the data, don't assume anything. Get in touch with the manufacturer's agent and have it checked. If you do, errors gradually get corrected, and you will at least know what you are doing.

In general, 5V VLSI conforms to TTL requirements, which are a *low* of 0.8V *maximum* and a *high* of 2.4V *minimum*. The dead band between helps to ensure defined logic states by limiting the effects of induced noise on the logic.

The R65C00 meets this specification with a safe margin of 0.4V in the high state — but note that the *clock inputs do not*. This is an example of the need for real care in reading a data sheet (refer to Fig. 1).

Below 'All Other Input Pins' in the Input High and Low Voltage sections, we find the clock input specifications. It is immediately apparent that these are device specific. The R65C02 requires a guaranteed *low* of 0.4V *maximum*, which is *half* the TTL limit. The R65C112 (the slave processor) requires a swing to within 0.4V of each supply rail, which is comparable to conventional CMOS input. Failure to meet these logic levels at the clock inputs will ensure a very erratic system. It may RUN, but more than likely it will be clocked much of the time by noise voltages.

Input Currents

The input leakage currents specified in the 65C00 data sheet are not of enormous importance to the small system builder, except where battery support is envisaged. There is, however, a much more important consideration, which is *drive capability versus loading*.

The general text of the data sheet describes the drive capability of the 65C00 series as one TTL load. There is often much confusion about the interpretation of this kind of descriptive specification, but it is not really abstruse.

Logic systems of interconnected devices communicate by driving each others' lines high or low. This means that a voltage is impressed at a point of relatively high impedance (the input) by the output of a preceeding device.

A typical 74LS input is shown in Fig 5. An undriven input floats nominally high due to the combined thresholds of the two series connected diodes D3 and D4 — about 1.2V each — presented to the bottom of the pull-up resistor. Diode D2 between the input and ground simply improves negative-going response time, and can almost be ignored from the point of view of DC loadings.

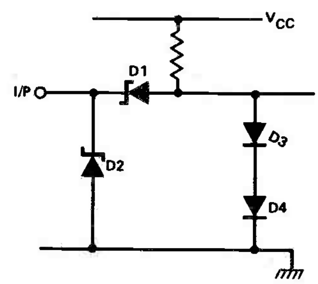


Fig. 5 Typical input stage of 74LS series TTL.

When a logic high is presented to this input, the input diode (D1) is reverse biased, so there will be a very small current flow *at* the input due to the diode reverse leakage. Here D2 does contribute to the loading, but the total is still very small.

If we take the input low, diode D1 forward biases, and there is a considerable current flow *out* of the input, effectively limited by the value of the pull-up resistor (usually around 18k).

The outcome of all this is that a low input loads the driving device a lot more than a high input, and as the flow is out of the input, the current must have somewhere to go!

Output Currents

To complete the picture we must take a similar look at outputs.

Referring back to the descripton of TTL outputs in my notes on noise, we see that the logic low current handling of a TTL output is more or less defined by the on resistance of the output transistor, and the logic high current by the resistor to Vcc. The low current sink (into the output) is still greater than the high current source (out of the output), and both are a lot chunkier than the input requirements, so several inputs can be connected to one output.

You will often find anomalies in characteristic tables — most of these turn out to be printing errors ...

The maximum number of inputs per output or *fan out* is the most important DC parameter for reliable design. The validity of *output voltage levels* (particularly logic low) depend on it absolutely.

In the next instalment I will cover the problems of overloading of outputs, which leads nicely on to the discussion of dynamic or AC parameters. **ETI**

THE NEXT GREAT LITTLE IC?

Paul Chappell introduces a device which may prove to be as useful as the 555, even though most people think of it as only a tachometer IC.

The LM2917 is an IC which has been almost entirely neglected by circuit designers and experimenters, although it is both versatile and easy to use. Figure 1 shows its functional blocks. The power supply is stabilised at 7.5V by an active shunt regulator, pictured as a zener in the diagram.

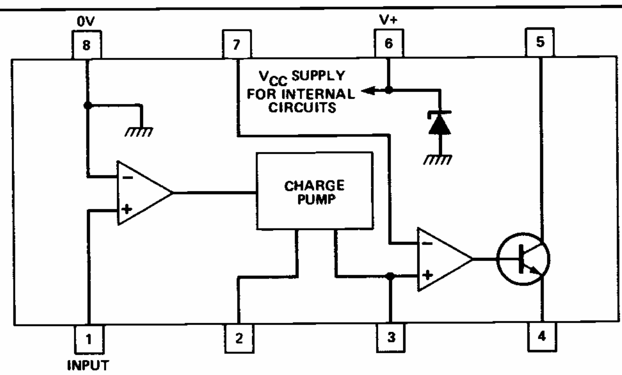
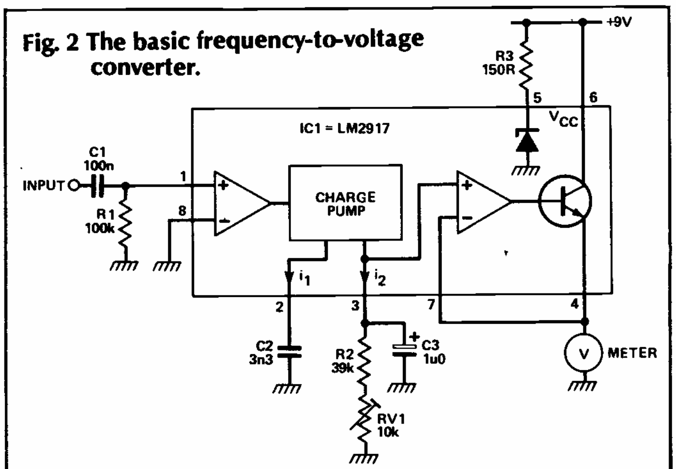


Fig. 1 Internal circuit blocks of the LM2917.

In the IC's usual role, the input signal is applied via pin 1 to a comparator. The other input of the comparator is grounded, so its output will change state each time the input signal crosses 0V. The comparator has a small amount of hysteresis, about 30mV, to ensure that it switches cleanly. Next comes a charge pump which delivers a pulse of current from pin 3 each time the comparator output changes state, giving an average current proportional to the input frequency. With a resistor and capacitor to ground from pin 3 to average out the pulses, we have a frequency to voltage converter.

Fig. 2 The basic frequency-to-voltage converter.

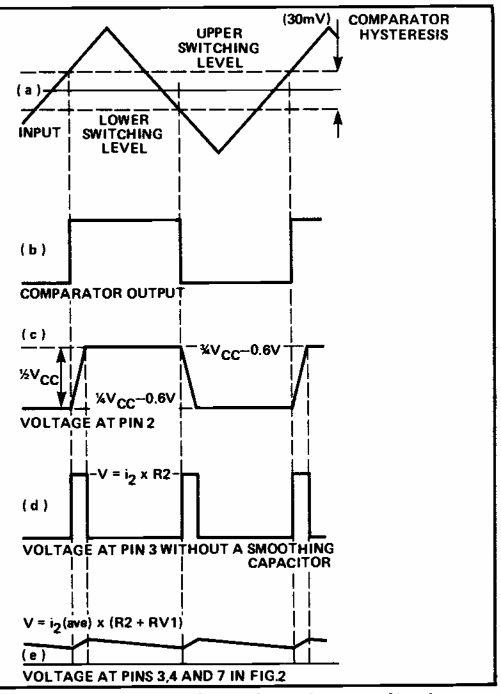


A simple frequency meter circuit is shown in Fig. 2. The component values shown are for an output of 1V per kHz, so that 2.7V, for instance, would represent 2.7kHz. The op-amp and transistor are connected as a voltage follower to provide a suitable output for the meter.

The Charge Pump

The heart of the LM2917 is its charge pump. Figure 3 shows the waveforms present at various points in the circuit for two different input frequencies. Each time the comparator output goes high, it turns on a current source i_1 (Fig. 2) which remains on until the voltage on C2 has increased by $\frac{1}{2}V_{cc}$. As soon as the voltage on C2 has reached its upper level, ($\frac{3}{4}V_{cc} - 0.6V$), the current source is turned off again. When the comparator output goes low, it turns on a current source, $-i_1$, which reduces the voltage on C2 by $\frac{1}{2}V_{cc}$. This gives the waveform shown in Fig. 3c.

Fig. 3 Waveforms at various points in the LM2917.



During the time that C2 is either charging or discharging, a current mirror arrangement in the IC provides a current of the same magnitude from pin 3, but this time always in the same direction. Figure 3d shows the waveform that would be seen at pin 3 if it had a small resistor R2 to ground connected to it — a series of pulses, all of the same height and width, at twice the frequency of the input waveform. Figure 3e shows the result of smoothing these pulses out with a capacitor — C2 in Fig. 2. The ripple is exaggerated in the diagram — with a large enough capacitor, it can be made as smooth as you like. The voltage level will be proportional to the pulse rate, and hence to the input frequency.

Component Values

In fact, the voltage on pin 3 is given by the conversion formula $V_{cc}CRf_{in}$, where V_{cc} is the internally generated supply voltage (7.5V), C is the capacitance on pin 2, R is the resistance on pin 3 and f_{in} is the input frequency. This is the basic formula you will need to calculate component values. There are certain constraints on the values you can use, but this is mainly a matter of common sense.

As an example, let's calculate the values for an audio frequency meter to give a full-scale reading of 2V for an input frequency of 20kHz. We'll use the same circuit as Fig. 2, but the component values will be different.

Take a value for the capacitance (C2) at random, say 220pF. The resistance (R2 + RV1) can be caculated from the conversion equation by substitution.

This gives 66k (or 68k to the nearest preferred value). Since we are not necessarily going to use precision components, and since the gain constant of the LM2917, Ii_2/i_1I, is not guaranteed to be exactly 1, we allow for some adjustment to the value of R by using 56k in series with a 20k preset to allow the meter to be calibrated.

It seems that we could equally well choose 220n and 68R, but we have to bear in mind the way the IC works. C2 must have time to change voltage by $\frac{1}{2}V_{cc}$ at a steady current, i_1, during one half-cycle of the input wave. The magnitude of i_1 is fixed by the IC manufacturer; it has a nominal value of 180μA, but it could be as low as 140μA.

At 20kHz, C2 must be small enough to change voltage by 3.75V (half of 7.5V) at a current of 140μA with 25μs (half the period of a 20kHz wave). This gives the largest possible value of C2 as a little under 1n0 (Fig. 4). (R2 + RV1) must also be large enough to give the required voltage at a maximum current of maybe 140μA.

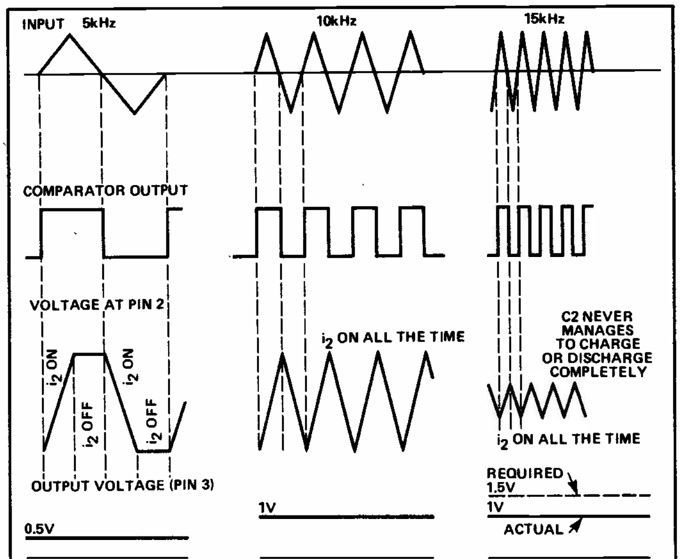
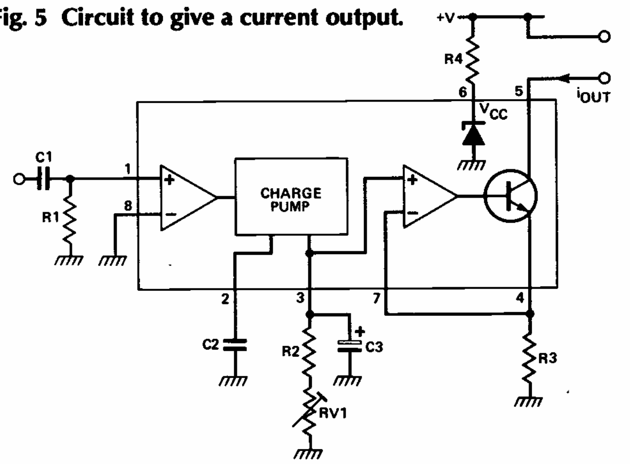


Fig. 4 The result of making C1 too large — 2nF here.

The rule which gives the *absolute* maximum value for C2 is $C2_{max} = (18/f_{max})\mu F$, where f_{max} is the highest frequency at which the circuit must operate. C2 is also used to provide internal compensation for the LM2917s charge pump, so there is a recommended *minimum* value of 100pF.

Fig. 5 Circuit to give a current output.



There are also limits to the values you can use for the resistance. For good linearity, it must be kept well below 1M0, but it can't be too small. If you have selected a suitable value for C2, the conversion formula will always give an acceptable figure.

The integrating capacitor (C3) does not affect the frequency to voltage ratio in any way, so its value is not critical. Make it about 50 times the value of C2 and adjust if there is too much ripple on the output or if the output is sluggish.

The dropper resistor for the shunt regulator (R3), must supply around 10mA. Its value should be 100 (V supply − 7.5) ohms.

Figure 5 shows how the LM2917 can produce a *current* proportional to frequency. Resistor R4 should be chosen to give the required output current. For instance, to change the assumed 0 to 2V output from the audio frequency meter to an output of 0 to 2mA, the value of R4 would be 2V/2mA = 1k0.

Circuits

1) Up to 40mA is available from the collector of the LM2917's output transistor — enough to trip a relay when, for example, an input frequency exceeds a preset value (Fig. 6). This could be used to detect a shaft rotating too fast (perhaps when over-revving a car engine). Certain types of sensor used in burglar alarms can be accidentally set off by traffic vibrations, which are generally at a lower frequency than those of interest for security purposes. The Fig. 6 circuit can detect vibration while tuning out unwanted frequencies. It could ignore mains hum but detect audio frequencies or detect the presence of an ultrasonic signal whilst ignoring audio frequencies.

The circuit will energize at frequencies above 1/(2RC) Hz. The switching frequency can be varied if R4 and R5 are replaced by a pot, and the circuit can be made to latch with a slight modification — both of these changes are incorporated in Fig. 7. The circuit can be reset by a push to break switch in series with the diode, or between the external +ve rail and pin 5.

You can get some interesting results by leaving out components from the basic circuit. Leaving out the smoothing capacitor results in a series of pulses at twice the input frequency (Fig. 3d). With a bit of filtering to make it sound more musical — an octave doubler for electric guitars?

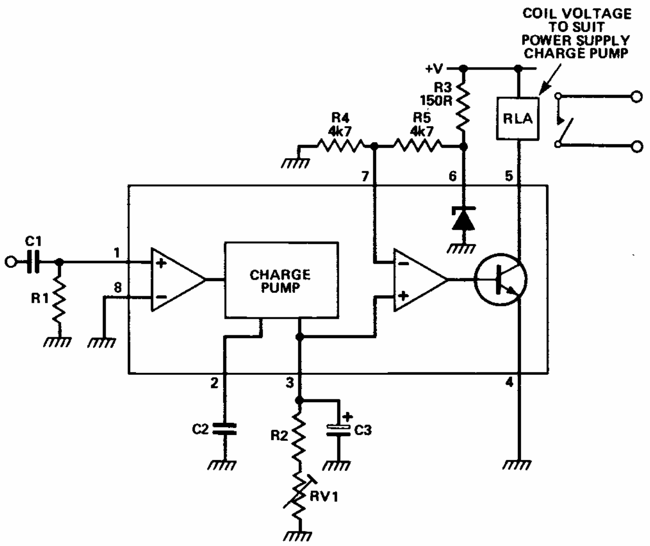


Fig. 6 The principle of the over-speed detector, or high-pass filter and switch.

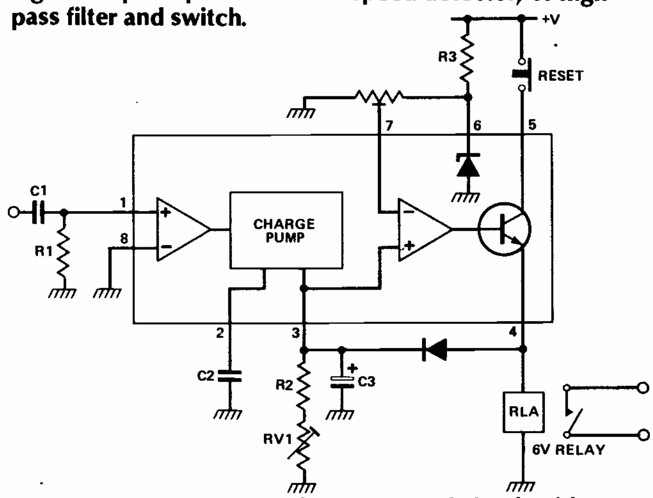


Fig. 7 Latching version of the over-speed circuit with variable switching threshold.

2) By leaving out the resistor instead (R2, RV1 in Fig. 2), the voltage across C3 will be a staircase waveform (Fig. 8). The duration of each step will be half the period of the input waveform; the rise in voltage on each step will be ½Vcc (C2/C3). The output of the circuit will trip after C3/(2C2) complete cycles of the input, regardless of frequency.

3) Figure 9 shows a low cost ADC based on the staircase idea. The START CONVERSION pulse clears the counter and discharges C3; BUSY will go high to indicate that a conversion is in progress. The conversion actually starts when the START CONVERSION signal goes low again. Each clock pulse raises the voltage on C3 by C2/(7.5C3)V and clocks the counter. When the voltage across C3 equals the analogue input, pin 5 of the 2917 goes low, preventing the counter from advancing any further and cancelling the BUSY signal. The counter will hold the digital value of the input until the next START CONVERSION pulse clears it and begins the whole process again. With the component values and clock frequency shown, the circuit will have a range of 0 to 5V at the input to give an output of 0 to 255 counts. Fine adjustment can be made by altering the clock frequency slightly; coarse adjustment by varying the ratio of C3 to C2.

4) On many zap-the-alien type computer games, the players have unlimited shots. You can add a new edge to old games with the circuit of Fig. 10. If you haven't take any pot shots for a while, C2 will have discharged via R2 and will be close to 0V. When you start to shoot, C3 will charge up in steps, as in the staircase type circuits mentioned above. This means that you can shoot as fast as you like ... for a while. As soon as the voltage across C3 approaches the cut-off point, you'll have to ease up.

The component values shown will give a reasonable starting point for experiment. The ratio of C3 to C2 will determine how many shots you can fire in quick succession; the value of R2 will determine the maximum continuous rate of fire. Different values of C3 can be switched in for different skill levels, and R2 can be made variable if you like.

5) So far we have been assuming that C3 and R3 are fixed and that the input frequency varies. If the input frequency is kept constant, output voltage will be proportional to C2 and (R2+RV1) (Fig. 2). This provides the basis for a resistance or capacitance meter, or a circuit to

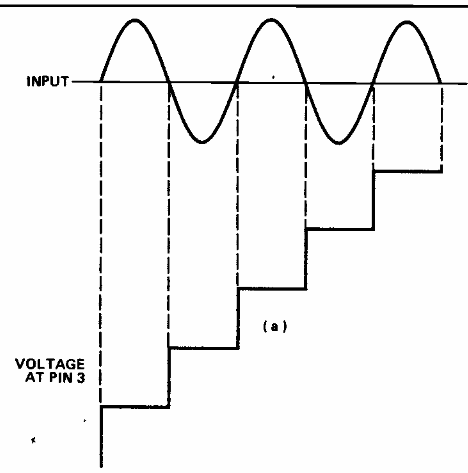


Fig. 8a Staircase waveform at pin 3.

