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FM STEREO TUNER

FROM JOHN LINSLEY HOOD

PLUS

THE ETI CAPACITOMETER
CREDIT CARD CASINO
COMPUTER INTERFACE STANDARDS
CIRCUIT DESIGN ON THE BBC MICRO
SNUBBER NETWORKS
INSIDE TRANSPUTERS

..AUDIO....COMPUTING....MUSIC....RADIO....ROBOTICS..

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74148	140p
74150	175p
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74156	100p
74157	80p
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74LS20	24p
74LS21	24p
74LS22	24p
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74LS43	150p
74LS47	80p
74LS48	90p
74LS49	100p
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74LS170	140p
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74LS181	200p
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74LS190	75p
74LS191	75p
74LS192	80p
74LS193	80p
74LS194A	75p
74LS195A	75p
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74LS197	80p
74LS221	90p
74LS240	80p
74LS241	80p
74LS242	90p
74LS243	90p
74LS 244	70p
74LS 245	90p
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74S112	150p
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74S124	300p
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4019	50p
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4553	240p
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4557	240p
4560	140p
4566	140p
4568	240p
4569	170p
4572	45p
4583	60p
4584	48p
4585	60p
4724	150p
14411	750p
14412	750p
14416	300p
14419	280p
14490	420p
14495	450p
14500	650p
14599	290p
22100	350p
22101	700p
22102	700p
40014/4584	
40106	48p
40085	120p
40097	36p
40098	60p
40100	150p
40101	125p
40102	140p
40103	200p
40104	120p
40105	150p
40106	48p
40107	55p
40108	320p
40109	20p
40110	225p
40114	225p
40147	280p
40163	100p
40173	120p
40174	100p
40175	100p
40192	100p
40244	150p
40245	150p
40257	180p
40373	180p
40374	180p
80C95	75p
80C97	75p
80C98	75p

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AM7910DC	£25
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AY-3-8912	500p
CA3019A	100p
CA3028A	110p
CA3046	70p
CA3059	325p
CA3080	50p
CA3080E	70p
CA3086	70p
CA3089E	210p
CA3090AQ	375p
CA3130E	90p
CA3130T	130p
CA3140E	40p
CA3140T	100p
CA3160E	100p
CA3161E	200p
CA3162E	600p
CA3189E	300p
CA3240E	150p
CA3280G	270p
D7002	£8
DAC1408-8	300p
DAC0800	300p
DAC0808	300p
DG308	300p
HA1366	180p
ICL7106	675p
ICL7611	95p
ICL7650	400p
ICL8038	400p
ICM7555	90p
ICM7556	140p
LC7120	300p
LC7130	300p
LC7137	350p
LF347	120p
LF351	60p
LF353	90p
LF355	90p
LF356N	110p
LF357	100p
LM10C	450p
LM301A	30p
LM307	45p
LM308CN	75p
LM310	225p
LM311	60p
LM318	150p
LM319	150p
LM324	45p
LM334Z	115p
LM335Z	130p
LM336	180p
LM339	40p
LM348	60p
LM358P	50p
LM377	300p
LM380N-8	150p
LM380	150p
LM381N	300p
LM382	200p
LM383	325
LM384	220
LM386N-1	100p
LM387	270p
LM391	180p
LM392N	110p
LM393	386p
LM394CH	400p
LM709	36p
LM710	48p
LM711	100p
LM723	80p
LM725CN	400p
LM733	85p
LM741	22p
LM747	70p
LM748	30p
LM1011	480p
LM1014	150p
LM1801	300p
LM1830	250p
LM1871	300p
LM1872	300p
LM1886	550p
LM1889	480p
LM2917	300p
LM3302	90p
LM3900	60p
LM3909	100p
LM3911	190p
LM3914	350p
LM3915	340p
LM3916	340p
LM13600	150p
M51513L	230p
M51516L	450p
MB3712	200p
MC1310P	150p
MC1413	75p
MC1458	45p
MC1495L	300p
MC1496	70p
MC3340P	200p
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MC3403	65p
MF10CN	400p
MK50240	900p
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NE531	120p
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NE5534P	100p
NE5534AP	150p
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RC4151	200p
RC4558	55p
SAA1900	£18
SFF96364	800p
SL490	300p
SN76033N	300p
SN76489	400p
SN76495	400p
SP0256AL2	700p
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TA7130	140p
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TA7205	90p
TA7222	150p
TA7310	150p
TBA231	120p
TBA800	90p
TBA810	90p
TBA820	90p
TBA820M	75p
TBA920	200p
TBA950	225p
TC9109	500p
TCA940	175p
TDA1010	225p
TDA1022	400p
TDA1024	110p
TDA1170S	300p
TDA2002	325p
TDA2003	180p
TDA2004	240p
TDA2006	320p
TDA2020	320p
TDA2030	250p
TDA2593	500p
TDA3810	750p
TDA7000	350p
TEA1002	700p
TL081CP	40p
TL082	60p
TL084	80p
TL071	40p
TL072	70p
TL074	110p
TL081	30p
TL082	55p
TL083	75p
TL084	100p
TL084	200p
UA759	320p
UA2240	150p
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ULN2004A	75p
ULN2068	280p
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XR210	400p
XR2206	400p
XR2207	375p
XR2211	575p
XR2216	675p
XR2240	120p
ZN409	180p
ZN414	90p
ZN419P	175p
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ZN424E	130p
ZN425E8	350p
ZN426E	300p
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ZN448	750p
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ZN459CP	300p
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ZNA134H	£33
ZNA234E	950p

VOLTAGE REGULATORS

FIXED PLASTIC

		+ve		−ve	
1A					
5V		7805	45p	7905	50p
6V		7806	50p	7906	50p
8V		7808	50p	7908	50p
12V		7812	45p	7912	50p
15V		7815	50p	7915	50p
18V		7818	50p	7918	50p
24V		7824	50p	7924	50p
5V	100mA	78L05	30p	79L05	45p
8V	100mA	78L08	30p		
12V	100mA	78L12	30p	79L12	50p
15V	100mA	78L15	30p	79L15	50p

OTHER REGULATORS

Fixed Regulators		
LM309K	1A 5V	140p
LM323K	3A 5V	250p
78H05KC	5A 5V	575p
78H12	5A 12V	750p
Variable Regulators		
LM305AH		250p
LM317T	TO-220	120p
LM317K	TO3	240p
LM337T	3A+VAR	225p
LM350T	5A+VAR	400p
LM396K	10A+VAR	£15
LM723N		50p
78HGKC	5A+VAR	650
79HGKC	5A+VAR	675p
78GUIC	1A+VAR	225p
79GUIC	1A+VAR	250p
Switching Regulators		
ICL7660		250p
SG3524		300p
TL494		300p
TL497		225p
78S40		250p

COMPUTER COMPONENTS

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1802CE	650p
2650A	1050p
6502	400p
8502A	450p
65C02A	£15
6800	250p
6802	300p
6809	650p
6809E	£8
68B09	£10
68B09E	£12
68000-LB	£38
8035	350p
8039	420p
80C39	700p
8080A	750p
8085A	300p
8087	120p
80C85A	900p
8086	£22
8088	1750p
8741	£12
8748	£12
TMS9980	£14.50
TMS9995	£18
Z80	250p
Z80A	290p
Z80B	550p
Z80CMOS (CMOS Z80)	750p
808A	850
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8284	460p
8287	380p
8288D	650p
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TMS4500	£14
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TMS9901	500p
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TMS9911	£18
TMS9914	£14
Z80PIO	240p
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Z80ACTC	275p
Z80BCTC	500p
Z80DART	650p
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Z80ADMA	750p
Z80ASIO-0/1/2/9	700p
Z80BP10	500p
Z80BCTC	500p
Z80DART	800p

Electrically programmable and erasable PROMS

2816-30	£20

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6632	480p
6551	550p
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68B21	300p
6829	£12.80
6840	375p
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68B50	300p
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6854	650p
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6875	500p
8154	850p
8155	380p
8156	380p
8205	225p
8212	200p
8216	160p
8224	300p
8226	425p
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8250	£12
8251A	325p
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8255AC-5	320p
8256	£16
8257C-5	400p
8259C-5	400p
8275	£29

EPROMs

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2532-30	550p
2564	£11
2708	400p
2716+5v	350p
2716-35	550p
2732	450p
2732A-2	900p
2732A-35	£7
2764-25	290p
27C64-25	£6
27128-25	250p
TMS2716	500p

CRT CONTROLLER

CRT5027	£18
CRT5037	£12
CRT6545	£8
EF9364	£8
EF9365	£25
EF9366	£25
EF9367	£38
MC6845	650p
MC6845SP	650p
MC6847	650p
EF 9369	£12
SFF96364	£8
TMS9928	£10

INTERFACE ICs

AD558CJ	778p
AD561J	£20
AD7581	£18
ADC0808	1180p
AM25S10	360p
AM25LS2521	350p
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MC1489	60p
MC3446	250p
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75114	140p
75115	140p
75121	140p
75122	140p
75150P	120p
75154	120p
75159	220p
75160	600p
75161	650p
75162	750p
75172	400p
75182	150p
75188	60p
75189	60p
75365	150p
75450	50p
75451	50p
75452	50p
75453	70p
75454	70p
75480	150p
75491	65p
75492	65p
8T26	120p
8T28	120p
8T95	120p
8T96	120p
8T97	120p
8T98	120p
81LS95	140p
81LS96	140p
81LS97	140p
81LS98	140p
88LS120	450p
9602	300p
9636A	160p
9637AP	160p
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2114-3L	250p
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4416-15	300p
4532-20	250p
5101	370p
5514	450p
5516	400p
5517	400p
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2.45760	200p
2.5	250p
3.12MHz	175p
10.00MHz	175p
3.276	150p
3.5796	100p
4.00	140p
4.194	150p
4.43	100p
4.608	250p
4.9152	200p
5.000	150p
6.00	140p
17.734	200p
7.00	150p
7.168	175p
8.00	150p
8.867	175p
10.50	250p
10.70	150p
11.00	300p
12.00	150p
14.00	175p
14.318	180p
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48.000	175p
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LOW PROFILE SOCKETS BY TEXAS

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16 pin	11p	28 pin	26p
18 pin	16p	40 pin	30p
20 pin	18p		

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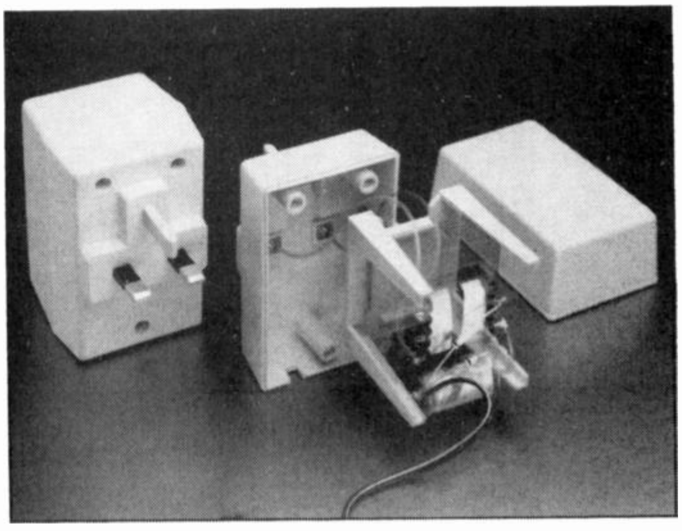


Making A Case For Safety

West Hyde Developments has introduced a new power supply case which meets the latest British Standard specification.

The plastic, plug-type enclosure has live and neutral pins which are sleeved for part of their length in accordance with the requirements of BS1363. The sleeving is intended to prevent accidental contact with a live conductor when the plug is being inserted or removed from a socket or at other times when it is not pushed fully home. West Hyde claims to be the first company to market a power supply enclosure which incorporates this feature.

The case is available in either black or white and has an internal moulded cradle which supports a standard size mains transformer. The cradle also covers the live pins when in position, reducing the risk of contact between mains wiring and the low voltage circuitry. The standard version has a non-conductive earth pin but an optional brass earth pin will be available shortly.

The mains power supply case costs £1.77 including VAT and is featured in the latest catalogue from West Hyde Developments Ltd, 9-10 Park Street Industrial Estate, Aylesbury, Buckinghamshire HP20 1ET, Tel (0296) 20441.

IEE and IERE To Merge

Members of the Institution of Electrical Engineers (IEE) and the Institution of Electronic and Radio Engineers (IERE) have voted overwhelmingly to join forces.

In a ballot held on 11th December last year, 97% of the members of the two Institutions voted in favour of the merger. The new body will be known as the Institution of Electrical Engineers and will be the largest Chartered Engineering Institution in the UK.

The decision to merge was prompted by a growing recognition that the two Institutions were converging in their fields of interest. Negotiations began almost three years ago and great care has been taken to seek the views of members at each stage in the process.

The new Institution has members among just about every grade of engineer from students to chief executives and aims to represent the electrical and electronics engineering profession in all matters of public concern. It will cover all aspects of electrical, electronic and software engineering in such fields as power, control, instrumentation, broadcasting, radio, telecommunications, computers and information systems.

A joint statement issued by the two bodies promises an enhanced range of Learned Society activities as a result of the merger and looks forward to the adoption of common standards for professional qualifications. It also suggests that agreement on technical standards will be reached more easily in future.

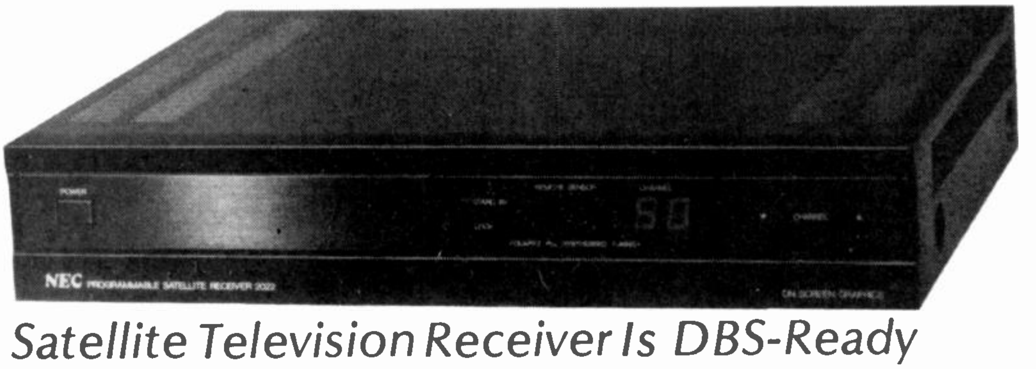
Work is already going ahead to implement the merger proposals and the new body will come fully into being on the 1st October 1988.

The Institution of Electrical Engineers, Savoy Place, London WC2R 0BL, Tel 01-240 1871. The Institution of Electronic and Radio Engineers, 99 Gower Street, London WC1E 6AZ, Tel 01-388 3071.

● *Job prospects in the electronics manufacturing industry look better this year than they did during the first quarter of 1986, says temporary staff specialist Manpower PLC. Slightly fewer employers said they would take on more staff this year (down from 29% to 27%) but only 11% plan to cut the size of their workforce compared with 20% last year. The survey notes that this improvement is not apparent in other sectors of manufacturing industry. Growth in the services sector is tailing off, public sector employment is improving and the gap between north and south is becoming wider. Manpower PLC, Manpower House, 270-272 High Street, Slough, Berkshire SL1 1LJ, Tel (0753) 73111.*

● **The 1987 Instrument Rentals catalogue has more than 100 pages of test equipment, computers and other instruments available for hire. Over 180 new lines have been added since the last catalogue was issued, among them a range of low-cost spectrum analysers and the latest logic analysers from Philips. There is also a section describing second-hand equipment for sale. Instrument Rentals, Dorcan House, Meadfield Road, Langley, Slough SL3 8AL, Tel 01-897 2434.**

● Texas Instruments have joined forces with Stag Electronic Designs and Personal Cad Systems to produce a PAL starter kit. It includes four Impact PAL devices from Texas, supporting software on five floppy discs (in IBM PC format) and comprehensive documentation. Stag are also offering a free-of-charge programming service for kit purchasers. The kit costs £75.00 inclusive and can be obtained from Stag Electronic Designs, Stag House, Tewin Court, Welwyn Garden City, Hertfordshire, Tel (0707) 325 136.



Satellite Television Receiver Is DBS-Ready

A new satellite television receiver from NEC is claimed to be the first on the market with a DBS facility.

As well as being able to receive existing satellite transmissions, the 2022 includes a MAC format output which conforms to the standard recently selected by EEC countries for future direct broadcasting by satellite (DBS) transmissions. The receiver will drive a B-MAC/D2-MAC adaptor for use with standard television sets and will connect directly to MAC-standard sets when these become available.

The complete system comprises a parabolic dish antenna with a motor drive unit, a low noise block (LNB) downconverter and a set-top demodulator (pictured above) which comes with infra-red remote control.

Up to 89 channels can be preset for instant selection, the 2022 automatically rotating the antenna and selecting X or Y polarisation as required. Selected channels can be locked by the user to prevent children watching them.

The 2022 can be supplied with a 1.5m one-piece antenna or a 1.8m dish made up of separate 'petals'.

The demodulator has 47 of the 89 channels already preset to receive existing satellite transmissions plus French and German DBS broadcasts due to begin within the next two years. The downconverter is completely weatherproof and offers a maximum noise level of 2.3dB.

The 2022 system will be available from selected NEC dealers at prices from £1245.00 inclusive.

NEC Business Systems (Europe) Ltd, Camdem Office, 35 Oval Road, London NW1 7EA, Tel 01-267 7000.

Buy Bi-Hi-Fi

Anyone who has read a hi-fi magazine recently will know that so-called bi-wiring of loudspeakers is the current fashion.

The idea is to separate out the treble and bass sections and feed each of them independently from a single power amplifier. According to the theory, this prevents the high current bass signal interferring with the treble signal and so improves sound quality.

Proponents of the system claim it offers significant improvements at very low cost, the only additional items requried being a further set of loudspeaker cables and connectors.

Bi-wiring (and tri-wiring on three-way loudspeakers) has been in use for some time in the USA and is fast becoming popular on top-price audio systems from other countries. It has had little impact on systems at the lower end of the price range.

Now Marantz is setting out to change that with up-dated versions of its successful Mini-Monitor design. Each loudspeaker is fitted with three terminals, a common signal (+) connection and separate ground (−) connections for the tweeter and the woofer.

A link supplied with the loudspeakers can be used to join the two ground terminals, allowing two-core cable to be used in the usual way. For higher fidelity the link can be removed and three-core cable used, the two ground leads being joined together at the amplifier output terminal.

The Marantz literature notes that four leads are normally used for bi-wiring, with separate ground and signal connections for each drive unit. However, the three-wire system is said to offer dramatic improvements over simple two-core wiring and has the advantage that three-core cable is cheap and easy to obtain.

The two new loudspeakers are the LD20DMS and the larger LD50DMS which offers higher power handling and an extended bass response. Both use a bass-reflex cabinet design. The LD20DMS measures 230 x 365 x 260mm (9⅜ x 14⅞ x 10⅝ ins) and has a 160mm (6½ in) bass driver while the LD50DMS measures 272 x 414 x 280mm (11⅛ x 16⅞ x 11⅜ ins) and uses a 200mm (8 in) bass driver.

The LD2DMS and LD50DMS are both available now from Marantz dealers and cost £125.00 and £179.00 per pair.

Marantz Audio UK Ltd, 15-16 Saxon Way Industrial Estate, Moor Lane, Harmondsworth, Middlesex UB7 0LW, Tel 01-897 6633.

The Winners!

Readers with excessively long memories will remember that back in the halcyon days of July last year (was it really that long ago?) we ran the 1986 Readers' Survey along with a free draw for ten free subscriptions to ETI.

Well, we've finally found the key to the office strong box where the survey entries are stored so here are the ten lucky winners.

Ian McCallum, Kilmarnock. W.S. Potter, Chesterfield. S.W. Marland, Wigan. Chris Knowles, Stafford. Martin Robertson, Glasgow. Matthew Wood, Swansea. David Hicklin, Derby. D.B. Smith, Sunderland. Alan Todd, Glasgow. K.B. Dales, Middlesborough.

All the winners were selected by GEOFF (geostationary electronic office form finder) and will receive 12 months free subscription to ETI or have their current subscription extended. Thanks to everyone else who took the trouble to complete the form. Better luck next time!

World's Fastest Silicon ICs

A new range of frequency dividers from Plessey is believed to offer the highest speeds yet achieved with silicon.

The SP8800 series of prescalars can operate at frequencies from 500MHz to 3.5GHz and are available in divide-by-two, divide-by-four and divide-by-eight versions. They operate from 5V supplies and have a dissipation of around 400mW.

The dividers are fabricated in bipolar silicon technology and feature complementary output stages with on-chip current sources. Plessey claims the performance exceeds that of comparable gallium arsenide devices in terms of current consumption, phase noise, sensitivity, frequency range and price.

Plessey Microsystems Ltd, Water Lane, Towcester, Northamptonshire NN2 7JN, Tel (0372) 50312.

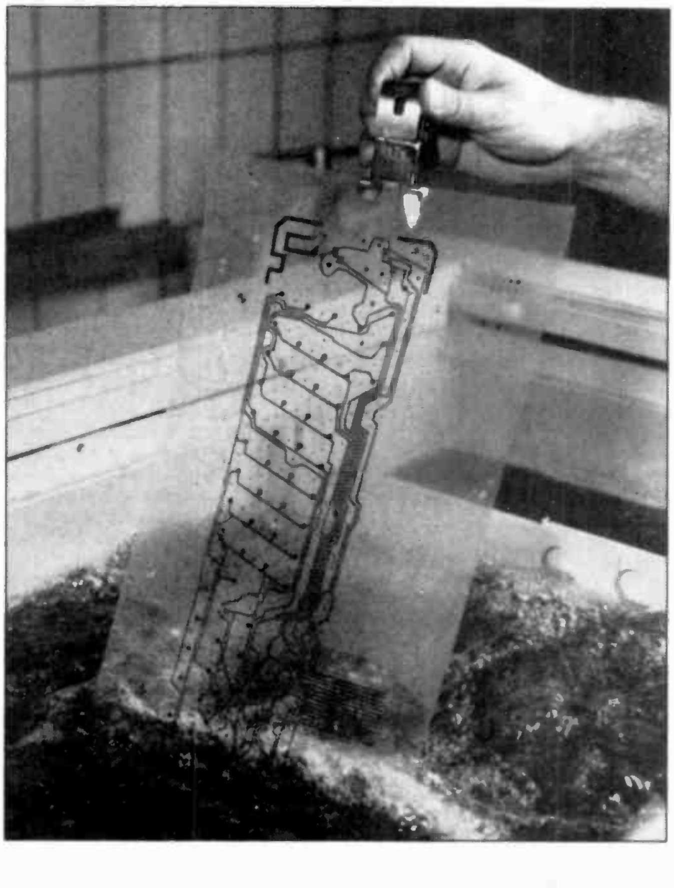
New PCB Production Process

A new screen-printing ink from Bayer is the key to a radically different PCB production process.

Unlike conventional screen-printing inks, Bayprint is designed to accept a coating of metallisation when dry. PCB track patterns can be printed onto suitable materials and then covered with copper in an electroplating bath. Because the plating only forms on the printed tracks, no etching is required and both raw materials and energy are saved.

Bayer says the printing can be applied both to rigid board materials and to flexible substrates such as polyester and polyimide film. Large areas and narrow tracks are plated with equal efficiency and a uniform plating thickness is obtained. Soldering properties are said to be excellent and the specific resistance is substantially lower than that obtained with conventional conductive inks.

Bayer UK Ltd, Bayer House, Strawberry Hill, Newbury, Berkshire RG13 1JA.



● The Image range of 19" racking cases and cardframes is described in an 8-page full-colour catalogue from Imhof-Bedco. Full technical specifications are included along with dimensions, options, accessories, etc. Copies are free from Imhof-Bedco, Ashley Works, Ashley Road, Uxbridge, Middlesex UB8 2SQ, Tel (0895) 37123.

● **Monolithic Memories has issued a new LSI data book (7th edition) which is available on request. It covers a wide range of products including PAL and other logic arrays. Contact Monolithic Memories Ltd, Monolithic House, 1 Queens Road, Farnborough, Hampshire GU14 6DJ, Tel (0252 317 431.**

● *The snow lies deep and crisp and none-too-even around ETI Towers, so it seems a good time to tell you about an Icy-Road Warning kit from ECW. It's designed for quick-and-easy fitting to the front of a car and has an electronics unit with warning LED which fits below the dashboard. The cost is £12.88 inclusive from Electronics and Computer Workshop, 171 Broomfield Road, Chelmsford, Essex CM1 1RY, Tel (245) 262 149.*

NEXT MONTH

AN ARGUS SPECIALIST PUBLICATION

electronics today INTERNATIONAL

GRAPHICS PROCESSOR
What are graphics processors and why should you be wanting one? All is revealed next month.

ROBOTICS TECH TIPS
A bumper collection of short circuits for robot fiends. There are circuits to drive them forwards and circuits to tell them where they're going.

THE TRUTH ABOUT HI-FI
What colour is the wire in your amp? Does it matter? We separate the fact from the fiction on this and many other supposed design criteria for audio equipment.

MIDI CONTROL WITH THE BBC MICRO
Continuing our torrid affair with the Musical Instrument Digital Interface, this compact but powerful add-on for BBC micro owners to build offers two MIDI channels to keep the music playing.

15 YEARS OLD NEXT MONTH
ETI can leave school when it gets to sixteen. Meanwhile we've got lots of goodies to celebrate this anniversary. Plus there's all the regulars — Tech Tips, letters, news, views, free readers ads, and many other features and projects which go to make ETI the number one electronics mag for April.

THE APRIL ISSUE OF ETI — ON SALE 6th MARCH

ONLY AN APRIL FOOL WOULD MISS IT!