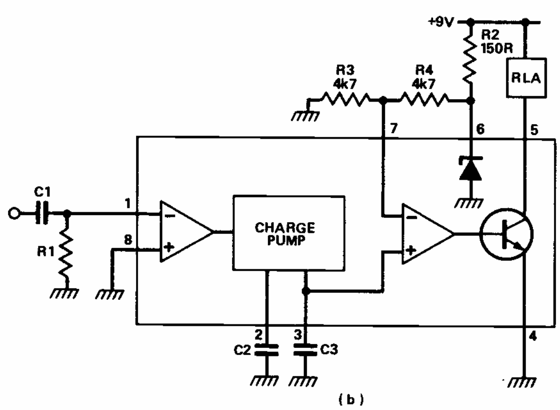
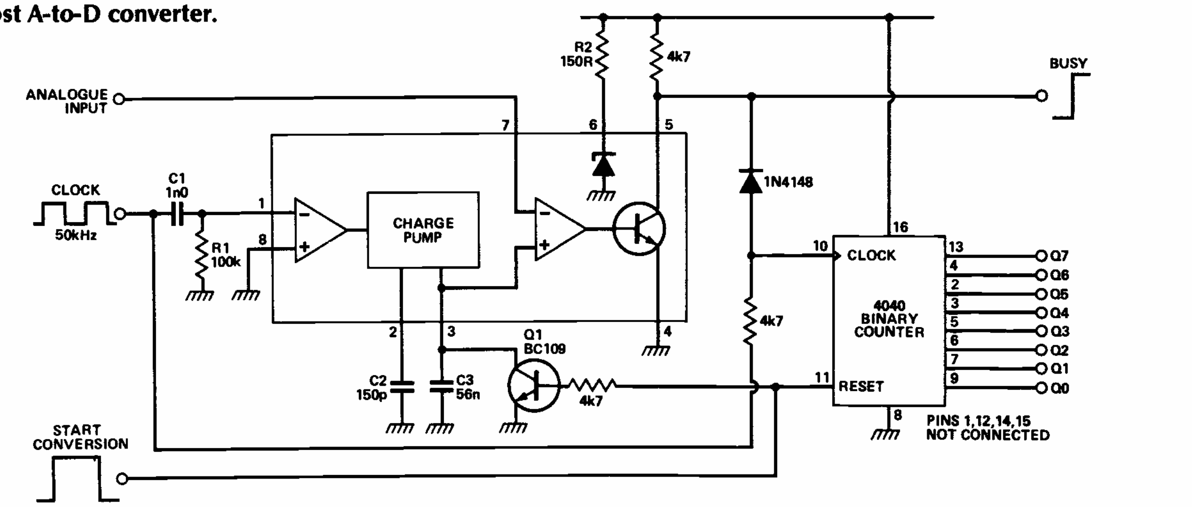


Fig. 8b Input pulse counting circuit. The relay switches after a preset number of input pulses (see text). The circuit can be reset by means of a push-to-make switch in parallel with C3.

Fig. 9 A low cost A-to-D converter.



interface with the various types of resistive or capacitative transducer.

Design Hints

The circuits described have all been based on the LM2917N–8, to give it its full title, which is one of a family of four very similar ICs. The LM2917J is a 14-pin version of the IC which is almost the same, but has the charge pump output and amplifier non-inverting input brought out to separate pins to give a little more versatility at the expense of a bigger backage. The inverting input of the comparator on this version is not internally grounded, so inputs do not have to vary about 0V. This version also lacks input protection, so any inputs must be between ground and V_{CC}.

The other two members of the family are the LM2907N–8 and LM2907J, which correspond to the LM2917N–8 and LM2917J respectively, but lack the internal voltage regulator. For convenience I will continue to use 'LM2917' to refer to the LM2917N–8, so please remember that some of the electrical specifications will not be applicable to other members of the family.

The input voltage range of the LM2917 can be up to ±25V, well beyond the supply voltage, since the input is internally protected. The collector of the output transistor can also be connected to voltages of up to 25V.

Although the IC has a 7.5V internal regulator, it can be used with supplies down to 4 or 5V (Fig. 10). The lack of internal regulation may affect accuracy and, when calculating component values, you must use the value of the actual supply instead of the 7.5V in the equations given. The lowest voltage for which the manufacturers give any performance data is 6V.

You can ground pin 4 of the IC, even though it appears that this will short the op-amp output to ground via the transistor's b-e junction. The base drive to the transistor is internally limited — you can think of the circuit as having a 5k0 resistor between the op-amp output and the transistor base.

The maximum useful input frequency to the LM2917 is limited by the value of the capacitor at pin 2. The smaller the capacitor, the higher the input frequency you can use. The manufacturers recommend a minimum value of 100p, since the capacitor is used as compensation for the internal charge pump circuit. The specified minimum value allows a safety margin, and all samples we have tried seem happy with 50p. By 20p, the instability is clearly visible on an oscilloscope, but the circuit still works! A good rules to follow is to use a minimum of 100p for instrumentation circuits where accuracy is important, and to use the lowest value you can get away with for novelty circuits that use a high frequency input.

The linearity of the LM2917 is guaranteed to be within ±1% over a 10:1 frequency range (see manufacturers' data for exact test specifications) and is 'typically' within 0.3% — quite a respectable accuracy for this type of circuit.

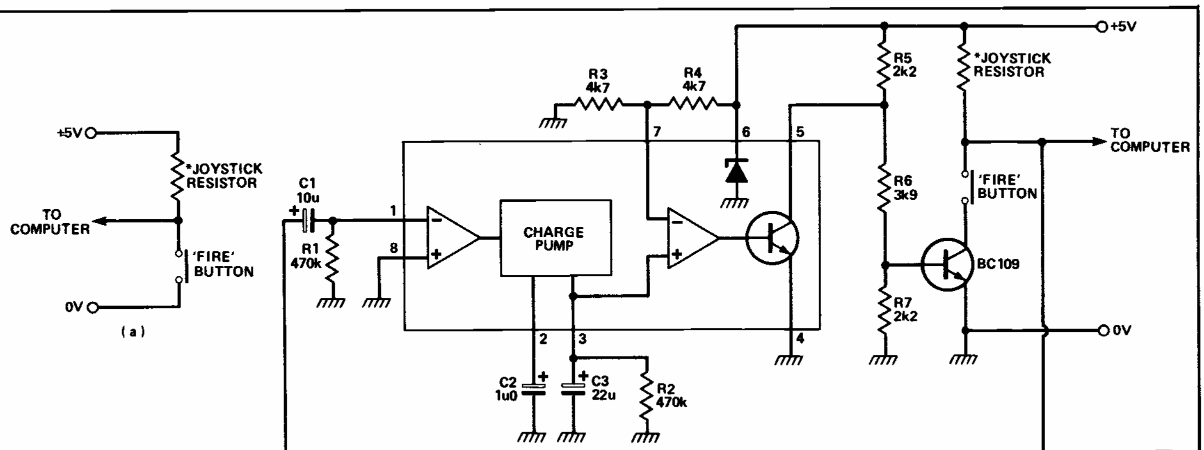


Fig. 10 Computer joystick modification.

ETI

SPECIAL PULL-OUT

TAKING CARE OF BUSINESS

In this month's pull-out business supplement, we'll be looking at marketing — that is, actually taking your goods or services to your customers. Nigel Wilkinson argues that marketing is the most important aspect of any business. He gives a great deal of food for thought in a short article. Stressing the importance of market research, he introduces the 'four Ps' of marketing: product, pricing, place, promotion — which lead, we hope, to a fifth P, profit.

Our profile this month is of a husband and wife team who run a successful company in what is, by any standard, a specialised area. Serge and Joyce Plessis make printed circuit boards and their company, Plessis Electronics, is one of a small number to do so.

Success has not been easy for the company. It has, on the contrary, involved many sacrifices along the way. But they have never been bored and that, to Serge at least, is very important. There can be few better reasons for going into business than to satisfy a sense of adventure.

Everybody seems to agree that electronics is a highly competitive market. Nigel Wilkinson's recommendation is getting to know your market. Serge and Joyce Plessis say that everything depends on high quality and good relationships with the customers. These are probably the same thing. Whatever your opinion, you'll need good research. Our address list should provide you with a useful starting point, especially if you need to know what products or services in your line are already available. The Patent Office, reference libraries, science parks, ITeCs, research and development institutes will give you an invaluable insight into the marketplace you're just about to enter.

The Editor

Helen Armstrong finds out why two people gave up an E-type and fell in love again.

For a long time eet was sheer 'ell, sheer 'ell. After that eet was just bloody 'ard work,' says Serge Plessis, echoing emotions which grip people making a printed circuit board for the first time. The native French accent can't disguise them.

The initiation into the art of PCB manufacture involves chemicals in the kitchen sink, ferric chloride stains on the Pyrex and the family oven tied up with the latest etch bath. M. Plessis's early experiences were no exception, with the difference that he and his wife and partner, Joyce, had abandoned well paid jobs to make PCBs a career.

The Kitchen Sink

'Production more or less started in the kitchen sink,' says Joyce Plessis. 'I had always wanted to start a business, and Serge wanted to work for himself. We were both determined to have a go, so there were no doubts about dedicating everything to the business.'

Plessis Electronics opened its doors in January, 1976, spreading in a year from the under-stair cupboard to the whole ground floor of the Plessis home, and then to a 14' x 12' industrial unit in Aylesbury. Orders came largely from designers contacted through Watford Electronics.

'Raza Jessa pushed me into making PCBs,' says Serge. 'Watford gave us very important help, recommending us and taking orders for us while we were getting started.'

PLESSIS' PC BOARD

Serge had come to England after the break-up of his first marriage, with a French HNC-equivalent and little English. Looking for a job in repairs, he went as a trainee television engineer to Rediffusion, where he completed four years' worth of training in 18 months.

Meanwhile, in the style of a true obsessive, he spent his spare time designing his own colour television. It was on one of many visits to Watford to buy parts that somebody asked if he could design circuits. He said yes. This answer led to Serge designing project kits, including the first digital multimeter published by ETI, back in 1975.

Serge also began to make contact with other designers who were buying components from the young Watford company. 'Through the designers, we eventually did the Heathrow security system ,work for the BBC, for Plessey, and some Ministry of Defence work via NATO,' says Joyce. 'We were getting photography from a local litho printer, and he let off some storage space to us.' They stayed there for nine months, tight on space, tight on money, husbanding their resources.

Wimpy And Chips

'We were already in the red, personally, with our divorces. We had to scrape up money,' Joyce says. 'Serge bought up old televisions and reconditioned them. I took in typing, I did a Provident round. We found some reject tape cassettes on an industrial dump, took a sackful home at five o'clock in the morning, repaired them, and took them round secondhand shops.

'Our 'E' type jag was sold to buy a roller tinner — there were some tears there! The mortgage we left in a state of being repossessed. We had the money together to repay it a year later, just as they were about to throw us out.

'The gas and phone were cut off. We had to keep the electricity going for the machinery ,but for three months I was taking calls passed on from Watford at a public call box. We told everyone we had a part time receptionist

Joyce and Serge Plessis

just for an hour a day. I pleaded with suppliers for a few days' credit. We had the bailiffs in, and we sold nearly everything.

'All our decisions were made in board meetings in the Wimpy Bar!'

Many fledgling businesses now count on getting start-up grants from government development agencies, but there was no money forthcoming in the late 1970s.

'We got no dole, no enterprise allowance, no legal aid with our divorce cases, nothing from the council — they actually took out an injunction against us when we were working from home,' says Joyce. 'Things have got better. For instance, I can get an advance on college fees for our staff with a phone call. But a specialised business like this still falls through the gaps.

'The engineering board wanted to help us, but we aren't even electronics. There is no open learning for would-be PCB manufacturers, an engineering ONC but no PCB ONC — only basic, generalised management courses. We used to take YOPs people and many of them have stayed with us, but we can't now, because the MSC wants day releases, and there aren't any suitable courses.'

Money, Money, Money

Early in 1978 Plessis moved — losing their only employee — to a larger unit in Leighton Buzzard, where they have stayed ever since, shifting to larger adjacent premises. In the earliest days they had been virtually hand building, starting with single side boards, expanding to double sided and plated through hole, relying on good quality, word of mouth recommendations and a very low profit margin to see them through. But heavy investment in equipment was necessary as soon as money was available.

As Serge explained, PCB manufacture is an unusually capital intensive business. 'A basic drilling machine costs

'I admit it's nice having fast cars, but we plough most of our money back into the company...'

£25,000 to £30,000, a complex one £100,000, a super one £250,000. That is £30,000 for one machine, and we have three. It's all computer controlled, but at the end of the day it only drills holes.

'One of the chemicals we use is £100 a litre, and we have a 150-litre tank. Firbe glass costs £2 a square foot, drill bits £5 each. There are only 700 companies doing this sort of thing, so the suppliers have a limited market and prices are very high. Small companies go down because they can't afford repayments, and big companies are hit very hard by any drop in demand.'

'We managed to avoid huge loans,' says Joyce. 'Our bank manager gave us lot of support. Most of the machinery was bought on hire purchase, which is always arranged by the selling company, because that is the only way people can buy it.

'There were a couple of close squeaks, but we were a modest size and could cut back. We thrash out every new piece of equipment from every angle before we buy it. But we couldn't start up on the same basis now — the technology has moved on too far.'

Talk, Talk, Talk

Neither Joyce nor Serge had any formal business training before starting Plessis. 'I was always a secretary for medium sized businesses,' says Joyce, 'so I knew about administration, and Serge has his electronics degree. But we rely on gut feeling and a lot of talk. Serge has final say in the factory, and I have final say in the office, because those are our areas, but we discuss everything before we make final decisions.'

Serge and general manager Robert Hopkins are pursuing business studies with their eye on the next round of expansion. All the staff, Serge included, are regularly lined up for courses on PCB technology and metallurgy at Slough College.

Racing Certainties

Morale and training among their 20 members of staff are a top priority. 'We don't cut corners on equipment, or morale, or safety, so we have good employees,' Joyce says. 'They go on outings and courses together, and they get to know each other and think as a team.'

The last move, into their present two-storey premises, was a calculated gamble. 'Our overheads went up several hundred percent, but we were prepared to go back to square one because we needed the image to expand. This is a high tech industry, so we came far on high quality and good relationships.

Wish you were here!

They have recently installed a second floor of 4,000 square feet, and are taking a further 800 sq ft in the old units, now refurbished, and their '1986 project' to move into multi-layer PCBs was up and running on schedule. The latest equipment addition is £15,000 worth of offline CNC programmer for the drilling machinery.

'The digitiser is one of only three in England,' says Serge proudly. 'It's good because it frees the drills for production instead of tying them up for programming. We are into the middle league of PCB manufacturers as far as size goes, but the top league in technology, which is a good balance. Not many manufacturers have a trained industrial chemist, for instance.

'We could have been bigger, but we struggled on rather than take in extra partners just for cash. We don't want to land with a partner we can't deal with.'

Love At Second Sight

Now Plessis are planning, with their usual meticulous attention to detail ,expansion into layout, assembly and surface mount technology. 'We're providing our own finance. I admit it's nice having fast cars, but we plough most of our money back into the company. We don't like being bored, and this expansion is like falling in love again and starting something completely new.' **ETI**

Nigel Wilkinson looks into marketing and argues that there's nothing more important.

SELL, SELL, SELL...

If you are going to set up any sort of business, the first thing you should remember is 'No customers — no business!' Most people take this for granted, but it actually involves a lot of thought, time and planning. That motto should be the foundation and determine the structure of your business.

This is where marketing comes in. Marketing is 'the management process of identifying, anticipating and satisfying customer requirements profitably'. Or, more succinctly, it is putting the customer first.

It's not good enough to invent the world's first combined TV and watch — you must find out whether customers want it and, if they do, you must sell it to them! Your aim is to make a profit, since profit, not turnover, keeps a business going and enables it to grow. For that you need customers who return regularly and keep buying.

Not surprisingly Britain — with a falling share of world trade and rising imports — is way down the league table of nations where marketing is a priority. In America and Japan, the idea is to find out what people want and then produce or provide it. Many other nations still tend to think in terms of making things and then looking around for people to buy them.

In a highly competitive world and, particularly, in a highly competitive market such as electronics, you need to make marketing the centre of your business planning. Otherwise, you will lose out to those who know their market from the outset.

Best Laid Plans

Planning can be divided into two parts. First, you must work out how you will get to know your market and your customers. Then, turn your attention to how you will reach and communicate with them.

The first part is more commonly known as 'market research' and means gathering information on:

- your market,
- your competitors, and
- your customers.

All this may sound like quite a lot of work, but a small amount of time carrying out market research — on a continuing basis — will add years of life to your business. You can liken market research to the power switch on a circuit board. Market research brings the whole thing to life, Without it you may be misdirecting your energy.

Some of the questions market research can answer are:

- what business are you in?
- what kind of money is in the market?
- who are your customers and what do they want from you?
- where are they, and where and why will they buy?
- what do they need and what can you offer them?
- what price are they prepared to pay?
- who are your competitors, and what do they do well and not so well?

This last point is especially useful and is often missed by most small businesses. People often react as if they've had an electric shock when asked who their competitors are:

'I haven't got any competitors — well, there's Tandy (Radio Shack) — but they're rubbish!'

So they might be, but they must be doing something right to be one of the largest electronics retailers in the world. And their range runs from components to computers, taking in toys and hi-fi, books and alarm clocks.

If you have competitors, at least it proves there's a demand for what you're offering. Studying those competitors can help you find your gap in the market and give you an idea for a different angle. In marketing terms, it will help you formulate a unique selling proposition.

Market research will also help you find your target group — the people who will buy and keep on coming back. It's worth remembering that approximately 80% of your trade will come from 20% of your customers.

Approximately 80% of your trade will come from 20% of your customers...

Unless you are sure who they are, you will miss everyone else and probably waste time and money in your advertising and promotions.

Which brings us to the second part of planning — reaching and communicating with your customers.

Advertisements For Yourself

Until you know who will need and buy your product or service, you should not begin to spend money on selling or advertising. There are too many different approaches, each one geared to particular customers.

You can advertise in newspapers or magazines (be they commercial or trade), on the radio, using leaflets through the door, by taking part in trade fairs or exhibitions, or by means of a public relations strategy of your own devising. You can sell face-to-face, from a shop, as a wholesaler, by mail order — and so on.

Whatever approach you choose, everything must fit together logically. Your promotion strategy must reflect your pricing policy, which will depend on your product and even the place you choose to operate from. Product, pricing, place and promotion are known as the four Ps of marketing. Get them right, and profit will follow.

Read ON!

The place to start your marketing is — the library! A day spent there will be both interesting and rewarding. Not enough small businesses realise what a wealth of material is already available to them.

In a highly competitive world and, particularly, in a highly competitive market such as electronics, you need to make marketing the centre of your business planning...

Start by reading 'The BBC Small Business Guide'. This will tell you where to carry on looking and what to look for. Then you might borrow — or even buy — the following books:

'The Greatest Little Business Book', by Peter Higston. This is an invaluable book backed by a wealth of experience. Peter Higston and his wife both run their own small business, and he also published this book himself.

'Successful Marketing For The Small Business', by Dave Patten, published by Kogan Page. This is a comprehensive guide for the beginner written from a practical point-of-view.

'Getting Sales — A Practical Guide To Getting More Sales for Your Business', by Richard D. Smith and Ginger Dick, published by Kogan Page. Another useful practical guide, especially for those whose businesses have been going for some time.

Now — go to it!

ETI

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Run by inventors for inventors, help can be given with patent applications and prototypes.

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The Institute of Patentees And Inventors

Gives advice to members in all aspects of inventing. Its journal, 'The Inventor', comes out quarterly.

Staple Inn Buildings South
335 High Holborn
London WC1V 7PZ
(01 242 7812)

The Patent Office

They will help with information and advice, as well as being the formal organisation undertaking searches and registration.

25 Southampton Buildings
London WC2 1AY
(01 405 8721)

The Registrar

Accepts and advises on registration of copyright.

Stationers Hall
Ludgate Hill
London EC4M 7DD
(01 248 9279)

The Science Reference Library

This library houses all details of patents.

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The Design Council

Design Advisory officers will advise on the design of products and help with technical problems.

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(01 839 8000)

British Overseas Trade Board

Can give advice and information on overseas markets to individual firms.

1-19 Victoria Street
London SW1H 0ET
(01 215 7877)

PA Patcentre International

Has a comprehensive technology service which can help take a client's idea right through to production.

Cambridge Division
Melbourn
Royston
Herts SG8 6DP
(0763 61222)

QMC Industrial Research Ltd

A wholly owned company of Queen Mary College, University of London. The expertise of the college is made available to industry.

229 Mile End Road
London E1 4AA
(01 790 0066)

Tech Alert

An information service of the Department of Trade and Industry.

Room 215
Ashdown House
123, Victoria Street
London SW1E 6RB
(01 212 6762)

Statistics And Marketing Intelligence Library

Situated off the Overseas Trade Board (see above). Reading room open to the public: 9.30 to 17.30, Monday to Friday.

1 Victoria Street
London SW1
(01 215 5444)

Co-operative Research Grants Scheme

Aims to provide co-operation between academics and firms.

Science Research Council
Polaris House
North Star Avenue
Swindon
(0793 26222)

The Calderdale Innovation Centre

A local initiative which has met with some success in encouraging small, technological businesses.

Calder College
Todmorden
West Yorkshire
(070681 4399)

The Centre for Innovation In Industry

99, Southwark St.
London SE1
(01 930 3258)

Information Technology Centres (ITeCs)

Their main purpose is to train young people in electronics, computing and office skills, but check to see if they can offer assistance in your area. Contact the Manpower Services Commission for local details or the Information Technology Consultancy Unit (ITCU)'

189 Freston Road
London W10
(01 969 7527)

London New Technology Network

Like the ITeCs, they may be able to help with workshop/office space, the loan of equipment and general advice.

86-100 St. Pancras Way
London NW1
(01 482 3816)

City Technology Centre

165 Shoreditch High Street
London E1 6HU
(01 739 8856)

National Computing Centre

Advice and assistance on all aspects of computer use in Britain. Head Office:

Oxford Road
Manchester M1 7ED
(061 228 6333)

Regional offices in London, Birmingham, Bristol, Glasgow and Belfast.

Neath Information Technology Centre

ITeC Centre
Neath
(0639 4141 ext 176)

Women And Computing

Will assist any women wishing to become involved with computing.

Microsyster
Wesley House
Wild Court
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SPECIAL PULL-OUT

Science Parks Innovation And Technology Centres

The idea of these is to bring together college expertise and industry. What they can offer to the small business or entrepreneur varies. Some can provide cheap premises, use of expertise, libraries and equipment.