All the articles listed above are in an advanced state of preparation but circumstances beyond our control may prevent publication.

Low Cost Breadboards

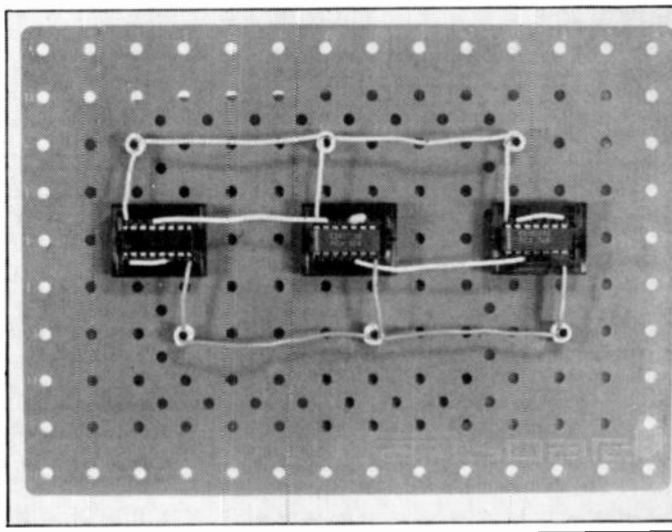
The recently-launched Camboard breadboards are now available at reduced prices thanks to an improved IC socket design.

The breadboards offer most of the facilities common to other solderless breadboard systems but have the added advantage that ICs can be placed in any position rather than being confined to the centre. Potentiometers, switches and other large components can also be mounted directly onto the board using sleeved brass studs. Camboard claims this flexibility makes it possible to arrange components exactly as they are in the circuit diagram, so simplifying layout and making development easier.

The new IC socket incorporates a plastic spring which pushes IC pins against a tin-plated contact. This arrangement is said to offer a good connection while keeping costs down.

The Camboard breadboard measures 180 x 129mm (7⅛ x 5¼ins) and is supplied with a quantity of sleeved studs and up to six IC sockets. Prices start at £2.99 plus VAT.

Camboard, Unit 16, Barnwell Business Park, Barnwell Road, Cambridge CB5 8UZ, Tel (0223) 240 926.



● The latest Greenweld catalogue lists kits for everyone including amplifiers, light dimmers, timers, transmitters and computer interfaces. There are also a number of breadboard kits which allow components to be re-used many times. For a free copy contact Greenweld Electronics Ltd, 443 Millbrook Road, Southampton SO1 0HX, Tel (0703) 772 501.

● Not a month goes by, it seems, without a new radiation monitor appearing on the market. The latest is the K2654 kit which detects gamma and beta radiation and uses a loudspeaker to indicate the results. It is battery operated and lightweight and costs £73.75 inclusive from Electronics and Computer Workshop Ltd, 171 Broomfield Road, Chelmsford, Essex CM1 1RY, Tel (0245) 262 149.

● Three new books from Sony provide an insight into fault-finding techniques in audio, television and home computers. The books cost £4.95 each and can be ordered from the Spare Parts Department of Sony (UK) at Thatcham, Newbury, Berkshire. Quote reference S-796-202-01 for the video book, S-796-000-01 for the TV and home computers book, and S-795-100-01 for the audio book.

Liquid Crystal Adds Colour

A new colour display unit from Ferranti offers high resolution at low cost by combining monochrome CRT technology with a liquid crystal shutter.

The display uses red and green filters which are selected alternately by the shutter. When the red filter is switched on the monochrome tube paints one scan, then the filter changes to green and a second scan is traced on the screen. Any level of brightness can be produced and the two basic colours can be mixed in any proportion to produce various intermediate colours such as orange and yellow.

The display cannot produce as wide a range of colours as conventional three-gun CRTs but this is not thought to be a problem in many applications. Ferranti expects it to be used in sonars and other military data displays as an alternative to expensive, ruggedised colour CRTs.

Ferranti Computer Systems Ltd, Cheadle Heath Division, Bird Hall Lane, Cheadle Heath, Stockport, Cheshire SK3 0XQ, Tel 061-428 0771.

DIARY:DIARY:DIARY:DIARY:DIARY:DIARY:DIARY:DIARY:DIARY:

The Opportunity of a Lifetime — February 3/4/5th
The Barbican centre, London. The 58th IEE Faraday Lecture presented by ICL at 2.00pm and 6.00pm on Tuesday and 10.30am, 2.00pm and 6.00pm on Wednesday and Thursday. Tickets free (in advance) from the Faraday Officer on (0462) 53331 ext. 292.

EMC-Susceptiblity Of Electronic Equipment — February 4th
Heathrow Penta Hotel, Hounslow, Middlesex. Seminar and exhibition organised by ERA Technology with the support of the IERE. Contact Laura Christie on (0372) 374 151.

Batteries: The Cinderella Of The Electronics World — February 10th
BSI Conference Centre, London. Forum organised by the British Standards Institution. Contact Jackie Mountain on 01-629 9000.

SMARTEX '87 — February 10-12th
The Barbican Centre, London. The 2nd Surface Mount and Related Technologies Exhibition. Contact Peter Evans on (01) 855-7777.

The Electronic Motor Car — February 11th
The IEE, London. Lecture by M.H. Westbrook of the Ford Motor Company. Contact the IEE at the address below.

The Which Computer? Show — February 17-20th
NEC, Birmingham. See February '87 ETI or contact Cahners Exhibitions on 01-891 5051.

Computer Technology And Architecture For The Next Decade — February 24th
The IEE, London. Lecture by Dr. Gene Amdahl. Tickets free (in advance) from the Overseas Officer on (0462) 53331 ext. 292

Power UK/Enclosures '87 — February 24-26th
Kensington Rainbow Exhibition Centre, London. See February '87 ETI or contact TCM Expositions on (0428) 724 660.

CADCAM '87 — March 14-16th
Metropole Hotel and NEC, Birmingham. Conference and exhibition covering the application of computer aided design and manufacturing to many engineering disciplines. Contact Christine Smith on 01-608 1161.

The Code-Breaking Computers Of 1944 — March 26th
The IEE, London, 2.15pm. Discussion meeting, followed by a lecture on Colossus and German high-grade cyphers in World War II. Contact the IEE at the address below.

Digitally Implemented Radios — April 1st
The IEE, London. Colloquium. Contact The IEE at the address below.

Fibre Optics In Communications — April 2rd
University of Cambridge, 7.00pm. Lecture organised by the IEEIE. For details 'phone 01-863 3357.

The Role of Alternatives In The World Energy Scene — April 7-9th
University of Reading. International conference jointly organised by a number of bodies including the IEE. Contact them at the address below.

British Electronics Week 1987 — April 28-30th
Olympia Exhibition Centre, London. See February '87 ETI or contact the Evan Steadman Communications Group on (0799) 26699.

Digital Audio Tape Recording — April 30th
The IEE, London. Lecture by Dr. J. Emmett of Thames Television PLC. Contact the IEE at the address below.

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

READ/WRITE

From QLs To Cars

Having read the January 1987 issue of ETI I must comment on a couple of the articles.

Firstly, the RGB-Composite converter. 'It is useful for QL users' it said. Well, the QL already has a composite video output as well as RGB, mainly because it has an MC1377P chip inside! I wouldn't think another one on the outside would serve any useful purpose!

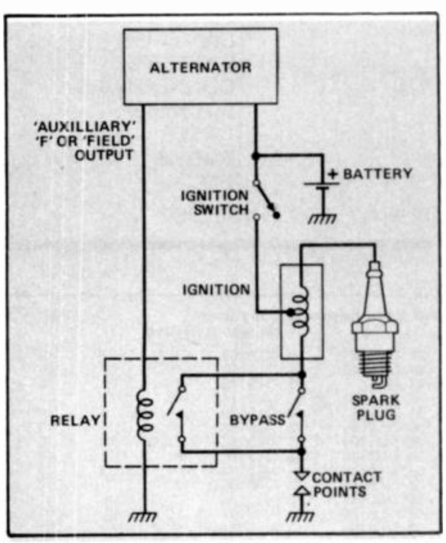
Secondly, the In-car Circuits featured a 'Thief Staller'. Believe it or not, all the components except the relay can be cut out from this design.

The diagram shows the idea. The relay coil is connected to the auxilliary output of the alternator. This connection gives no output when the engine is stationary and an increasing voltage up to 12V as the engine speed increases. A relay that will open contacts (connected in the ignition coil supply) when 12V is supplied across its coil will prevent the engine from running above idling speed. The Lucas 6RA relay is suitable.

A (hefty) switch in parallel with the relay contacts will act as a bypass.

This is a much simpler circuit and one which has been working well for many years.

H.R. Briggs,
Adamston, Shropshire.



Okay, so we boobed. The QL has got a composite video output but it's cunningly disguised as one pin of the RGB output socket. The circuit itself is none the worse for that.

As to the thief staller, it just goes to show what you can do with a little ingenuity instead of a lot of electronics!

Aerial Without Smoke

I am writing to you in connection with the 'Aerial without holes' rear window heater aerial In-car Tech Tip in the January issue of ETI.

This company has designed and developed a similar system and it has been manufactured under licnece for inclusion in such cars as the Ford Granada and Rover Sterling.

I think your readers should be made aware that building this design according to the instructions given could lead to an inherently dangerous device which could become exceedingly hot and catch fire. If the unit is placed in the car boot (as usually it would) close to the petrol tank, there is the risk of an explosion.

The problem arises from the diameter of wire (0.5mm) specified by the author for the bifilar coils. We haue seen Italian devices using 0.8mm wire which have started to smoke in less than five minutes when used. We use 1.2mm wire with only ten turns which we find to be just sufficient for heaters drawing less than 10A. This, we estimate, would cover less than 20% of cars on UK roads today.

D. Waller
BSH Electronics, Manchester.

Andrew Armstrong, the author of the In-Car Tech Tips, assures us that all the cars he has fitted with this design have continued to run without problems. However, he does admit that these have been modest and older vehicles (of the type prevalent amongst impoverished ETI contributors), which do not draw large currents for the rear screen heater.

It would be advisable for any reader building a heater aerial adaptor to Andrew's design to increase the diameter of the coil wire and to test the device thoroughly before consigning it to the car boot.

Upgradeable Spec

I have been following the upgradeable amp project over the months, June to November 1986. I have fcund this to be one of the best projects you have ever published. The explanations and descriptions by Graham Nalty were well informed and easy to follow.

I have built many ETI projects in the past but I've held back from audio designs, being a bit sceptical over sound quality.

Why, then, did the series of articles nowhere mention any measurements? To build the fully upgraded version you are looking at £375 plus. I cannot believe most people will pay out that kind of money without a basic spec. sheet.

Perhaps the figures are too bad to print ...

Rick Hughes,
Clydach, Swansea.

Graham Nalty replies: When an audio amplifier sounds as good as the Virtuoso preamp, no relevant measurements can be bad!

In my experience the only measurement which directly relates to sound quality is power supply ripple rejection. This is tricky to compare between amplifiers.

I could easily have published the input and output specs but I have more productive things to do such as developing the follow-up Virtuoso power amplifier I am currently working on.

I can only invite Mr. Hughes to join the many readers who have completed the project and have been delighted with the sound quality.

RIAA Again

Although Steve Newing's comments (READ/WRITE, January 1987) on the RIAA equalisation of the Macaulay Experimental Preamplifier may be correct, he has fallen into the component tolerance 'trap' like so many others.

When using 5% or even 1% tolerance components it is ridiculous to quote calculated values to six significant figures as he does. If the overall response was ±1% then a three significant figure result is the best that can be realistically quoted.

A. Moore,
Handsworth, Birmingham.

ETI welcomes letters from readers on any topic. If you disagree with our learned contributors or just think the world is going to pieces, don't just sit there. Tell us all your troubles. We can't promise to solve anything, but we can print your letter.
Write to: Electronics Today International, 1, Golden Square, London W1R 3AB.

FOREIGN PORTS

Mike Bedford sorts out his bits and gets down to some serious handshaking in this comprehensive description of the ways and means of computer interface standards.

Interfacing 'black box' computers to their standard peripherals using the prescribed leads rarely presents problems. For computer enthusiasts with more aspirations in the realm of hardware, impressive systems can be built up at a comparatively low cost by shopping around for printers, VDUs, plotters etc, but only at the expense of complicated interfacing. When home built equipment is to be connected to commercial equipment the challenge of interfacing is even greater. Here we will investigate the various communications standards to which computer peripherals adhere and give advice on how to ensure compatibility between two pieces of equipment.

Transmission Codes

Before describing the electronic features of common interfaces and how data is transmitted, it will be useful to take a brief look at how data is encoded as this is common to all types of interface. In this context, data is something which can be expressed in the form of letters, figures, punctuation marks and so forth. Encoding schemes allow this character information to be represented in a binary form for transmission by electronic means.

Early codes preceded computers. They were intended for teleprinter applications. One was Baudot code, also known as Murray code. This is a 5-bit code familiar to many radio amateurs where it is used for radio teleprinter (RTTY) communications. A five bit code only allows 3 to the power of 5 (or 32) different characters to be transmitted. This is clearly less than the total number of figures and letters, even if we stick with upper case letters only. This limitation was overcome by providing a special code to switch the receiving set into either numeric or alphabet shift, allowing a single code to be used for both a letter and a figure. However, transmission is slowed as a result of sending frequent shift characters.

The most common codes encountered in computing are ASCII (American Standard Code for Information Interchange) and EBCDIC (Extended Binary Coded Decimal Interchange Code). ASCII may be either 7 or 8 bits. EBCDIC is always an 8 bit code. These sizes allow 128 or 256 character combinations respectively and so obviate the need for an alpha/numeric shift. EBCDIC is generally used on large IBM mainframe computers leaving ASCII as the code usually found on mini and microcomputers, including, of course, home computers. Figure 1 shows the 7-bit ASCII code, illustrated as a code table. 8-bit ASCII is an extension to this allowing 256 characters. The extended form is used to provide semi-graphics characters on a printer or the display of European languages which require extra accented letters. It will be noticed the first two columns of the ASCII code table plus characters 20 (hex) and 7F (hex) are control characters. This means they don't have a printable representation as do most characters. Instead, they perform some control function at the receiving device. Common examples of control characters are carriage return (CR) and line feed (LF). Control characters can also be used to extend ASCII to give more than 128 (or 256) combinations by using a technique similar to the Baudot shift.

Differences in transmission code is one possible area of incompatibility between communicating devices. Although all the electronics enthusiast is likely to own will use ASCII, it is conceivable an EBCDIC peripheral may be encountered. If the user writes the I/O routines it is an easy task to carry out the code conversion in software. If this is not possible, it may be practical to build a hardware ASCII to EBCDIC convertor. For a serial interface this would not be a trivial task but parallel data may be converted quite easily using an EPROM. (Use of PROMS to carry out data conversion was covered in articles by the author in the February and March 1986 issues of ETI).

Handshaking

Another concept common to all communictions interfaces is handshaking, also known as flagging or flow control. When data is transmitted to a computer or peripheral, the equipment will carry out some operation on it. Depending on the type of device and the particular data received, this operation could take some considerable time. Clearly it will often be possible to send data to a device more rapidly than the data can be handled and so lose some data.

One way to get around this problem is to send the data sufficiently slowly that the receiving device can always accept it. However, if different data patterns take

				D7	0	0	0	0	0	0	0	0
				D6	0	0	0	0	1	1	1	1
				D5	0	0	1	1	0	0	1	1
				D4	0	1	0	1	0	1	0	1
D3	D2	D1	D0		0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	'	p
0	0	0	0	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	/	l	|
1	1	0	1	13	CR	GS	-	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N		n	
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

Fig. 1 ASCII code table.

different lengths of time to execute, selecting a transmission speed which gives the receiving device time to cope with the longest operations means some data is sent slower than necessary. Handshaking is a way to inform the transmitting device that the receiver is ready to receive the next data. This effectively allows for a variable transmission speed.

A slight variation on this theme is concerned with peripherals, such as printers, which can be turned off-line manually. With a printer in this state, the computer connected would need to wait indefinitely before it could send data to be printed. Once again handshaking methods allow this printer-computer co-operation to take place.

Certain methods of handshaking are interface specific. They make use of hardware features of a particular type of interface. However, there are two common systems which can be applied to any interface. These work by sending special control characters down the same lines used to send ordinary data, rather than making use of control lines as is the case for the interface-specific systems. Since this requires data to be sent in both directions, their use is limited to bi-directional interfaces and this tends to limit their application to serial interfaces. Peripherals such as VDUs will always be connected to the host computer by a bi-directional interface, a printer on the other hand may well be interfaced via a uni-directional port.

The terms 'transmitting' and 'receiving' devices, when referring to bi-directional ports means the device's function at a particular time. The roles will swap with a VDU, as the user types data at the keyboard or observes results on the screen.

XON/XOFF

The first type of handshaking system is called XON/XOFF handshaking. XON and XOFF are mnemonics for two control characters which inform the transmitting device to suspend and to resume transmission respectively. In ASCII terms, XON and XOFF are usually taken to be the control characters DC1 (11 hex) and DC4 (14 hex) respectively. Normally, receiving devices have an internal buffer — an area of memory set aside as a queue into which characters are placed before processing. A point in that queue such as half or three quarters full is the usual time to send XOFF, XON being sent when the buffer becomes almost empty. The receiver does not wait until the queue is full so the transmitting device has time to respond to XOFF.

The second common interface-independent method is ENQ/ACK handshaking. This differs from XON/XOFF in that it is the responsibility of the transmitting devices to specifically check the receiver is ready to accept data, rather than assuming that the receiving device is ready unless instructed otherwise.

When the transmitting device is ready to transmit a block of data it sends the ENQ control character (ASCII 05 to the receiving device. If the receiver has enough room in its input buffer to accept a full block of data it responds with the control character ACK (ASCII 06). Then the data is sent. This system can be operated with a wide variation in the size of a block of data. A pair of devices using ENQ/ACK handshaking are only compatible if they are set up to use the same block size.

Incompatibility of handshaking methods is something which is only likely to be encountered with serial interfaces (such as RS232). The common parallel interfaces all have a single hardware-specific system of flow control. Connecting devices with different handshaking protocols will probably result in data loss by the receiving device. This can be avoided by selecting a very slow transmission speed but this is not an acceptable solution. Differences in handshaking methods can often be overcome by software if the user has access to the I/O driver routines. Alternatively, it is possible to buy or build special adaptors although these will probably have their own internal processors and are expensive devices.

The BBC micro is a home micro with more interfaces as standard than many business and scientific micros.

Serial And Parallel

Communications interfaces are divided into two broad categories. It is important to recognise this classification, so we will examine the pros and cons of each. As always, when two diverse methods are available for carrying out a particular task each one has its own particular merits. If this were not the case one method would have become obsolete.

The two major types of data interface are serial and parallel. A parallel interface has one conductor for each binary digit (bit) of the character code and so allows a complete character to be transmitted in a single time interval.

A serial interface, on the other hand, uses a single conductor for the data and requires one time interval for each bit of the data which are transmitted consecutively. Assuming a constant bandwidth for a single conductor, data can be transmitted at a higher rate if bits are sent in parallel. For 8-Bit ASCII there will be at least a factor of 8 difference between serial and parallel. (In fact the difference will be in the region of 10 to 12 as a result of start, stop and parity bits which we will come to later).

The price to be paid the greater speed of a parallel interface is a bulkier and more expensive cable. The difference in cost between serial and parallel also increases with the length of the communications path. This means the ideal application for a parallel interface is a short link requiring a large data handling capacity whereas serial interfaces are ideal for longer distance communications where the amount of data to be transmitted is lower.

Whichever is chosen, a long high speed link is going to be expensive!

We will look at a number of different serial and parallel interfaces but at this stage it is worthwhile saying a little about interfacing serial devices to parallel ones. The first point is that the hardware of the interfaces is totally different so it is usually out of the question to carry out a software conversion. Instead a conversion box will be required. This usually consists of a simple microprocessor system with one serial and one parallel interface. The resident firmware will simply read from one interface and write to the other, handling all the handshaking meanwhile.

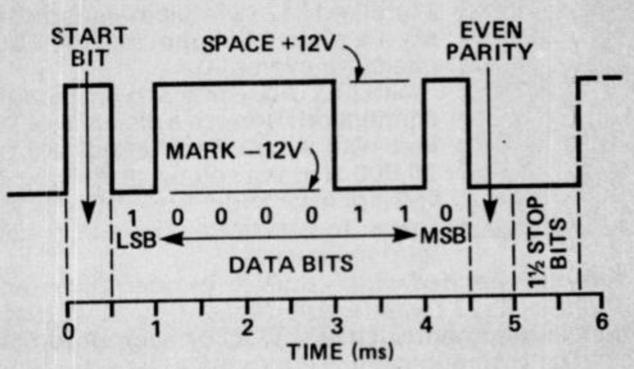


Fig. 2 Example of asynchronous data transmission at RS232 voltage levels. ASCII character 'a' (01100001 binary) with 8 data bits, even parity and 1½ stop bits at 2,000 baud.

Serial Data Transmission

Serial data can take one of two forms called synchronous and asynchronous transmission. In synchronous transmission the transmitter and receiver are synchronised so the receiving device knows exactly when to expect the next bit of data.

Synchronous transmission may be further divided into 'character synchronous' (such as IBM BISYNC — BSC) and 'bit synchronous' protocols (such as HDLC, SDLC). This needn't concern most readers, but the general technique involves combining a synchronising clock with the data in the transmitter to ensure that the received data stream contains enough transitions to enable the receiver to re-constitute this clock. Furthermore, data is packed into blocks which are bracketed by framing information.

The advantage of synchronous interfaces is that start and stop bits are eliminated with a potential increase in the rate of data exchange. The disadvantage is the equipment is more expensive and transmission needs to be constant to ensure that the two devices remain in synchronisation. Furthermore, the overhead of the framing characters is significant for small blocks of intermittent data such as that from a keyboard.

The type of serial interface most likely to be encountered by the reader is asynchronous. In an asynchronous interface the transmission of characters may start at any time, so long as the previous character has finished. Figure 2 shows the makeup of a 'word' of asynchronous serial data. The diagram shows the composition of a word representing the ASCII character 'a' which has a hex value of 61 (hex) or 01100001 in binary. The serial interface can take one of two states referred to as 'mark' and 'space'. These two states are represented by two different voltage levels, the magnitude of which depend on the electrical specifcation of the particular interface used. Figure 2 assumes the RS232 interface and accordingly the voltage levels for mark and space are normally −12V and +12V respectively.

Before a character starts, the signal will be at the mark level which represents an idle state. The start of a character is indicated by the signal going to space for a single time interval. This portion of the word is called the start bit.

Next, the binary code for the character is sent using mark to indicate a binary one and space for zero. The least significant bit is transmitted first. The duration of each bit is the same single time interval used for the start bit. Of course, the number of bits depends on the code used. For ASCII this will be seven or eight. The example of Fig. 2 assumes 8-bit ASCII.

The next time interval is occupied by the parity bit, although this bit may be omitted. If used, the parity bit provides a means of checking the data has been correctly received. This is particularly useful when transmitting high speed data over a long path where interference may be significant. Occasionally the parity bit may be forced to one of the two levels irrespective of the preceding data. This is called mark or space parity but serves no purpose in error checking. More normally, however, even or odd parity is used. In these cases the transmitter sets the parity bit to whatever level is required to ensure that the total number of data and parity bits in the logic 1 (or mark) state is even or odd, respectively. The receiving device carries out the same calculation and checks whether the parity bit is in the expected state. If this is not the case there is a 'parity error' signifying something is wrong with the received data.

To complete the serial word the signal must remain in the mark state for a minimum period of time before the start of the next character. These bits at the end of a word are called stop bits. 1, 1½ or 2 stop bits are commonly encountered. If a space is detected before the prescribed number of stop bits are complete, the receiver recognises this as a 'framing error'.

Even if the data is simple ASCII there are a number of different formats in which the data could be transmitted. There may be seven or eight data bits (although if 8-bit ASCII was in use this would have to be eight), parity may be even, odd, ignored (ie mark or space) or not present and there may be 1, 1½ or 2 stop bits. This gives a total of 30 combinations and shows the difficulty of ensuring compatibility of two pieces of equipment.

Baud Rates

To complicate matters further, there is the issue of baud rates. This is a measure of the speed of data transmission. High baud rates are clearly preferable. However, high baud rates are more susceptible to noise, this often being a function of the length of the line. In practice this means the longer the transmission path the lower the usable baud rate. As we shall see later some serial interface types allow longer paths and/or higher speeds so the equation includes baud rate, speed, interface type and cable type. A baud is a bit per second and includes the start/stop bits and parity. Commonly encountered baud rates are 50, 75, 110, 134, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 7200, 9600, 19600 and 38400. Fortunately some of the lower baud rates are not used much on modern equipment although it may be possible to select them as an option. Nevertheless, the total number of combinations of word composition and baud rates must reach a high number.

It is not usually a hardware task to change these aspects of a serial interface. Serial interfaces are usually driven by a chip called a UART (Universal Asynchronous Receiver/Transmitter) or a ACIA (Asynchronous Communications Interface Adaptor). Common types are the 6850 and 6551. To take these two as typical examples, both allow the word composition to be set up by programming the values of internal registers and the 6551 allows baud rates to be changed in a similar way. Older devices such as the 6850 usually have DIL switches connected to them for altering the baud rate. This means the serial interface characteristics of a computer can be changed by making modifications to the I/O initialisation routines or occasionally by setting DIL switches. On the other hand, peripherals such as printers are usually controlled only by DIL switches, even if this means the firmware reading the DIL switch values and programming the UART accordingly.

ACIAs and UARTS produce data at TTL levels. However, generally data is not transmitted at these levels and

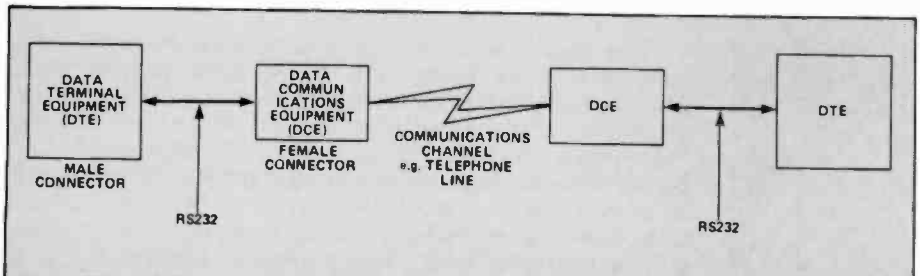
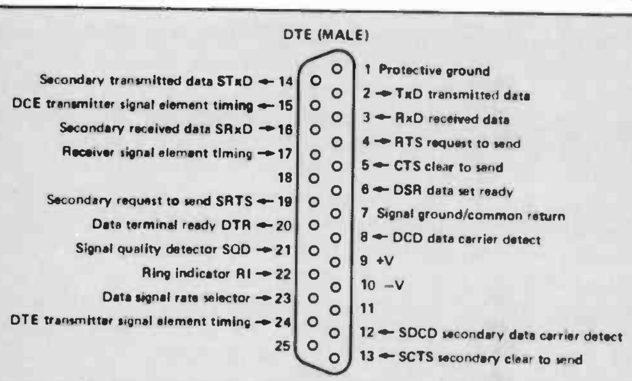


Fig. 3 The original intended application of the RS232 interface.

requires converting to some other voltage before being put onto the transmission line. Conversely, the inputs to these devices are also TTL which will not match the voltage levels found on the received data line. The conversion of transmitted and received data is carried out by line drivers and line receivers.

RS232 Interface

The RS232 interface standard as specified by the Electronics Industries Association (EIA) describes both the functional aspects (the signals available) and electrical aspects (voltage levels, etc) of a serial interface. RS232 runs in parallel with two Comité Consultatif Internationale de Télégraphie Téléphoneie (CCITT) standards, namely V24 and V28, which respectively describe the functional and electrical aspects. So RS232 is frequently also referred to as V24. RS232 is usually taken to imply the use of a 25-pin D-type connector. Although this is not actually specified by the EIA, it is covered in ISO (International Standards Organisation) 2110. For the purpose of this description RS232 will be assumed to



Transmitted Data. This is the line which carries data from the DTE to the DCE. This will always be present except in the case of a uni-directional link.
Received Data. This is the line which carries data from the DCE to the DETE. Once again this will always be present except in the case of a uni-directional link. Clearly either Transmitted Data or Received Data will certainly be present.
Request To Send. Direction : from the DTE to the DCE. Requests the transmission of data.
Clear To Send. Direction : from the DCE to the DTE. This signal is a handshaking response to RTS and indicates the DCE's readiness to transmit to the DTE, something which can only happen when the DCE is asserting DSR.
Data Set Ready. Direction : from DCE to DTE. This indicates the DCE is effectively on line and ready.
Data Terminal Ready. Direction : from DTE to DCE. This signal is used to control switching of the DCE to the communications channel.
Received Line Signal Detector. (Often called Data Carrier Detect). Direction : From DCE to DTE. This signals the DCE is receiving a valid signal from the DTE.

Fig. 4 The RS232 interface.

a reduced RS232 implementation on say a 5 pin DIN connector (the BBC micro, for example).

RS232 is specified to work with connections of up to a distance of 50 feet with a maximum baud rate of 20,000. It uses a voltage of −15 to −5 volts for mark and +5 to +15 volts for space. In practice −12V and +12V tend to be used.

Although applied widely outside its originally intended sphere, RS232 was designed to connect a DTE (data terminal equipment such as a VDU or computer) to a DCE (data communications equipment like a modem) as shown in Fig. 3.

The assignment of RS232 signals to a 25-way D-type connector is shown in Fig. 4. This also shows the direction of each connection and describes the function of the more commonly encountered ones. The signal descriptions are abbreviated forms of those found in the RS232 specification and it will be noticed they are very much tailored to the modem/telephone line application for which RS232 was intended. Most implementations of RS232 use only a subset of the signals available.

The absolute minimum configuration is Signal Ground plus Transmitted Data and Received Data for a bi-directional interface or Signal Ground plus one of these for a uni-directional link with no handshaking.

The other signals described perform various handshaking functions between the DCE and DTE. DTR is the usual handshaking signal for flow control, a high level (space) indicating to the DCE that the DTE is in a condition to accept data. Conversely, a low level indicates the DTE is not ready. Use of this signal therefore provides an alternative to the XON/XOFF or ENQ/ACK handshaking.

The signals not fully described in Fig. 4 are much less likely to be encountered. They include more obscure handshaking signals, the provision of a secondary data channel complete with its own handshaking and timing signals to enable transmitting and receiving devices to synchronise to the same baud rate.

RS232 interfacing is made difficult because of a number of factors which stem from the fact it is commonly pressed into service outside its specified application. It is often used for connecting a terminal to a computer, or a printer to a VDU without a modem in sight! So there is frequently confusion whether a particular piece of equipment should be considered a DCE or a DTE. Often it is required to connect two DTEs together. It will soon be appreicated that connecting two DTEs together on a pin-to-pin basis does not work. The result would be pairs of transmitters feeding into each other and pairs of receivers connected together, rather than each transmitter feeding a receiver. Another problem encountered is when two devices use different sub-sets of the RS232 signals. One device may require a particular signal which the other device cannot provide. A further situation which, although electrically trivial, can be quite inconvenient is when the two pieces of equipment both use male or both female connectors. Three different cable types are required to cover all eventualities even assuming electrical compatibility.

All this assumes the equipment approximately adheres to the RS232 specification. Experience shows even this can't be taken for granted. RS232 has become one of the most un-standard standards. Some practical suggestions for interfacing RS232 devices will be given in the following up constructional article which describes hardware to simplify the process.

RS449/RS423/RS422 Interfaces

By the mid 1970s, the limitations of RS232 were becoming obvious. As higher speed hardware became available, the performance of RS232 at high rates of data transmission over long distances became important. To overcome these limitations the EIA introduced a new serial standard, RS449, compatible with existing RS232 equipment. This standard is intended to work in conjunction with one of two electrical specifications, RS423 and RS422, each suited to different applications. The resulting interfaces are therefore referred to as RS449/RS423 or RS449/RS422.

RS449 specifies a 37-way and a 9-way D-type connector. The 9-way connector is only used for the secondary data channel and so is omitted on the majority of equipment. Figure 5 shows the RS449 pin designations.

The major cause of the poor high speed/long distance performance of RS232 is the fact it does not use differential inputs on the line receivers. Failure to use differential inputs increases the likelihood of electrical interference being induced in the communication line. This interference may originate externally or may be induced from other lines within the interface (crosstalk). A further problem occurs when the ground potentials at the two ends of the interface are different. This can cause the receiver to see a quite different signal voltage level to that actually transmitted.

Both RS423 and RS422 use differential inputs. The difference between the two is that RS422 is a balanced interface whereas RS423 and RS232 are unbalanced. In RS423, the differential input is referenced to one of two signal returns, one for each signal direction (an improvement over RS232 where there is only a single signal return). In the RS422 balanced interface each signal also has its own return and the signals are complementary pairs generated by the line drivers. This provides a significant reduction of interference. Any interference induced in a signal line is cancelled by an equal interfering signal in its return. As a result of the much improved electrical specification both RS422 and RS423 specify voltage levels lower than RS232. These are −6V to −4V for mark and +4V to +6V for space.

The resulting performance of an RS423 interface is 40 feet at 10^5 baud or 4000 feet at 900 baud and for RS422, 40 feet at 10^7 baud or 4000 feet at 10^5 baud. Both are a considerable improvement over RS232. Clearly, if the extra performance of RS422 is not required in a particular application RS423 will be of advantage due to the reduced cabling requirements, balanced interfaces requiring twisted pairs for each circuit. Surprisingly, RS232 still continues to be used in new applications. However, the RS449 standards are certainly starting to make ground.

20mA Current Loop

This commonly encountered interface for the transmission of serial data has its origins in teleprinter technology. It does not conform to formal standards in the same way as RS232 or RS449. As the name suggests it is possible to configure a loop with a transmitter and a number of receiving devices although the normal computing application will have a transmitter coupled with a single receiver. A logic 1 is represented by the transmitter causing a current of 20mA to flow through the receiver. A logic 0 is represented by no current. This contrasts with the situation in other serial interfaces where logic levels are represented by voltages.

In a 20mA system, the voltage level required to cause 20mA to flow depends on the internal resistance of the receiving device according to Ohm's Law. Unfortunately, the lack of standardisation of 20mA current loops means this internal resitance, and hence the voltage required, can vary considerably. Furthermore, the number of receivers in the loop and the length of the cabling will also affect the required voltage level. Use of too low a voltage will simply prohibit a logic level one from being recognised and using too high a voltage will probably destroy the receiver. Fortunately, most modern equipment largely overcomes this problem by use of constant current circuitry.

The voltage source need not even be within the transmitter circuitry. If the transmitter does contain the voltage source it is called an active transmitter but it is also possible to have an active receiver. Obviously an active transmitter must usually be paired with a passive receiver and an active receiver should be connected to a passive transmitter (effectively a current switch). It is

Primary Connector (37 way D-type)

Pin	Mnemonic	Description	RS232 Equivalent
1		Shield	Protective Ground
2	SI	Signalling Rate Indicator	Data Signal Rate Selector (DCE Source)
4-22	SD	Send Data	Transmitted Data
5-23	ST	Send Timing	Transmitter Signal Timing Element (DCE Source)
6-24	RD	Receive Data	Received Data
7-25	RS	Request To Send	Request To Send
8-26	RT	Receive Timing	Receiver Signal Timing Element
9-27	CS	Clear To Send	Clear To Send
10	LL	Local Loop Back	
11-29	DM	Data Mode	Data Set Ready
12-30	TR	Terminal Ready	Data Terminal Ready
13-31	RR	Receiver Ready	Received Line Signal Detector
14	RL	Remote Loop Back	
15	IC	Incoming Call	Ring Indicator
16	SF	Select Frequency	
16	SR	Signalling Rate Selector	Data Signal Rate Selector (DTE Source)
17-35	TT	Terminal Timing	Transmitter Signal Timing Element (DTE Source)
18	TM	Test Mode	
19	SG	Signal Ground	Signal Ground
20	RC	Receive Common	
28	IS	Terminal In Service	
32	SS	Select Standby	
33	SQ	Signal Quality	Signal Quality Detector
34	NS	New Signal	
36	SB	Standby Indicator	
37	SC	Send Common	

Secondary Connector (9 way D-type)

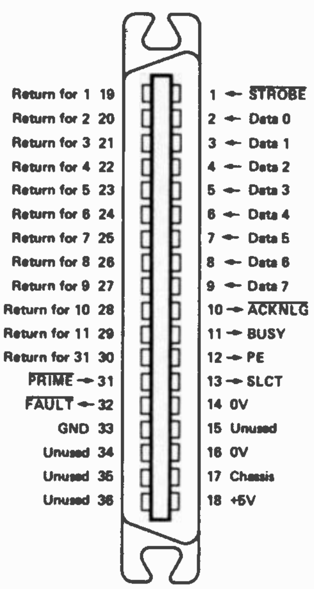
Pin	Mnemonic	Description	RS232 Equivalent
1		Shield	Protective Ground
2	SRR	Secondary Receiver Ready	Secondary RX Line Signal Detector
3	SSD	Secondary Send Data	Secondary Transmitted Data
4	SRD	Secondary Receive Data	Secondary Received Data
5	SG	Signal Ground	Signal Ground
6	RC	Receive Common	
7	SRS	Secondary Request To Send	Secondary Request To Send
8	SCS	Secondary Clear To Send	Secondary Clear To Send
9	SC	Send Common	

Fig. 5 RS449 pin designations.

nevertheless possible to interface an active receiver and an active tranmitter or a pair of passive devices with some additional hardware. Two passive devices require an external power supply to act as the voltage source and two active devices may be interfaced by use of an optical coupler.

As far as wiring is concerned a 20mA current loop interface will have two conductors for each circuit. So a typical bi-directional computer interface without handshaking lines will have four conductors. Usually a simple four way connector will be used but occasionally a device having both RS232 and current loop will use the pins unused by RS232 on the 25 way D-type to implement the current loop signals. It is also worthwhile pointing out that 60mA and even 5mA (in MIDI equipment) current loop interfaces may also be encountered. These both work on the same principle as their 20mA counterpart but are not nearly as common.

Having covered a number of different serial interfaces, it will be useful to say something about converting from one to another. Fortunately this is not usually a complicated task requiring simple conversion of voltage levels or perhaps a conversion of voltage to or from current. This type of interfacing is quite trivial, the circuitry generally requring just a number of different line drivers and receivers connected together.



$\overline{\text{STROBE}}$ This is a negative going pulse to indicate to the printer that valid data is present on the data lines.

Data 0- Data 7 These lines carry the actual data to the printer, the least significant bit on DATA 0. A high level represents logic 1 and a low level logic 0.

$\overline{\text{ACKNLG}}$ This negative going pulse generated by the printer indicates that it is ready to accept further data.

BUSY The level of this signal indicates printer status. The printer outputs a low level if it is ready to accept data or a high level if it is busy, off line or in error condition.

PE The printer uses this signal to indicate the out of paper condition. A low level is the normal state.

SLCT The printer uses this signal to indicate that it is on line. A high level indicates this selected state.

$\overline{\text{PRIME}}$ This is a negative going pulse sent to the printer to cause it to reset to its initial state.

$\overline{\text{FAULT}}$ A low level on this printer generated signal indicates a fault condition, including out of paper.

Fig. 6 The Centronics interface.

Centronics Interface

Turning to parallel interfaces we find the type in most common use (certainly on personal computers) does not adhere to a formal standard. Instead the specification is named after the printer manufacturer who first devised the interface. Nevertheless, Centronics interfaces have become accepted as an industry standard.

The voltage levels on the Centronics interface are TTL which means it is not designed for long distance communications. Instead, a typical application is the interfacing of local printers to microcomputers over a distance of a couple of feet. A Centronics interface is only uni-directional so two interfaces would be required for bi-directional operation. However, use of a Centronics interface for a bi-directional channel would be very unusual. Another result of the uni-directional nature of the interface is that XON/XOFF or ENQ/ACK handshaking cannot be used. Instead, specific control lines are used to control the flow of data.

The connector used for this interface is a 36 way type generally refered to simply as a 'Centronics connector'. Both peripherals and computers tend to use the female connector, an interconnecting lead having a male connector on both ends.

Figure 6 describes the pin designations on a Centronics connector. Generally, it will be found there will be none of the problems of interfacing serial devices when connecting together two devices with Centronics interfaces. Certainly, the computer may not support all the status signals such as PE, SLCT and $\overline{\text{PRIME}}$ but this shouldn't prove to be a problem as its I/O routines will be designed to just look at the BUSY signal to get some idea of the printer status.

IEEE-488 Interface

Otherwise known as the General Purpose Instrumentation Bus (GPIB), the IEEE-488 standard is a parallel interface for the connection of laboratory equipment to computers. GPIB differs from most other interfaces mentioned here in that it is bus structured. That is, it is an interface onto which numerous peripherals may be attached, each accessed individually using a unique address. Since IEEE-488 is not primarily intended for interfacing standard peripherals such as printers or VDUs as are the other interfaces we have covered, we will not deal with it further. Nevertheless, it is a subject worthy of further investigation for the the electronics and computer enthusiast and indeed the construction of IEEE-488 compatible instruments make interesting and useful projects. With automated test equipment made up of a computer and GPIB devices, multiple voltage readings and numerous other measurements can be made in a short period of time and graphs generated by the computer, obviating numerous tedious manual measurements and graph plotting.

And Finally

Data communications is an enormous field. The subjects covered here should give the reader enough information to attempt connecting together most pieces of equipment which may be encountered whether this involves merely matching interfaces or modifying hardware or software.

Next month Mike Bedford builds the ETIFaker. This useful item of hardware is an RS232 patch box to make easier the connection of any two devices using this most troublesome of standards.

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34 way	1 40	1 69	1 69	2 27
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		74LS181	1 80	74LS368	0 35	7406	0 38	74367	0 65
74LS374	0 50	74LS182	2 00	74LS37	0 18	7407	0 38	7438	0 35
74LS00	0 17	74LS183	1 50	74LS373	0 50	7408	0 25	7440	0 22
74LS02	0 18	74LS190	0 55	74LS378	0 75	7409	0 25	7441	0 60
74LS03	0 18	74LS191	0 50	74LS38	0 18	7410	0 25	7442	0 60
74LS04	0 17	74LS192	0 50	74LS390	0 50	74100	1 90	7443	0 80
74LS08	0 18	74LS193	0 50	74LS393	0 50				
74LS09	0 18	74LS194A	0 80	74LS395A	0 90				
74LS10	0 18	74LS196	0 80	74LS40	0 18				
74LS107	0 30	74LS197	0 60	74LS42	0 30				
74LS109	0 30	74LS20	0 18	74LS47	0 50				
74LS11	0 18	74LS21	0 18	74LS48	0 60				
74LS112	0 30	74LS22	0 18	74LS49	0 65				
74LS113	0 30	74LS240	0 60	74LS51	0 20				
74LS114	0 30	74LS241	0 55	74LS54	0 20				
74LS122	0 35	74LS242	0 55	74LS541	0 90				
74LS123	0 40	74LS245	0 70	74LS55	0 20				
74LS125	0 30	74LS244	0 50	74LS640	1 20				
74LS126	0 30	74LS245	0 50	74LS641	1 20				
74LS12	0 18	74LS247	0 55	74LS642	1 20				
74LS132	0 35	74LS248	0 90	74LS643	1 20				
74LS133	0 35	74LS249	0 90	74LS644	1 20				
74LS136	0 28	74LS251	0 40	74LS645	1 20				
74LS137	0 70	74LS253	0 60	74LS668	0 80				
74LS138	0 30	74LS256	0 80	74LS669	0 80				
74LS139	0 30	74LS257	0 40	74LS670	1 00				
74LS13	0 30	74LS258	0 50	74LS673	5 00				
74LS14	0 30	74LS259	0 65	74LS674	5 00				
74LS145	0 80	74LS26	0 18	74LS682	2 10				
74LS147	1 10	74LS280	0 65	74LS684	2 75				
74LS148	1 00	74LS266	0 30	74LS685	2 75				
74LS15	0 18	74LS27	0 18	74LS686	5 00				
74LS151	0 30	74LS273	0 50	74LS687	2 75				
74LS153	0 50	74LS279	0 50	74LS689	2 75				
74LS155	0 40	74LS280	1 50	74LS73	0 30				
74LS156	0 40	74LS283	0 50	74LS74AN	0 22				
74LS157	0 30	74LS290	0 70	74LS75	0 27				
74LS158	0 30	74LS293	0 70	74LS76	0 27				
74LS160	0 50	74LS295	1 00	74LS78	0 27				
74LS161	0 50	74LS298	0 95	74LS83	0 40				
74LS162	0 55	74LS299	2 00	74LS85	0 45				
74LS163	0 50	74LS30	0 18	74LS86	0 20				
74LS164	0 50	74LS32	0 18	74LS90	0 22				
74LS165	0 75	74LS322	3 00	74LS92	0 30				
74LS166	0 75	74LS323	2 50	74LS93	0 27				
74LS168	1 10	74LS33	0 25	74LS95B	0 45				
74LS169	0 80	74LS352	1 00	74LS96	0 65				
74LS170	0 90	74LS353	0 80	7400	0 20				
74LS173	0 40	74LS365	0 35	7401	0 20				
74LS174	0 35	74LS366	0 35	7402	0 22				

7446	0 90	7486	0 40		
7448	0 90	7490A	0 50		
7450	0 22	7491	0 60		
7470	0 38	7492	0 50		
7474	0 35	7493	0 48		
7475	0 45	7494	0 85		
7476 + 7485	0 90	7496	0 85		

TTL74

7400	0 20
7401	0 20
7402	0 22
7404	0 25
7406	0 35
7407	0 35
7408	0 22
7409	0 22
7410	0 22
74100	1 90
74114	0 20
7412	0 22
74121	0 40
74123	0 60
7413	0 30
7414	0 45
74141	0 60
74147	1 25
74153	0 45
74155	0 70
74157	0 70
74159	1 50
74160	0 60
74161	0 80
74163	0 80
74165	0 85
7417	0 30
74170	1 50
74173	0 95
74174	0 90
74180	0 80
74181	1 20
74182	0 80
74184	1 55
74188	2 10
74190	1 00
74191	1 00
74193	1 00
7420	0 22
7422	0 28
74251	0 85
74284	2 25

TRANSISTORS

AC128	0 25	BF200	0 35	MPSA55	0 20
AC142	0 33	BF244	0 30	MPSU05	0 80
AC176	0 22	BF256B	0 45	TIP29A	0 35
AC187/8	0 23	BF257 8	0 32	TIP29C	0 38
AD149	0 75	BF259	0 30	TIP2955	0 65
AD161	0 40	BF324	0 25	TIP30	0 30
AD162	0 40	BF336	0 30	TIP30C	0 35
AF124 127	0 50	BF337	0 35	TIP3055	0 65
AF139	0 38	BF421-423	0 22	TIP31A	0 35
AF239	0 50	BF469-472	0 40	TIP31C	0 40
BC107B-110	0 11	BF870-872	0 30	TIP32A	0 45
BC114	0 15	BFR41	0 22	TIP32C	0 40
BC140	0 27	BFR51	0 20	TIP33C	0 85
BC147-159B	0 12	BFR90	0 60	TIP34A	0 75
BC170	0 06	BFR91	0 75	TIP34C	0 90
BC182 239C	0 09	BFR94	5 88	TIP36	1 25
BC256A	0 20	BFX29	0 28	TIP41A	0 45
BC307B 338	0 12	BFX84	0 33	TIP41B	0 50
BC441 461	0 33	BFX85	0 31	TIP42A	0 50
BC477	0 20	BFX87/88	0 33	TIP42B	0 50
BC516/7	0 30	BFY17	0 30	TIP42C	0 40
BC547B 559	0 11	BFY41	0 30	TIS90	0 20
BD124P	1 00	BFY50	0 30	TIS91	0 30
BD131	0 50	BFY51	0 30	2N2219A	0 27
BD132	0 50	BFY52	0 30	2N2221A	0 27
BD133	0 48	BFY90	0 76	2N2368	0 24
BD135	0 40	BSX20/21	0 25	2N2369A	0 23
BD136 140	0 30	BSX26	0 30	2N2483	0 45
BD245B	0 55	BSX29	0 32	2N2648	0 65
BD517	0 70	BU104	1 70	2N2904A	0 25
BF115	0 40	BU105	1 50	2N2906/7	0 20
BF154	0 20	BSY95	0 30	2N2926	0 18
BF167	0 33	BUY69	2 10	2N3053	0 30
BF177	0 30	MJE2955	0 78	2N3054	0 70
BF178	0 35	MJE3055	0 70	2N3055	0 48
BF181	0 25	MJE340	0 48	2N3819	0 40
BF184	0 30	MJE370	0 90	2N3904	0 15
BF185	0 30	MJE520	0 45	2N3905/3906	0 12
BF196	0 12	MJ2955	0 85	3N128	1 60
BF197	0 18	MJSA05	0 20		
BF198/9	0 15	MPSA12	0 25		

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
CA3080A	2 00
CA3080E	0 55
CA3085	1 30
CA3088	0 50
CA3088E	2 00
CA3089Q	2 00
CA3090AQ	2 30
CA3100S	2 00
CA3130E	0 75
CA3140T	0 70
CA3161E	1 50
CA3162E	5 00
CA3189E	1 70
CA3193E	1 50
CA3240E	0 90
CA3260E	2 50
CA3290E	1 10
HA1366W	1 70
LA3300	1 90
LA4032P	2 45
LA4400	3 00
LA4420	2 25
LA4422	2 80
LA4461	3 50
LC7120	3 00
LC7130	3 00
LC7131	3 00
LM1889N	2 50
M51513L	2 00
M51515L	3 00
MB3712	1 80
MC1315P	2 90
MC1330P	1 90
MC1349P	1 50
MC1460G	2 90
MC1463R	4 80
MC1469R	3 00
MFC6040	0 70
ML237B	2 50
ML238B	4 50
NE535T	1 10
NE5501N	0 90
NE5534N	1 00
SAB3209	3 75
SN76008N	2 25
SN76110N	1 20
SN76115AN	1 60
SN76131N	1 70
SN76396N	1 65
SN76600P	1 40
SN76660N	0 80
SN76707N	2 10
SN76708N	3 00
TA7204P	1 30
TA7205AP	0 85
TA7208P	1 30
TA7222P	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
LM556	1 50
LM710CN	0 90
LM711CN	0 90
LM741	0 50
LM747CN	0 80
MB3756	3 50
NE555	0 20
NE556	0 55
NE566	1 30
TBA120S	0 60
TBA920	1 75
TDA1011	2 00
TDA1022	4 00
TDA2006	2 75
TDA2190	2 40
TDA2591	2 75
TDA2670	1 50
TL071CP	0 40
TL072CP	0 60
TL074CN	1 00
TL081CP	0 30
TL082CP	0 50
TL084CN	0 90
TBA990Q	2 75
TC9100	7 50
TC9109P	7 50
TCA270SB	3 00
TCA850	3 50
TCA660B	3 50
TCA740	2 50
TCA900	1 90
TCA910	1 90
TDA1003A	1 90
TDA1035T	2 50
TDA2002	2 75
TDA2010	3 00
TDA2030	1 80
TDA2522	2 50
UPC1025H	3 25
UPC1156H	2 50
UPC1182H3	3 25
UPC1366C	1 75
ZN425E8	3 50
ZN426E8	3 50
ZN427E	6 00
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ZN447E	8 75
ZN449E	2 90
ZN435E	5 00