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(021 359 0981)
Birchwood Science Park
(0925 51144)
Brunel Science Park
(0895 39234)
Cambridge Science Park
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Hull Innovation Centre
(0482 226348)
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Salford Science Park
(061 794 4711)
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South Bank Technopark, London
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Tyne & Wear Innovation and Development Company Ltd.
(0632 380500)
Unilink, Edinburgh
(031 449 5111 ext 2299)
University of Warwick Science Park
(0203 24011)
West of Scotland Science Park
(041 946 7161)

Libraries

A list of specialist business libraries throughout the country is available from:
The London Business School Library
Sussex Place
Regents Park
London NW1 4SA
(01 262 5050)
(The list is published by ASLIB Economic and Business Information Group Directory)

The Business Information Service Of The Science Reference Library

Exactly what it says.
(01 404 0406)

Official Publication Library

The British Library
Great Russell Street
London WC1B 3DG
(01 636 1544 ext. 234/5)

Business Statistics Office Library

Cardiff Road
Newport
Gwent NPT 1XG
(0633 56111 ext. 2973)

British Institute Of Management Library And Management Information Centre

Management House
Parker Street
London WC2B 5PT
(01 405 3456 ext 126/7/8/9)

Exchange Resources

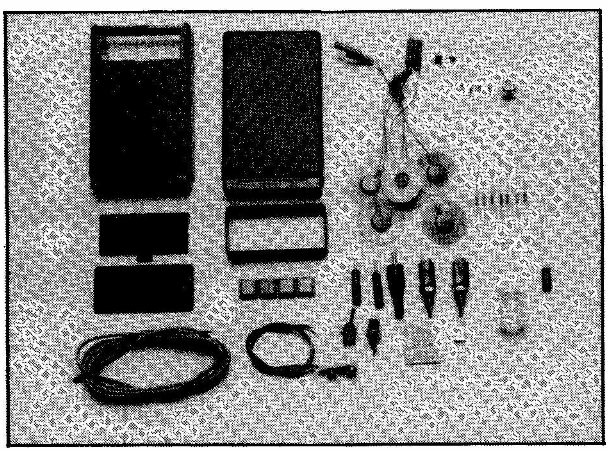
Exchange Resources, the recruitment agency and business consultancy dedicated to the peaceful uses of electronics, computing and, eventually, other technologies now has a new permanent address. They will be happy to give whatever advice and assistance they can to people starting up in business on their own.
28 Milson Street
Bath BA1 1DP
Avon
(0225 69671/2)

London Innovation Network

One of the development agencies within the London area funded by the Greater London Enterprise Board (GLEB) — see also the London New Technology Network. Their aim is to encourage and promote new and socially useful businesses and they can help with space, equipment and experienced advisers. LIN specialise in mechanical and electronic engineering.
Unit b
Hornsey Street
London N7 8HR
(01 607 8141)

More addresses next month.
List compiled by C.M. Herman.

ETI



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To order by post, please send the order form (or copy) with your remittance to: ASP Readers Services (RO ET4), 9 Hall Road, Maylands Wood Estate, Hemel Hempstead, Herts.

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NAME ....

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..

..

REMITTANCE ENCLOSED: £......................................

CREDIT CARD ORDERS: I authorise you to debit my

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Please allow up to 28 days for delivery. Thank you.

YOUR EXPANSION PARTS SET:

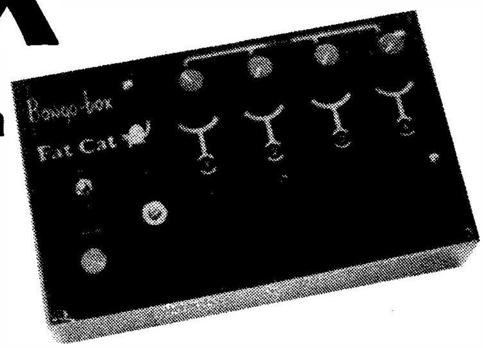
CASE WITH BUILT-IN BATTERY COMPARTMENT — BATTERY CONNECTOR — PLASTIC FEET FOR CASE — MINIATURE TOGGLE SWITCH — PHONO PLUG AND SOCKET — TERMINALS FOR METER CONNECTION — SIX PROFESSIONAL ELECTRODE PADS — SACHET OF CONDUCTIVE GEL — PADS FOR FIXING PCB TO CASE — LEAD AND — PLUGS FOR ELECTRODES — SIXTEEN COMPONENTS

ONLY £12.95 + 60p p&p

All the parts you need to turn your free bio-feedback circuit into a highly responsive GSR monitor. The resulting instrument is sensitive enough to respond to the slightest change of mood.

Note: Parts supplied may not correspond exactly to the photograph. Offer while stocks last — order early!

BONGO BOX



Peter Davie describes a four-channel drum synthesiser which can be used either as a stand-alone unit or in conjunction with a Commodore 64 microcomputer.

The Bongo Box contains four resonant drum synthesiser circuits which produce damped sine-wave oscillations at different pitches. The pitch of each drum is fixed by the capacitor values used in the circuit, but a feedback level control on each channel allows the user to vary the amount of 'bong' in the sound. The drums can be triggered either by striking a piezo-electric transducer on the front panel or by applying a logic high to the required channel from a computer port. This allows lengthy rhythm patterns to be programmed and edited. The output signal can be taken directly to an amplifier or returned to a computer for further processing. The Bongo Box is powered from an internal PP3 battery and is therefore completely self-contained.

The unit is intended to be connected to that under-used slot on the back of the C64, the user port. When triggered from the computer, a red LED lights up for each drum. Besides looking pretty this can be used to demonstrate the logic state of each of the four outputs from the computer. Some hints for programming the C64 output port are to be found at the end of this article. For those with less knowledge or time to spare, a comprehensive software cassette is available. This contains a professional menu-driven package of programmes to create, edit,

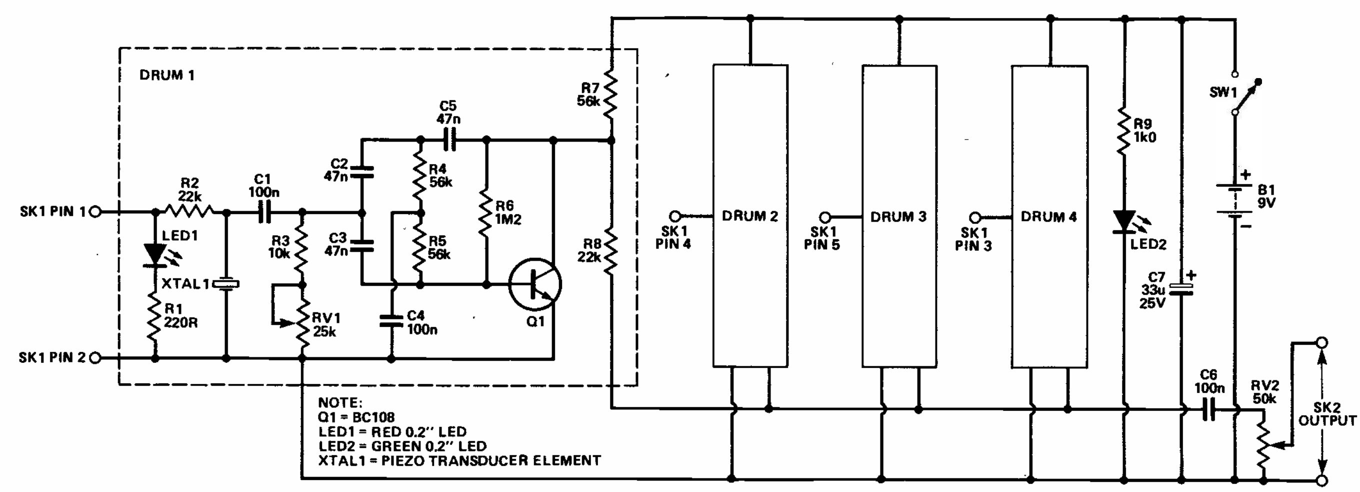


Fig. 1 Circuit diagram of the Bongo Box. Only one drum channel has been shown in full but the other three are identical except for some of the capacitor values. Component numbers for the second, third and fourth drum channels are the first channel component numbers plus 200, 300 and 400 respectively.

HOW IT WORKS

Nothing terribly complicated here, and not an IC in sight! Trigger pulses from the computer are fed to the input. LED 1 is illuminated for the period of the pulse. Note that the computer output port provides the small amount of current required for this, which is limited by R1. The input pulse is applied to R2, which reduces it in level. XTAL 1 is a piezo-electric transducer. Its output, along with the computer trigger pulse is buffered by C1.

The rest of each drum circuit consists of a twin-t oscillator circuit built around Q1, Q201, etc. A free-running oscillator of this type would produce a continuous sine wave output; what is required here is a dampened oscillation which dies down after a few cycles. The main resonant frequency of the circuit is set by the values of C2, C3, C4, C5, R4 and R5. RV1 is adjusted so that the circuit is just shocked into oscillation by a positive-going pulse on the junction of C2 and C3. This control gives a measure of 'resonance' adjustment to each drum, the pitch being largely unaffected by adjustments to it.

The dampened sine-wave oscillations from each drum are mixed together by the resistors R8, R208, etc. RV2 is a passive volume control, the drum outputs being of sufficient level to drive an audio amplifier without further amplification. C6 is a DC blocking capacitor, and C7 helps smooth the battery supply.

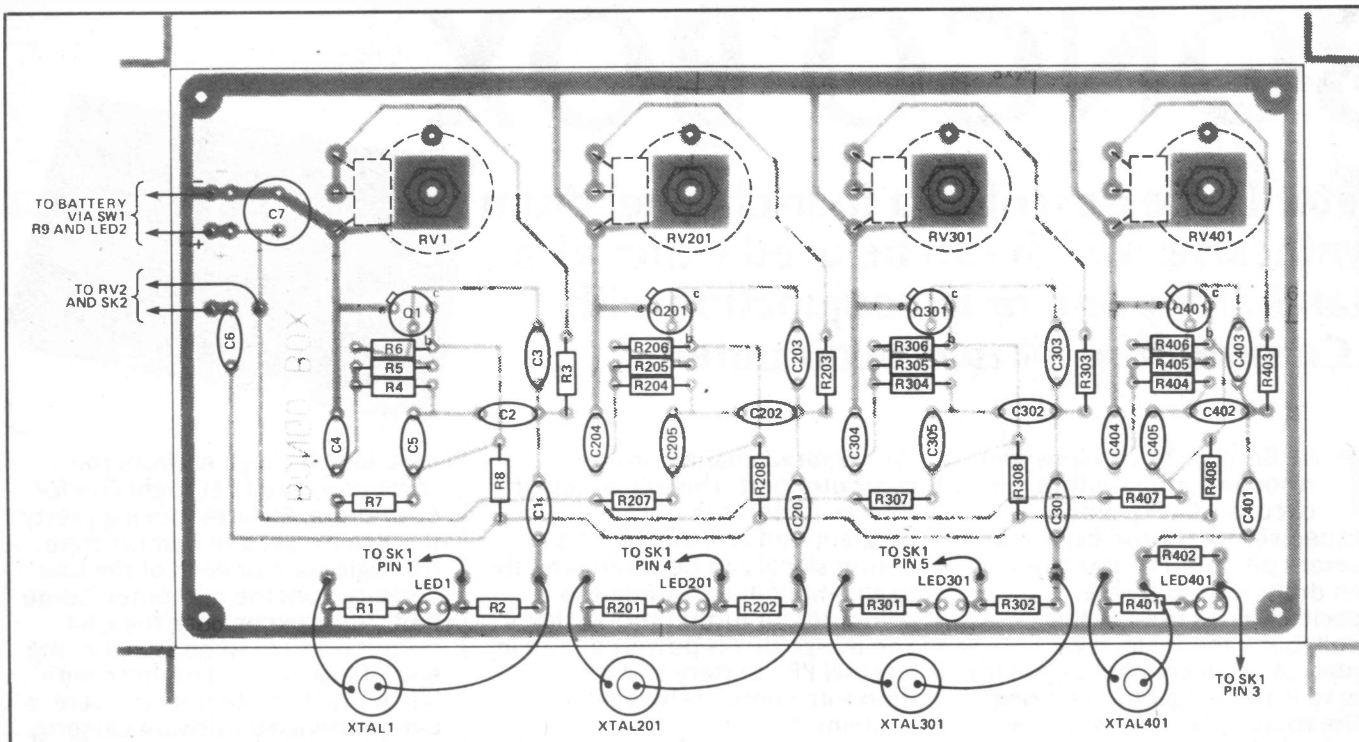


Fig. 2 Component overlay for the Bongo Box PCB.

playback, save and load rhythm patterns of up to 255 steps in length.

Each drum output is mixed to a common volume control and taken to a standard ¼" jack socket. This output can either be connected to a music instrument amplifier or alternatively the audio output can be returned to the C64, making use of yet another under-utilised socket on this remarkable micro, its audio input socket. The output of the Bongo Box is passed through the sound chip of the C64 (the infamous SID) and thence to the TV or monitor speaker.

Those with some experience of programming the C64 will appreciate that the audio output of the 'Bongo Box' can thus be further processed by SID, and bass/melody lines composed to synchronise with the drum. All three sound channels can be used as Bongo Box can take care of the rhythm, enabling seven-part composition on the C64. Such programming is however outside the scope of this article.

Construction

Construction of the Bongo Box is quite simple. Apart from the volume control, on/off switch, power-on LED, trigger platés and battery, all the drum circuits, controls and LEDs are contained on one PCB. Start by soldering in the resistors, followed by the capacitors. Note the different

PARTS LIST

RESISTORS (all ¼W, 5%)

R1, 201, 301, 401	220R
R2, 8, 202, 208, 302, 308, 402, 408	22k
R3, 203, 303, 403	10k
R4, 5, 7, 204, 205, 207, 304, 305, 307, 404, 405, 407	56k
R6, 206, 306, 406	1M2
R9	1k0
RV1, 201, 301, 401	25k linear potentiometer
RV2	50k logarithmic potentiometer

CAPACITORS (all 63V, miniature metal film except where stated)

C1, 4, 6, 201, 301, 401	100n
C2, 3, 5, 202, 203, 204, 205	47n
C7	33u 25V miniature radial electrolytic
C302, 303, 402, 403	10n
C304, 305	33n
C404, 405	15n

SEMICONDUCTORS

Q1, 201, 301, 401	BC108 or similar general-purpose NPN
LED1, 201, 301, 401	red 0.2" LED and panel-mounting clip
LED2	green 0.2" LED and panel-mounting clip
XTAL1, 201, 301, 401	piezo transducer element

MISCELLANEOUS

SK1	5-pin 180° DIN socket, chassis-mounting
SK2	¼" mono jack socket
SW1	SPST toggle switch

PCB; case, 210mm x 130mm x 60mm; knobs, 5 off; PP3 battery and battery clip; PCB stand-off pillars, 4 off; foam pads to cover transducers; nuts, bolts, etc.

Additional items for connecting leads (as required): 12+12 way 0.156" edge connector; 5-pin DIN plug; four-core screened cable; ¼" mono jack plug; 5-pin DIN plug; single-core screened cable.

Component numbers beginning with 200, 300 and 400 belong respectively to the second, third and fourth drum circuits, all of which are identical to the first drum circuit (see circuit diagram). Note that whilst resistor and other component values are idential in all four drum circuits, some of the capacitor values differ.

values of C2-C5 for each drum. Solder in the four transistors, but leave out the LEDs for now. Fit and solder in the pots.

Prepare a short length of five-way ribbon cable (you will have to strip this down from a piece with six or more ways) and solder to the four outputs and ground on the PCB. Take the four piezo transducers and carefully solder a connecting wire to the centre of each, and the outer rim of each. Scrape the surface gently first, to assist in soldering.

Drill the control panel and apply lettering as desired. Fit the five LED clips, the on/off switch and the green LED and solder the 1k0 resistor to the anode of the LED (usually the longest leg). Drill the holes in the case for the 5-pin DIN socket and ¼" jack socket, and fit these. Glue or bolt the PP3 clip to the bottom of the case, allowing plenty of room for the PCB.

Fit the four red LEDs into their clips, and the four stand-off mounts to the panel. Gently lower the PCB onto the mounts, positioning the legs of the LEDs carefully as you go. Solder the LEDs in position.

Solder the outputs and ground to the DIN socket, then solder a short piece of screened cable to the output socket and PCB. Solder the green LED's anode resistor

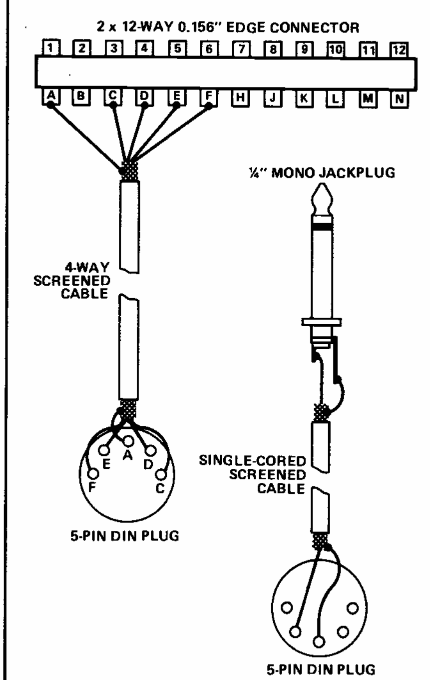
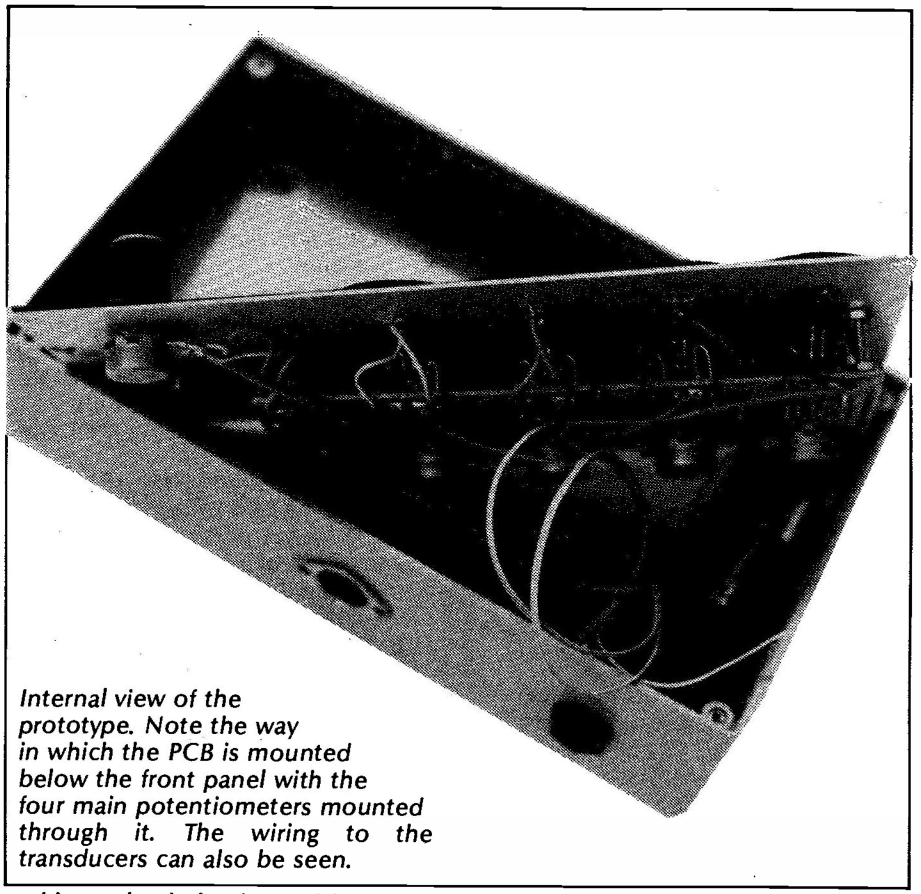


Fig. 3 Wiring of the connection leads.



Internal view of the prototype. Note the way in which the PCB is mounted below the front panel with the four main potentiometers mounted through it. The wiring to the transducers can also be seen.

and its cathode leg in position.

Slip the piezo plate connections through the appropriate holes and secure the plates to the front panel. This can be done with glue or bluetack. If you use glue, it is better to use something like Araldite as it is necessary to slide the plates around to line them up neatly. Superglue is a bit final!

Make sure that the soldered connection points on the piezo plates are not touching the metal panel and then solder the wire connections to the PCB.

Finally, solder the two battery connections to the switch and PCB, fit the knobs and that's it!

Testing

Insert a PP3 battery and switch on. The green LED should light. If it doesn't, switch off and check your soldering, battery polarity etc. Turn the volume control and all four resonance controls fully anti-clockwise and connect the bongo box up to an audio amplifier. Turn the volume control up to half-way, and tap any of the four pads. You should hear a loud click. Slowly turn the resonance control of that pad clockwise, and the click should turn into a satisfying 'bong' sound. As you turn the resonance control, the 'bong' should be more sustained, until eventually a point is reached at which the circuit produces a continuous note (continuous instead of damped oscillation). Back the control off slightly until the note dies way as required. Do the same for all four drums.