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D8755AD	15 00
HD6402P	2 80
MC8T28P	1 15
MC8T97P	1 15
MC8T98P	1 15
M5L8035LP	3 00
M5L8085AP	2 70
M5L8155P	3 00
M5L8156P	3 20
M5L8212P	1 45
M5L8216P	1 45
M5L8251AP-5	2 95
M5L8253P-5	2 70
M5L8255AP-5	2 55
M5L8279P-5	3 50
UPD8284AD	[illegible]
UPD8156C-2	[illegible]
UPD8243C	[illegible]
UPD8748HO	[illegible]
6821P	[illegible]
6850P	1 15
8086	17 00
8088	9 50
8228	3 00
8748D	13 00
7201	6 90
Z80ACTC	1 50
Z80ACPU	1 50
TMS9929	5 00
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76489AN	2 50
MC6845SP	5 00
Z80ADART	6 50
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Z80APIO	2 40
Z80ASIO-0/1/2	7 00
VL4500A	13 00
8272	9 00
8272A	11 00
6551A	4 50
6800	2 50
6809P	8 00
68B09P	12 00
68000P8	20 00
1793	12 00
1691	12 00
9216	12 00
1770	15 00
1772	15 00
8271	33 00
2793	20 00
2797	20 00
ULN2003	0 70
ULN2004	0 70
MC1488	0 58
MC1489	0 58
SN75108	0 90
SN75189	0 70
SN75450	0 70
SN75480	0 99
SN76013	2 70
SN76023	2 80
SN76110	0 90
SN76226	0 90
SN76530	0 70
SN76660	0 70
SN76666	1 00
SN76666N	1 00
ULN2001	0 70
ULN2002	0 70
ULN2002AN	1 10
5522A 3 50 6502A	4 25

MEMORIES

2016AP12	2 95
2114-2	2 75
2716 350N/S	2 50
2732-450N/S	2 50
2732A-200	2 75
2764-200	2 50
2764-25	2 00
27C64-25	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
4884P-2 150N/S	1 50
50256-12	3 00
6116LP3 150N S	1 50
6116P4 200N/S	1 50
HM6264LP12	3 40
HM6264LP15	3 00
TC5501P	4 00
TC5514AP3	2 95
TC5516APL2	2 90
TC5517BP	2 95
TC5565PL15	3 55
UPD41464C-15	6 00

DIODES

AA119	0 08
AA129	0 20
1N4001	0 04
1N4002	0 04
1N4003	0 05
1N4004	0 05
1N4005	0 05
1N4006	0 06
1N4007	0 06
1N4148	0 03
1N5401	0 09
1N5402	0 09
1N5404	0 12
1N5406	0 12
1N5408	0 14
1S44	0 08
1S920	0 07
1S921	0 08
6A800	0 40

JOYSTICKS

Gunshot I	£5.50	Kraft microswitch	£6.95
Gunshot 2	£6.00	NEW Master	£8.95
Gunshot MSX	£6.50	NEW Kraft IBM Compatible	£21.95

74HC & 74HCT

HC00	0 28
HC02	0 28
HC03	0 28
HC04	0 28
HC08	0 28
HC107	0 35
HC109	0 40
HC10	0 28
HC112	0 40
HC113	0 40
HC11	0 28
HC125	0 40
HC126	0 40
HC132	0 70
HC133	0 28
HC137	0 70
HC138	0 70
HC139	0 70
[illegible]	0 70
HC15	0 70
[illegible]	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
HC390	1 00
HC393	1 00
HC42	0 50
HC51	0 28
HC534	1 00
HC540	2 00
HC541	2 00
HC74	0 50
HC75	0 50
HC85	1 00
HCT240	1 75
HCT241	1 75
HCT244	1 50
HCT245	2 20
HCT640	2 40

CRYSTALS

32 768 KHz	0 95
100 0 KHz	4 00
1 MHz	2 65
1 8432 MHz	1 75
2 0 MHz	2 00
2 4578 MHz	1 75
2 5 MHz	1 80
3 0 MHz	1 20
3 2768 MHz	3 00
3 579545 MHz	1 25
3 6864 MHz	1 70
4 00 MHz	1 50
4 194304 MHz	1 50
4 433619 MHz	0 75
4 9152 MHz	1 20
6 00 MHz	1 30
6 144 MHz	1 30
6 4 MHz	1 30
6 5536 MHz	1 50
7 158 MHz	1 50
7 3728 MHz	1 50
8 0 MHz	1 20
10 0 MHz	1 50
12 00 MHz	1 50
15 00 MHz	1 80
16 0 MHz	1 30
18 432 MHz	1 30
20 0 MHz	1 30
32 00 MHz	1 30
36 00 MHz	1 30
48 00 MHz	1 30

VOLTAGE REGS

7805	0 35
7808	0 35
7808CK	0 56
7812	0 35
7815	0 35
7815CK	0 56
7818	0 35
7824	0 35
78L05	0 20
78L08	0 20
78L12	0 20
78L15	0 30
78L24	0 30
7905	0 40
7908	0 40
7912	0 40
7915	0 40
7918	0 40
7924	0 40
79L05	0 33
79L08	0 40
79L12	0 33
79L15	0 40
79L24	0 80

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
40106	1 50
40107	0 40
40108	2 36
40109	0 87
4010	0 25
40110	1 85
40114	2 10
4011	0 18
4012	0 18
4013	0 25
40147	0 85
4014	0 40
4015	0 40
40160	1 25
40161	1 25
40162B	0 50
40163B	0 50
4016B	0 25
40174B	0 50
40175B	0 50
4017B	0 40
40181B	1 80
4018B	0 40
40192B	0 50
40193B	0 80
40194B	0 80
4019B	0 35
40106B	0 36
40208B	2 10
4020B	0 50
4021B	0 50
4022B	0 50
4023B	0 18
4024B	0 30
40257B	1 50
4025B	0 18
4026B	0 80
4027B	0 25
4028B	0 32
4029B	0 50
4030B	0 18
4031B	1 00
4033B	1 00
4034B	1 10
4035B	0 50
4038B	0 80
4040B	0 45
4043B	0 40
4044B	0 45
4045B	1 00
4046B	0 50
4047B	0 50
4048B	0 30
4049B	0 25
4050B	0 25
4051B	0 50
4052B	0 45
4053B	0 45
4054B	0 60
4055B	0 60
4056B	0 60
4060B	0 70
4063B	0 75
4066B	0 25
4067B	2 00
4068B	0 18
4069B	0 18
4070B	0 18
4071B	0 18
4072B	0 18
4073B	0 18
4075B	0 18
4076B	0 50
4077B	0 18
4076B	0 18
4081B	0 18
4082B	0 18
4086B	0 45
4089B	0 95
4093B	0 25
4094B	0 65
4095B	0 75
4096B	0 75
4097B	2 25
4099B	0 75
4502B	0 50
4503B	0 33
4508B	0 80
4510B	0 40
4511B	0 40
4512B	0 40
4514B	1 00
4515B	1 00
4516B	0 40
4517B	2 25
4518B	0 40
4520B	0 40
4522B	1 10
4526B	0 45
4527B	0 50
4532B	0 50
4538B	2 00
4539B	0 60
4543B	0 55
4555B	0 30
4556B	0 45
4584B	0 40
4585B	0 40
4724B	1 00

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
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28 PIN ZIF	4 87	
40 PIN ZIF	7 02	

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HARDWARE DESIGN CONCEPTS

Mike Barwise continues to build his pulse generator. This month he looks at getting the circuit up to speed.

Period, delay and width are the three parameters which combine to produce a controlled pulse train, as opposed to just a square wave output. The pulse period begins with a trigger signal. This is a narrow pulse used for synchronisation of external equipment. Following a specified delay after the trigger a pulse of specified width is generated. The only absolute relation between these three parameters is that the total of delay and width must be less than the pulse period.

Putting It Together

The correct sequence of events can be accomplised by cascading the programmable counters designed last month (Fig. 1) subject to a few subtle modifications. The delay and width counters are converted to one-shot operation instead of free running by interposition of set/reset (SR) flip-flops between them.

The full theoretical circuit is shown in Fig. 2. The $\overline{T}$ input of the first stage of each counter acts as a synchronous enable for the whole (three chip) counter. The period counter enable serves as a general run/stop control for the whole pulse generator.

The output pulse (composite RCO) of this counter sets an SR flip-flop, the output of which controls the $\overline{T}$ input of the next counter (delay). To avoid the counter free running, its own output pulse is fed back to the reset input of the SR flip-flop. The counter thus stops itself when it rolls over. An identical circuit controls the final (width) stage.

The mechanism operates as follows. When enabled, the first (period) stage free runs. It outputs a pulse each time it rolls over. This pulse is output to a trigger out socket, and also enables the second (delay) stage. This outputs a pulse as it rolls over, which stops it and starts the final (width) stage. This last stage outputs a pulse similarly as it rolls over, which stops it. The delay and width stages then wait disabled until the next period pulse arrives.

Signals can be taken from various points to provide alternative outputs. The most convenient points are the true (non-inverting) outputs of the run/stop flip-flops on the delay and width stages. The output of the final stage (width) flip-flop provides the conventional delayed positive going pulse of specified width, and the output of

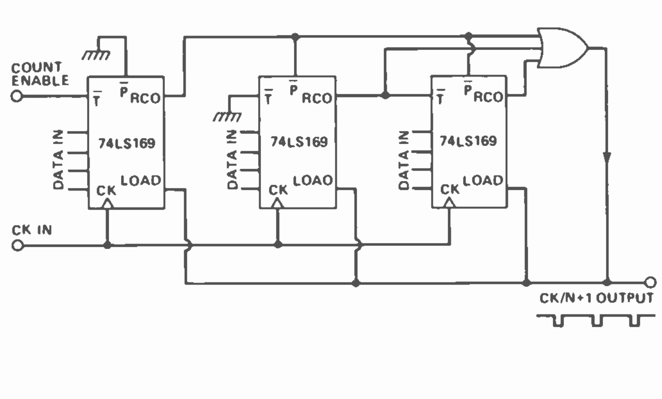


Fig. 1 The complete circuit for a single programmable counter, designed last month.

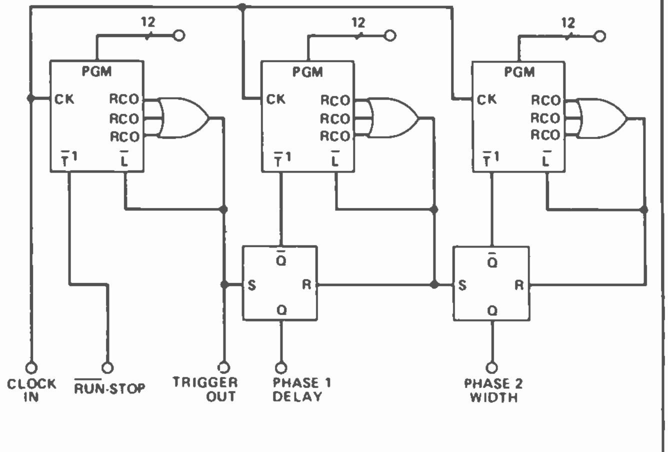


Fig. 2 The full theoretical circuit for the pulse generator.

the second stage (delay) flip-flop provides a positive going pulse equivalent to the delay duration. Both these signals are useful.

Practicalities

It would be very easy to just sling the theoretical circuit together without much thought, and it would probably work.

However, I have specified that this is going to be a *precision* pulse generator. Let's investigate where hazards exist and refinements could be made.

Step one is to look at our three chip counter (three by 74LS169 or 74F169). It is immediately apparent that there is no method of external reset or preset in Fig. 1. The counter will power up at an arbitrary point in its sequence, and we have no over-ride.

This is not a good idea at all. It leads to very messy start-up as each of our three counters (for period, delay and width) will probably power up in a different condition.

However, there is an excellent and simple solution to this problem. Our three RCO signals pass via a three input NOR gate and an inverter to the LOAD feedback. Replacing the inverter with a two input NOR gate (Fig. 3) allows external preconditioning of the counter by taking the spare input to the NOR high, thus enforcing a LOAD state at all stages of the counter. This input must be held LOW to run the counter.

How Fast Can We Go?

This problem solved, we now have to look at timings. Let's take the 74LS169 to start with. The Texas Instruments data sheet shows the delay between CLOCK and RCO going low as typically 17ns and as a worst case 25ns. The propagation time of the three input NOR (74LS27) or a two input NOR (74LS02) is the same for both transitions — typically 10ns, worst case 15ns.

The total delay for the feedback loop between a clock and the application of a valid LOAD at the 74LS169 LOAD pins is therefore typically 17+10+10ns (37ns) and worst case 25+25+15ns (55ns). The worst case figure is always the important one as you can't assume any individual device will perform better than worst case, although most do.

Looking again at the 74LS169 data sheet, we find that the recommended operating conditions require a setup time for LOAD of minimum 6ns. For safety, we have to call this 10ns. This is the length of time a stable signal must be present at the LOAD pin before the clock which performs the LOAD. This 10ns must therefore be added to the previous propagation delays, yielding a worst case (ie safe) total of 65ns. From this it is simple to calculate the maximum acceptable clock frequency the counter will respond to, in this case 15.38MHz.

10 MHz

To make programming more meaningful (65ns increments are silly!) we call it 10MHz for the 74LS components, giving a resolution of 200ns to the counter (remember from last month that the minimum output period is twice the clock period). Note, though, how these results compare with the published maximum frequency for the 74LS169 — typically 35MHz, worst case 20MHz.

These values are for open loop (non-feedback) circuits. Whenever you use feedback with counters, you must expect to roughly halve the maximum operating frequency. Some people will call this excessively cautious, but at least the result is absolutely guaranteed to run.

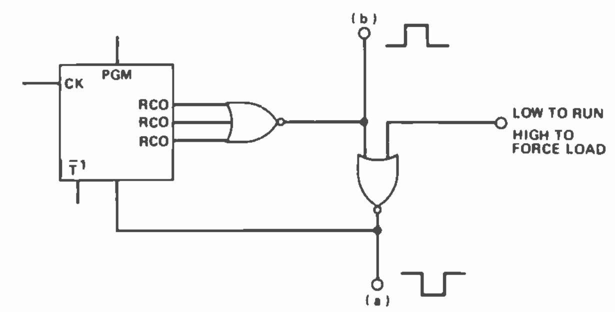


Fig. 3 The real counter feedback loop with (a) active low and (b) active high flip-flop drive signals.

Now come the SR flip-flops which control the counters. Unless we are careful, the transition between one counter and the next will be sloppy, and performance will be spoilt.

For example, if the period counter load signal (Fig. 3 (a)) is fed forward to the set input of the SR flip-flop, the propagation delay of that flip-flop plus the set up time for the T input of the next (delay) counter must be added to the previously calculated delay to determine the safety margin available before the clock pulse that will start the delay counter.

Flip-Flops

A typical SR flip-flop such as the 74LS74 might seem a suitable choice for this application. However, before we jump for this choice we should look more closely at?

The propagation delays for rising and falling outputs are substantially different — 13-25ns (rising) and 25-40ns (falling). This does not bode well but for the moment let's just look at the rising output required to start the following counter.

We already have a cumulative propagation and setup delay of 65ns. Add to this the worst case rising edge propagation delay of the 74LS74 (25ns) and you get 90ns. The flip-flop output is applied to the T of the following counter to enable it and the T input requires a *minimum* 14ns setup time.

The grand total is therefore *at least* 109ns and probably something like 115ns for real safety, bearing in mind that all these worst case figures are quoted in the data sheets at the almost unachievable 5V and 25°C.

This already reduces the maximum frequency of operation below the 10MHz we just chose and there's worse to come. As each counter stops itself by resetting the flip-flop with the same signal that starts the next counter, the total feedback time is still further increased on reset by the 74LS74 negative going delay of 40ns instead of 25ns.

The grand total is therefore 130ns, yielding a maximum frequency of 7.69MHz, which rationalises to 5MHz for convenience or to 6.66MHz for a moderately useful 300ns resolution. We have thus lost 30% of our single counter performance in cascading two counters and rendering the second a one-shot.

Improving Performance

Obviously, we need a much faster flip-flop and also one with less discrepancy between rising and falling pro-

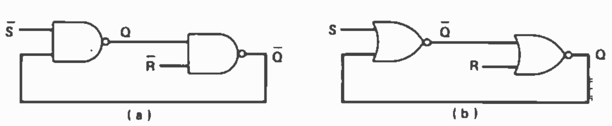


Fig. 4 NAND and NOR level driven flip-flops.

pagation delays. One answer is to build a simple flip-flop out of cross-coupled inverting gates. Either NAND (74LS00) or NOR (74LS02) gates may be used (Fig. 4) and the choice depends on the polarity of the driving signals available. Let's reason it out.

NAND flip-flops require low level inputs to cause change of state and NOR flip-flops require high levels. It is important to appreciate that, although a change of state follows rapidly on the application of the relevant input, these are NOT edge triggered, but level controlled circuits. This means that both inputs must never be activated simultaneously, or an undefined output will result. We don't have a problem here, as our cascaded counters cannot possibly cause this to happen, due to the sequential activation of each by the previous one.

The obvious driving signal is the active low LOAD feedback as in Fig. 3(a), so we will choose a NAND flip-flop to start with.

The propagation delay of the flip-flop is effectively twice the propagation delay of the gates used, so we look this up and find that for a 74LS00 the delay is 9ns (rising) and 10ns (falling) typical, and 15ns (either direction) worst case. Again taking worst case figures this makes our flip-flop propagation time 30ns, or roughly midway between the two extremes of the 74LS74 so the main benefit is equal delays in both transition directions. The total propagation plus setup delay using the NAND flip-flop is thus 25+15+15+10+30+15ns, or 110ns, so we still can't quite achieve 10MHz.

Fine Tuning

However, we can improve on this a little bit, and achieve a real 10MHz clock rate. As all the timings we've looked at above are guaranteed worst case, we can squeeze every extra nanosecond out of the system as long as we don't cross the specified limits. This is why I insist on worst case timings, so you have a small tuning latitude.

Where can we save a little time? Looking back at Fig.3, we can see the flip-flops are driven simultaneously with the counter LOAD, by a signal which is an inverted replica of the combined RCO. The inverting gate adds a 15ns delay and also introduces a hazard in Fig. 3(a). Did you notice it?

The hazard results from the external reset we built in, combined with the take-off point for flip-flop control. When we enforce the reset (counter LOAD), we also drive the following flip-flop SET. As the next counter is also driven to LOAD condition, it feeds back to drive the RESET of the same flip-flop simultaneously. This is not allowed. In this configuration, the first input to go away would decide the final state of the flip-flop and this would be the result of internal speed differentials in the order of a couple of nanoseconds. Each flip-flop would effectively take up an arbitrary state and we would have no control over the system.

Taking the flip-flop drive from the 74LS27 three input NOR (Fig. 3(b)) before the two input NOR (74LS02) covers this hazard. The SET input of the flip-flop remains undriven, and the succeeding counter reaches round and resets it ensuring a defined state. However, the big gain is the precious 15ns. We have already established that an individual counter built from three 74LS169 chips can run at 15.38MHz or comfortably at, say, 15MHz, but the cascaded one-shot system would not quite attain 10MHz (110ns cycle).

By covering the reset hazard as above, we save the propagation time of the 74LS02, or 15ns. This yields 95ns total which is well within the 10MHz operating range. The proviso is that we now need flip-flops which respond to *high* level inputs instead of low levels, so we substitute NOR gates in the flip-flops. The propagation time of the NOR gates (74LS02) is the same as the NAND (74LS00) so we are all square, and able to run at 10MHz using 74LS series devices.

Implementation

At 10MHz, using 74LS series TTL, as long as the circuit is adequately decoupled, you have more or less total freedom of layout and use of redundant gates. The inventory can thus be reduced to nine 74LS169 counters, one 74LS27 triple three input NOR, and two 74LS02 quad two input NOR packages.

In order to attain twice the system speed, the whole circuit must be implemented in 74AS(Texas) or preferably 74F (Fairchild) series TTL. The same calculations apply, but as 74F works at up to about 90MHz (open loop), a 20MHz clock yielding 100ns resolution is quite practicable. However, there are problems.

When using 74F or 74AS very stringent physical layout rules must be adhered to. Device decoupling is essential and should be accomplished by a low inductance ceramic capacitor close to the Vcc pin of every chip. The whole top surface of the PCB should be a common ground plane, with the ground pin of each device directly coupled to it.

It is most important to avoid significant differential clocking rates within a chip, and preferable to ensure that there is a progressive, rather than a sudden rise in speed between adjacent devices.

This means using more chips and leaving redundant gates unused where there could be conflicts. Thus each counter stage of our pulse generator will consist of three 74F169 counters, one 74F27 and one 74F02, leaving two three input NOR gates and one two input NOR gate spare in each stage. These should all have their inputs terminated as in CMOS practice to avoid them switching due to noise, and each counter stage should ideally be well spaced from the others. Even so, the whole circuit should fit on an extended single eurocard of 100x200mm.

In either version, the CLOCK should be buffered with a fast high current driver, as nine chips have to be clocked, which is too much load for a conventional crystal oscillator. One of the neatest solutions is to use a device like a 74LS (or F) 244 buffer, which will deliver enough drive for 10 inputs guaranteed. Once again, when using the 74F device, all unused inputs should be terminated.

And Now

The complete pulse generator so far has a range of frequencies of 1000:1 controlled by the data inputs to the individual counters. This is not nearly good enough for our proposed top notch instrument. Next month I shall look at the design of a programmable clock divider to accompany the pulse generator to increase that range to 1000000:1.

We shall also begin construction of the pulse generator. As the PCB design and layout for the 74F series TTL used is quite crucial, next month I shall begin with the construction of the range board — a comparatively simple circuit.

ETI

THE TRANSPUTER

Semiconductor saviour or silicon hype? Mike Barwise delves into the workings of the wonder chip from Inmos.

The Inmos Transputer range of microprocessors first became available around November 1985, but has been easily obtainable on a small order basis only within the last few months. It is too new to have been extensively described, but it is worthy of attention as a remarkably innovative design.

The Transputers are the outcome of more than three years development, and represent a radical departure from traditional Von Neumann architecture microprocessors. They were developed simultaneously with the Inmos high level language, Occam, and the machine level architecture and instruction set have been optimised for the support of high level languages, with the emphasis on concurrent processing (multi-tasking).

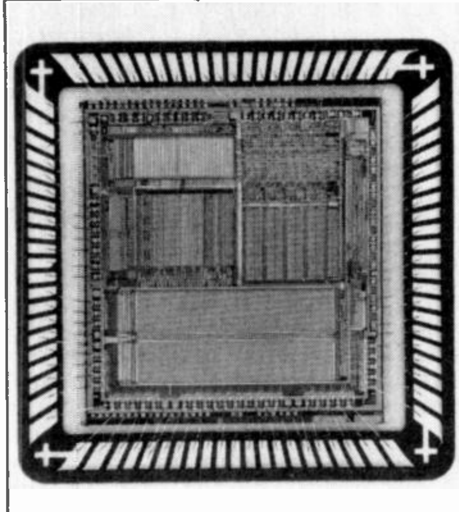
Concurrency is supported by the hardware implementation, rather than by the software real-time executive (RTE) used in most micro systems. This approach substantially reduces the control overhead in single processor time-multiplexed pseudo-concurrency, and additionally automatically chooses the optimum points for task switching, according to such factors as the size of the restoration parameter block needed, or whether a routine is idling pending input from a data channel.

The Transputers do even better than this. Each processor is equipped with a number of high speed asynchronous serial links. These appear to the processor identical to the mechanisms it sets up for inter-process communication in single processor pseudo-concurrency. It is thus possible to take a set of concurrent procedures running on a single Transputer and install each routine on a separate processor connected to the others by the serial links, allowing true concurrency. This means software can be developed on a (relatively) low cost single processor development system to run on a multi-processor array.

Transputer processor arrays have enormous advantages over conventional multi-processor systems. In multi-tasking systems, the bandwidth available to any task is roughly proportional to the reciprocal of the product of: the memory access cycle time, the number of processors sharing the memory, the scheduling overhead time, and the number of re-arbitrations per second.

From this it is clear there is little gain in throughput by using several conventional processors over task-switching on a single processor. Unless some processors can perform independent tasks without reference to shared memory, the only real gain is any reduction in the scheduling overhead due to local variables being stored in the maps of different processors and thus not requiring saving and reloading to and from parameter blocks.

Multi-tasking on a single Transputer is similarly constrained, although the hardware control of timeslicing reduces the scheduling overhead drastically. However, the Transputer multi-processor array has bandwidth which rises effectively in proportion to the number of Transputers operating in the system, due to the total absence of shared memory (allowing true concurrency) and the ability of tasks to be scheduled according to data demand and availability.



The IC mask of the T414 32 bit Transputer chip.

This means that to upgrade the system performance, you simply add more Transputers. There is obviously a limit, but I have seen a system with 64 Transputers operating concurrently in parallel in a nineteen inch rack about two feet high, and yielding 640 million instructions per second (MIPS)!

The simplicity of the user-visible Transputer hardware implementation is very appealing, as is the rare virtue of compatibility across the range of Transputers:

T414 32 bit, 4 Gbyte map, 20 MIPS
T212 16 bit, 64 Kbyte map, 10 MIPS
M212 16 bit, 64 Kbyte map dedicated disk processor.
T800 The latest announcement. Floating point maths processor. 32 bit integer, 64 bit floating point processors, 1.5 MFLOPS, 4 Gbyte map.

For practical purposes, a program written for any Transputer can be executed on any other, regardless of processor word length.

General Architecture

For those of us who can afford Occam (about £10,000) the processor architecture is really irrelevant, but it is worthy of description.

Obviously there are differences in the memory maps of Transputers with different word lengths, but they all obey the same principles. All Transputer address maps are coded in twos-complement. So the lowest address is 80n (hex), and the highest address is 7Fn (hex). In any Transputer, the communication links are positioned at the lowest addresses of the map and are each one word wide. Above these, a small block of memory is dedicated to processor use and the rest of the map is free to the user.

Each Transputer has fast read/write memory built-in. This is addressed in the lowest 2K or 1K of the map. So it is possible to use the processor for limited tasks without any external memory.

Peripheral devices may be memory-mapped to the external addresses and any device can take command of the external bus for DMA transfers. This is fairly standard on 16 and 32 bit micros, but a feature unique to the Transputers is that during DMA to the external map, a procedure in internal memory can continue executing without interruption.

One minor difference between the 32 bit and 16 bit devices is the external memory interface.

The 32 bit device is designed to drive dynamic RAM, and provides all the required control signals without any external support. The interface can be configured for almost any timing specification likely to be encountered. This causes a small block of memory at the top of the map (where ROM normally resides) to be set aside for RAM interface parameters.

The 16 bit Transputer expects fast static RAM as external memory. It supports the standard interface timing expected by byte-wide devices of 2K, 8K and 32K. A hardware (externally driven) wait state can extend access time for slower memories. Additionally, a real-time command pin can cause dual byte-wide memory access to eight-bit interfaces.

Largely concealed from the user are the communication components — the link interfaces (supporting full duplex 10 or 20 Mbaud asynchronous communication) and two timers used for concurrent task scheduling.

Perhaps the most amazing thing is that all this fits on a single silicon die not quite 12mm square!

Processor Registers

All Transputers have a common set of word-wide processor registers.

I register. The Instruction pointer. This is a standard program pointer which increments as the program runs. All instructions are one byte long, to avoid conflict with differing word lengths across the Transputer range.

W Register. The Workspace pointer. This is a pointer to the base address of the current workspace area. There is a minimum of one workspace area per processor in memory, and each is a conventional base plus offset array.

O Register. The Operand register. This register holds the operand of the instruction about to be executed. The O Register is cleared after each execution.

A, B and C Registers. These three word-wide registers form a three level 'last in, first out' evaluation stack. The stack can be manipulated to a certain extent (inversion of the top two elements) and has a lot in common with the software driven stack in Forth.

All these registers are used by conventional sequential processes. When switching between processes, the contents of the relevant registers are exchanged with RAM parameter blocks. There is also an error flag register for use by arithmetic operations. The error flag can be directly controlled by the user, both in terms of its state, and the action taken when it is active.

A separate set of registers is provided to control concurrent processing. These can be initialised by the user, but are mainly manipulated in the execution of specific instructions associated with concurrent processing. One subset contains pointers to the front and back of two alternative priority queues for concurrent processes, and the remaining subset contains timer and clock control parameters for timeslicing.

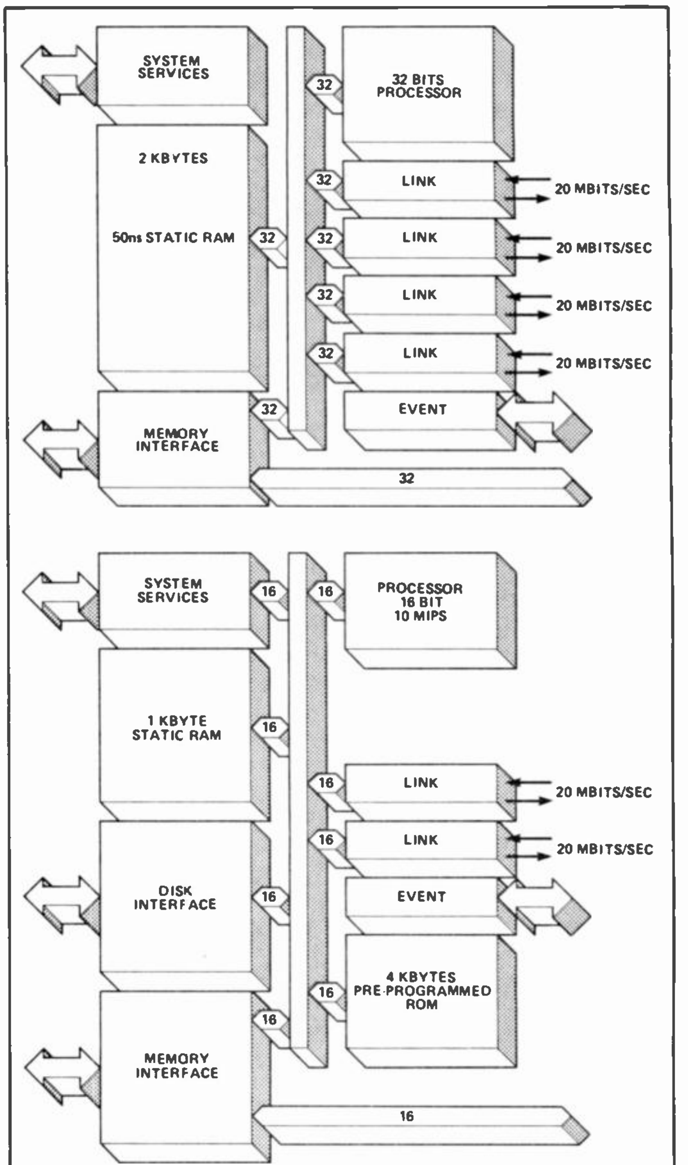


Fig. 1 Architecture of the T414 and M212 Transputers.

Special Features

The Transputer is equipped with some extremely imaginative solutions to standard 'heavy' problems associated with debugging and initialisation.

According to the logic state of a select pin, RESET either jumps to the highest map address (ROM space) or expects boot data from a hardware link. When starting in ROM, the first instruction will be a backward jump to the real program start as in a conventional system.

If the second option is selected, the first link to go active becomes the boot source and data is then accepted until a specified number of bytes has been received. These are entered sequentially in memory from the lowest free address and when all have been accepted, execution is passed to this address. This facility allows both fast debug and ROMless system operation.

While the Transputer is waiting for a boot from link, a PEEK or POKE instruction may be sent down the link and this will be performed before the wait for boot data is resumed.

On general reset register information is lost. However, the activation of an ANALYSE pin at reset time causes retention of certain critical parameters for debug purposes.

Interconnections

A support chip, the CO11 link adapter, allows the serial links to be connected to parallel interfaces. This device has two modes of operation. It can act as a memory-mapped bidirectional peripheral look-alike, for coupling to other microprocessors, or as a dual handshaked port, each half of which is reminiscent of a (fast) Centronics interface.

Transputers can be directly interconnected to each other without link adapters if they are no more than about 30cm apart, and in this configuration data transfers are effected at 20MBaud. Over long distances, each Transputer drives a local link adapter, and the long interconnection is via a parallel link between the two back-to-back adapters. The standard data rate in this configuration is 10 MBaud, but as handshake is automatic, two transputer links working at different rates can be coupled without problems. The faster link will be handshaked to intermittent byte transfer, and the overall throughput will be that of the slowest link.

The link adapters also interface to the outside world and other processor families, allowing an enormous variety of intelligent peripheral handling options.

Appraisal

The Transputers are effectively reduced instruction set processors, and as such have a phenomenal throughput for their clock rate. This, combined with the almost zero requirement for external support devices, makes them a very attractive solution for compact high performance systems.

The main current objection is one of cost. Although the chips themselves are comparatively cheap (at the time of writing they start from about £160), Occam is horrendously expensive at £10,000. This is obviously not an economic proposition unless you are programming Transputers commercially all day long. On the other hand, most conventional development systems pan out at this sort of figure, even for devices like 8086, so the transputers are by no means unrealistically priced.

Overall, I like the Transputers. All the innovative features are intensely *practical*. They form an entirely new departure in microprocessor concepts. They are essentially high level processors. That is, their hardware conforms to the constructs of high level language practice, rather than being an arbitrary configuration which requires a high level software model.

Among others, a significant outcome of this is the absence of the need for real-time executive, releasing masses of memory to the Transputers for extended user applications. The hardware timeslicing still further reduces the need for RTE, yielding maximal performance at execution time.

The Transputer code's virtual independence of hardware implementation renders extant working targets upgradeable without exensive reconfiguration. The 'it won't run on an XYX model 2' should never arise.

To sum up, it's well worth keeping in touch with Transputer developments. Although few of us will be owning or running Transputer systems for a while yet (though there is an Inmos evaluation board for the IBM PC), this is definitely the way of the future. **ETI**

SNUBBER NETWORKS

Paul Chappell makes sure his triacs go on and off on time.

Many circuits in recent issues of ETI have made use of triacs to control mains powered loads. Almost without exception these have included an innocent looking capacitor and resistor across the triac — a snubber network. The action of these components is not quite as simple as it looks. It would be worthwhile to take a close look at snubbers, beginning with some basic triac theory.

A triac can be turned on in several different ways. Applying a suitable current to the gate will do the trick, of course. Exceeding the blocking voltage will also turn it on. In fact, it is quite difficult to destroy a triac by excessive voltage since it will just begin normal conduction and not enter some destructive breakdown mode as other semiconductors often do.

A third method is to cause a sudden change of voltage across the triac. If the rate of change of voltage exceeds a critical value, the triac will turn on regardless of the fact that the voltage may be well below its rated blocking voltage (V_{DRM}).

The last two ways of triggering a triac are, generally speaking, a nuisance, and the purpose of the snubber is to prevent the triac being inadvertently turned on by them. To see why it might be so take a look at Fig. 1(a). The triac is driving an inductive load, represented by the inductor and resistor in the box. The control circuit provides current to the triacs gate to turn it on, and as usual the turn off relies on the current through the triac falling to zero. (Strictly speaking, the current must fall below the triac's holding current, which may be 50mA or so for a small device). Figure 1(b) shows the voltage across the triac and load — the mains voltage. Figure 1(c) is the current through the triac which lags behind the mains voltage because of the inductive component of the load.

At point A, suppose that the control circuit removes the gate current from the triac in the hope that it will turn off the next time the current falls to zero. At point B this is exactly what happens. However, because of the voltage present across the circuit at this time, the voltage across the triac rises very rapidly, (Fig. 1(c)) causing it to turn straight back on again! At point C, the same thing happens again, with the polarity reversed, and so it continues. The triac will never turn off.

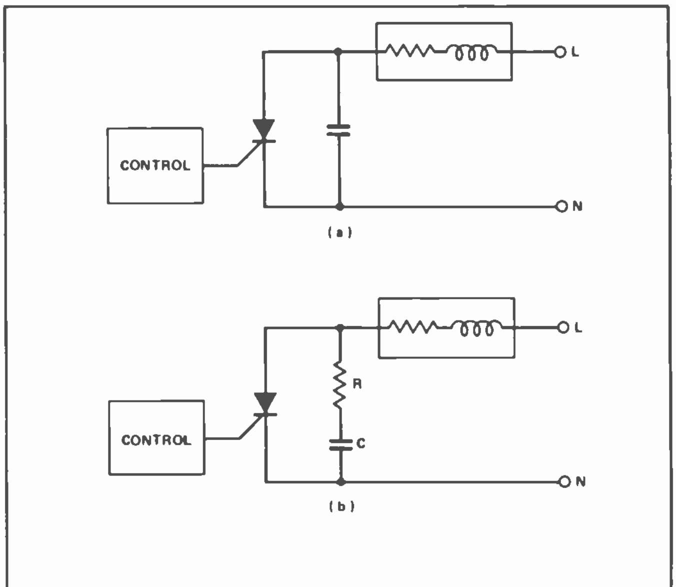


Fig. 2 Circuits to limit the voltage rise at turn off.

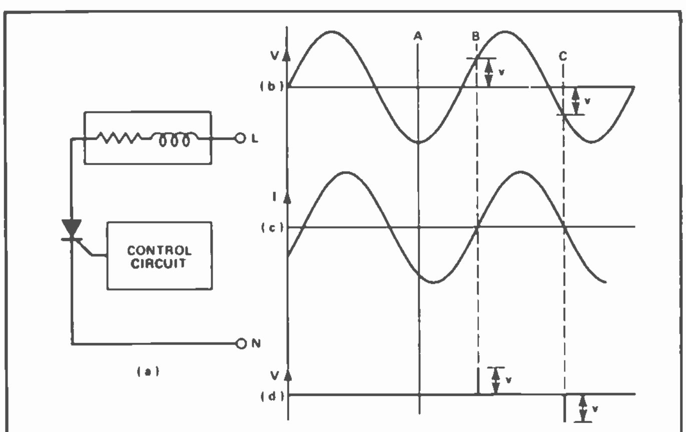


Fig. 1 Controlling an inductive load with a triac. (a) the circuit. (b) the mains voltage. (c) the current through the load. (d) the voltage across the triac.

Snubbing

Our first instinct may be to put a capacitor across the triac to prevent the sudden rise in voltage, as shown in Fig. 2(a). This won't do at all. Suppose the triac happens to turn on when the capacitor is charged to the peak mains voltage. It will be storing a considerable amount of energy which the triac will be expected to get rid of. This is an obvious point, but a fact worth noting is that at turn-on the surge current a triac can handle is very much less than the value shown in the data sheets. This has been the cause of many puzzling failures in circuits apparently designed 'by the book'.

With a resistor in series with the capacitor to limit the surge current (it also has another purpose which we'll come to later) we have the standard snubber shown in Fig. 2(b).

Surely we can relax now. After all, everybody uses that circuit and encapsulated snubbers are readily available. Well, that's OK up to a point. Unfortunately the standard values (100n in series with 100R) do not always work. If we are to be sure of finding the correct values for every eventuality, we must look a little more closely at the effect of the snubber.

At the time the triac turns off, the snubber capacitor will be completely discharged (ignoring the small on-state voltage of the triac), the inductor current will be zero (ignoring the small holding current of the triac) and the snubber and load will have a voltage v across it (Fig. 1). In this condition the combination of the load and snubber will act like an RLC circuit with a suddden voltage step applied to it.

The exact behaviour will depend on the component values but the basic tendency of the circuit is to oscillate, as shown in Fig. 3(a). If the load inductance is large and the series resistance small, the voltage v across the triac at turn off will be close to the mains peak voltage. The first cycle of oscillation will approach 2v at its peak — almost twice the peak mains voltage! Clearly a triac with a V_{DRM} of 400V will turn on again long before the voltage reaches its peak. It seems that as fast as we cure one problem, another one crops up.

Fortunately, it is possible to prevent the circuit from oscillating and thereby avoid the need for a very high voltage triac (although it's interesting to note that most industry standard triacs for mains use are rated at 600V!) Increasing the value of C reduces the initial rate of rise of voltage across the triac (which is what we set out to do in the first place) and also damps the oscillations, as shown in Fig. 3(b). Increasing the snubber resistor value damps the oscillations too, but unfortunately it increases the rate of change of voltage across the triac.

Somehow, the two values must be balanced so that the initial overshoot is kept to a value below the triac's V_{DRM} and the rate of change of voltage is also kept low. It seems a safe way to do this is to increase the value of C, which has all the desirable effects and none of the undesirable ones. But there are problems.

As you might expect, the problems with the usual snubber components arise when the load has a particularly high inductance and low resitance — a powerful solenoid or heavy duty contactor, for example. Inductances of 1H are not uncommon, and a friend recently ran into difficulties when trying to switch loads of 10H!

With inductances such as these, it is possible to find the load and snubber perilously close to resonance at 50Hz. With a 10H load a capacitor of only 1µF would do the trick. Capacitors anywhere near this value would cause all manner of problems. Even with a small enough capacitor to avoid energising the load and to prevent the voltages across the triac from reaching the point where it would turn on, there may still be enough current flowing through the snubber and load to burn out the snubber resistor.

Let's gather the pieces together and see what we can make of them. Having painted rather a black picture of the difficulties, I should say straight away that most loads will not cause any problems, and can be used with the standard component values. Problem loads are essentially those with a low resistance, and since the current will then be limited by the inductance, they will either have a high inductance or will run at a very high current. These need special attention if they are to behave themselves properly.

The general principle is that loads with low resistance and an inductance well below 1H will probably benefit from a capacitor greater than 100n to reduce the rate of voltage rise to an acceptable level.

High inductance loads require a reduced value of C. The appropriate value of R to give sufficient damping can then be calculated from the formula given below. Unfortunately, there is no formula into which numbers can be plugged to churn out suitable R and C values for any load, but with an understanding of

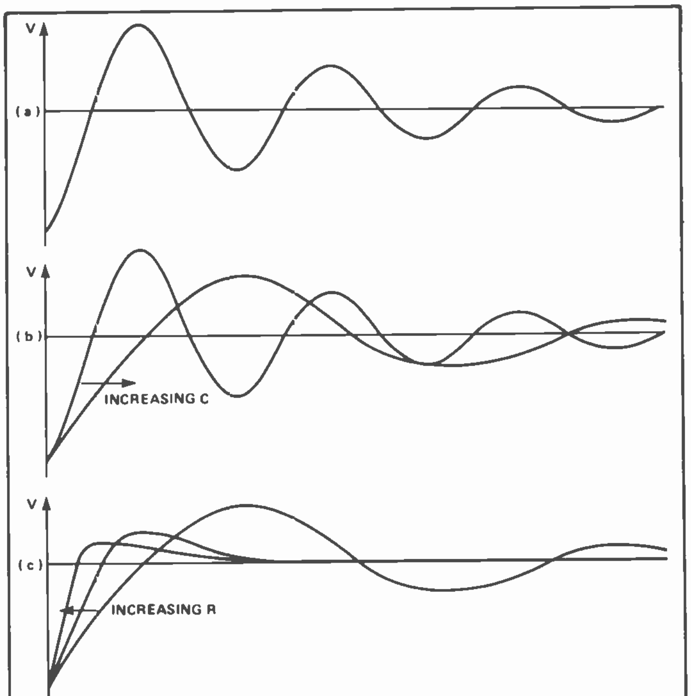


Fig. 3 The behaviour of the snubber network after turn off and the effects of altering component values.

the effects of component changes and a few 'rule of thumb' calculations you can find suitable values without difficulty.

The upper limit for the value of C is set by the need to avoid excessive current flowing through the snubber and load at mains frequency. A reasonable rule of thumb is to calculate the value of C needed for resonance at 50Hz then divide by 20 to give the highest value that should be used. For a 10H load, C should be 50n or below, for 1H it should be below 500n, and so on. The lowest value is determined by the rate of change of voltage the triac will stand. On the data sheet you will usually find this described as 'critical $\frac{dv}{dt}$' and expressed in volts per microsecond. A typical value for a small triac is 100V/µs. To find the smallest useable value of C, calculate:

$$C \text{ (in pF)} = \frac{v^2}{\left(\frac{dv}{dt}\right)^2 \times L}$$

where $\frac{dv}{dt}$ is the critical value in volts per microsecond from the data sheet, L is the inductance of the load and v is the voltage across the circuit at the time the triac turns off. If you can't measure L, estimate it on the low side to be safe. For v you can use the peak voltage of the mains. This is the absolute worst case and would be the voltage at turn off if the load was a pure inductance.

Having calculated the maximum and minimum values for C, choose a suitable value somewhere in the middle. Now you can calculate the value of R needed for critical damping:

$$R = 2\sqrt{\frac{L}{C}} - R_L$$

're R_L is the resistance of the load.

f the value you get is less than 30 ohms, use a 33R resistor to avoid turn-on current problems. If greater, add 50% to the answer you get, and use this value for R so that the circuit is over-damped.

These calculations should cope with just about any problem case, and your triacs should never fail to turn off again!

ETI

CIRCUITS ON THE SMALL SCREEN

Gareth Connor puts his BBC micro to work with four software packages for circuit and PCB design.

For some years computer aided PCB design has been available to industry, but due to the high cost it has remained well out of the reach of hobbyists and small companies. A 1983 PCB design station would not give much change out of £50,000. Its 1986 equivalent running on an IBM PC (or compatible) costs about £10,000.

However, the state of the art is such that even home computer set-ups with £1,000 worth of BBC micro, disk drive and printer can produce professional results.

Each of these software packages has been designed for a particular application. Although they are generally aimed at electronics, useage is limited only by the ingenuity of the user.

Diagram. *£25 +VAT*
Pineapple Software,
39 Brownlea Gardens, Ilford,
IG3 9NL.
Tel: 01-599 1476

This program is written for the BBC micro equipped with a disk drive. It is for the creation, storage and printing of any kind of diagram containing large amounts of information in symbolic and textual form. Although only a circuit diagram and a PCB are discussed here, the program could even be used to write sheet music!

Pineapple offers an upgrade service for all registered users to take account of changes to the software. Custom modification is also offered . . . at a price.

With a blank 80 track disk, the maximum size of a diagram is 39 screens all in mode 0 (the BBCmicro's high resolution mode). If a disk with other files is used, space is reduced to 34 screens (for 40 track disks it's 19 screens and 14 screens respectively). The user can reduce the drawing size (the number of screens used) to accomodate more than one diagram on a disk.

A drawing is created or edited a screenful at a time. A set of user-defined symbols appears at the bottom of the screen. A symbol is selected with two function keys, moved into position with the cursor keys and then 'fixed' with RETURN.

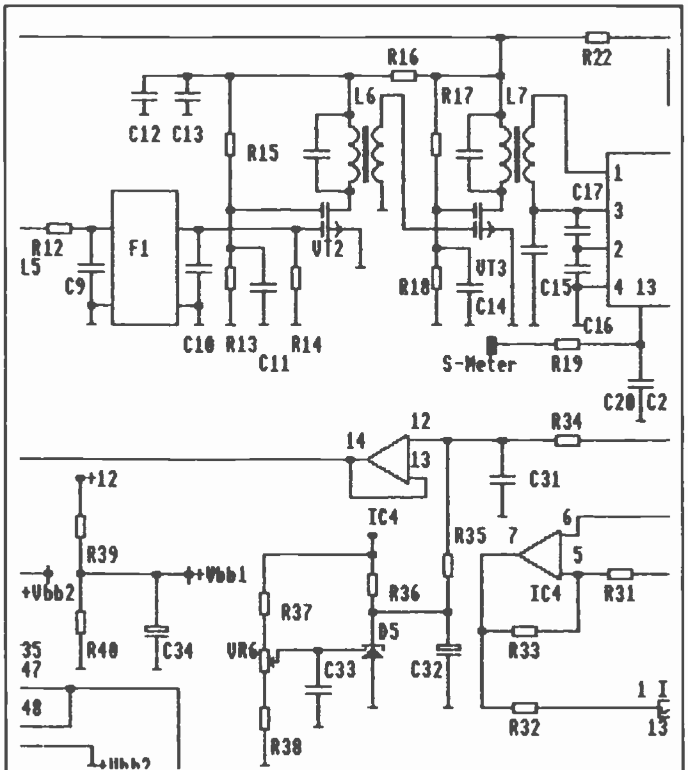


Fig. 1 Part of a Diagram diagram

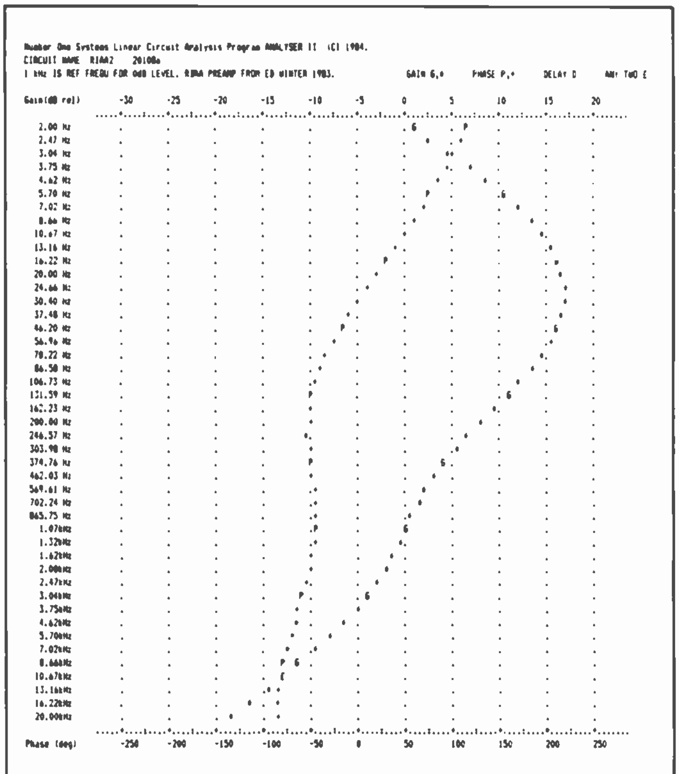


Fig. 2 The Analyser II printout for the R1AA stage.

What distinguishes Diagram from other drawing packages is that symbols can only be placed in discrete grid positions.

There are 16 symbols per set and three sets are provided by Pineapple. Even lines are made up of discrete symbols.

Each symbol consists of up to four by three BBCmicro user-definable characters. The symbols are defined in another section of the program which blows up a symbol to about eight times normal size for editing pixel by pixel. This allows neat, accurate and detailed symbols to be designed. Up to 128 characters can be held in the micro's memory, distributed among the symbols as required by the user.

Whole areas of the screen can be moved, copied or deleted. The copy function will be particularly useful for repetitive circuits. Each screenful of a diagram can then be saved to disk.

Real-time scrolling across the drawing frame is one method used to move around the diagram. If a particular item is required to be located, its reference name can be typed in (say, IC5) and the diagram will then be drawn with IC5 at the centre of the screen.

To familiarise oneself with the system there are two sample drawings, a circuit and a PCB layout. I started by loading the circuit and my initial impression was 'Wow! Just like my professional circuit capture software at work.'

Printing is on a standard dot matrix printer with single or double strike. The results are very impressive — quite suitable for most amateur, and even some professional applications.