Make up the C64 connection leads as shown in the diagram. Before connecting to the user port, it is as well to point out that incorrect connections could cause

BUYLINES

Just about all of the parts of the Bongo Box are available from the usual advertisers. The piezo-transducer elements are available from Maplin, along with a black foam-rubber self-adhesive pad to fit over the top of them, as in the photograph. The case and battery clip used in the prototype are from RS Components. The software tape mentioned in the article is available from PHD Computer Services, 52 Donnington Street, Leicester LE2 0DD, Tel (0533) 543013. Price is £4.00, including postage and packing. Please allow 28 days for delivery. A complete kit of parts for the Bongo Box is available from the same address and costs £29.99 inclusive. The PCB will also be available separately from our PCB Service.

damage to your computer, so check your wiring carefully!

Connect the DIN plug to the Bongo Box. Take a PP3 battery, connect the –ve to the ground connection of the edge connector and briefly connect and disconnect the +ve side of the battery to each of the port connections on the cable edge connector. You should see each of the red LEDs light up as you make the +ve connection and, if you still have the audio amplifier connected, each drum should trigger. If you do not get these results, do not connect the edge connector to the computer. Switch off and check your work thoroughly.

If all is OK, then you are ready to enjoy some computer-type drum sounds.

The C64 User Port

If you possess a copy of the *Programmers Reference Guide* for the C64 (the fat, expensive version, not the thin one given away free with the C64) then have a look at pages 359–362. Those without access to this book should find the following of help in linking the Bongo Box to a micro.

The four connections of the user port used by Bongo Box can be thought of as memory locations in the C64. By POKEing the appropriate location, a logic high is produced, which is used to trigger each drum.

In practice, things are not quite as simple as this, in that each terminal of the user port can either be an input or an output. The state of each is set by another memory location, the 'Data Direction Register', or DDR.

To trigger the drum, we need to do the following:

1) Set the DDR for a particular output
2) POKE the port memory location to high
3) Keep the port memory location high for a short period
4) POKE the port memory location low again

The DDR address is 56579. Each of the eight lines has a bit in this eight-bit memory location, or REGISTER. If a bit is high, or logic 'one' then the line will be an output. If a bit is set low, that line will be an input.

We only need to consider the first four bits (0–3) for the Bongo Box. If we wanted to set port line 0 to an be an output, for example, then we would POKE 56579,1. If we wanted to set lines 0 and 1 to be outputs, then we would POKE 56579,3. Each bit in the port corresponds to its binary equivalent:

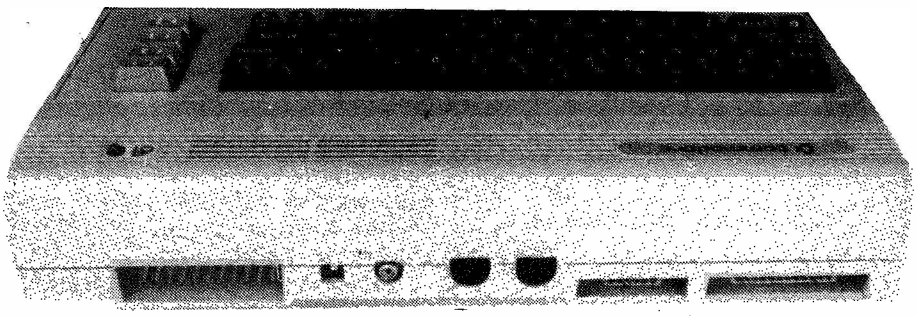
BIT number	3	2	1	0
Binary equiv.	8	4	2	1

So, by adding the appropriate numbers, combinations or individual lines can be set.

This has only set the DDR, remember. The actual port itself is located at 56577. It too has an 8-bit register. If a bit is at 'one' then a logic high is present at the corresponding terminal. If a bit is at 'zero' then a logic low is present. In the same way as we set the DDR, we now have to set the corresponding line high, hold it high for a period, then lower it.

```
10 DDR=56579:P=56577
20 POKE DDR,15:REM SET 4 LINES TO OUTPUT
30 POKE P,1:   REM SET 1ST LINE HIGH
40 GOSUB 200
50 POKE P,2:   REM SET 2ND LINE HIGH
60 GOSUB 200
70 POKE P,4:   REM SET 3RD LINE HIGH
80 GOSUB 200
90 POKE P,8:   REM SET 4TH LINE HIGH
100 GOSUB 200
110 GOTO 30:   REM DO IT ALL AGAIN
200 FORT=1TO20:REM STAY HIGH BRIEFLY
210 NEXT
220 POKE P,0:  REM GO LOW
230 FORT=1TO100:   REM PAUSE BETWEEN BEATS
240 NEXT
250 RETURN:    REM NEXT DRUM
```

Table 1 A short programme which will trigger each drum in turn. Changing the value of T in line 230 will alter the tempo while using different values of T for each drum will allow rhythm patenrs to be built up.



Those under-utilised sockets on the C64 ... just in case you've forgotten what they look like!

ETI

DIGITAL AUDIO SELECTOR

In the second part of this project, Andy Armstrong investigates the all-important signal buffering and switching circuit.

Part one of this project covered the push-button latching system. That was the more difficult unit in a mechanical sense, but this module is the heart of the system. It uses analogue switches to select the signals, with one advantage that the signal remains on the PCB, so that the likelihood of interference pick-up in the wiring is much reduced.

Also, this type of control allows the enterprising constructor to add a remote control system and it minimizes the work of wiring-up — which is one job I hate.

Design Criteria

One strong incentive for building this pre-amp in the first place was to provide more switched inputs, and more versatility in switching them than is commonly available in commercial designs. It would defeat the object if performance quality were to be sacrificed in favour of comprehensive switching facilities. In terms of noise, interference and distortion in particular the output signal should bear a striking resemblance to the input signal.

This means that low noise components must be used throughout, and that the analogue gates should be used in a configuration which minimizes any imperfections which they possess. All common sense really, and no esoteric hi-fi 'black art' is necessary.

Switch Quality

The use of analogue gates to switch the audio signal is the most unusual feature of this design. In order to make it effective two potential problems must be considered, non-linearity and crosstalk. Of these, crosstalk is the easiest to deal with.

Figure 1 shows the effect of just one analogue switch, and it is clear that this does not provide an adequate difference between the ON and OFF states. It has been said analogue switches are not suitable for audio for just this reason. Ain't necessarily so, as Fig. 2 shows. Where there are two or more switches fed from a low impedance signal source, and one of them is always on, the situation is vastly better. In practice, I have found that with similar designs of switching systems there is more crosstalk between the screened cables that connect to the input sockets than in the analogue switch system itself, even at video frequencies.

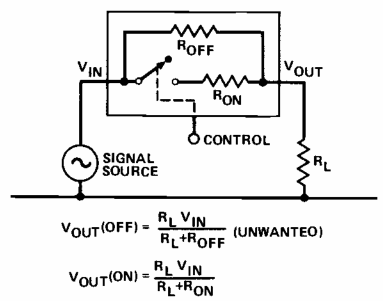


Fig. 1 Analogue switches have a finite off-resistance.

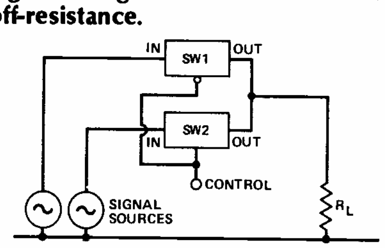


Fig. 2 This either/or arrangement reduces effects of off-resistance.

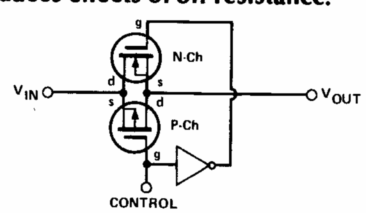


Fig. 3 Gate-source voltage varies with V_{in} so modulating each FET's channel resistance which, though opposite, do not quite cancel.

The other spectre which always surfaces when people consider analogue switches for audio is that the ON resistance of the switch is not zero, and is slightly dependent on the signal voltage (Fig. 3). Again, the solution is straightforward. If the multi-way analogue switch is driven from a low impedance, but fed into a high impedance, then the effects of the non-linearity are minimal.

Suppose that a channel resistance of 100R had a maximum change of 10% over the signal swing. If this is fed into a load impedance of 100k, then the signal is potted down by approximately 0.1%, and the potting down ratio changes by 10% of this, or 0.01%. If we feed into a higher impedance, such as 1M0, and make sure that the signal swing is much less than the power supply voltage so as to reduce the non-linearity, then the distortion introduced into the signal by the analogue switch will only be marginally more than that caused by a straight piece of wire!

The analogue gate type chosen for this task is the DG507A, which is a dual eight way multiplexer. That is, of course, ideal for stereo. Its maximum channel OFF state leakage is quoted as 1nA (typically 0.002nA!), and the maximum channel resistance is quoted as 400R. The change in resistance with signal is not quoted in the data sheet, but the process notes state that the change is very small. The maximum signal range is equal to the power supply used, which in this case is ±12V. The signal swing is not normally expected to exceed ±2V so the resistance change will be correspondingly small.

Signal Processing

The module is intended to form the input section of a preamplifier, so it must cope with the normal signal sources used in domestic hi-fi. For this reason, a disc input stage is provided. All other signal inputs have a flat frequency response. Because different signal sources may have different output levels these stages are laid out to provide gain if required, or to allow the signal to be attenuated. By using this facility, all the known signal sources can be balanced up at the time of construction to give approximately the same sound level on switching on from one to another.

Tape Outputs

Many pre-amplifiers make inadequate provision for tape recorders. It is not uncomon to copy from tape to tape, but the options for monitoring in this case are often limited. With this design it is possible to monitor the source recorder or the destination machine. If the latter has separate record and replay heads then this monitor facility offers an immediate check on recording quality.

Because the signal selection for tape recording is totally separate from that for monitoring, it would indeed be possible to record a compact disc while listening to the omnibus edition of The Archers from the tuner. With all this comprehensive switching it is important to avoid the possibility of trying to record from a tape recorder to itself, which might result in a loud howling noise or a series of echoes. An extra gating circuit is included to prevent this from happening.

Astute readers may have noticed that the circuitry described here copes with up to eight inputs, while the button latch described last month was designed for six ways. The reason is that six ways seemed a convenient number to use and to design the latch for, but the chosen type of analogue multiplexer has eight ways available. The audio PCB was therefore laid out to accept eight inputs so that those constructors who want more than six inputs can use the audio PCB with a different design of latch. A suitable circuit will be provided in the next part, but no PCB layout will be given.

In the next part, we'll show the component overlay for this module and bring you the parts list and assembly and testing details. In particular, we'll deal with the choice and calculation of components which are unspecified or optional.

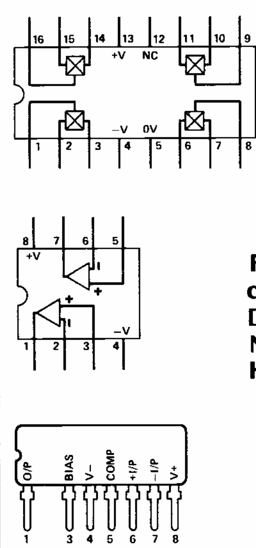


Fig. 4 Pin connections of DG 308 (top) NE 5532 and HA 12017.

HOW IT WORKS

On the circuit diagram (Fig. 4) the component numbering is arranged with the left and right hand channel having equivalent component numbers, but with 100 added to the right channel numbers. Thus R101 is the right hand channel equivalent of R1 in the left channel. In this description, left hand channel component numbers are used as an example, or in cases of circuitry repeated several times, one representative set of numbering is referred to.

Some of the components are marked with an asterisk. These are optional components, which are not all necessary for all applications.

The disc input (IC1) uses the HA12017 IC which is specially intended for this type of application. It has a very low noise figure and it can give the gain required from a disc input without running into gain/bandwidth problems. Because of the high gain of the circuit at low frequencies, capacitor C2 is used to reduce the DC gain to unity, and hence reduce the DC offset on the output of the stage.

The feedback circuit of the stage employs parallel arrangements of capacitors and series resistors to give a close approximation to the RIAA disc equalisation curve. Clearly close tolerance components must be used if this is to be worthwhile. C3, C9, C10 and R10 are compensation components to keep the circuit stable.

The output from the disc equaliser is DC coupled to the analogue gate, IC10. There should be negligible DC offset at this point so there is no reason to add another capacitor, which would diminish the bass response by a tiny amount.

A similar concern for the frequency response is apparent in the connection of the DC blocking capacitor on the input of the disc equaliser. In order to minimise the effect of the capacitor, the bias resistor following it is 100k rather than 47k which is the usual input impedance for a disc preamp. This gives a break frequency of 3.4Hz which should have minimal effect on the sound. The customary 47k input impedance is provided by the optional input load resistor, R1.

The flat response input stages all use 5532 dual low noise op-amps, which should not produce hiss unless the volume of the amplifier is turned up to about the pain level. Once again, there are optional components. These provide gain or attenuation, or decrease the input impedance, as required.

The output buffers to feed the volume control each have two optional components. These are to prevent any slight offset from the input stages from reahcing the output. Most constructors will not need them because offset is only likely to become a problem if a high gain is used on one of the input buffers.

In the tape output buffers, the capacitors are optional for the same reason. The resistors are needed, however, because a tape output is disabled if that machine is selected as a source for recording. The purpose of this is to prevent oscillation if the machine currently recording is selected by mistake. This could damage both your hearing and your loudspeakers. The outputs are disabled by an extra analogue switch in series with the signal to the tape buffer, so the resistors are needed to keep the op-amps biased.

The control signals for these analogue switches are generated by a 4051, with its common connection to 0V. Two of its switched input/outputs are connected to pull-up resistors and to the analogue switch control inputs. When the corresponding tape channel is selected the control terminal is pulled to logic low and the signal is interrupted.

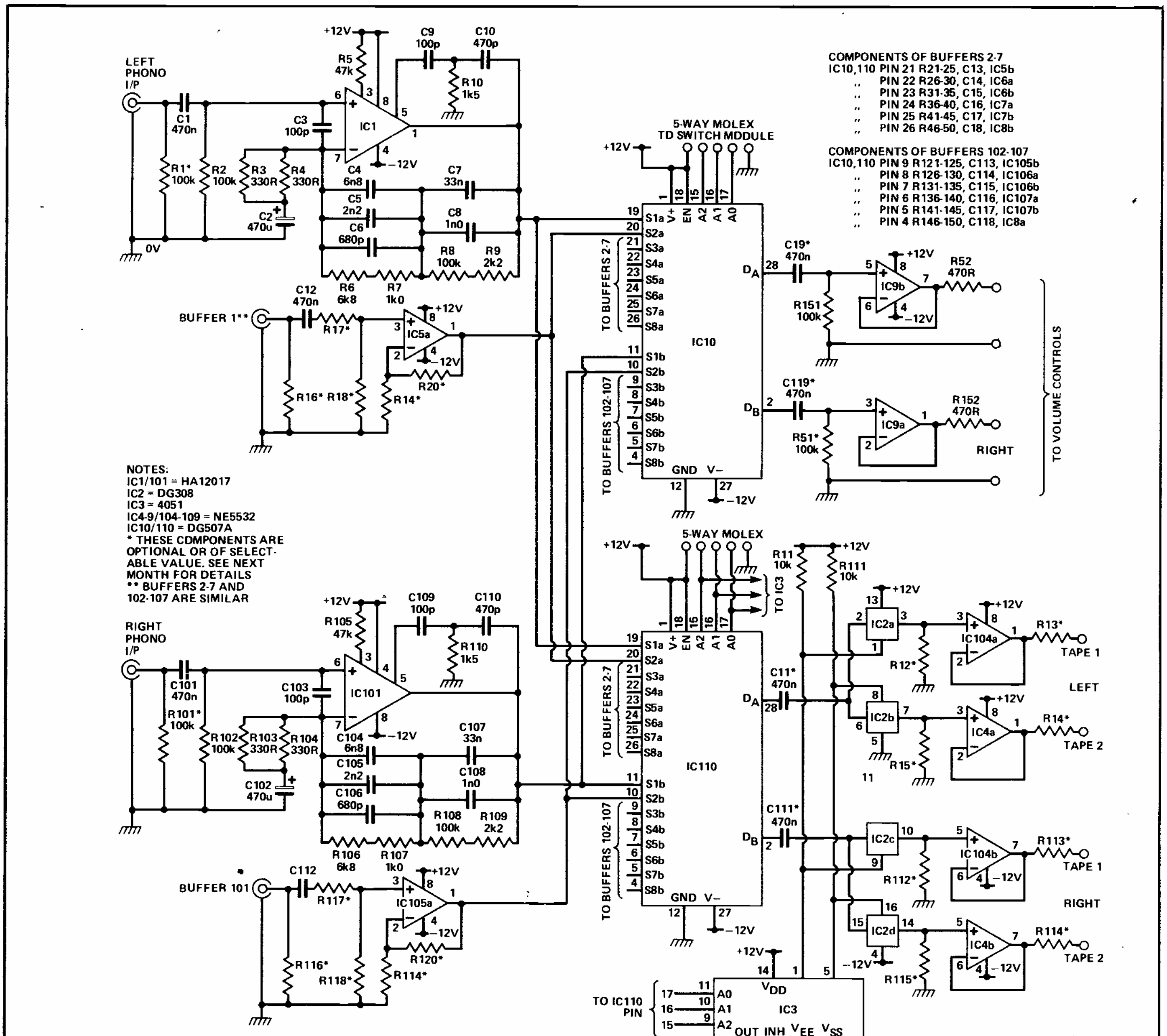


Fig. 5 Circuit diagram of the signal buffering and switching circuit.

ETI

BIOFEEDBACK MONITOR

With the free PCB and your free components, you can build a basic GSR monitor or read on and find out how to build and use a more advanced version.

The circuit of the basic GSR monitor (see Fig. 1) is an oscillator whose frequency varies inversely with the resistance across the input terminals. The output can be connected to a crystal earpiece or an amplifier and loudspeaker to produce an audible tone.

At their most basic, the electrodes could be the bared ends of some stranded wire stuck to your palms with tape. You will achieve better results by soldering a large washer to the end of each lead and, with a strip of felt, some Velcro and a little foam rubber and glue, you can make yourself a pair of strap-on electrodes (Fig. 2).

The component overlay is shown in Fig. 3. The circuit will run from a 9V PP3 battery — it could be dangerous to use a mains power supply, so don't.

The circuit was designed to work over a wide range to accommodate the possible variations in skin resistance between one person and another. Around 90% of individuals will have a skin resistance in the range 50k to 200k, but the monitor will be responsive to them at the cost of sensitivity to small resistance changes. It is, in any case, difficult to be sure whether the tone has risen or fallen over a period of time.

To produce a more sensitive and effective monitor, the basic circuit can be extended (see Fig. 1). Room has been allowed for this on the PCB.

The input from the electrodes still drives an oscillator but the resulting signal is now processed to give an output suitable for connecting to a meter. The circuit will adapt itself to any resistance, while giving a clear indication of variations.

An analogue multi-meter is the best choice for the display — it is easy to take in at a glance whether the needle has moved to left or right, and the sensitivity of the instrument can be adjusted by switching meter ranges. A 50μA range should be suitable — it gives a clear indication of small changes without pushing the meter needle off the scale for large variations.

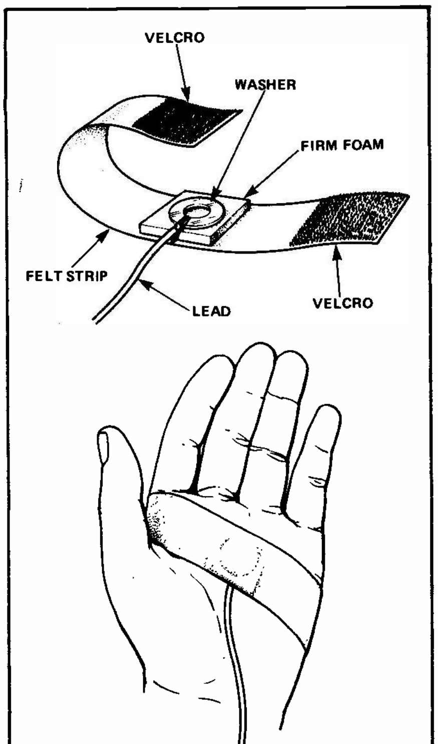


Fig. 2 Home made electrodes — the foam gives pressure to the contact.

Construction

Figure 3 shows the component overlay for the extended circuit and Fig. 4 and the photograph show the internal layout of a suitable case (the one supplied by our Readers Service). Self-adhesive pads hold the PCB in place — they have more than enough strength for such a light

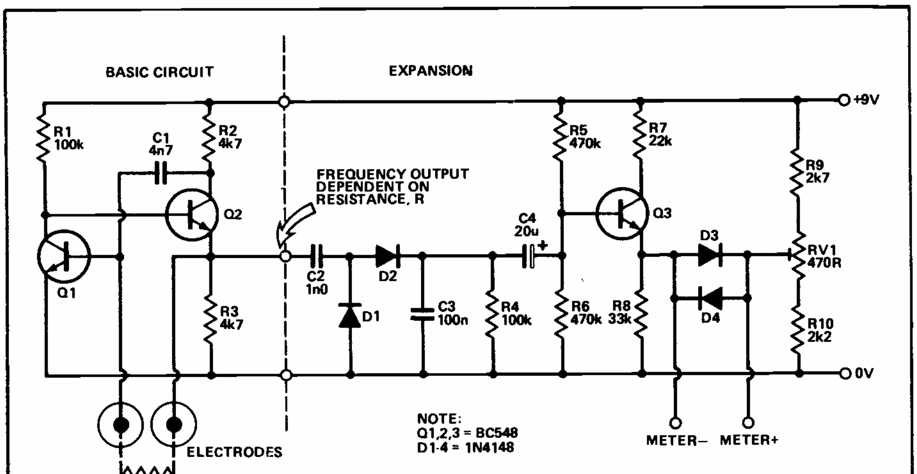


Fig. 1 Circuit of the basic and expanded monitor.