For circuit diagrams it's hard to fault this software. If, like me, you tend to misplace or mess up drawings this is the ideal solution. It is a shame it cannot drive a plotter, but reasonably priced at just under £29, anyone wanting plotter drive capability is asking to have his cake and eat it — twice!

Analyser II. *£130 +VAT*
Number One Systems,
9a Crown Street, St. Ives,
Cambs., PE17 4EB.
Tel: (0480) 61778

Analyser II is a program for analogue circuit analysis and runs on the BBC B, B+ and Master. There is even a version for IBM PC compatibles.

Analyser II caters for circuits with up to 27 nodes (30 under certain circumstances), and 100 components. Analysis of Input impedance, output impedance, gain (frequency response), group delay and phase are possible. Results are presented in tabular and graphic form and can be printed out. In auto run mode, the computer and printer can be left to do the job while you do other things — a useful time saver. Resistors, capacitors, inductors, transformers, op-amps, bipolar and field effect transistors can all be analysed.

Each of the three semiconductor types has a library of six devices whose parameters can be user defined and the definitions stored on disk.

After parameter editing the main program starts with a menu of nine options. 'Start a new circuit' prompts for a circuit name which becomes the file name on disk. Component values can now be entered. A 4,700 ohm resistor can be entered as 4k7, 4K7, 4700, 4.7E3, 0.0047M or M0047. After entry, the values are returned for checking in exponential form, so it is important you know and fully realise the meaning of E!

Analysis can now begin and the system asks for the number of steps (less than 46) at log or linear intervals, start frequency and end frequency. The start default is 1Hz, the end default is 1MHz. Higher and lower frequencies can be specified. A second five part gain menu is offered: dB absolute, dB relative, linear absolute, linear relative, real and imaginary. When analysing impedance, gain is replaced by Zin or Zout.

The results may be printed and a comment (for identification and reference) can be added to appear on the graph. Typing RETURN to any prompt will re-use the previous entry.

An automatic run allows the results to be calculated and a graph to be printed without the system being attended to. The graph plotter utility is sophisticated and scaling calculations are done automatically to create sensible results.

Several examples are given which can be modified to show different results. These are useful for gaining familiarity and confidence with the program. The circuit I tested was a phono pre-amplifier from the February 1982 issue of ETI. After sorting out my E's I was able to get results that show the chosen component values conform very closely to the RIAA curve and prove Analyser II knows its job.

For anyone involved in analogue circuit design from AF to RF this is a very useful tool for proving circuits before going on to hardware prototyping. It is also a sight cheaper than a spectrum analyser and a storage 'scope! The number of nodes and components should prove more than adequate for most applications.

PCB Plotting. *£20*
Vinderen Associates, PO Box 130,
Belfast, BT9 6NB.

From the start my experience with this package has been one of frustration. I agree with the opening to the introduction: 'This program is aimed at the experimenter who needs a simple aid to develop small PCB layouts.' The instruction leaflet says enough to enable a

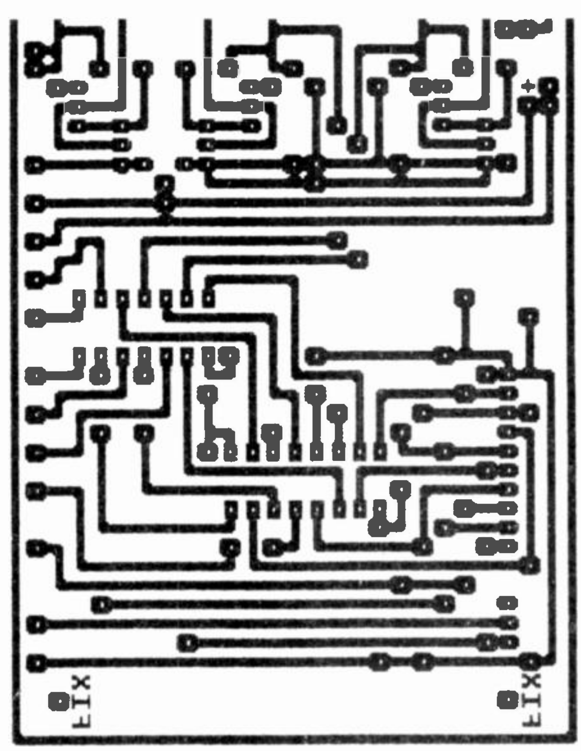


Fig. 3 Part of a PCB Plotting printout.

PCB to be laid out and a component overlay to be created, but is lacking in detailed information on obtaining a printout on a dot matrix printer.

However, there are two very important points in this program's favour. It has plotter drive capability and the tracks can be swapped from side to side of a double-sided board.

The photocopy of the '6809 Mini' board supplied with the package shows the program is capable of a very good finish when used with a plotter. Vinderen advise the Watford Electronics 'Dumpout' ROM to be used for dot matrix printouts. I duly obtained one of these. It is an excellent piece of software but I was faced with a detailed manual and no idea of where to start. It would be to Vinderen's advantage to include a guide to the use of Dumpout for this particular application.

The component overlay cannot be superimposed on the track layout, which makes following a circuit while tracking difficult. The limit of 40 'free' pads that can be placed anywhere is also rather restrictive.

From the educational side, say introducing students to CAD and its application in PCB layout, this program makes a useful guide. Experimenters with time on their hands and who are not very neat with drafting pens or PCB transfers will also find this a good package.

However, for serious layouts or quick turn-around I must give it the thumbs-down. Vinderen has the basis of a good, reasonably priced program, but it is lacking in detailed guidance.

PCB. *£85 +VAT*
Pineapple Software,
39 Brownlea Gardens,
Ilford, IG3 9NL
Tel: 01-599 1476

Like the other programs in this review, PCB requires a BBC micro with a disk drive. However, the software is on ROM. This frees large amounts of memory for the storage of working data. An example PCB is supplied on the disk and both 40 and 80 track formats are catered for.

As with Diagram, Pineapple offers an update service to all registered PCB users. Further improvements are being worked on all the time so this is worthwhile.

The largest size of PCB accommodated is 8.0in x 5.6in (full size). The whole PCB fits onto the screen. If larger boards are required, they can be designed in sections and joined after printing. Unfortunately no scrolling arrangement, as used in Diagram, is provided. A board can contain up to 500 components and 500 ASCII strings.

Printout is on a dot matrix printer and operates in a quad density, three-pass mode. Resolution is about six times that of the screen display. Printouts can be scaled at 1:1 or 2:1. At both scales diagonals are smooth and where tracks pass between IC pads suitable clearance is automatically ensured. The component layout can be printed at 1:1 or 2:1, so can be used for the making of screen printed component labels for commercial applications. However, when this is done a little touching-up is required for a perfect finish.

A sample PCB is provided on a write-protected disk for experimentation. My one complaint about the presentation is that no instructions were given to copy the disk so as not to over-write anything useful. This solved, I proceeded to explore what is a really good and useful program.

The set of components provided is basic, but very flexible. The basic 14 pin IC can be varied in size, both in pin count and pitch between rows, so any size of IC can be created. The same applies to the resistor, which is represented by a box with two legs. It can, of course, be used to represent any two leg component and its ASCII label changed to define it as a capacitor, resistor, link or whatever.

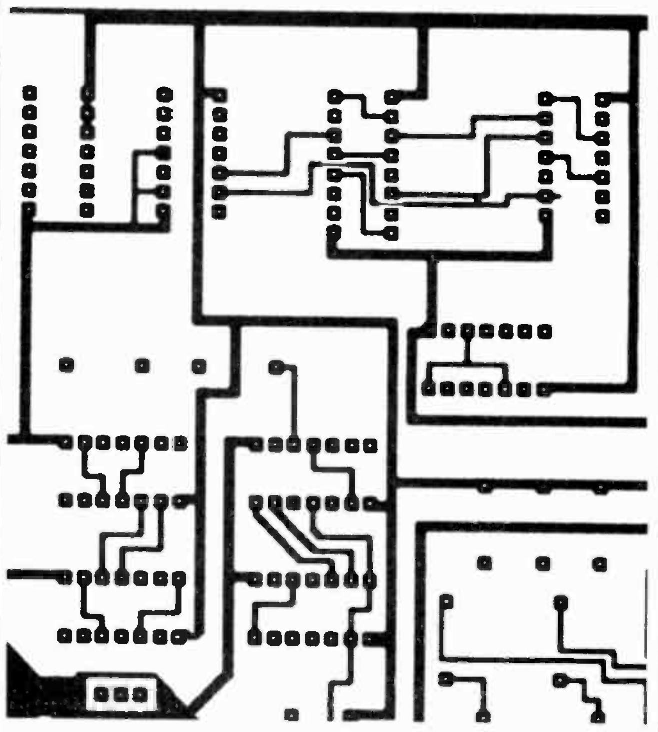


Fig. 4 Part of a PCB from Pineapple's program.

Transistors and other circular components must be constructed by the user with the circle drawing routine. Perhaps a sign of the times that the chip is king! Components such as connectors consisting of rows of pads can also be produced very easily by changing the 'size' of a single pad.

The component and solder sides of a double-sided board can be displayed separately or together. Superimposition of the component layout on the track layout is great for getting the whole picture but naturally a bit crowded.

To delete incorrect tracks a flood fill in the background colour is used. For this the cursor must be accurately positioned on the track — not an easy task. Ground planes and other areas of copper are produced in the same way, using a foreground colour.

An area can be defined for printing, deleting or copying. Screen memory is used and this makes copying virtually instantaneous.

To really appreciate this software it must be tried. I had never seriously considered using a BBC micro for quality PCB design until now. As Pineapple admit there is room for improvement, but the present results are good and accurate. I printed at 1:1 and 2:1 and inspected the results on a grid. Across the printer carriage accuracy was almost perfect. Lengthways, both scales showed some slight creep, but not enough to cause worry for most users.

Pineapple's PCB is highly recommended and good value for money at around £100. It compares well with software that costs ten times as much. The results are professionally acceptable and this package will be at home in a small company as well as with hobbyists. Pineapple is working on auto-routing of tracks at the moment. When that's complete the BBC micro will be hard to beat for the electronics hobbyist.

ETI

M&A SERIES FOUR MIXER KIT

Ian Pitt takes a look at an old friend in an (almost) new guise.

It must come as a bit of a surprise to see ETI reviewing a product which has already been on sale for five years. The Series 4, a budget-priced modular mixer with studio-style facilities, is so well established that M&A is starting to make noises about a Series 5 (of which more later). So why review it now?

The answer is contained in that word kit. Until recently, the Series 4 was officially available only in its ready-built form. It was a modular system, allowing purchasers to start with a minimum of channels and add more as finances allowed, but the modules were sold (and charged for) as factory built units.

Now, with the increasing popularity of home studios and the consequent demand for good-quality equipment at rock bottom prices, M&A has moved firmly into the kits market and is aiming to provide a comprehensive service to small studio owners. In addition to supplying kits, individual parts or even just the plans for the Series 4 mixer, the company provides guidance to users who wish to develop their own add-ons or modifications and will advertise such designs in its advertising literature. Parts and service back-up is still available on mixers built from the kits and M&A also supply a range of cheaply-produced but well illustrated guides which introduce the new mixer owner to recording studio techniques, MIDI, and much else.

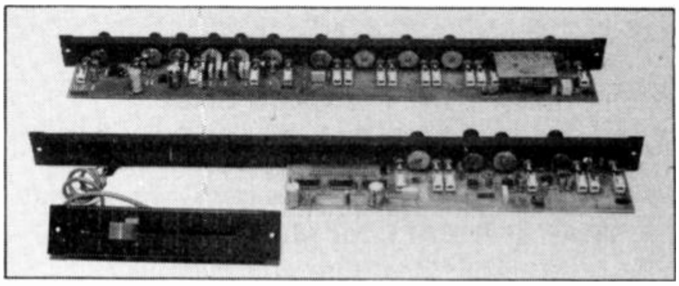
The mixer itself is assembled from three basic module types and can be built in any configuration up to 50-16-2. It features electronically balanced inputs which are switchable for microphone or line level, LED VU indicators and comprehensive routing and signal path facilities. The individual channel faders are 100mm types and the input and output sockets can either be fitted to the back of the case or provided in the form of a patch bay at one side. M&A supplies ready-built cases or can provide plans so that users can build their own.

The input module features variable input gain, LED indication of peak signal level, a five-band equaliser, four auxiliary signal sends and a stereo pan pot. A channel-cut switch allows the channel to be isolated from the mixing busses and there is also a pre-fade monitor, both of these being equipped with LEDs to remind the user that they have been selected.

The second type of module is the sub-group which takes its feed from one of the mixing busses and provides a line output (to feed a multi-track tape machine) and separate monitor and auxiliary outputs. An LED bargraph display monitors the mixing bus or line input level and can be set to give either peak or VU indication.

The final main module is the recording master unit, one of which is required in every Series 4 mixer. It provides the output buffers for the four auxiliary channels plus the left and right master stereo outputs, a pair of bargraph LED displays and a pair of monitor outputs.

In addition to the main modules there are also a number of special types available such as a dual



equaliser and a communications unit, plus blank panels and various other accessories. M&A can also supply a suitable PSU with overload and short-circuit protection which is capable of driving a full complement of Series 4 modules.

Cue The Review

A sub-group module was chosen for the kit review. As supplied, it included a screen-printed front panel, a separate fader panel already wired, a PCB, a set of instructions with circuit diagram, overlay, etc, and several polythene bags containing the components. The small amount of connecting wire needed was also supplied, leaving the constructor to provide only the solder and the tools.

The components in the kit were of good but not excessively high quality and 741 op-amps were supplied for all the audio stages (the only exception is the microphone stage on the input module where a 4558 dual op-amp is used). Those who want to use higher quality op-amps and are prepared to pay the extra can purchase a kit without the 741s.

The instruction sheets reflect the budget nature of the kit in that they are photocopied and the typeset directions are supplemented by handwritten notes. The 'small is beautiful' approach is also reflected in a rather folksy style of presentation which includes cartoons of Peter Kunzler (owner of M&A) and assorted 'studio types' demonstrating various aspects of the mixer's operation. Thankfully, none of this detracts from the legibility of either the text or the illustrations.

In spite of this overtly 'user friendly' approach, the kit is obviously not aimed at beginners. The instructions recommend a sequence for the insertion of the components and describe the various assembly and connection routines, but the individual components are not identified in any way and there is no mention of the soldering process. In short, the kit is fine for anyone with experience of electronics construction but perhaps not for musicians unless they are very technically-inclined.

My only real complaint about the literature is that the component overlay is not shown against the PCB track pattern. In practice, most component locations were perfectly clear, but once or twice I installed components only to find later that I had used a hole belonging to another component. I spoke to M&A about this and was told that future versions of the kit will probably include a PCB which is screen printed with the component numbers.

These hiccups aside, the kit went together without problems and worked perfectly when tested with a bench power supply and a signal generator. It wasn't practical to make any detailed tests or measurements in this way, and in any case the results obtained from a single module would give little indication of the performance to be expected from a complete mixer.

Trying Wolf

For the second part of the review I went to the Wolf Studio in Brixton to see a Series 4 mixer in action. The studio was set up about three years ago by Dominique Brethes and featured a 16:16:2 version of the Series 4. Since then a 24-track tape recorder has been installed, an Aces MT24HS, and the mixer has been expanded to suit.

Most of the recordings made at Wolf Studio are of electronic music and the mixer is usually fed via its line inputs from a collection of synthesisers and electronic keyboards. A few channels are set aside for microphone use and patched through to a separate room where they can be used for vocals or to record an acoustic piano. The microphones include a Neumann U87 and several elderly AKG C28s with valve preamplifiers. Mindful of all those 741s in the mixer, I asked if noise was a problem. Dominique told me that it had to be taken into account when using the C28s but was not significant with the U87, suggesting that the mixer itself was not particularly noisy.

Another point of possible concern was the quality of the slider faders. The giants of the recording industry often find it necessary to equip their mixers with conductive plastic faders costing £30-40 or more each, whereas the Series 4 uses Japanese-made Alps potentiometers which cost barely a tenth of that sum.

In reality, the difference is not as great as might be expected. Alps potentiometers offer a surprisingly high level of performance for their price, as certain ETI writers have pointed out in the past, and while they lack some of the silky feel of top-grade sliders they remain pleasant to use and are very robust. Dominque could not recall a single fader problem during the studio's period of operation, even though the mixer is usually operated solidly for some 7-8 hours a day.

The only parts of the mixer Wolf Studio has had any problems with are the PCB connectors which link each module to the mixing buss. Several of these have become noisy at some time and needed attention. A permanent solution, Dominique suggests, would be to do away with the connectors and solder the ribbon cable directly to each module. In practice, the problem has not been sufficiently annoying to warrant such a modification.

In this and countless other matters, Dominique is quick to praise the level of support he has received from M&A. Advice on modifications and matching to other equipment has been freely given and there have been no difficulties with spares or servicing, an important consideration where a piece of equipment forms the heart of a commercial operation.

There was no initial recording work underway on the day I visited Wolf Studio so I had to be content with listening to a multitrack recording made some time earlier. The piece, a song with backing tracks compiled entirely on electronic instruments, was destined for commercial release in France and had come to the studio for mix-down. Watching Dominique at work, I asked how much longer he expected to be using the Series 4. It was still a budget mixer however good it might be. Did he hope to move on to something better soon?

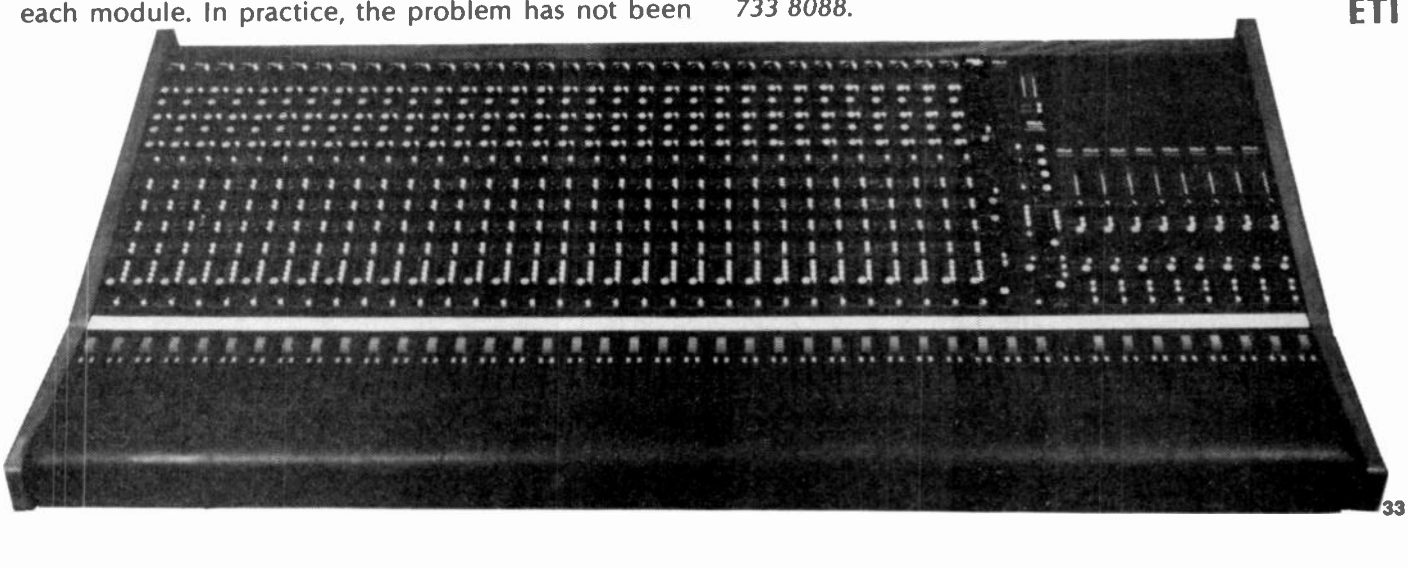
He replied by directing my attention back to the music pouring from the studio's monitor system. This was work of good commercial quaility, he felt, and the mixer in no way limited his ability to handle such recordings. There might come a time when the studio's requirements outgrew the Series 4, but that point was a long way off. For the forseeable future he expected to continue using it, with upgrades if necessary to suit changing requirements.

Which brings us to the future of the Series 4 design itself. M&A is now talking about its successor, the Series 5. That too will be a modular design available in kit form, and for obvious reasons the basic format will remain unchanged. New owners will enjoy such benefits as MIDI control facilities and optional automation while existing owners will find the life of their equipment extended and the scope for improvement significantly increased. If M&A have their way, it seems, the Series 4 and its successors are going to be with us for some time.

Prices: input module with fader assembly, £55.00 in kit form, £75.00 ready built; sub-group module with fader assembly, prices as for input module; master module with fader assembly (specify recording or PA module as required), £98.00 ready built (no kit available); Ultra-low ripple power supply, 15-0-15V 7A, £109.67 ready built (no kit available). Cases with mahogany end panels and padded arm-rest, approximately £7.00 per channel. Full set of Series 4 circuit diagrams, £9.50. All prices include VAT. Other prices on application. K-Tek PO Box 172A, Surbiton, Surrey KT6 6HN, Tel 01-399 3990.

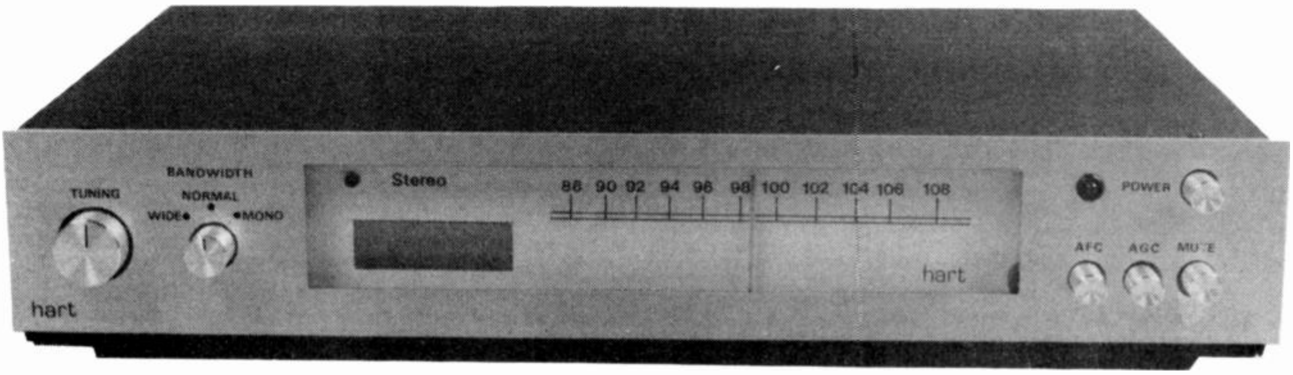
Our thanks to Dominique Brethes of Wolf Studio, 8 Homer House, Rushcroft Road, London SW2 1JT, Tel 01-733 8088.

ETI



PLL FM TUNER

John Linsley Hood describes an FM tuner using a phase-locked loop demodulator arrangement, to accompany last month's stereo decoder circuit.



I have long felt that the phase locked loop (PLL) is by far the best way of demodulating an FM signal and I have been both surprised and saddened at the way designers of commercial units have neglected this technique. It is especially curious when one sees the lengths to which they go in order to get a little bit lower distortion, or a slightly higher capture ratio — all benefits which are easily obtained with a PLL.

Most contemporary FM tuners use a demodulator circuit of the type shown in Fig. 1. In this the 10.7MHz IF signal is fed from a wide bandwidth amplitude limited amplifier (A1) to a phase detector, (PD1), for which a second input (reference or quadrature) is derived from an ancillary quadrature coil assembly (L2C3).

This quadrature coil circuit is usually driven from a second output point on the limiting amplifier through a small coupling capacitor, C1, or perhaps through an inductor having a similar RF impedance, and is tuned to the mid-point of the 10.7MHz tuning range. The idea is that the phase of the reference input at point A will alter relative to the main signal input as the frequency moves up and down, and will cause the phase detector to give a varying voltage output.

The use of a second, inductively-coupled tuned circuit (L1, C2) added to the quadrature coil helps make the phase/frequency relationship of this circuit more linear, and this improved layout is widely used in the better FM receivers.

There are several snags with this quadrature coil arrangement. The principal one is that the phase of the incoming signal is shifted, as a function of frequency, by non-ideal characteristics in the RF or IF tuned circuits or ceramic filters in the preceding amplifier stages. These phase shifts will cause distortions of the audio output signal because the phase detector cannot distinguish them from actual frequency shifts.

Minimizing these unwanted RF/IF phase shifts is a costly business, which is why tuners with a very low THD figure tend to be very costly.

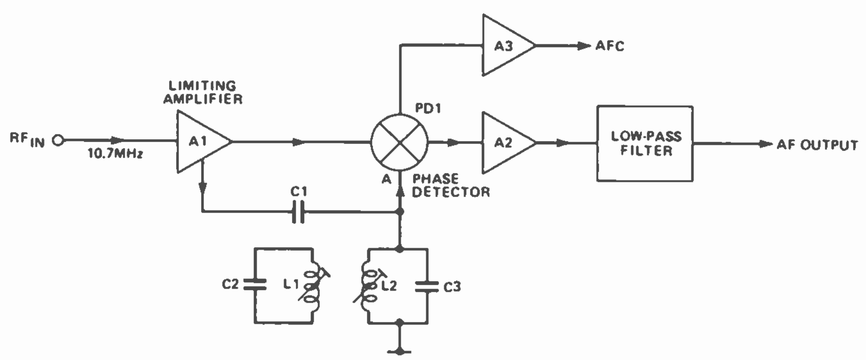


Fig. 1 The quadrature coil demodulator arrangement used in most modern FM receivers.

The PLL Demodulator

This system (shown in Fig. 2) operates by forcing a voltage controlled oscillator to operate in phase and frequency synchronism with the incoming signal — a condition in which the loop is said to be 'in lock'.

If the output frequency of the VCO has a linear relationship with the input control voltage (and with good design this relationship can be very linear indeed) the VCO control voltage will vary with the incoming frequency. The result is an accurate replica of the variations in the incoming frequency — and inadvertent phase errors in the incoming IF signal will largely be ignored.

To make such a system work, the VCO must be tuned so that its natural oscillation frequency (the frequency at which the filtered DC control signal from the phase detector is at its mean potential) is close in frequency to that of the incoming signal. There must also be sufficient gain in the control loop to make it keep in step as the incoming frequency alters.

There will also be a low-pass filter included in the loop to prevent the VCO from chasing its own tail, and it is essential that this

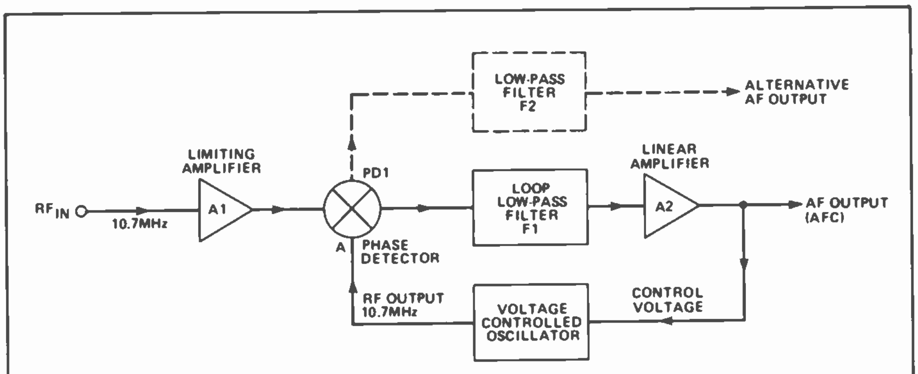


Fig. 2 Basic arrangement of a phase locked loop (PLL) FM demculator.

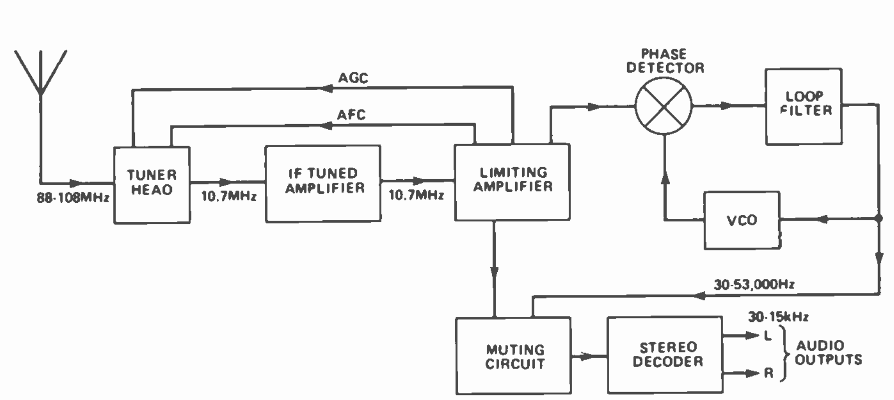


Fig. 3 Block diagram of an FM receiver using a PLL demodulator.

has the correct characteristics to stabilise the loop without restricting its ability to follow fast modulation shifts in the incoming signal frequency. Provided this is done, the control signal fed to the VCO will be an accurate replica of the original signal modulation.

As an alternative, it is possible to take a separate output from the phase detector and give it similar filtration to that of the control loop, thus retaining the quality of the AF signal output but reducing the risk of interfering with the loop operation. This is the layout which I prefer.

Other advantages which the PLL system offers are a very high 'capture ratio' (the ability to reject a slightly weaker interfering signal on the same frequency) and a remarkable ability to extract weak signals from the general background noise. A further useful quality is that the PLL has its own 'selectivity', adjustable by means of the loop gain and quite independent of that of the IF stage. This makes the performance of the receiver(for example, the stereo channel separation) less dependent on the IF stage characteristics, which is useful.

There are, of course, snags — otherwise everybody would use PLLs instead of the technically inferior alternatives. Happily, these snags can be removed by attention to the design and I will refer to this later.

The PLL FM Receiver

Apart from the demodulator stage, the circuit layout of a PLL receiver will be very similar to that of more conventional designs, with a form generally as shown in Fig. 3.

If one of the highly-developed modern FM ICs, such as the RCA CA3189, is used for the limiting IF amplifier and phase detector stages, this can also provide automatic gain control (AGC) and frequency control (AFC) signals to the head amplifier. In addition, since the 3089/3189 ICs are by far the most popular among the commercial circuit designers it is possible that the head amplifier unit will have been designed to suit them which saves a lot of work. The major tasks which then remain are to arrange an adequately linear VCO and to marry this to the 3189.

Two general alternatives exist for a VCO circuit which will operate at the required frequency: an LC tuned circuit system, whose frequency can be adjusted by, say, a varicap diode, or some form of multivibrator. The first of these alternatives gives a pure sinewave output and low noise but it is difficult to get a high degree of linearity since, left to itself, the varicap diode has a highly non-linear capacitance/voltage relationship. This is shown in Fig. 4a.

On the other hand, although it is possible to design multivibrator systems whose operating frequency can be varied by an input control voltage and which have a high degree of linearity in the relationship between output frequency and input control voltage, such circuits usually have the snag that their frequency will drift with changes in temperature. This will spoil the distortion performance of the receiver at the moment of switch-on, before things have settled down. Unfortunately, the problem becomes worse at higher frequencies, and at 10.7MHz it can be a major embarrassment.

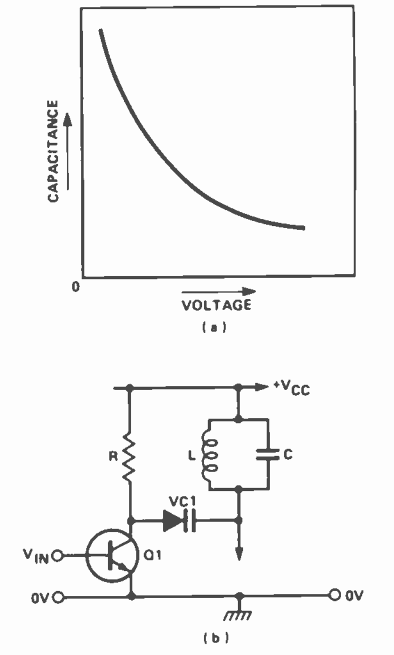


Fig. 4 (a) The capacitance/voltage characteristic of a varicap diode and (b), a circuit in which the non-linear collector current/base voltage characteristic of a silicon transistor is used to balance out the non-linearity in the varicap diode characteristic.

Happily, a technique exists for linearising the voltage/frequency characteristics of a varicap tuned circuit (Fig. 4b). The curvature in the way in which the collector current of a silicon transistor varies as the base voltage is increased is balanced against the varicap diode voltage/frequency non-linearities, and if the correct value of R is used for the transistor and varicap diode chosen the overall linearity can be very good.

A practical VCO circuit layout is shown in Fig. 5 and the excellent linearity of the voltage/frequency relationship is shown in Fig. 6.

In this circuit Q17 is an input emitter follower which provides the necessary low impedance drive to Q18, and a PNP/NPN pair layout is used for Q17/Q18 to cancel the offset of the base-emitter voltages which would otherwise be affected by ambient temperatures.

Q19 is a conventional grounded-base Colpitts oscillator and the HF output signal is taken from the emitter which is a low impedance point. RV4 is used to set the HF output level.

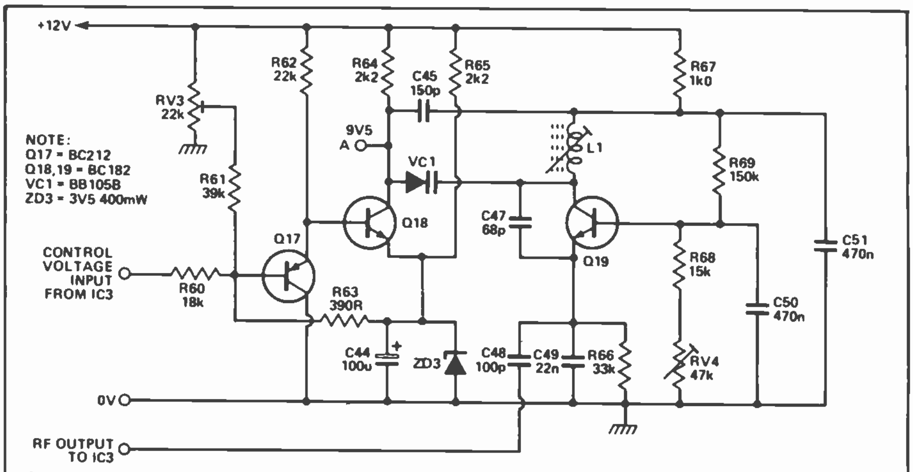


Fig. 5 A practical voltage controlled oscillator circuit using the arrangement of Fig. 4 b to achieve linearity with a varicap diode. Note that the component numbering used here and in Figs. 8, 9, 11 and 12 follows on from the numbering used in last month's stereo decoder circuit.

The Need For Signal Muting

If the voltage/frequency relationship of the VCO is a linear one, the control voltage will alter linearly with input frequency as I have shown in Fig. 7. However, beyond certain frequency limits above or below the frequency to which the VCO is tuned, the loop will lose lock. The width of this frequency band is known as the lock or capture range.

This illustrates the basic problem of the PLL when used as an FM demodulator. If a frequency modulated signal, as at A, B or C in Fig. 7, is presented to the PLL while it is at the centre of the lock range (position B) all will be well and the incoming signal will be accurately demodulated. However, if the signal is at positions A or C then, as the signal swings up and down in frequency, the loop will jump into and out of lock with quite large swings in the output signal voltage.

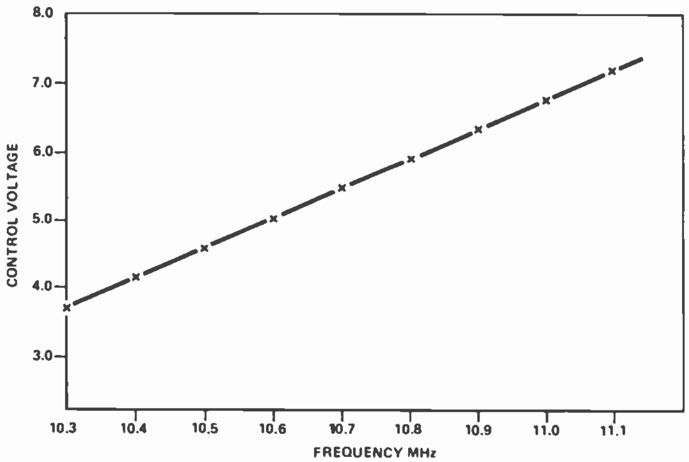


Fig. 6 The control voltage/frequency characteristic of the circuit shown in Fig. 5.

This would be heard as loud and unpleasant rasping noises as the receiver was tuned into and away from a station. I suppose this is the principal difficulty which has militated against the use of the PLL in the collective view of the tuner designers.

The solution is to ensure that the loop capture range is wider than the IF bandwidth so that the signal is pretty small by the time the loop is about to lose lock. A good quality 'muting' system can then be used to disconnect the AF output circuit when the signal strength at the loop input falls below some predetermined value.

With this improvement, the behaviour of the PLL receiver from the listener's point of view is quite impeccable with silence in the gaps between clean, low distortion received signals.

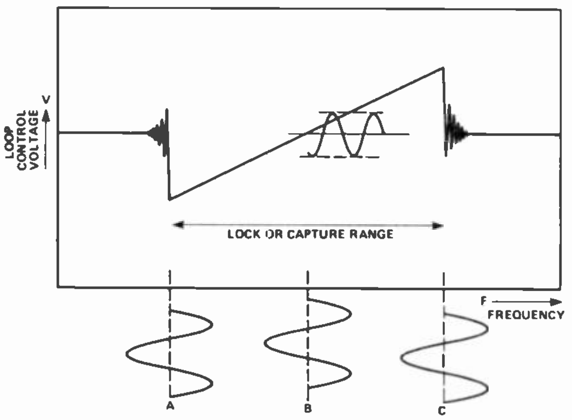


Fig. 7 The control voltage/frequency characteristic is linear only over a certain range and above and below these limits the loop will fail to lock. Signals with a frequency at the limits of the range (A and C) will cause the circuit to swing in and out of lock.

Considering the separate circuit building blocks shown in Fig. 3, I have opted to use a commercially available tuner head unit. There are quite a number of these available, differing in price and specification but all offering a 10.7MHz IF output.

There is no particular reason why this PLL tuner design should not be built using any head unit available to the constructor.

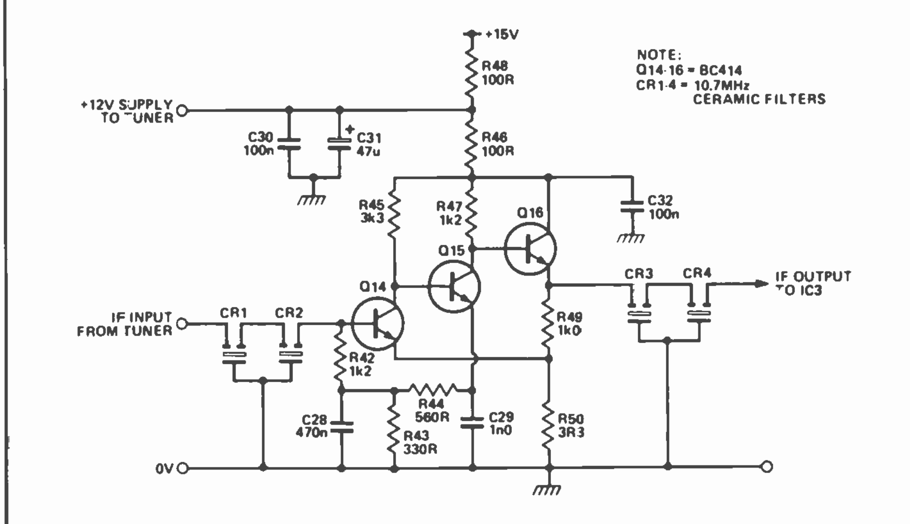


Fig. 8 The 10.7MHz selective IF amplifier circuit.

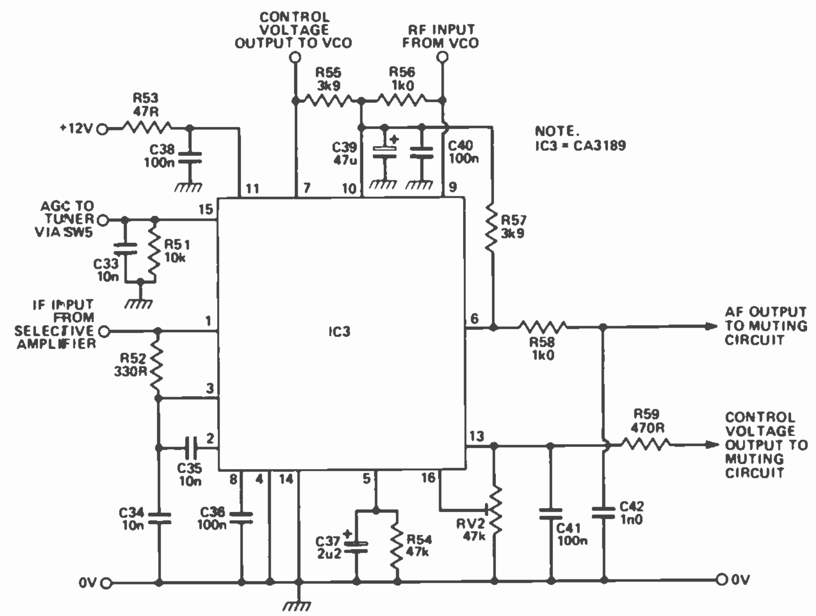


Fig. 9 The circuitry around the CA3189.

However, for the prototype I chose the ALPS FF317U which is a well-designed and sensitive unit, readily available at a reasonable price. This is a variable capacitor tuned unit, avoiding the need to apply thermal compensation to the tuning voltages which would be needed in a varicap tuned unit.

It also has the practical advantage that it is designed to work in harness with the 3189 demodulator IC, so both the AGC and AFC voltages from the IC are suitable for this tuner head. Additionally, as is becoming a fairly common feature with such tuner heads, the IF output impedance is 300 ohms which means it can be directly connected to the input ceramic filter of the tuned IF amplifier.

In order to exploit the high sensitivity of the PLL, which is helped by the characteristics of the 3189, I have used a high gain, three transistor IF amplifier using two pairs of cascaded 10.7MHZ ceramic filters. The complete IF amplifier circuit is shown in Fig. 8 and is based on a wide bandwidth, gain stabilised layout derived from the old valve-type 'ring of three' circuit which has excellent characteristics. Moreover, the performance is not particularly affected by the transistor types used so although I have specified BC414s as a good, modern, low noise type, BC184s would work just as well.

The ceramic 'ladder filters' are a convenient and compact way of obtaining selectivity but they have the disadvantage that they introduce a substantial degree of attenuation from input to output when compared with a tuned circuit. Typically, a single filter element will lead to a signal loss of 3x. Two, in series, will increase this insertion loss to 5x. If, therefore, two pairs are used, the total signal loss through the filters will be 25x.

The design value for the overall stage gain of the 10.7MHz amplifier of Fig. 8 is 14x, so the stage gain from Q14 to Q16 needs to be 350x. This is set by the feedback resistors R49 and R50. All of the resistors should be reasonably non-inductive, which rules out a wire-wound component for R50.

The tuner head IF output impedance is 300 ohms and since this is the required input/output impedance for the ceramic filters the IF output from the tuner head can be taken directly to CR1.

The circuit connections to the CA 3189 (Fig. 9) are much as recommended by the makers, except where circuit modifications are needed to make it operate within a PLL. There is not space here to discuss in detail the internal circuitry of the 3189, which is an ingenious and carefully designed component. However, in simple terms the input to the limiting amplifier is at pin 1 and the DC bias for this is taken from pin 3. An AGC signal is available from pin 15, which sits at about +6V until the input signal exceeds a value determined by the setting of RV2.

Two audio output points are provided. One is taken from pin 6 and can be controlled by an internal deviation muting circuit, while the other is taken from pin 7 and cannot. I have chosen to use the pin 6 output for the audio signal and that from pin 7 (normally used to operate a centre zero tuning meter and AGC circuitry) as the control voltage output to the PLL.

Since I am using a high quality external muting circuit, I have disabled the muting level control for which pin 5 is provided.

The Muting Circuit

As I mentioned earlier, the ability to use a phase locked loop system to demodulate an incoming FM signal (as distinct from the ubiquitous PLL circuit used in the stereo decoder) depends entirely on the designer's ability to suppress the nasty noises which would otherwise occur on tuning the receiver into and away from a station.

The method I have used for this

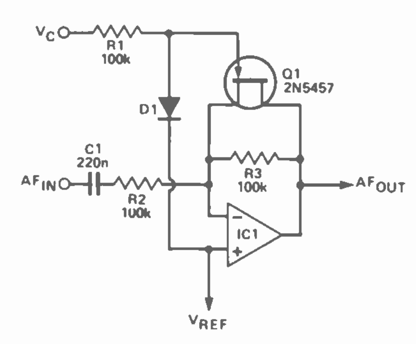
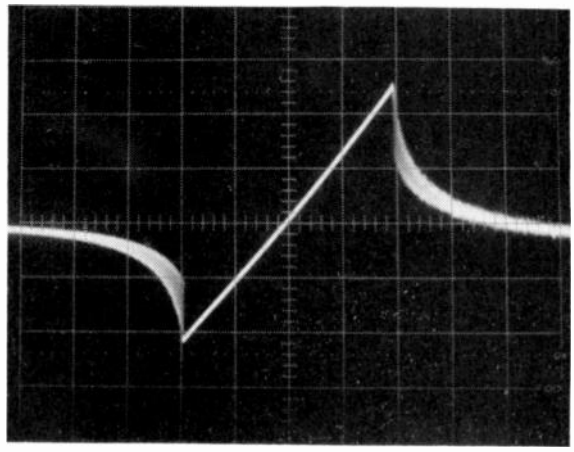


Fig. 10 A simple FET muting circuit.

Oscillogram showing a linear change of voltage at the audio output of the receiver as an RF input signal is swept in frequency from 95.2 - 95.6MHz. The horizontal scale represents 10kHz/ division and the vertical scale is set at 300mV/ division.



is shown in simplified form in Fig. 10. A good quality, low distortion op-amp (such as an LF351/3 or a TL071/2 is connected as a unity gain inverting amplifier. I am satisfied that even the most critical audiophile will not fault such an op-amp in unity gain mode. A junction FET (Q1) is then connected across the feedback resistor. When this is conducting the gain of the stage is very nearly zero and any distortion due to the non-linearity of the FET is irrelevant.

If the FET is biased off it becomes an extremely high impedance indeed and, again, there is no significant effect due to its connection across R3. The diode D1 is included to prevent the FET gate from being biased into conduction, which would disturb the DC output level from the op-amp.

This circuit is incorporated, in practical form, in the muting stage shown in Fig. 11. In this, the output voltage for the signal strength meter from pin 13 of the 3189 (which varies from about 0.8V to between 3 and 4V) is taken to one half of a dual op-amp which converts it to a +14 to +1V swing from noise threshold to signal levels.

Since the TL071/72 does not include 0V as a permissible input level when run from a single supply line, Q20, D1 and R72 are used as a DC level shifting network. The preset (RV5) is used to set the level at which IC4a output swings from +14 to +1V, to convert the FET (Q21) from its short circuit to its open circuit condition.

The muting circuit can be disabled by SW3, which biases the FET (Q21) into an open circuit state under all signal conditions. The audio output from the tuner is taken from the output of IC4b to the stereo decoder circuit described last month.

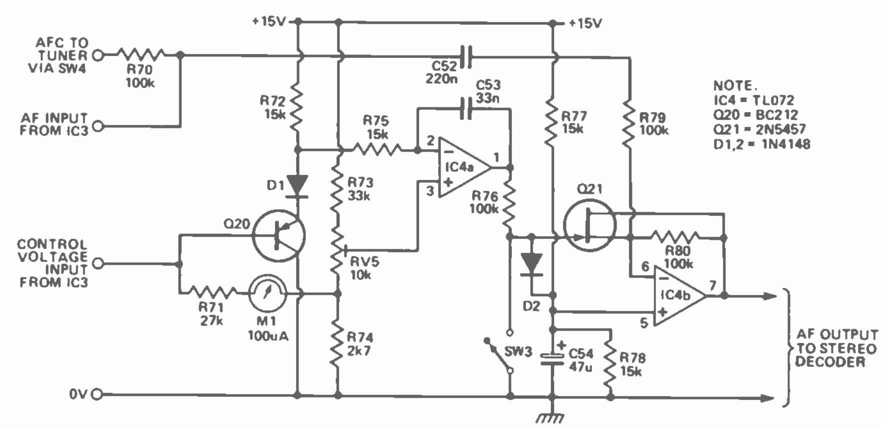


Fig. 11 A practical muting circuit incorporating the FET arrangement of Fig. 9.

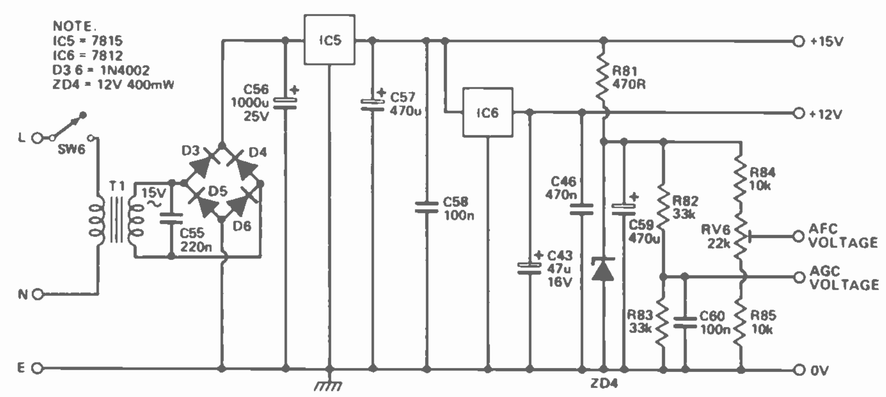


Fig. 12 Circuit of the power supply.

AFC And AGC Connections

The output voltage at pin 6 of the 3189 normally sits at about 5–6V under no signal conditions and will swing up and down by about ±1V on tuning through a signal. This can be used as an AFC signal to the head but there should be no shift of tuned position when the AFC is switched in. This is achieved by using RV6 (Fig. 12). To preset the same voltage level as that from the 3189.

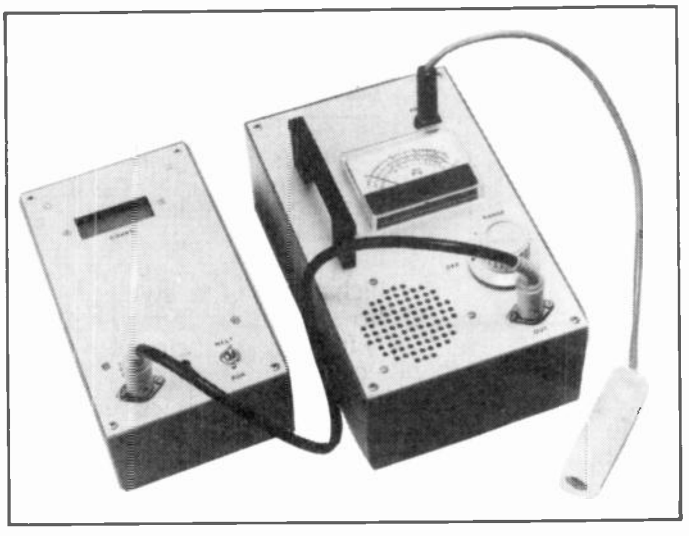
The AGC control voltage level, taken from pin 15 of the 3189, will normally sit at about 6–8V on no signal. An equivalent potential is set by R43 and R44 for the AGC off setting. The whole tuner circuit is powered by a single +15V supply, but because the VCO is voltage operated, it is essential that the positive line supply voltage to this is held constant. This is done by inserting a standard 12V IC voltage regulator, IC6, between the input +15V supply and the 12V line which feeds the CA3189 and the VCO.