PCB and save drilling the case. You will find a hole at the bottom of the battery compartment for the connector leads. Remember to thread them through before soldering. Soldering the components should present no problems.

The 4mm plugs for the electrodes have an insulated cover which pushes down over the metal terminal. It is quite a tight fit. The trick of getting it on easily is to solder the wire to the tag neatly, without excess solder, and to make sure the tag is standing upright. Hold the metal part of the plug (don't try to pull it through by the wire), apply firm pressure, and the cover will slip on without fuss.

The case should be screwed together after setting up the circuit. On the case supplied, you will find holes for self-tapping screws at the bottom of the battery compartment. The front of this case just snaps into place. The internal layout is quite straightforward, so you should have no trouble using almost any case.

Setting Up

Connect a 47k resistor temporarily between the two electrode plugs. Turn your meter to the 1mA range and connect it to the terminal posts. Now, switch on. The meter needle should read about 100µA. If it tries to swing to

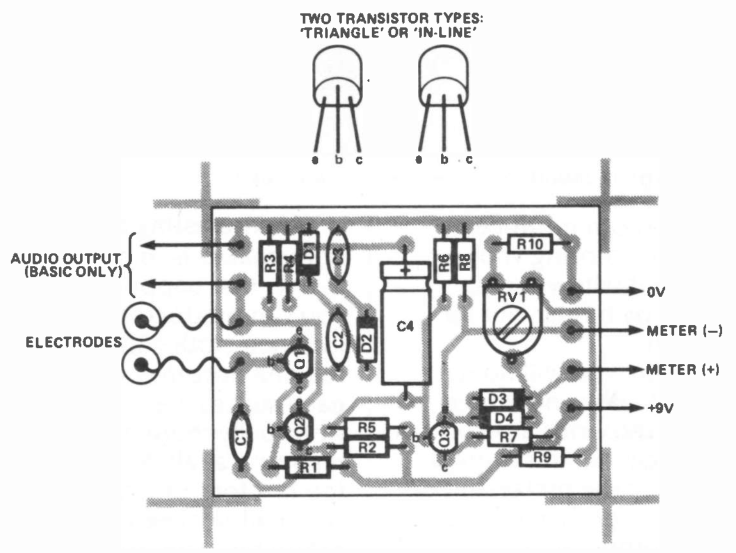


Fig. 4 Component overlay for both the basic monitor and the expanded version.

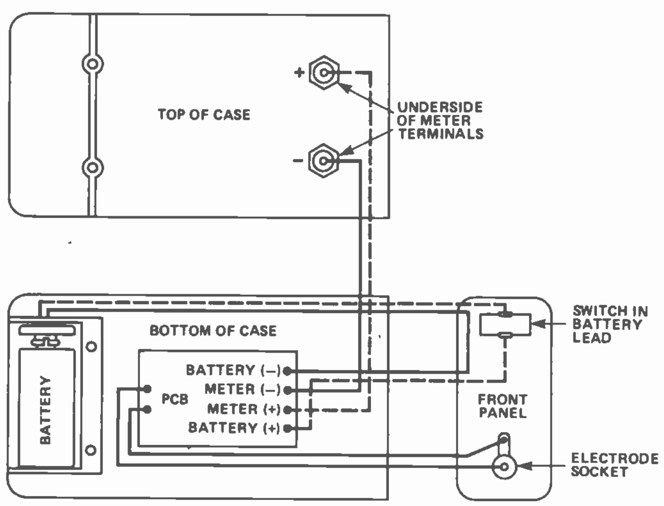


Fig. 5 Casing the unit.

HOW IT WORKS

Q1 and Q2 (Fig. 1) form an oscillator whose frequency depends on the resistance between the electrodes. In the basic circuit, biofeedback is obtained by listening to the output of the oscillator at the emitter of Q2.

In the extended circuit, C2, D1, D2, C3 and R4 form a non-linear charge pump circuit which produces a voltage across R4 dependent on the oscillator frequency. The charge pump has been made non-linear to accommodate a wide range of frequencies, and because it must give an indication of the percentage change in frequency, rather than the number of Hz by which the frequency changes.

A bridge is formed by R5, R6, R9, R10 and RV1. Q3 is included to give one arm of the bridge a high input resistance and low output resistance. R7 and R8 are chosen to limit the maximum output current to 100µA or so; D3 and D4 give further protection to the meter if it is set to the wrong range.

Normally, the bridge is balanced by RV1 (strictly speaking, it is offset to give a mid-scale reading on the meter, to avoid the need for a centre-zero meter). The bridge can be pushed out of balance by a voltage applied to C4 from the charge pump. If the charge pump output voltage rises or falls, the bridge will indicate this. If the voltage remains steady, the bridge will return to the balanced condition after twenty seconds or so.

The result is that the output responds with great sensitivity to *changes* in skin resistance, and can accommodate a wide range of inputs without adjustment.

PARTS LIST

RESISTORS (all ¼ W 5%)

R1*	100k
R2*	4k7
R3*	4k7
R4	100k
R5	470k
R6	470k
R7	22k
R8	33k
R9	2k7
R10	2k2
RV1	470R

CAPACITORS

C1*	4n7
C2	1n0
C3	100n
C4	20µ electrolytic

SEMICONDUCTORS

Q1*, 2*, 3	BC548 or equivalent
D1, 2, 3, 4	1N4148

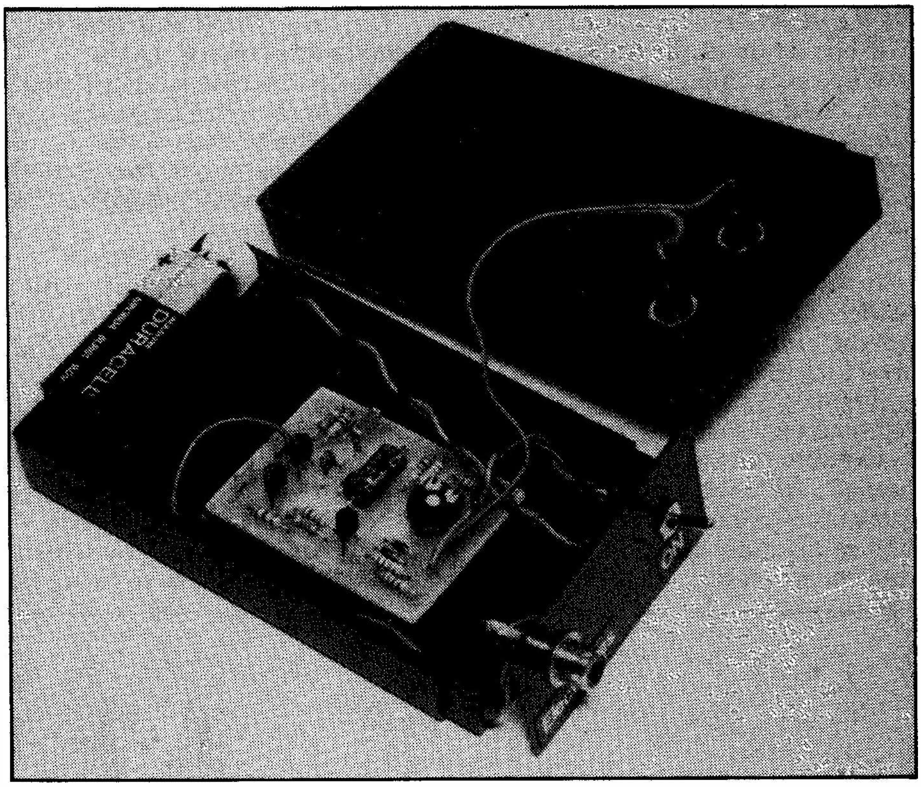
MISCELLANEOUS

Switch, case, PCB*, phono plug and socket, terminal posts, PP3 battery connector*, connecting wire*, 4mm plugs, electrodes (see text)*, conductive gel*, crystal earpiece (basic monitor only)*.

(* Items necessary to basic monitor)

the left, turn off the monitor and check that the connections to the terminal posts are the right way round. After about ten seconds, the needle will gradually fall back of its own accord to a lower reading. If it goes off the scale at this stage, adjust RV1 to bring it back. When it has settled, adjust RV1 so that the meter reads just a little over zero, then switch to the 50μA range (or the nearest range to this that your meter offers). Adjust RV1 to give a centre-scale reading and leave for a minute or so to be sure the circuit has settled. Adjust RV1 again if necessary. Now disconnect the meter, switch off the monitor, screw the case together, and you are ready to begin.

The circuit contains components to protect the meter from overload, but it is a sensible precaution in any case to turn to a less sensistive range each time you power up the monitor (the peak current will be about 100μA) or make any changes to the electrodes. In use, a leftward swing of the meter needle corresponds to a rise in pitch on the basic GSR monitor (and vice versa).



The GSR monitor installed in the recommended case.

Getting Started

Take a little conductive gel on your fingertip and fill the recess in each electrode pad with it. If you bend your hand slightly, you will see that there is a part of your palm that moves very little — this is the best place for the pads (see Fig. 2)

Make sure your hands are clean. If you really want to be thorough, rub your palms lightly with a pumice stone to remove any loose dead cells. Remove the covering from the adhesive on the rim of the pads and attach them firmly to your palms — one on each hand.

Find a comfortable place to sit, and rest your hands with the palms facing inwards or upwards so as not to put pressure on the electrodes. Find a hand position that feels natural and unstrained. When the meter needle has settled try taking a few deep breaths. After a second or so, the needle should move to the left and then, if you breathe normally again, should move back towards the centre. You can produce a similar effect by tensing your muscles — try it with your leg muscles — or by biting your lip (not too hard!).

In each case, you will notice that the needle does not move instantly — it responds a second or two after the cause. This is not a characteristic of the meter, but of your body. It takes that long to respond and produce the resistance change. Another thing you will notice is that the recovery takes much longer than the initial response. The needle moves smartly to the left, but only gradually back to the right again.

Producing a change without any of the physical aids is almost as easy — just think of a worrying or exciting situation. Unless you have a vivid imagination, a real situation will probably produce a much greater response than an imaginary one.

While you are experimenting with the monitor, you may see the needle move for no particular reason. Your body is constantly affected by your surroundings and responds to things you are hardly aware of. Many people produce quite large resistance changes in response to traffic noise, even if they claim not to notice it!

An interesting adaptation the body makes is to habituate to events that happen regularly. If you can produce a regular click, for instance, notice that the GSR reading becomes less and less on each successive click until eventually there is no visible response at all. A metronome is too fast for this experiment — it won't allow time for the needle to return between successive clicks — but it shouldn't be beyond ETI readers to make a circuit which gives a slow, regular beat.

Relaxation

The GSR monitor can be a valuable aid to stress control, relaxation and meditation. Find a quiet situation where you will not be disturbed. Traffic noise should be avoided if possible, but more important is to be out of sight of anything that may remind you of things that need to be done. Find a comfortable chair to sit in (if you lie down, you may become drowsy, which is not the point of the exercise).

Relaxation is not something you do, it is something you let happen. The repetition of a nonsense word, or mantra, may help this along.

Keep your eyes open, but don't stare at the meter needle. Just allow yourself to notice it every now and again. If you concentrate on it, it will almost certainly swing over to the left and you'll lose the mood. After a while, the needle should deflect to the right; it may began to swing freely about the central position, or a little to the right of it. Both are signs that you are on the right track. After ten or fifteen minutes, you should in any case stop.

Lie Detection

Lie detection depends on the observation that a person's autonomic nervous system reacts more strongly when telling a lie than when telling the truth. It's big business in the USA, but thankfully has not caught on here yet. The instrument used commercially — a 'polygraph' — consists of a number of pieces of bio-monitoring equipment in the same box — a GSR monitor, blood pressure meter, heart rate detector, and so on. The output usually drives a chart recorder so that the results can be analysed later.

Lie detection works well with neutral topics. When used to pry into someone's personal affairs, the results can be very misleading since responses can be caused by all manner of things. Don't ask personal questions of anyone connected to the GSR monitor — at best it can only cause embarrassment.

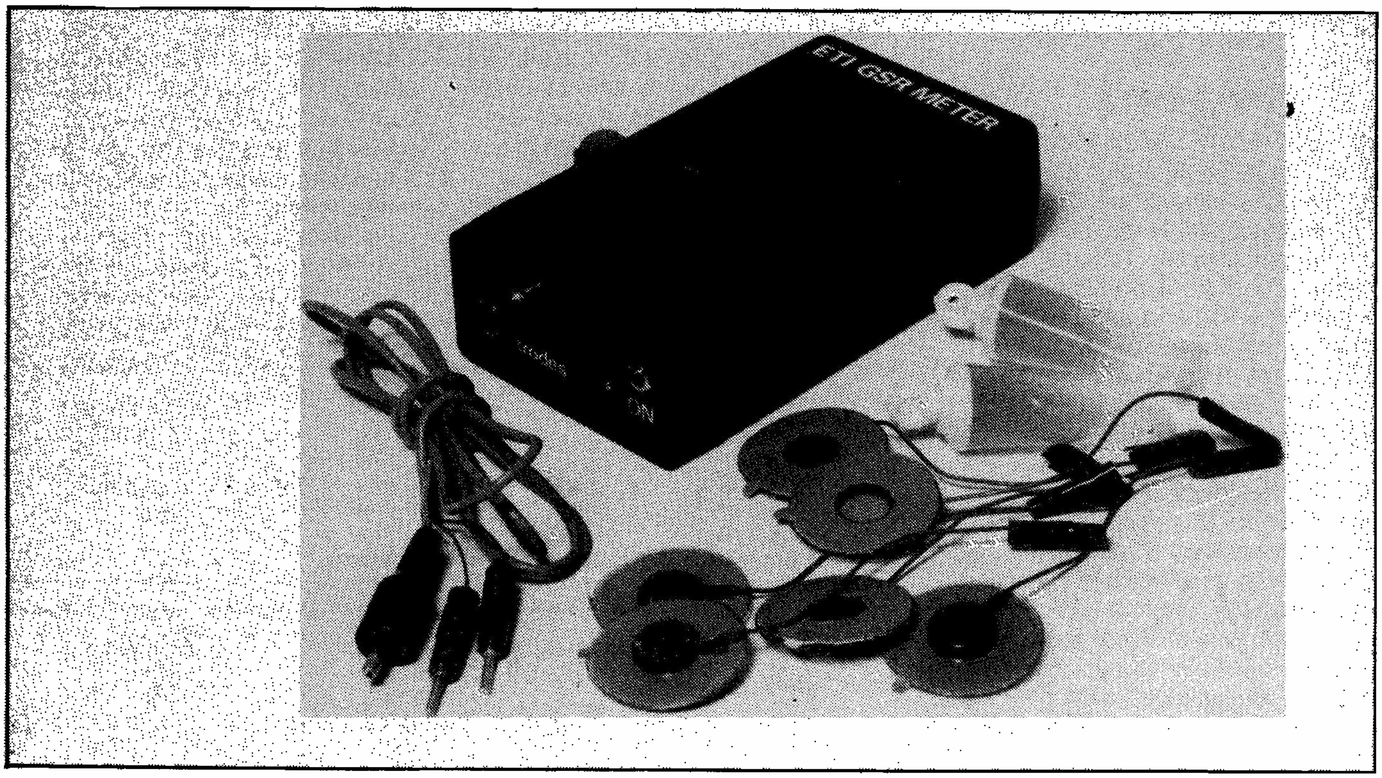
Ask someone to pick a card from a set of ten (if you use more, the test will take too long!) and memorise it. Now, show the cards one at a time and ask 'Is this the card you picked?' Each time, the person must answer 'No, it isn't'. When the selected card appears, the answer will be a lie and the meter needle should swing to the left, so you will be able to identify the chosen card. Remember to allow enough time between each card for the meter needle to return to the central position — it will probably move slightly after each answer.

Biofeedback can strengthen the results. If the person connected to the monitor can see the needle move, the deflection should be greater than if they can't. A more devious method is to give false biofeedback — let the subject beleive that the meter they see is measuring their responses when what they are really looking at is a meter under your control (a multimeter on ohms range connected to a pot, for instance). Ask a few questions and if the answers are untrue, tweak the pot to give a huge swing of the needle! This should cause the genuine GSR response to be more pronounced.

Cheating the lie detector is easy, since there are so many ways to produce a GSR response at will. More difficult is to try to cancel your GSR response to a lie, but relaxation techniques can help here.

BUYLINES

A complete set of parts, including case, electrodes, conductive gel, leads, etc. to convert the basic GSR monitor to the advanced version is available from our Readers' Service department. See the special offer in this issue. If you would prefer to seek out the components for yourself, the only items likely to cause any problem are the electrodes and gel. Most medical suppliers are only prepared to sell the electrodes in large quantities, so we have arranged for supplies to be available from: Specialist Semiconductors, Founders House, Redbrook, Monmouth, Gwent. They will supply a set of ten electrode pads and a sachet of conductive gel for £2.90, inclusive of postage. If you would prefer to make the strap-on electrodes, materials will be available from any good haberdashery shop! All the electronic components are entirely non-critical.



The completed monitor.

ETI

INTELLIGENT CALL METER

Chris Ranklin completes his description of the fully-automatic call charge meter with some notes on programming the ROM and setting up the system.

Before the call meter can be tested and set up, a programmed EPROM must be prepared and installed in the IC12 position. It is not possible for the author or ETI to make a programmed EPROM generally available because, as explained below, some parts of the programme vary according to which part of the country you live in. Those who do not have access to programming facilities can produce a full listing for their area using the notes below and then have it blown into an EPROM by one of the companies who provide such a service. Some useful addresses were given on page nine of the September '86 issue.

Programming

The bulk of the programme is shown in Table 3 and this applies throughout the country. The section which must be added by the constructor is the list of telephone dialling codes between locations 0400 and 0493. A total of up to 73, three- and four-digit STD codes must be obtained from the local code book and entered into the programme.

The first group of numbers is a list of three-digit, B1-rate code numbers, for example, 021 Birmingham, 061 Manchester, etc. Go through your code book and enter these in the manner shown in Table 1, beginning at memory location 0400. When you have entered all the three-digit B1-rate numbers from your code book, fill any unused bytes with zeroes down to memory location 040D.

The next list is of four-digit, B1-rate numbers such as 0482 Hull, 0632 Newcastle, etc. These are entered in the manner shown in Table 2. Enter all the four-digit B1-rate numbers from your code book starting at memory location 040E, then fill unused bytes with zeroes down to memory location 0427.

The next entry is only one number, the Ireland/Dublin code 0001. This is entered as 01 00 at memory locations 0428 and 0429, as shown in Table 3. Constructors in the Irish Republic should enter their own code for Dublin from the code book.

List four consists of local dialling codes beginning with zero, for example, 026288, 0262, 09466, etc. Use the first four digits of each code only, ignoring the subsequent digits, and enter the codes in the same manner as the four-digit, B1-rate numbers shown in Table 2. Start at location 042A, and when you have entered all the local numbers beginning with zero from your code book, fill any unused bytes with zeroes down to memory loclation 0447.

The final list contains four-digit, A-rate code numbers. Enter these in the same way as the previous four-digit codes (see Table 2), starting at memory location 0448. Enter all the four-digit, A-rate codes you can find in your codebook and then fill any unused bytes with zeroes down to memory location 0493.

It was clearly not practical to compile lists for each part of the country so the initial testing was carried out in just three areas,

OOPS!

In order to keep prices down, boards for this project supplied by our PCB Service will not have plated-through holes. Because of this, in addition to following all the other instructions given last month, constructors using our boards must insert wire links through all the holes not occupied by component leads. Note also that it is not possible to use IC sockets on these boards since some of the IC pins must be soldered on both sides.

STD CODE	DECIMAL	HEX	NUMBER STORED
021	21	15	15
	0	0	0
061	61	3D	3D
	0	0	0

Table 1 Entering three-digit codes into the memory.

STD CODE	DECIMAL	HEX	NUMBER STORED
0482	82	52	52
	04	4	4
0632	32	20	20
	06	6	6

Table 2 Entering four-digit codes into the memory.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0000	31	56	08	AF	06	83	21	04	08	77	23	10	FC	C3	03	01
10	7E	D3	01	2B	7E	D3	02	2B	7E	D3	04	2B	7E	D3	08	C9
20	D3	01	AF	D3	02	D3	04	D3	08	C9	D3	01	D3	02	D3	04
30	D3	08	C9	DD	21	EC	0F	DD	36	00	00	DD	7E	00	B8	20
40	FA	C9	0E	06	0D	79	CD	2A	00	06	32	CD	33	00	41	10
50	F3	C9	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
60	FF	FF	FF	FF	FF	FF	08	D9	21	FC	0F	3A	E8	0F	FE	00
70	20	1B	23	3A	EA	0F	FE	00	20	0A	23	34	3E	32	BE	20
80	45	AF	77	2B	34	3E	3C	BE	20	3C	AF	77	2B	34	3E	0A
90	BE	20	33	AF	77	2B	34	3E	06	BE	20	2A	AF	77	2B	34
A0	3E	0A	BE	20	04	AF	77	2B	34	21	F8	0F	34	3E	18	BE
B0	20	14	AF	77	23	77	23	77	32	F6	0F	21	F7	0F	34	3E
C0	07	BE	20	02	AF	77	21	ED	0F	34	2B	34	2B	AF	77	28
D0	77	08	D9	ED	45	21	03	08	36	05	16	02	7E	CD	2A	00
E0	06	32	CD	33	00	DB	10	CB	6F	28	0E	CB	67	20	F6	34
F0	7E	C6	F6	30	02	AF	77	18	E3	2B	15	36	08	7A	FE	00
0100	20	DA	C9	21	FC	0F	CD	10	00	DB	10	CB	47	C2	48	02
10	CB	5F	28	02	18	ED	CD	42	00	AF	32	E9	0F	3A	E9	0F
20	CD	2A	00	06	32	CD	33	00	3A	E9	0F	FE	02	28	1B	FE
30	03	28	17	FE	04	28	18	FE	05	28	19	FE	06	28	22	FE
40	07	CA	F7	01	FE	08	28	BB	18	1D	21	FC	0F	18	15	3A
50	F7	0F	18	03	3A	F6	0F	CD	20	00	06	20	CD	33	00	18
60	06	21	F2	0F	CD	10	00	DB	10	CB	6F	28	0A	CB	67	28
70	0C	00	00	00	00	18	F0	21	E9	0F	34	18	A0	3A	E9	0F
80	FE	00	28	4C	FE	01	28	59	FE	02	28	22	FE	03	28	19
90	FE	04	28	21	FE	05	28	2A	FE	06	20	4A	21	F4	0F	06
A0	06	AF	77	2B	10	FC	18	B9	00	21	EA	0F	18	03	21	EB
B0	0F	36	01	18	95	21	F7	0F	34	3E	07	BE	20	02	AF	[illegible]
C0	18	8D	21	F6	0F	AF	BE	20	03	34	18	02	36	00	18	84
D0	AF	21	57	08	0E	08	06	F5	77	23	10	FC	0D	20	F7	18
E0	86	CD	D5	00	18	F9	AF	21	DF	0F	0E	08	06	E7	77	2B
F0	10	FC	0D	20	F7	18	ED	21	CF	0F	16	88	1E	03	DB	10
0200	CB	5F	28	3D	CB	6F	20	F6	7E	D3	08	2B	7E	D3	04	2B
10	7E	D3	02	2B	7E	D3	01	2B	06	32	CD	33	00	1D	20	DE
20	DB	10	CB	6F	20	FA	7E	D3	08	2B	7E	D3	04	2B	3E	0A
30	D3	02	D3	01	06	64	CD	33	00	15	20	C0	CD	42	00	18
40	84	06	96	CD	33	00	18	F7	06	19	AF	4F	21	E8	0F	77
50	2B	10	FC	DB	10	CB	4F	28	01	4F	CB	47	20	F5	79	CB
60	4F	C2	03	01	AF	21	EC	0F	77	7E	FE	23	28	4A	DB	10
70	CB	47	28	F5	21	E1	0F	34	AF	32	EC	0F	3A	EC	0F	FE
80	1B	28	08	DB	10	CB	47	20	F3	18	D9	21	E2	0F	34	7E
90	C6	07	47	2B	7E	2B	10	FD	FE	0A	20	01	AF	77	CD	2A
A0	00	3A	E2	0F	C6	F8	38	13	DB	10	CB	4F	20	2A	CB	47
B0	20	F6	AF	32	E1	0F	18	AC	C3	03	01	AF	32	E5	0F	21
C0	D9	0F	7E	FE	00	20	74	2B	7E	FE	01	20	0D	2B	7E	FE
D0	00	28	55	3E	30	32	E5	0F	18	61	21	D9	0F	CD	78	07
E0	21	00	04	0E	30	06	08	CD	5D	07	21	D8	0F	CD	78	07
F0	21	0E	04	06	0E	CD	5D	07	0E	60	06	02	CD	5D	07	0E
0300	FF	06	10	CD	5D	07	3A	E5	0F	FE	FF	20	06	AF	32	E5
10	0F	18	13	0E	18	06	27	CD	5D	07	3A	E5	0F	FE	00	20
20	05	3E	48	32	E5	0F	18	13	CD	78	07	21	40	04	3A	E3
30	0F	4F	06	00	09	7E	32	E5	0F	18	38	DB	10	4F	3A	E5
40	0F	FE	00	28	08	00	00	00	00	CB	51	20	28	CB	49	20
50	71	CB	41	20	E6	3A	E2	0F	C6	F6	38	03	C3	B2	02	AF
60	32	EC	0F	DB	10	CB	47	20	D2	3A	EC	0F	FE	23	20	F3
70	C3	03	01	18	58	AF	32	EC	0F	DB	10	CB	57	28	BC	3A
80	EC	0F	FE	0E	20	F3	DB	10	CB	57	20	FA	AF	32	EC	0F
90	DB	10	CB	57	20	F0	CB	4F	20	28	CB	47	28	09	3A	EC
A0	0F	C6	88	30	EB	18	14	AF	32	ED	0F	DB	10	CB	47	20
B0	DF	3A	ED	0F	FE	23	20	F3	C3	03	01	3E	32	32	E6	0F
C0	18	2E	3E	FA	32	E6	0F	AF	32	E5	0F	18	23	3E	05	32
D0	E6	0F	DB	10	CB	6F	28	18	CB	47	20	F6	AF	32	EC	0F
E0	DB	10	CB	47	20	EC	3A	EC	0F	FE	23	20	F3	C3	B4	06
F0	06	05	AF	21	DF	0F	77	2B	10	FC	C3	40	06	FF	FF	FF

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0400	LIST 1 7 Numbers 14 Bytes															
10	LIST 2 13 Numbers 26 Bytes															
20									01	00						
30	LIST 4 15 Numbers 30 Bytes															
40																
50																
60	LIST 5 38 Numbers 76 Bytes															
70																
80																
90					FF	FF	FF	FF	FF	FF	19	19	19	19	19	19
A0	19	19	19	19	A8	A8	A8	A8	A8	A8	A8	A8	A8	A8	D8	A8
B0	D8	D8	D8	D8	D8	C0	19	19	78	78	78	78	78	78	90	90
C0	90	78	A8	78	90	90	19	78	90	90	90	78	D8	D8	D8	A8
D0	D8	D8	D8	D8	D8	A8	19	01	19	19	01	01	19	19	D8	19
E0	A8	A8	A8	A8	A8	A8	A8	A8	A8	A8	19	19	19	19	19	01
F0	19	19	19	19	90	19	19	19	19	19	D8	D8	D8	19	FF	FF
0500	60	60	60	60	60	60	60	60	18	12	12	12	12	18	18	18
10	18	18	60	60	60	60	60	60	78	78	78	78	78	78	78	78
20	2D	1E	1E	1E	1E	2D	2D	2D	2D	2D	78	78	78	78	78	78
30	3C	3C	3C	3C	3C	3C	3C	3C	18	12	12	12	12	18	18	18
40	18	18	3C	3C	3C	3C	3C	3C	30	30	30	30	30	30	30	30
50	14	0F	0F	0F	0F	14	14	14	14	14	30	30	30	30	30	30
60	0F	0F	0F	0F	0F	0F	0F	0F	08	08	08	08	08	08	08	08
70	08	08	0F	0F	0F	0F	0F	0F	5D	5D	5D	5D	5D	5D	5D	5D
80	4B	4B	4B	4B	4B	4B	4B	4B	4B	4B	5D	5D	5D	5D	5D	5D
90	46	46	46	46	46	46	46	46	3A	3A	3A	3A	3A	3A	3A	3A
A0	3A	3A	46	46	46	46	46	46	38	38	38	38	38	38	38	38
B0	30	30	30	30	30	30	30	2D	2D	30	30	30	30	30	30	30
C0	29	29	29	29	29	29	29	29	21	21	21	21	21	21	21	21
D0	21	21	29	29	29	29	29	29	29	29	29	29	29	29	29	29
E0	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	29	29	29	29	29	29
F0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
0600	FF	29	29	29	29	29	29	29	21	21	21	21	21	21	21	29
10	29	29	29	29	21	21	21	21	21	1F	1F	1F	1F	1F	1F	1F
20	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F	1F
30	1F	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
40	CD	00	07	16	00	AF	32	EC	0F	3A	E5	0F	FE	01	28	09
50	FE	19	28	05	21	00	05	18	03	21	01	06	6F	0E	00	3A
60	F6	0F	FE	01	28	09	3A	F7	0F	C6	FB	38	02	18	02	0E
70	01	79	FE	01	28	05	3A	F8	0F	85	6F	7E	5F	DB	10	CB
80	47	20	19	3A	E8	0F	FE	01	28	08	3E	01	32	E8	0F	32
90	ED	0F	3A	ED	0F	FE	32	CA	B4	06	18	04	AF	32	E8	0F
A0	3A	E6	0F	47	3A	EC	0F	B8	20	D3	14	7B	BA	20	96	CD
B0	00	07	18	8F	01	6C	07	21	6E	08	11	60	08	ED	B0	06
C0	04	21	DE	0F	11	CC	0F	7E	12	2B	13	10	FA	C3	03	01
D0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
E0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
F0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
0700	C5	D5	E5	F5	21	F4	0F	06	00	3A	02	08	86	77	C6	F6
10	30	0A	7E	D6	0A	77	3A	03	08	3C	18	03	3A	03	08	2B
20	86	77	C6	F6	30	21	7E	D6	0A	77	3E	0A	2B	34	BE	20
30	16	AF	77	2B	34	7E	FE	0A	20	0D	AF	77	2B	34	7E	FE
40	0A	20	04	AF	77	2B	34	78	FE	00	20	06	04	21	DF	0F
50	18	B7	21	DE	0F	CD	10	00	F1	E1	D1	C1	C9	10	02	18
60	16	1A	BE	20	0A	13	23	1A	BE	28	08	1B	23	18	EE	23
70	23	18	EA	79	32	E5	0F	C9	11	E4	0F	7E	12	18	2B	06
80	0A	AF	86	10	FD	2B	86	12	C9	FF	FF	FF	FF	FF	FF	FF
90	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
A0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
B0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
C0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
D0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
E0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF
F0	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF	FF

Table 3 The complete ROM listing. Note the area between 0400 and 0493 which is reserved for a list of dialling codes specific to each part of the country.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0400	15	00	33	00	3D	00	5B	00	00	00	00	00	00	00	52	04
10	20	06	5E	08	00	00	00	00	00	00	00	00	00	00	00	00
20	00	00	00	00	00	00	00	00	01	00	00	00	00	00	00	00
30	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
40	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
50	00	00	00	00	00	00	00	00	00	02	1A	02	52	02	02	03
60	2F	03	05	04	16	04	1E	04	21	04	39	04	54	04	23	05
70	3F	06	4D	06	06	07	09	07	2A	07	38	07	39	07	3B	07
80	41	07	2D	08	01	09	04	09	00	00	00	00	00	00	00	00
90	00	00	00	00												

Table 4 Dialling code listing for the Leeds area.

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0400	15	00	1F	00	29	00	33	00	5B	00	00	00	00	00	35	02
10	5B	03	20	05	02	06	07	06	20	06	46	07	5E	08	00	00
20	00	00	00	00	00	00	00	00	01	00	00	00	00	00	00	00
30	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
40	00	00	00	00	00	00	00	00	00	02	1A	02	2C	02	36	02
50	39	02	3C	02	46	02	4A	02	52	02	62	02	16	04	21	04
60	4D	04	54	04	23	05	26	05	06	06	5F	06	04	07	2A	07
70	2C	07	38	07	48	07	4A	07	51	07	52	07	1D	08	18	09
80	1C	09	24	09	00	00	00	00	00	00	00	00	00	00	00	00
90	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

Table 5 Dialling code listing for the Manchester area.

Leeds, Birmingham and Manchester. In each case the code lists were compiled as described and the system worked correctly. For the benefit of readers living in these three areas we have shown the listings in Tables 4, 5 and 6.

Setting-up

When the boards have been completed and the power supply has been tested, the call meter should be disconnected from the mains supply and the programmed EPROM and memory back-up battery installed. Preset potentiometers RV1 and RV2 on the interface board should be set roughly to the mid-point of their travel and a link should be inserted between pin 1 of IC3 and ground.

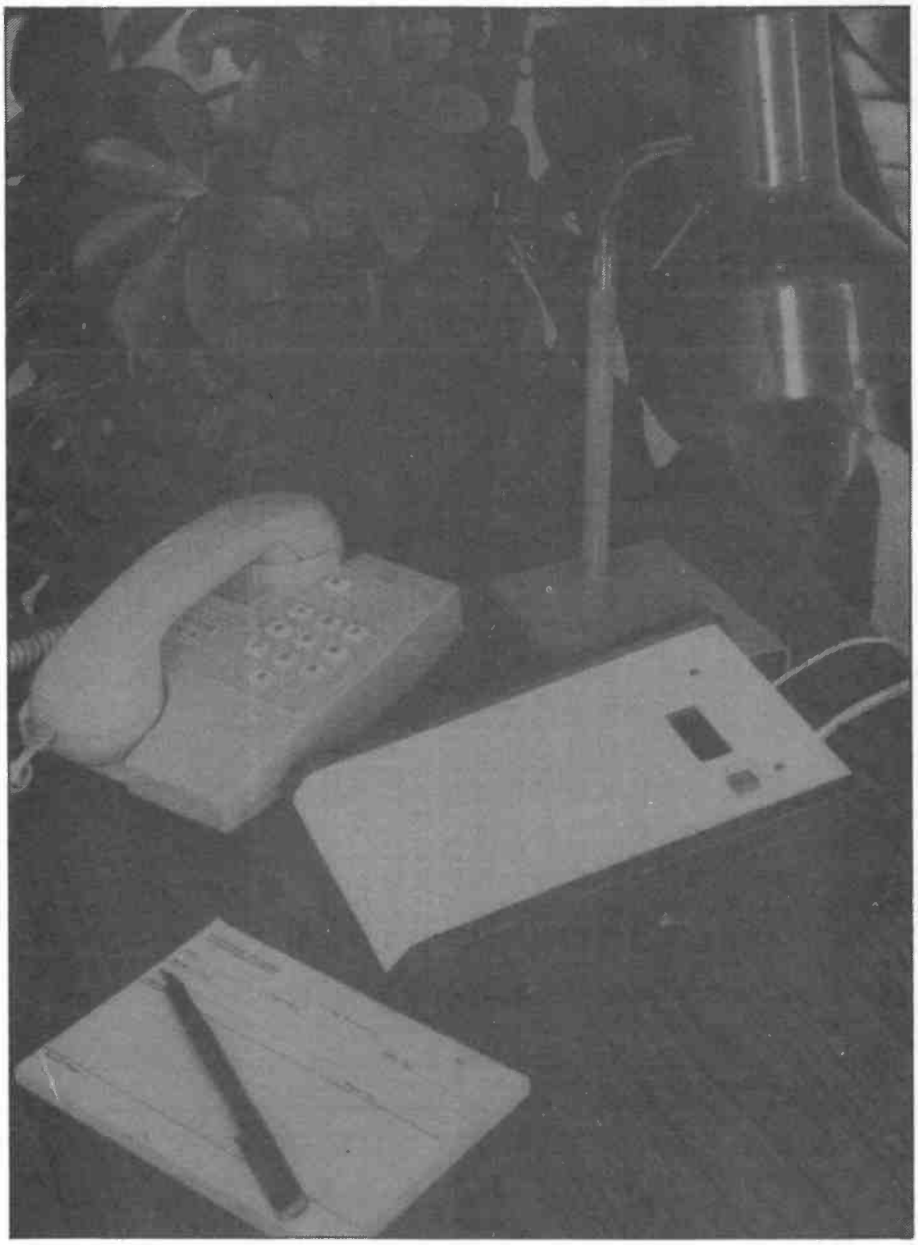
With the telephone line input disconnected, switch on the mains supply to the call meter. LEDs 1 and 2 on the interface board should light up while LEDs 3 and 4 remain unlit. Press the ENTRY/EXIT button (SW2 on the interface board) and the display should count down from 5 to 0 at intervals of one second.

At this stage, the RAM will be filled with random numbers. Press the ALTER button (SW1 on the interface) and all RAM locations between 0857 and OFFF will be cleared. The display should now show 0000.

Counting The Cost

Press the STEP button (SW3 on the main board) and the display should show 1111. Press ALTER and the display will change to 5555. The programme is now monitoring the area of RAM which should hold the unit call cost in whole pence. Pressing ALTER now will cause the number displayed to step from 0 to 9. The current unit call cost is 4.4p (as from November 1st 1986) to which must be added VAT at 15%. The unit charge is therefore 5.1 pence so the display should be set at '5'.

Press the STEP button again and 4444 will be displayed. The programme is now monitoring the area of RAM which stores the unit call cost in tenths of a penny. Step through from 0 to 9 as before using the ALTER button and leave the display set at the appropriate sum in tenths of a penny (currently '1').



Press STEP and the display will show 2222 for one second and then the time which has elapsed since switch-on. Press STEP again and the display will change to 3333 for one second and then show the time as it will be displayed when the call meter is on stand-by. Press ALTER to make the time increment and leave it set at the correct time of day.

Press STEP again and 4444 will be displayed for one second followed by 0000. Pressing ALTER will cause this to step through the numbers 0 to 6. This should be set to represent the day of the week, 0 being Monday, 1 being Tuesday and so on through to 6 which is Sunday.

Press STEP again and the display will show 5555 for one second and then either 0 or 1. Pressing ALTER will cause the display to change from one to the other. 1 indicates a bank holiday, during which BT charge calls at the cheap rate, and 0 indicates no holiday. The display should be left at 0 under normal circumstnaces and changed to 1 when necessary. The code in RAM will be reset to 0 automatically at the end of each day, so when two bank holidays occur on subsequent days (for example, Christmas Day and Boxing Day) the code will need to

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0400	33	00	3D	00	00	00	00	00	00	00	00	00	00	00	48	02
10	4B	02	1F	03	20	03	20	05	01	06	02	06	04	06	07	06
20	2A	07	51	07	52	07	00	00	01	00	54	03	1B	05	2B	05
30	3E	05	40	05	4B	06	4C	06	1B	08	02	09	07	09	16	09
40	00	00	00	00	00	00	00	00	03	02	53	02	63	02	56	03
50	37	04	1E	05	21	05	25	05	54	05	52	06	54	06	2E	07
60	55	07	58	07	59	07	55	08	56	08	59	08	05	09	1A	09
70	34	09	00	00	00	00	00	00	00	00	00	00	00	00	00	00
80	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
90	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

Table 6 Dialling code listing for the Birmingham area.

be changed to 1 on both days.

A further press of the STEP button will cause 6666 to be displayed for one second followed by the total cost of all the calls made to date. The sum is shown in pounds and tens of pennies, so if the figures displayed are 1234 the total cost is £123.40. Pressing ALTER will zero the figure stored as total cost.

Pressing Business

If the STEP button is pressed once again, the display will show 7777 followed by the cost of the last call made. This time the sum is shown in pounds and pennies, so the figures 0123 would represent £1.23. Further presses of the STEP button will cause the last number dialled to be displayed, four digits at a time. Ten digits are stored, so the first two presses will yield a full four digits while the third press will produce two digits followed by two blanks. The STD code will be included in the number, so a London number such as 01-234 5678 would be displayed as 0123, 4567, 80(blank)(blank).

From here on, each four presses of the STEP button will recall the cost and number of another telephone call from the memory. The first press will show the cost of the call and the next three presses will show the number dialled in groups of four, four and two digits, as described above. In this way, the complete list of 135 calls stored in the RAM can be displayed. Pressing ALTER will zero the values stored.

If you wish to leave the USER mode during this sequence, cycle through until the call meter is displaying the final figures of a dialled number (the digit-digit-blank-blank sequence) and press the ENTRY/EXIT button. Wait for a couple of seconds and press STEP. The display will show 8888 for 1 second and then display the time. The unit is now in the standby mode, awaiting outgoing calls.

If you have followed the above procedure and not encountered any problems, the call meter can be disconnected from the mains and the link between IC3 pin 1 and ground removed. Connect points A and B to the telephone line, A going to the −50V line (usually green) and B to the other wire. Switch on the mains again and check that LEDs 1 and 2 light up. If not, try reversing the A and B connections.

Going To Pots

The final stage in setting-up the call meter is to adjust the two presets, RV1 and RV2, so that the phase-locked-loops detect the 400Hz and 450Hz dialling tones. It doesn't matter which detects which since their outputs are connected via a diode OR gate and either going high will cause the D2 line to change to the high state. Lift the receiver, listen for a dialling tone and then adjust RV1 so that LED3 lights. You should find that this happens at two resistance settings. Leave the preset at the lower of the two (the one furthest clockwise, assuming you are adjusting the preset from the side of the board where the LEDs and switches are). Repeat the procedure with RV2 and LED4, but this time leave the preset at the higher resistance setting. The call meter is now ready for use.

On Call

Since the whole point of the intelligent call meter is that it is fully automatic, very little needs to be said about using it. It will display the time continuously until an outgoing call is made, whereupon it will show the cost mounting up as the call progresses. The only times you should need to touch the call meter once it is set up are when entering a 'bank holiday' code and when recalling or altering stored data. The use of the three switches for viewing and altering data can be summarised as follows:

to change from the standby mode (displaying the time and awaiting calls) to the user mode, press the ENTRY/EXIT button, SW2;

once in the user mode, press the STEP button (SW3) to cause different parts of the memory to be displayed;

when a particular piece of information is being displayed, it can be changed by pressing the ALTER button (SW1);

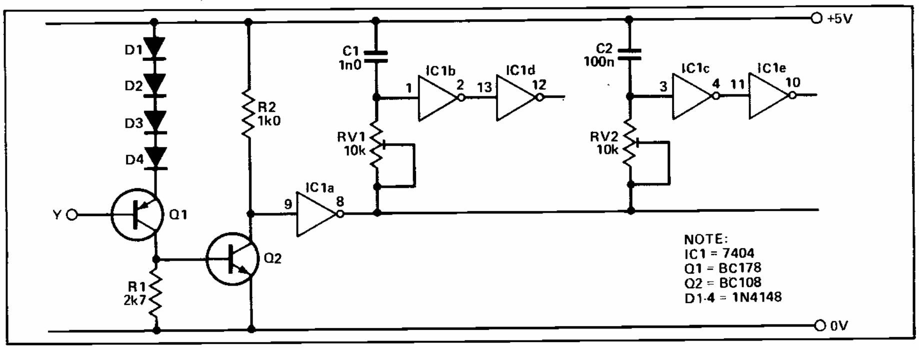
to return to the standby mode, STEP through the memory until you come to 7777 then STEP again until you have digit-digit-blank-blank displayed. Press ENTRY/EXIT and then STEP.

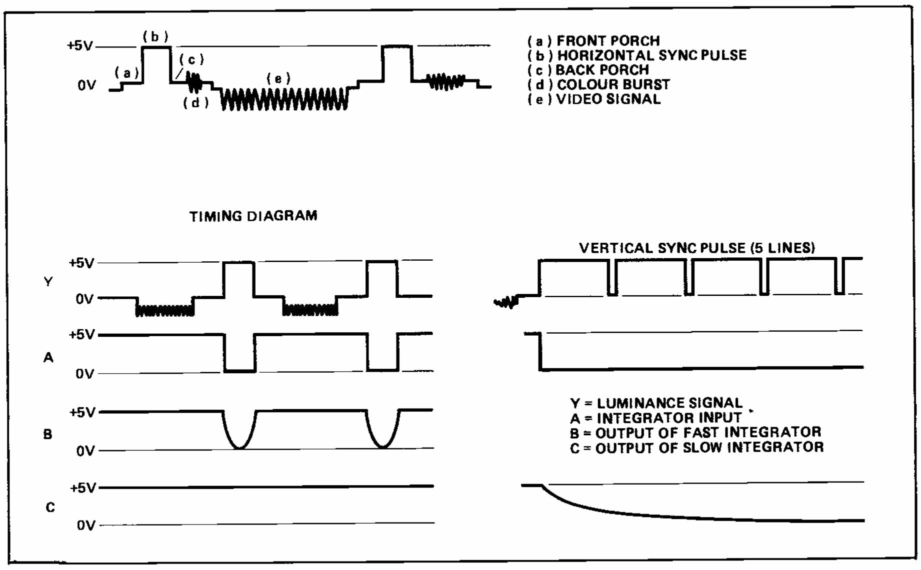
ETI

TECH TIPS

Spectrum Sync Pulse Separator

Timothy Vellacott
Oxford





The ZX Spectrum generates its sync pulses and combines them with the luminance signal inside its ULA. This means they are inaccessible, making it difficult to adapt the Spectrum for use with monitors which require separate sync signals.

The circuit is designed to overcome the problem. No claims of originality are made for it, but it is cheap to build.

The video signal on the Spectrum is shown in the timing diagram. The colour burst (marked d) synchronises the colour circuits in the PAL system — it is not present in the Y signal (ULA pin 17 and edge connector pin 16B) which is used here. By convention, when Y is at a voltage greater than 2.4V it contains sync pulse information; anything less is line intensity. Horizontal sync pulses are about 4.7 us long and vertical pulses are five lines (320 us) long.

Q1 will conduct during the picture scan when its base voltage is taken below about 2.5V. Q2 will also conduct then, bringing the input of IC1a down to about 0.4V during line scan and allowing it to rise during the sync pulses. The output of IC1a is therefore low during sync pulses and high during line scan.

The two resistor/capacitor combinations, C1/RV1, C2/RV2, separate long vertical pulses from the short horizontal ones; RV1 is set so that the inverter gates which follow this integrator (IC1b,c) will contain the horizontal pulses, while RV2 is set so that the output from IC1d,e will contain the vertical pulses.

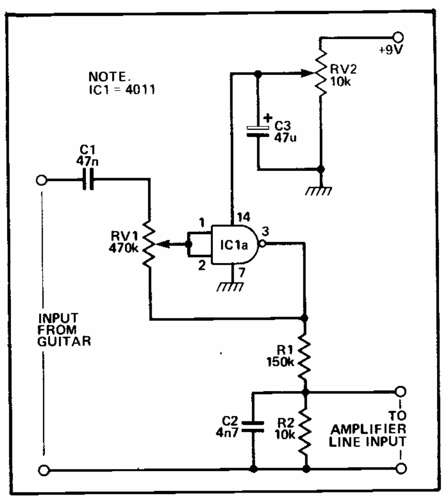
Before using the circuit, check two things: first, that the ULA pin 17 is connected to the connector socket 1 (on mine, an issue 1 board, a link was required beneath the 150R resistor R34 — marked Y). Second, check that there is adequate power from the PSU for the circuit. The standard TTL used in the prototype required quite a lot of current — I can see no reason why LS TTL shouldn't be used instead, but I haven't tried it.

Simple Fuzz Unit

Les Sage
Bingley

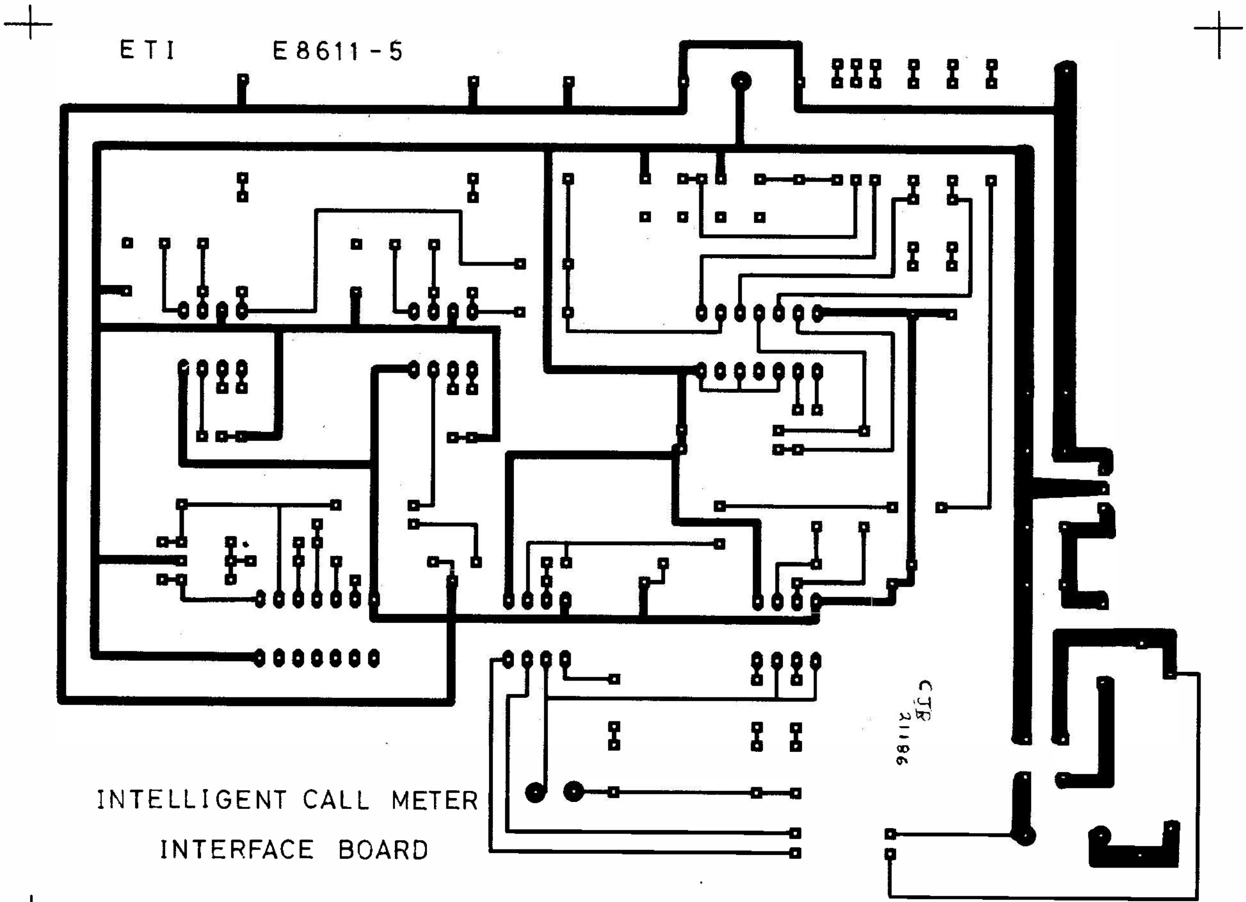
A standard CMOS NAND gate can be made to generate a very good fuzz effect by biasing it into a linear mode of operation. The resulting transfer characteristic is symmetrical but non-linear, an ideal characteristic for a fuzz box since it produces a high level of third harmonic but does not clip so sharply that amplitude variations are lost.

RV1 is connected between the output and the inputs of the gate to bias it into linear mode and can be varied to adjust the gain and hence the depth of the fuzz effect. C1 works as a high-pass filter in conjunction with RV1 to filter out low frequencies progressively as the fuzz level is increased. This prevents low frequencies masking and modulating the more important high frequencies.

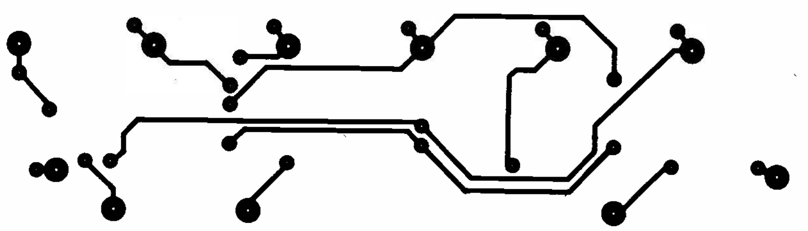


R1 and R2 reduce the output level so that it is suitable for feeding to an audio amplifier and C2 filters away the upper harmonics. RV2 adjusts the supply voltage of the NAND gate and so varies the level of symmetry. This changes the amount of second harmonic produced and so alters the tonal quality of the fuzz. **ETI**

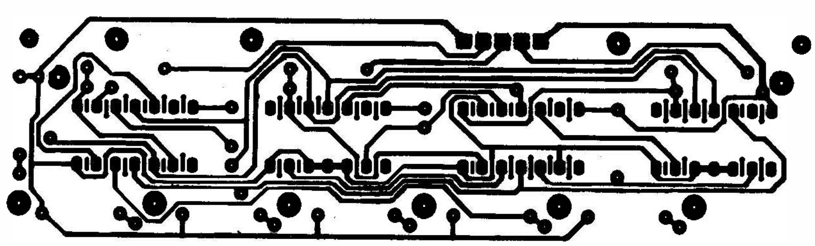
PCB FOIL PATTERNS

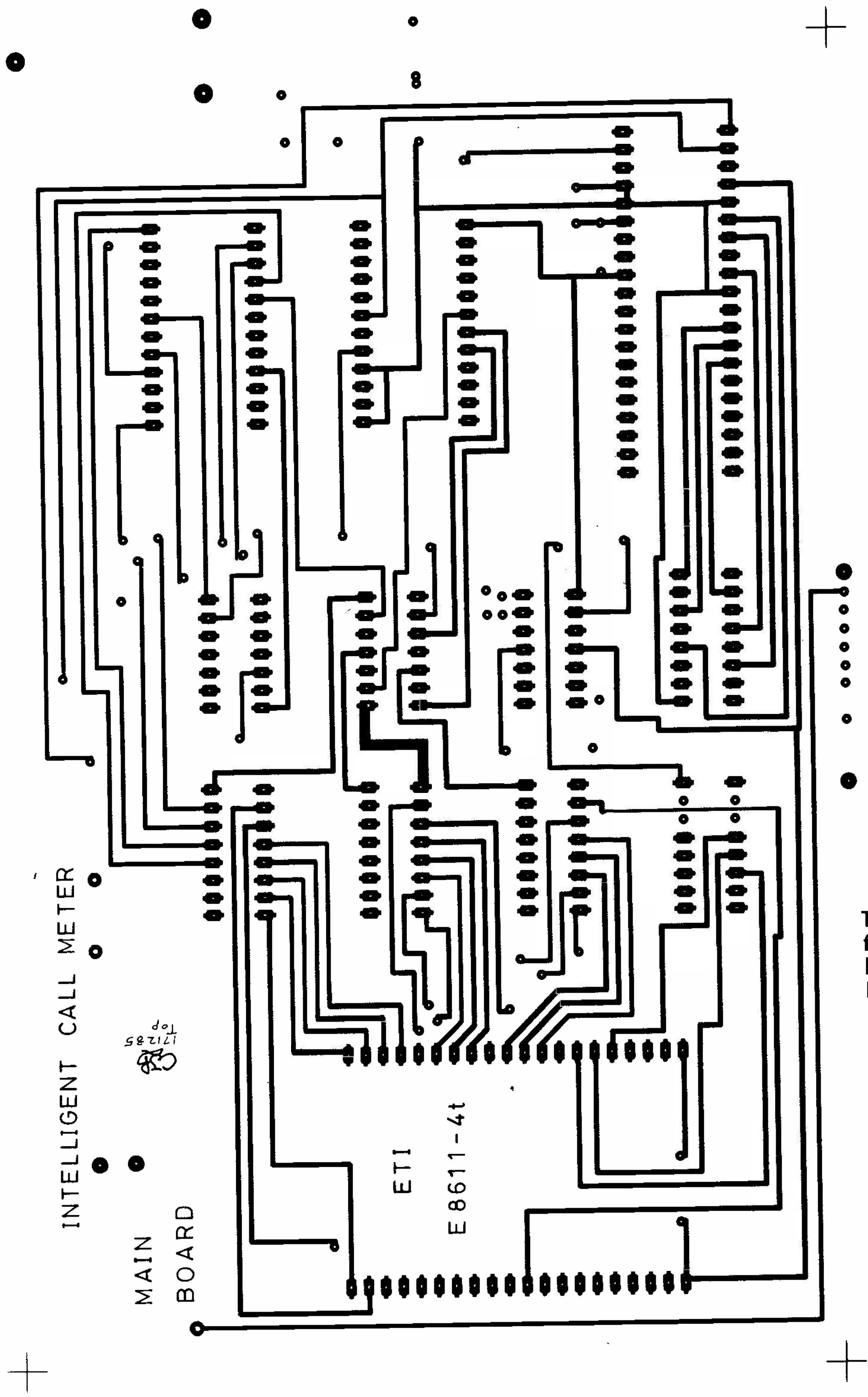


The foil pattern for the Intelligent Call Meter interface board.

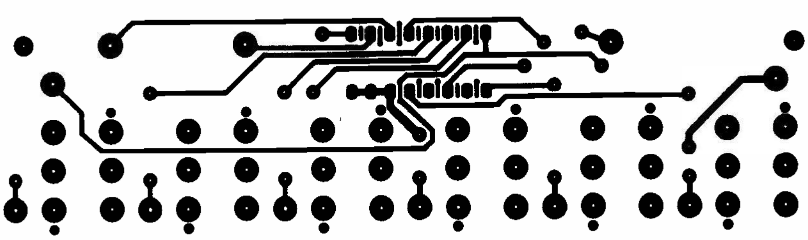


The top and bottom foils for the Audio Selector control board, held-over from last month.

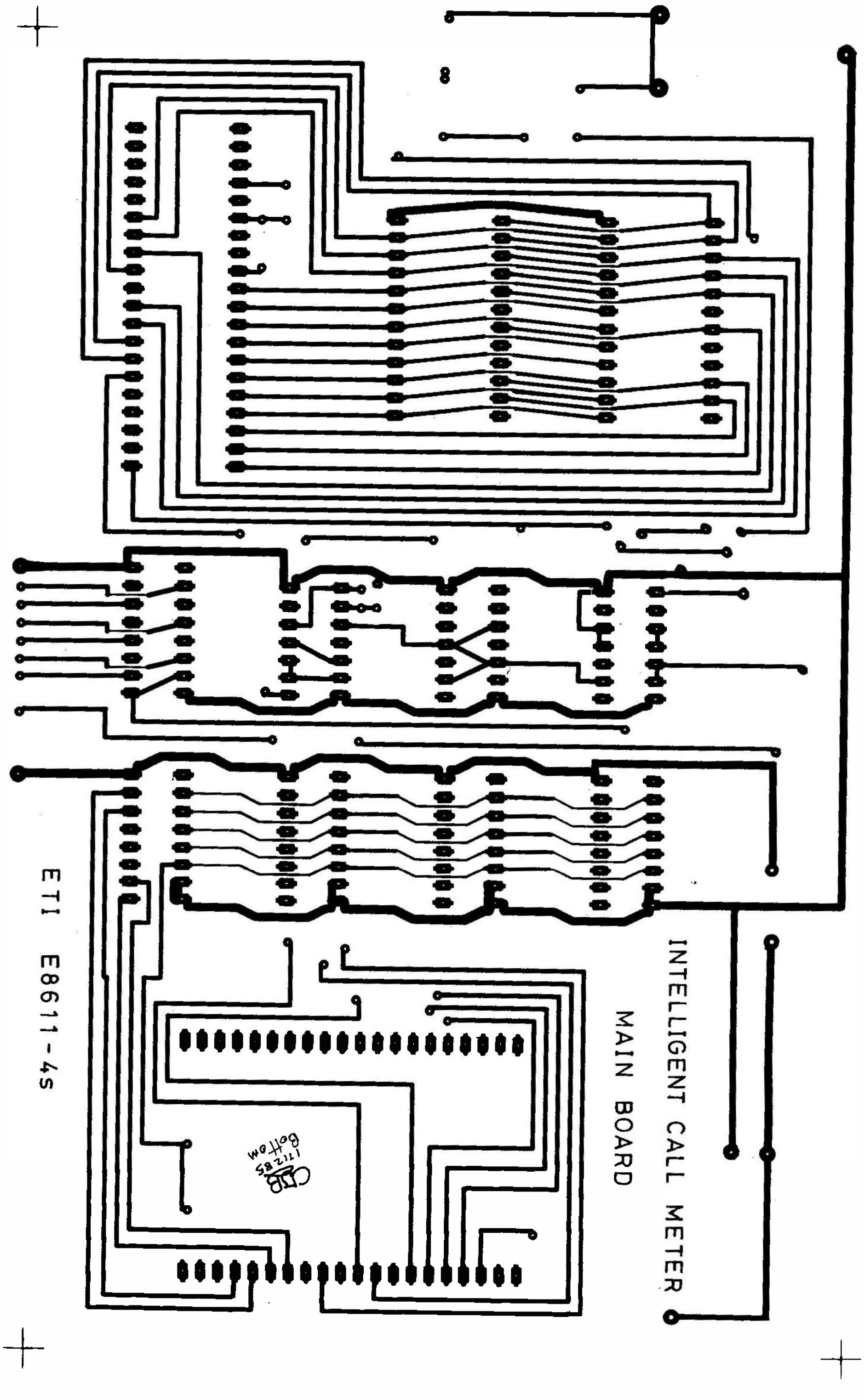


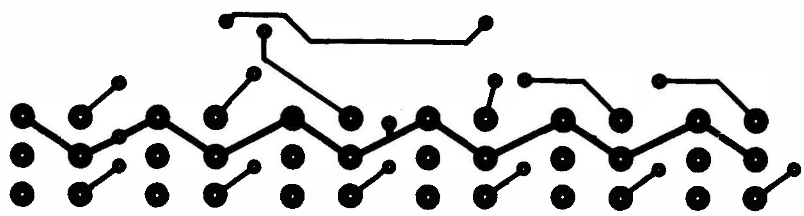


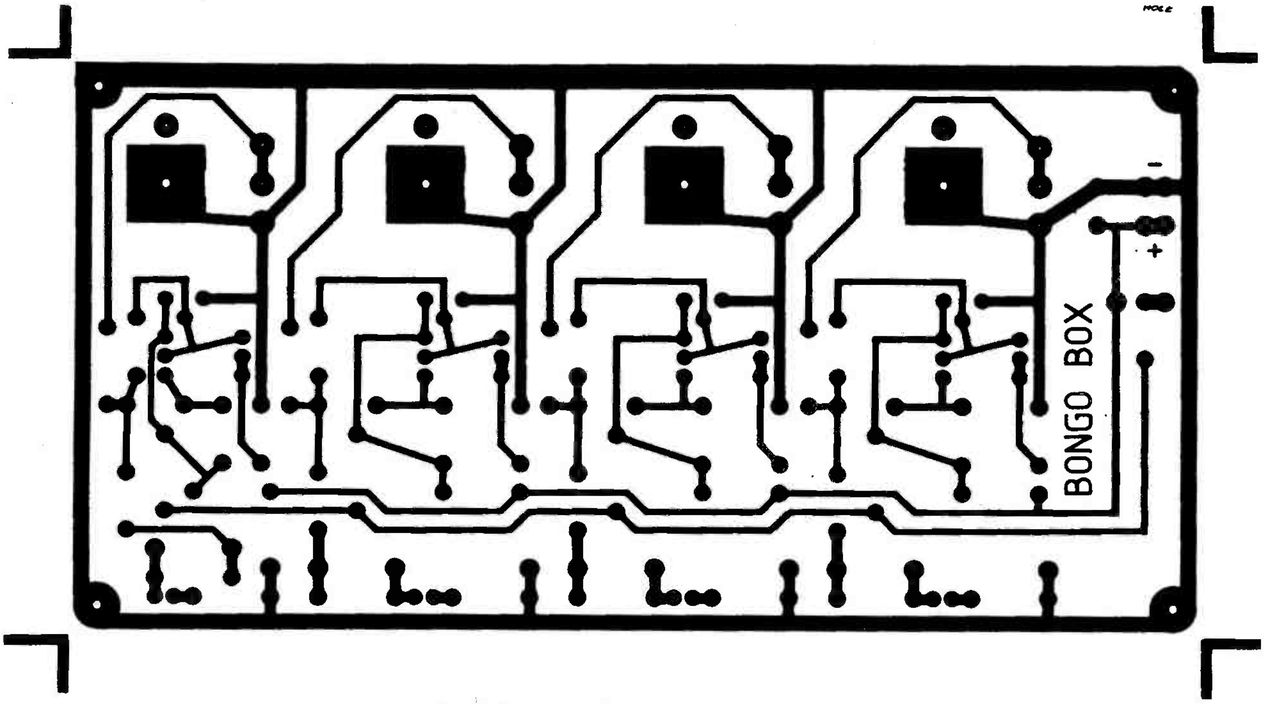
The top and bottom foils for the main board of the Intelligent Call Meter.



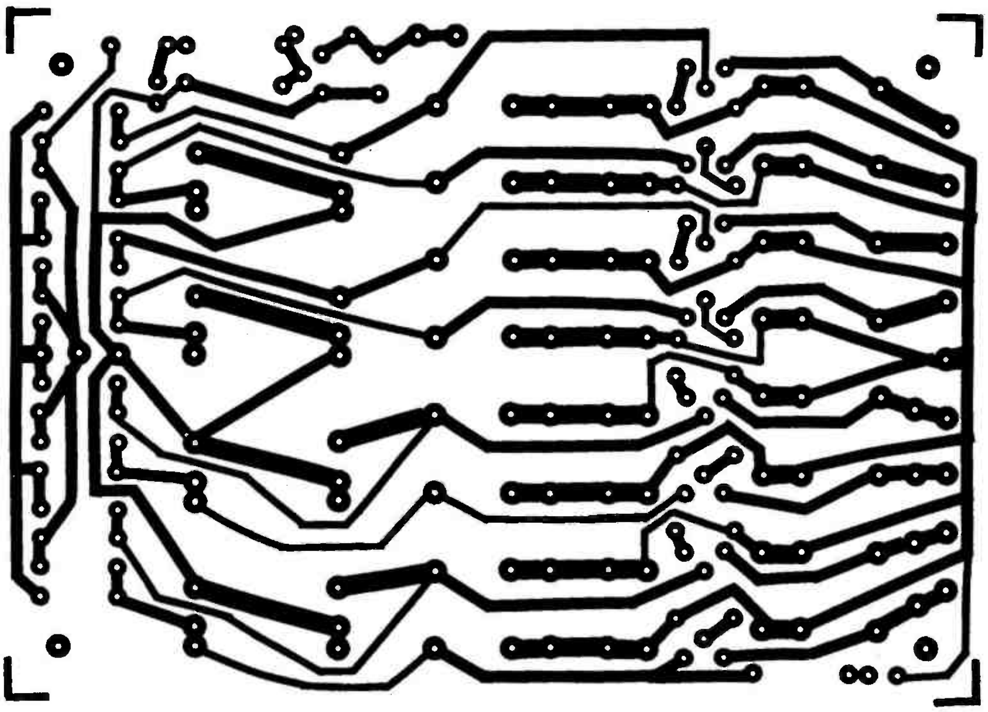
The top and bottom foils for the Audio Selector switch board, held-over from last month.


ETI E8611-4S
INTELLIGENT CALL METER
MAIN BOARD





The foil pattern for the Bongo Box PCB



The foil pattern for the Upgradeable Preamplifier PSU board, held-over from last month.

REVIEWS — BOOKS

MORE ADVANCED ELECTRONIC MUSIC PROJECTS *R.A. Penfold. Price £2.95.*

COUNTING ON THE QL ABACUS *J.W. Penfold. Price £2.50*

EASY ADD-ON PROJECTS FOR AMSTRAD CPC464, 664, 6128 AND MSX COMPUTERS *Owen Bishop. Price £2.95.*

Bernard Babani (Publishing) Ltd, The Grampians, Shepherds Bush Rd, London W6 7NF.

In an ideal world I should not recommend anyone to buy Babani books — I wouldn't have to. They have always been very reasonably priced and for the most part convey an infectious enthusiasm. It is this sort of 'Let's get on with it' approach that gets the reader itching to be heating iron and etching copper. Two of the three examples here are typical of the genre (© Channel Four); the remaining one, unfortunately, does not quite meet the mark.

Robert Penfold has been responsible for a goodly number of magazine articles — including some for ETI — as well as a considerable quantity of Babanis. His experience and ability to give a clear explanation comes across well in 'More Advanced Electronic Music Projects', which lived up to my highest expectations. Because he has taken the time to show his readers what each chunk of circuitry does, the book educates, encourages experimentation and provides building blocks for DIY design all in one. Divided into two sections, the first describes eight main projects for bending and stretching sound, together with a number of adaptations for producing specific effects. The second part concentrates on electronic percussion, beginning with an envelope shaper and then describing a variety of sound generators, to give the shaper something to work on. None of the designs should damage the wallet more than a good night in the pub. One caveat: PCB patterns are not provided, so the absolute beginner might have to buy 'How to Design and Make Your Own PCBs' — another cheerful Babani that I'd wholeheartedly recommend.

With 'Counting on the QL Abacus', J.W. Penfold counted on the QL becoming a popular micro. Although the machine is still selling (largely due to a steep fall in price)it has not achieved anything like the ubiquitous status of the old Spectrum. Given the current state of the PC market, to write a book for one machine might be thought brave; to devote that book to a single programme is verging on the foolhardy. Certainly, one or two items may possibly be of interest to other spread-sheet users, but unless you *have* a QL *and* use Abacus *and* want to learn more about it, then you don't need this book.

Owen Bishop, another established Babani man, has avoided the trap of being dependent upon a lame duck with his 'Easy Add-on Projects'. Not only will this circuit work with the various Amstrads, but all the MSX tribe too. As well as this, with a little nous and a working knowledge of their machines, other computer users should be able to adapt most of the ideas in this book. The beauty of these projects is that they use the joystick and printer ports, dispensing with the need for address decoders. For the enthusiast taking his first steps into computer interfacing, this book is easily one of the best ways to begin. My only grumble is that if you were to build either the sunshine recorder, or the whole weather station using the 'data-selector' circuit (Mr Bishop is very keen on meteorological projects) you wouldn't be able to get a print-out of the readings! Still, what do you want for three quid? Blood?

Nicholas Hacking

SWITCH-MODE POWER SUPPLY DESIGN *P.R.K. Chetty. Price £17.90*

John Wiley and Sons Ltd, Baffins Lane, Chichester, West Sussex PO19 1UD.

Switch-mode power supply design is still an area of electronics where non-specialists tread very warily, despite the fact that the general principles are now well known. Although it is by no means impossible to design a switcher by rule of thumb, intuition, rough calculations and good luck — particularly with the aid of the many control ICs that are now available — the design of high performance supplies to strict specifications is still considered to be something of a black art. Much of the literature on the subject seems designed to mystify rather than enlighten, so it is a great pleasure to find a book written by someone who thoroughly understands his subject and takes pains to explain it clearly.

The book is a collection of papers on switch-mode PSU design — some written for conference presentation and others specially for the book. There is some duplication of material, but this could be considered an advantage in that it is treated slightly differently each time.

One of the main problems in designing switching supplies is that standard techniques for linear circuit analysis cannot be directly applied — switchers, by definition, include a switch, which is about as nonlinear as you can get. To overcome this, the book sets out to develop linear circuit models for the power stages of various types of converter. The steps taken are clearly explained, and the resulting models allow a good physical insight into the operation of the switching circuit. The author continues by analysing one or two specific types of supply in detail, deriving performance and stability criteria ,and describing sensible ways to make open and closed-loop measurements on the control circuit.

The chapter covering practical design examples I found particularly interesting. At all stages, the author mentions options which he considered and rejected, giving a clear insight into the design process and the relative merits of various ways of achieving the same end. Particularly detailed was the description of the inductor design — another tricky area for the non-specialist, so the information is very valuable.

Other chapters of interest include a survey of control ICs for switch mode PSUs and a section on reliability. If your interests lie in the area of spacecraft PSU design you won't be disappointed, this being the author's speciality.

Highly recommended.

Paul Chappell.

ALF'S PUZZLE

Alf has spent the last few weeks building himself a computer to keep a record of his component stocks and remind him to order more when anything is running out.

'What's that metal box?' asked Jean Paul Eno, the head janitor, who was sweeping past Alf's bench just as he tightened the final screw.

'It's a computer,' replied Alf.

'Doesn't look much like a computer to me,' said Jean Paul, scornfully. 'Where are all the flashing lights?'

'If it's flashing lights you want, I'll cover the whole box with them,' said Alf, then pulled open his LED drawer, only to find that in his haste to finish the computer, he'd forgotten to order any.

The next drawer was full of neon bulbs. To make those flash, he'd need some triacs and an oscillator and ... Just then, he remembered seeing a circuit in one of his old mags, long ago thrown away, to make a pair of neons flash with just a couple of resistors and a capacitor. Alf sat down and tried to remember the circuit. He drew several (Fig. 1), which all looked OK to him, but which one(s) would work? Can you help him? (The striking voltage of his neons is 80V).

The answer to the October puzzle:

The IC that Alf had in mind was a 4030 or 4070 quad exclusive OR gate, connected as shown in Fig. 2. The same device will encrypt and decrypt his messages. Another IC that would work is the 4077 quad exclusive NOR gate. The configuration is identical.

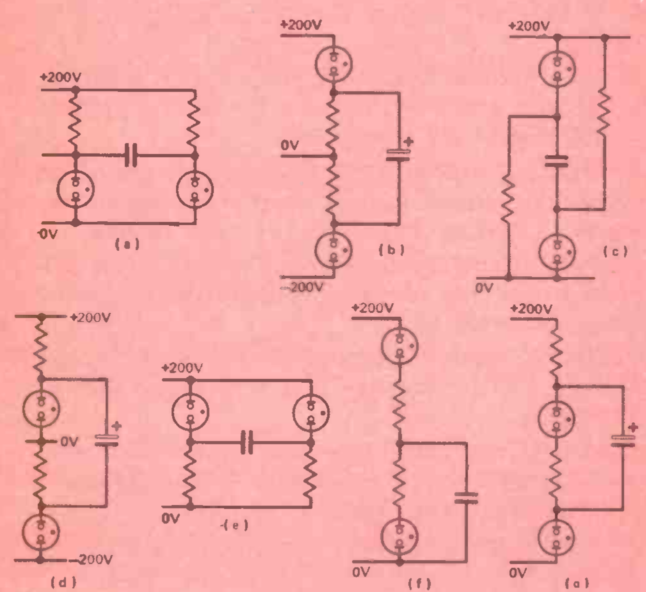


Fig. 1 Which neons will flash?

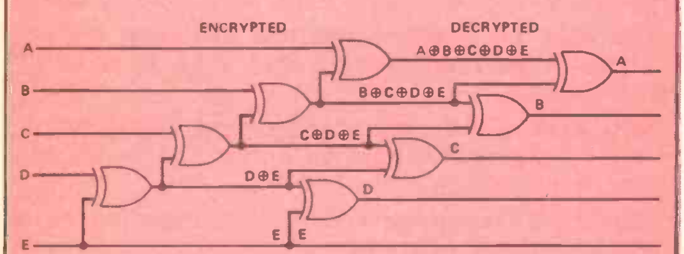


Fig. 2 Simple encryption/decryption.

OPEN CHANNEL

There are times when I sit, at night, alone in my garret, in my Midlands mountaintop abode. With no-one or nothing to console me; when sleep does not relieve my anguish or rest my weary bones.

Well, I don't actually have a garret; but I do live on a hill-top in Leicestershire, and I suffer from occasional bouts of insomnia. At these times, rather than toss and turn in bed, wakening the missus and the budgerigar, I tiptoe down downstairs and suffer in silence. I did, that is, until Richard Branson (yes, him of Virgin fame) persuaded executives at Yorkshire Television that all-night television transmissions are the in thing.

A few weeks ago, Yorkshire Television began transmitting Branson's Music Box between about midnight and the start of TV-AM, in an experiment designed to judge viewer requirements for 24 hours a day television. Music Box is a non-stop pop music and video channel, featuring the latest UK, continental and American pop music.

Now, if you read my column regularly, you'll know that I'm not one for changes merely for change's sake. In fact, some of you will probably feel that I'm a relative stick-in-the-mud where some recent 'advances' in communications have been made. However, in the case of 24-hour a day television, I say congratulations are in order to Yorkshire Television. Its choice of Branson's Music Box to fill the overnight gap seems a good one, because the people most likely to want to watch television at those unearthly hours are probably those who enjoy pop music and pop videos. And why shouldn't people who work unsociable hours or who merely suffer occasional bouts of insomnia have the choice of watching television when they want. After all, chances are it's not their fault they are in the predicament.

The signal I receive from Yorkshire Television is remarkably good, bearing in mind the potential problems. I am using my ordinary Group D television aerial pointed at the Waltham transmitter, and I'm picking up Yorkshire Television from (I think) the Chesterfield transmitter, a good 50 miles away, at an estimated angle of 80° from Waltham, with Group A transmissions, and at a power of only 2 watts to boot! The picture is a bit snowy but sound is perfect. Fortunately, my house position, on a hilltop with no high ground and more-or-less open countryside between it and Chesterfield gives me this advantage. With a simple Group A aerial pointed in the right direction I'm sure a perfect picture will be the result.

Now, when insomnia strikes, armed with a pair of headphones I can bop away to my heart's content (quietly, that is) all night long.

Master, We Obey

From December 1st anyone can install domestic extension (ie, secondary) telephone sockets and fit telephones, because on that date the monopoly which British Telecom has so far enjoyed will be taken away, in one more step of telephone liberalisation. This is being done following a recent recommendation from Oftel.

However, take note that the monopoly on the fitting of *master* sockets (ie, the first socket installed on the premises) remains in the hands of British Telecom. This is wrong, and should not be allowed to continue.

It is wrong for two reasons. First, householders whose telephones were installed before the new plug and socket system began to be used are disadvantaged. If they wish to have an extension they must first arrange for British Telecom to install a master socket and either have their existing telephone apparatus adapted or obtain a new telephone. Needless to say, this all costs money and the money goes to the British Telecom coffers. Unfair, totally unfair!

Second, what moral right has British Telecom to be in the position where it can prevent people from adapting their telephone services if they so wish — including the master socket. After all, they are paying good money to British Telecom for the services. I have made this point before in this column: it is morally (and should be legally) wrong for a service provider to have a monopoly on the service it provides. If a monopoly on any service exists, it is difficult to ensure that the customer (ie, the person paying hard earned money to the monopolising service provider) gets a fair deal. Take that monopoly away, and everyone (including the service provider in the long run) benefits.

The removal of the secondary domestic wiring monopoly from British Telecom is one more step in the right direction. But there are still some steps to go until we reach our destination.

Keith Brindley

Readers' Ads

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WANTED: circuit diagram for telequipment D43 type oscilloscope, will pay. Please contact Mr Price Torpoint 814666.

WANTED: Nascom2 disc interface board (not Gemini), plus manual. Mr M. Annable, 5 Sheepcot Drive, Watford, Herts WD2 6DZ.

WIRELESS World magazines June 1972–Dec 1981, mostly in binders. £18. plus postage. B. Jackson, 051-355 9579.

MEDIC disc, printer, 512K RAM, interface for QL. £150. Contact Mark, 0772-561952 day, 0772-722904 night.

WANTED manual for Wayne Kerr Component Bridge CT492. P. Austin, 30 Hamilton Rd, Thame, Oxon OX9 3XZ.

P.S.U. 0-30V, 20mA-1.2A variable, many extras. £45. R. Vahid, 147 Aspen Gardens, Parkstone, Poole, Dorset.

J.L.H. Amplifier, ETI 1985, information wanted on pre/power amplifier. I've constructional problems. Tel. 0296-651122 (weekends).

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TRANSCEIVER Super Star, all mode, £100, World receiver 0–30 MHz digital, £285. Tel. 01-207 2326.

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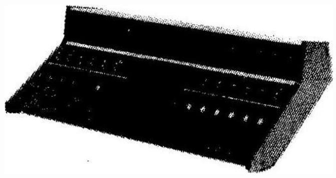

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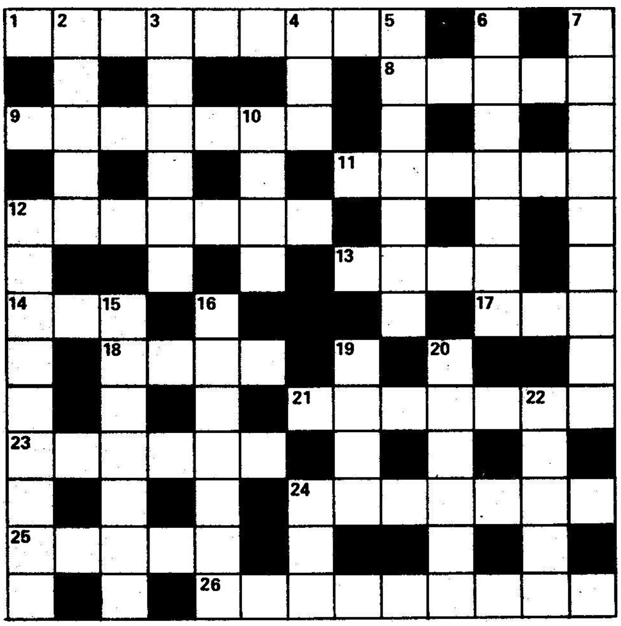

CROSSWORD No. 11

ACROSS

1) A flexible single core cable with plugs at either end, for rapid interconnection of electronic modules (5, 4).
8) A persistent audio signaller, to draw attention to something (5).
9) A machine-dependent variation in a computer language (7).
11) Computer peripheral which performs a similar function to a joystick (6).
12) The part of a soldering iron which supplies the heat (7).
13) Over-current protection device (4).
14) Very common plastic, used for project boxes (1,1,1).
17) One of the main constituents of solder (3).
18) The former that acts as a path for the magnetic flux in a coil (4).
21) Control which adjusts the stereo image in hi-fi systems (7).
23) The filament in a valve which warms the cathode terminal (6).
24) The return of the spot on a CRT to its starting point (7).
25 Universally accepted set of character codes (1,1,1,1,1).
26) Obsolete term for capacitor (9).

DOWN

2) A component whose leads are at opposite ends of the body (5).
3) A vertical list, whereas a horizontal list is a row (6).
4) Command used for placing data on a computer port (3).
5) For most home micros, this is only eight bits wide (4,3).
6) Handheld communications device (7).
7) In simple terms, AC resistance (9).
10) The part of a loudspeaker which moves (4).
12) Means of wiping previous recordings from magnetic tape (5,4).
15) Damage to a vinyl record, or the filter on a pre-amp which removes the effects (7).
16) Semi-metal, Atomic No. 33, used as a donor impurity in semiconductors (7).
19) In machine code, a jump to a subroutine with a return address on the stack (4).
20) Element used in the construction of resistors, microphones and batteries (6).
22 A signal of one hertz would have one of these per second (5).
24) Means of aircooling electrical equaipment (3).

Solution to Crossword No. 10

ACROSS
3) Reactance
8) Even
9) Symmetry
10) Orange
12) Tap
15) Octal
16) Howl
17) Dolby
19) Ramp
20) Ohmic
21) Fax
25) Getter
26) Motorola
27) LIST
28) Component

DOWN
2) Veroboard
2) Decay time
4) ELSE
5) comma
6) Apex
7) Cord
11) Gold
12) Telex
13) Dotmatrix
14) Clock rate
18) Yoke
22) Acorn
23) Logo
24) Loop
25) Gain.

Our apologies to readers who attempted last month's crossword. The clue for 8 across was incorrectly given as 4 across and the clue for 13 down was omitted entirely. It should have read: A type of printer (3, 6).