This project will be concluded with a description of the construction and setting up of the complete FM tuner.

ETI

GEIGER COUNTER

Colin Seymour describes a pulse counter to accompany last month's Geiger Ratemeter project.



The Geiger Counter complete with the ratemeter described last month.

Geiger ratemeters of the type described last month are of little use where the radiation levels being measured are close to the natural background. The count rate will be very low (with the tube specified, around 25 pulses will be detected per minute) and the random nature of the radiation will cause the meter needle to give a series of brief kicks rather than a steady deflection. These problems can be overcome by taking measurements over a reasonably long period of time to average out the fluctuations, and comparing the result with a previously-established background count

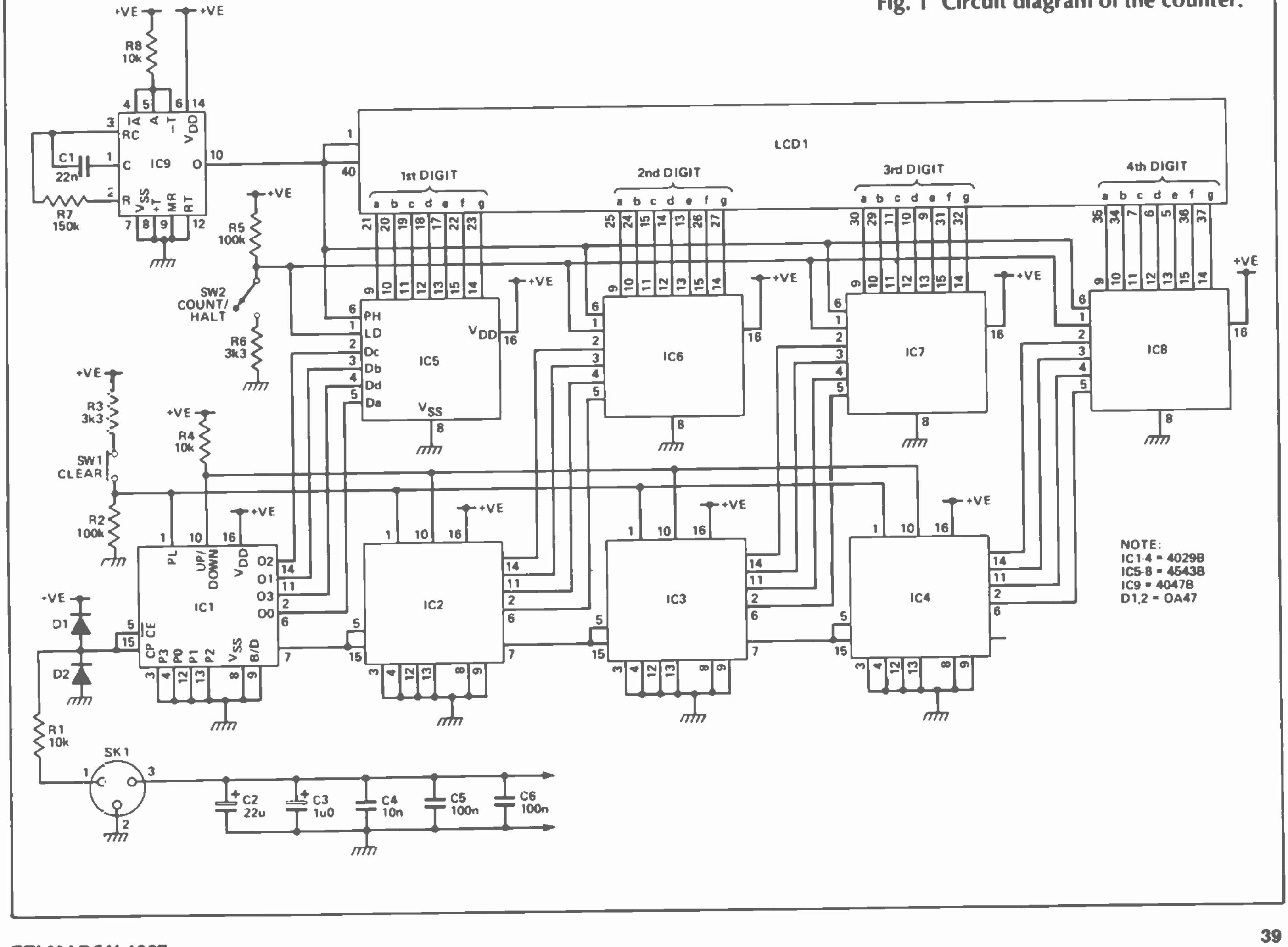


Fig. 1 Circuit diagram of the counter.

measured over the same period.

The counter described here is a portable unit which connects directly to the Geiger ratemeter. It takes its power from the ratemeter's 6V battery and counts the pulses detected up to a total of 9999. No timing circuitry is included in the counter — it is simply left on for the required period of time and the final count noted down. A useful refinement is a halt switch which allows the display to be 'frozen' while the count itself continues. This enables the user to record the count at intermediate time intervals without upsetting the final count.

The counter uses CMOS ICs and a liquid crystal display to keep power consumption to a minimum. The total current drain of the complete circuit is around 0.1mA at 6V ± 1V. An LSI counter module could have been used to save space and might have cost slightly less, but the MSI approach used here is more resistant to radiation damage.

HOW IT WORKS

The input from the ratemeter arrives via SK1 pin 1 and is passed to the input of IC1 by R1 and the protection diodes D1, D2. IC1 is a four-stage counter which provides a binary-coded output to the display driver, IC5. It also clocks the next counter, IC2, which in turn clocks IC3, and IC3 in its turn clocks IC4. The binary outputs of ICs 2, 3, and 4 are fed to the display drivers IC6, IC7 and IC8 respectively. The PL inputs to the counters are normally held low but can be taken high by means of SW1 to reset them.

IC9 is an astable multivibrator providing a 70Hz square wave. This signal feeds the display drivers, IC5, 6, 7 and 8, and the backplane/common connection of the LCD. The latch inputs (LD) of the driver ICs are normally held high by R5, allowing counting to continue in the normal fashion. Pulling these inputs low by means of SW2 causes the current state to be latched and fed continuously to the display. ICs 1, 2, 3 and 4 are unaffected by this and continue to count the incoming pulses. Returning the LD inputs of ICs 5-8 to the logic high state will remove the latched data and cause the current total count value to be displayed.

THE NATURE

All matter is built up from a number of naturally-occurring atoms which combine with one another in various ways to form molecules of different substances. Atoms consist of clouds of negatively-charged electrons circling a positive nucleus. The nucleus is tiny in relation to the size of the atom as a whole and contains positively-charged particles called protons. In a stable, non-charged atom, the number of protons is equal to the number of electrons and the positive and negative charges cancel each other out. The number of protons in an atom (and hence the number of electrons) is known as the atomic number and is different for each element. For example, hydrogen has one proton and one electron and its atomic number is one, helium has two protons and two electrons and its atomic number is two, and so on.

The electrons are normally some distance from each other in their orbits around the nucleus, but the protons are packed closely together. Since the protons all have a positive charge, we might expect them to repel one another and move apart. This doesn't happen because the nucleus also contains a third type of particle, the neutron. These have no electrical charge and (to put it simply) act as a sort of glue, holding the nucleus together. There are usually about the same number of neutrons as there are protons in the nucleus of an atom, slightly less in atoms with high atomic numbers. However, the number of neutrons is not tied to the number of protons and it is possible to find atoms with the same atomic number which have different numbers of neutrons. These are known as isotopes. The number of neutrons in an atom is indicated by the atomic weight, a figure which is obtained by adding together the number of protons and the number of neutrons. It is therefore convenient to refer to an isotope by naming the element (which implies a certain atomic number) and then stating the atomic weight, for example cobalt ^{6C}, strontium ^{90}, etc.

It should be clear from all this that there are a very large number of possible atomic constructions. However, most of these will be unstable and will break up or decay by emitting nuclear particles and turning into other atoms. This process may be repeated until a stable element is created. In this way, most of the unstable atoms which may have existed have vanished and only very long-lasting ones remain such as potassium^{40} and the isotopes of lead and heavier elements up to uranimum. There also exist shorter-lived isotopes which result from the decay of uranium and thorium.

The radiation emitted from unstable atoms usually takes one of several forms. An alpha particle is the equivalent of a helium nucleus, two protons and two neutrons, travelling at great velocity. It penetrates matter very little and a sheet of paper will stop it. Beta is equivalent to an electron travelling at great speed with high energy. Its mass is 1/1837 that of the proton and it can be stopped by a few millimetres of aluminium. Gamma is a form of electromagnetic radiation, of wavelength one million to 100 million times smaller than light. The energy of such radiation is very high, and it is usually emitted along with an alpha or beta particle as a secondary effect of the nucleus being left in an excited (high energy) state. It is very penetrating, and at least 5 cm of lead would be needed to reduce radiation to one tenth of the unshielded level.

Units Of Radiation

Measurement of radiation is essential if protection is to be provided, and the process involves many complexities which cannot be covered here.

Radiation is commonly measured either in terms of the absorbed dose or the dose equivalent. The *absorbed dose* is the ratio of the absorbed energy in a volume of matter to the total mass of that matter. The present SI unit for absorbed dose is the Gray (Gy) which is equivalent to one joule of energy absorbed per kilogram. Prior to the introduction of the Gy, the unit of absorbed dose was the Rad. This was equivalent to 0.01 joules of energy absorbed per kilogram, and instruments calibrated in Rads will continue to be seen for some time.

Different types of radiation have different effects on living tissue depending on the range of absorption. Alpha particles do not penetrate the outer layers of

Construction

With the exception of the socket and the two switches, everything mounts onto one, double-sided PCB. As with the boards used for last month's ratemeter, the upper side of the board carries a ground plane which is formed simply from un-etched copper cladding. This removes the need for a second foil pattern and helps to keep the board cost down.

Because the ground plane is formed in this way, the first stage of the construction is to remove some of the copper around component lead holes using a counterbore drill. Refer to the overlay diagram (Fig. 2) and note which holes carry component leads or links and which are used for earthing. The ones used for earthing are indicated by a small circle. All holes not so indicated should be carefully counterbored until there is sufficient clearance to ensure that component leads cannot come into contact with the ground plane.

When this has been done, insert short wire links through all the earthing holes and solder them on both sides of the board. Refer to Fig. 2 again and install the resistors, the capacitors, the IC sockets (if you intend using them) and the diodes. Note that some of the resistors and all of the capacitors aside from C1 must be soldered to the ground at one end. Diode D2 should have its anode soldered to the ground plane.

Install the two rows of solder pins for LCD1 and then use insulated wire to form the links indicated on the overlay diagram. There are quite a number of these and some of them are close together. You may find it helpful to work through them one row at a time and to use different coloured wires for each row.

With the rest of the construction complete, connect the various flying leads to the points indicated in the overlay and then install the ICs. Solder the two switches and the DIN socket to the ends of the flying leads and the counter is ready for testing.

A short connecting lead is required to link the counter and the ratemeter. Use three-core cable with three-pin DIN plugs at either

OF RADIATION

Units of nuclear activity
1 Ci (Curie) = 3.7×10^{10} nuclear disintegrations per second.
1 Bq (Becquerel) = 1 nuclear disintegration per second.

Units of absorbed dose
1 R (Rad) = 0.01 joules per kilogram of absorbing material.
1 Gy (Gray) = 1 joule per kilogram of absorbing material.
(the absorbing material must be specified).

Units of dose equivalent
Dose equivalent in Rem = absorbed dose (Rad x Q (relative biological effectiveness)
Dose equivalent in Sv (Sievert) = absorbed dose (Gy) x Q x N
where Q = 1 for X and Gamma rays and beta particles.
Q = 20 for alpha particles (formerly 10).
(N is another scale factor accounting for other absorption processes such as dose rate, and is set to 1 until further notice)

Conversion
1 Ci = 3.7×10^{10} Bq
1 Gy = 100 Rad
1 Sv = 100 Rem

the skin, but if an alpha-emitting substance is inside the body the energy will be dissipated in a small area, causing great damage to cells. Beta and gamma radiation are absorbed over a long distance and are less damaging to individual cells. To take account of this we have a number of units which measure dose *equivalent*. These make use of a factor Q which indicates the Relative Biological Effectiveness (RBE) of the radiation. This factor is one for beta and gamma radiation and 20 for alpha radiation. The present SI unit for dose equivalent is the Sievert (Sv) which is obtained by multiplying the absorbed dose figure in Grays by the Q factor. The previous unit of dose equivalent was the Rem which was obtained in the same way but used Rads as the absorbed dose unit. The majority of instruments are still scaled in Rems (and milliRems) rather than Sieverts, hence the decision to calibrate the instrument described here in this way

Radiation In The Environment

There is a background of natural radiation always present, which is caused mostly by natural radioactive isotopes in the environment and cosmic radiation. This is around 100mRem/year in Great Britain but can be thousands of mRem/year in some parts of the world.

Table 2 lists radiation levels recorded from various sources using the Geiger counter. The radioactive constitutents are indicated where possible.

Location	Level	Level
Typical Background	100 mR/year	0.01 mR/hr
Adjacent to radium paint on WW2 marching compass (Inc. beta)	700 R/year	80 mR/hr

Location	Counts/min	Counts/sec
Background in 1930 s flat	25	0.4
Background in 1980 s office building	16	0.3
Near modern smoke detector (0.6 uC1 Americium 241)	43	0.7
Near old smoke detector (60 uC1 Americium 241)	817	14
Pack of camping gas mantles (due to thorium oxide)	396	7
Thorium oxide in glass tube (240 mm_3)	1000	17
Adjacent to radium paint on WW2 marching compass (Inc beta) (Radium-226 including decay products)	90000	1500
Adjacent to case of WW2 marching compass	4668	78
330 mm from compass	52	0.9

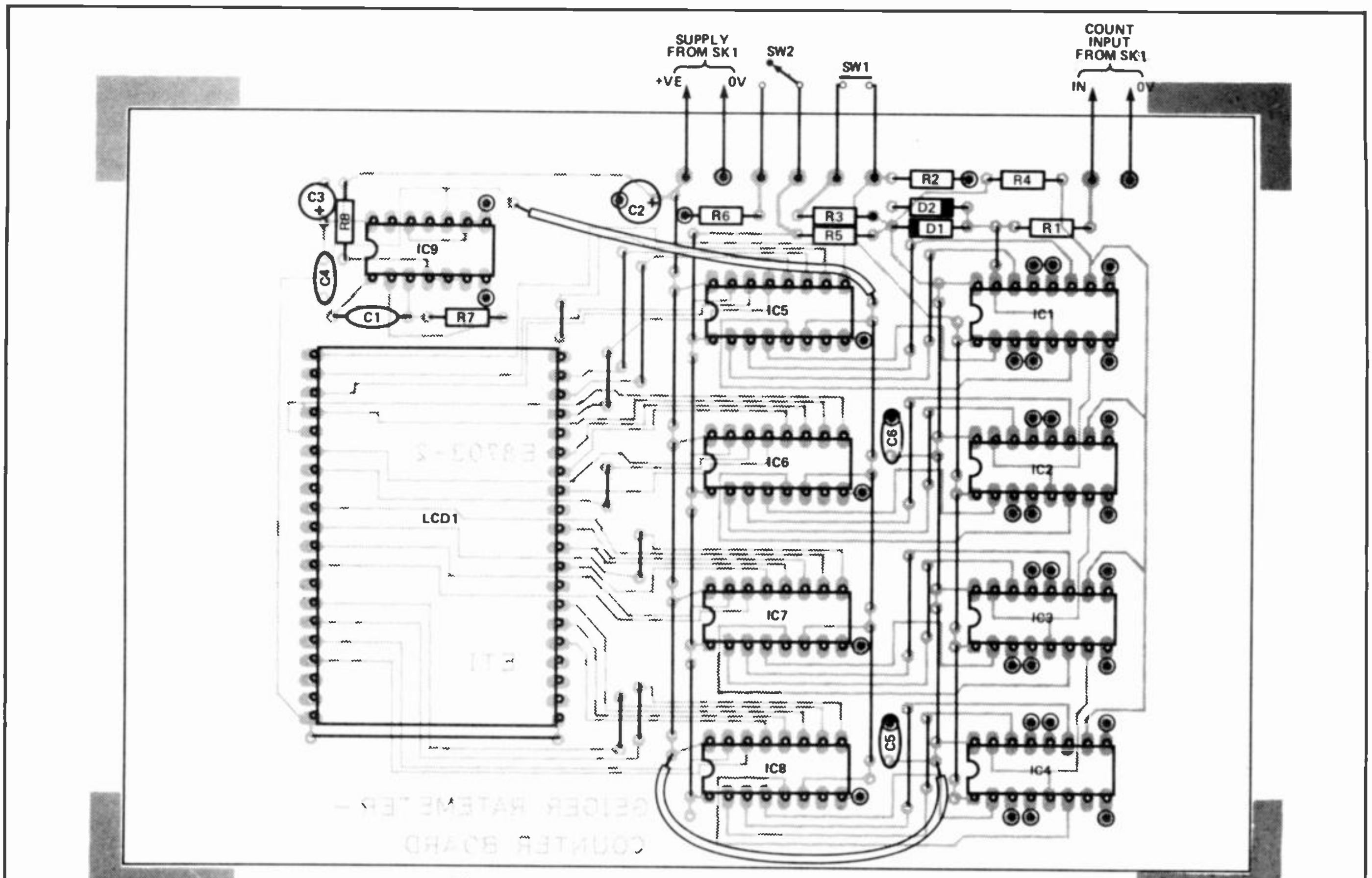


Fig. 2 Component overlay for the counter PCB.

end, and choose a length which allows the two boxes to be held a comfortable distance apart without having loops of cable dangling in the way. About 12-18in (300-450mm) should be sufficient. The cable need not be screened — ordinary light-duty mains flex would be more than adequate — and should be wired with pin 1 connected to pin 1, pin 2 connected to pin 2 and pin 3 connected to pin 3.

Connect the counter board to the ratemeter and switch on. Alternatively, connect the counter directly to a 6V supply. The LCD should indicate 0000. If nothing happens, switch off and check for wiring errors. If the display shows something other than 0000, the counter has probably been powered-up in the HALT condition. Move SW2 into the COUNT position and press SW1 to reset the count. If the display still gives the wrong indication, switch off and check the board.

If all seems well, place the detector assembly of the ratemeter near a source of radiation and check that the display increments with each 'click' from the loudspeaker. If you are testing the counter without using the ratemeter, connect its input to a signal generator with a CMOS-compatible output. It should count reliably at frequencies up to a few hundred kilohertz. Check that the count can be reset by pressing SW1 and then try halting the display with SW2. The display should 'freeze' at the last figure indicated when the halt button is pressed. If the input signal is left connected while the display is halted, the counter figure should jump forward by a suitable amount when SW2 is set to COUNT again. This indicates that the counting circuitry has carried on working while the display was held.

The assembled and tested board can now be sprayed with a protective lacquer and then installed in its case. The pototype was housed in a plastic box with an aluminium front panel, similar in style to the box which held the prototype ratemeter but slightly smaller all round. Any box which is large enough to hold the counter PCB should do. It is a nice touch to use something which matches the ratemeter box so that there is a

PARTS LIST

RESISTORS (all ¼W, 5%)	
R1, 4, 8	10k
R2, 5	100k
R3, 6	3k3
R7	150k
CAPACITORS	
C1	22n polycarbonate, polyester, mylar or polystyrene
C2	22µ 10V tantalum
C3	1µ0 10V tantalum
C4	10n ceramic
C5, 6	100n ceramic
SEMICONDUCTORS	
IC1-4	4029B
IC5-8	4543B
IC9	4047B
D1, 2	OA47

MISCELLANEOUS	
LCD1	4-digit liquid crystal display with 12.7mm high characters (Epson LD-H7916AE or similar)
SK1	3-pin DIN chassis socket
SW1	push-button switch, momentary action, push to make
SW2	SPDT miniature toggle switch

PCB; case (see text); IC sockets if required, 8 off 16-way and 1 off 14-way; IC socket strip, 40-way (2 x 20 way) for mounting LCD1; PCB-mounting pillars, 4 off; perspex or celluloid filter for display if required; nuts, bolts, etc, for mounting pillars, DIN socket and display filter.

strong visual link between the two halves of the project.

In the prototype, the board was attached to the front panel using 15mm (5/8") spacers. The cut-out for the display was covered with a piece of perspex underneath the panel, and the screws holding this and the PCB were countersunk into the aluminium to preserve the appearance of the finished unit. The box chosen was a little longer than the PCB which allowed the socket and the switches to be mounted at the bottom of the front panel. This removed the need to have flying leads attached to various parts of the case and made it possible to remove the complete counter assembly simply by detaching the front panel.

In Use

A stopwatch will be required in order to use the counter. Zero the counter and start the timer at the same time. After sufficient counts have been taken, stop the timer and simultaneously set the counter to HALT. The count rate is the relative measure of the intensity of radiation intercepting the detection volume of the GM tube. The accumulated dose to a living organism is proportional to the intensity of radiation, the time spent exposed to that intensity, and the relative biological effectiveness (or Q factor) defined for the type of radiation. Hence a higher than background level may not be significant if it occurs only over a few minutes, whereas the constant background radiation is giving an accumulating dose continuously. However, low level radionuclides taken into the body can be concentrated in particular organs and in that case any presence of abnormal radionuclides may be harmful (for example, the radium-226 in radium paint which concentrates in bones).

Because of the random disintegration of radioactive atoms, the count rate over a fixed time may vary randomly above and below an average. Over a long time period with many counts, the fluctuations are averaged out. The statistics of radioactive decay can be used to estimate how much error is likely in the reading. If there are enough counts (more than 100) then the 'normal distribution' can be assumed. If the standard deviation of the measurement (measure of its variation), is known, the probability of the result falling within a certain number of standard deviations either side of the mean can be found.

For radioactive decay, the standard deviation of a single count can be expressed as the square root of the count. It happens that about 95% (95.44%) of the readings will lie within plus or minus two standard deviations of the mean, that is, twice the square root of the number of counts.

Because of the random fluctuation in count readings, comparison of readings against background counts must bear the error limits in mind. To reduce the error in the background count, the count number must be as high as possible, which means waiting sufficient time for them to accumulate. To get 400 counts with a statistical error of ± 40 counts might require 20 minutes of counting. You should also bear in mind that the background count varies from place to place and also varies over the course of a day by as much as 30:1. Therefore, make background readings at the same time as the other test reading.

If the test reading is higher than the background, consider the errors. On each reading, there is 2.5% probability of the error exceeding the limit on one side only. If the background plus error is less than the test reading minus error, the chance of there still being an overlap is 2.5% squared which is 0.625%. So, if the test reading is still greater than the background taking into account errors, then that is a 99.9% probability. If 400 counts are taken and the count rates obtained by dividing each count by the time taken for it, then the test reading rate must be at least 20% higher than the background rate to be clear of the errors. If more counts are taken then the errors can be reduced, and if fewer counts are taken then the errors will be greater. **ETI**

Count	95% Error Limits	Error Limits in %
100	± 20 counts	± 20%
400	± 40 counts	± 10%
1000	± 63 counts	± 6.3%
10000	± 200 counts	± 2%

Suggested Reading

J. Sharpe, "Nuclear Radiation Detectors", Methuen & Co Ltd, 1965.

K. Kandiah, "Nuclear Instruments Over The Last Fifty Years", Journal of Scientific Instruments (Journal of Physics E) Vol 1 pp. 369-372, 1968.

F. S. Goulding, "Transistorized Radiation Monitors", IRE Transactions on Nuclear Science, No. 2, August 1958, Vol. NS-5, pp. 38-43.

"Nuclear Electronics III", Conference Proceedings, Belgrade, 15th-20th May 1961, International Atomic Energy Agency Vienna 1962: p. 429, C. J. Borkowski & R. H. Dilworth, "Personal Radiation Monitor," Oak Ridge National Laboratory; p. 487, J. Keller, "A Single Transistor GM Monitor with A Stabilised GM Supply" Instytut Badan Jadrowych, Warsaw.

J.N. Andrews & D. J. Hornsey, "Basic Experiments with Radioisotopes", Pitman Publishing, 1972.

Alan Martin & Samuel A. Harbison, "An Introduction to Radiation Protection". Chapman and Hall, 3rd edition. 1986.

Edward Pochin, "Nuclear Radiation: Risks and benefits", Oxford University Press, 1985.

BUYLINES

Everything here is perfectly straightforward and should be available from almost any electronic components dealer. The Epson display can be obtained from Midwich Computer Company Ltd, Gilray Road, Diss, Norfolk 1P22 3EV or from STC Electronic Services, Edinburgh Way, Harlow, Essex CM20 2DF, Tel: (0279) 26777. Similar displays sold by Electrovalue, RS/Electromail and others should be suitable since the pin-out is just about standard, but do make sure you get one with pins for PCB-mounting. The case isn't critical and any type which is a little larger all round than the PCB should do nicely. Choose one with an aluminium front panel if possible since this will allow everything to be mounted in the same way as on the prototype, simplifying construction and allowing easy access to the circuitry for checking and servicing. The PCB will be available from our PCB Service. See page 62 for details.

THE ETI CAPACITOMETER

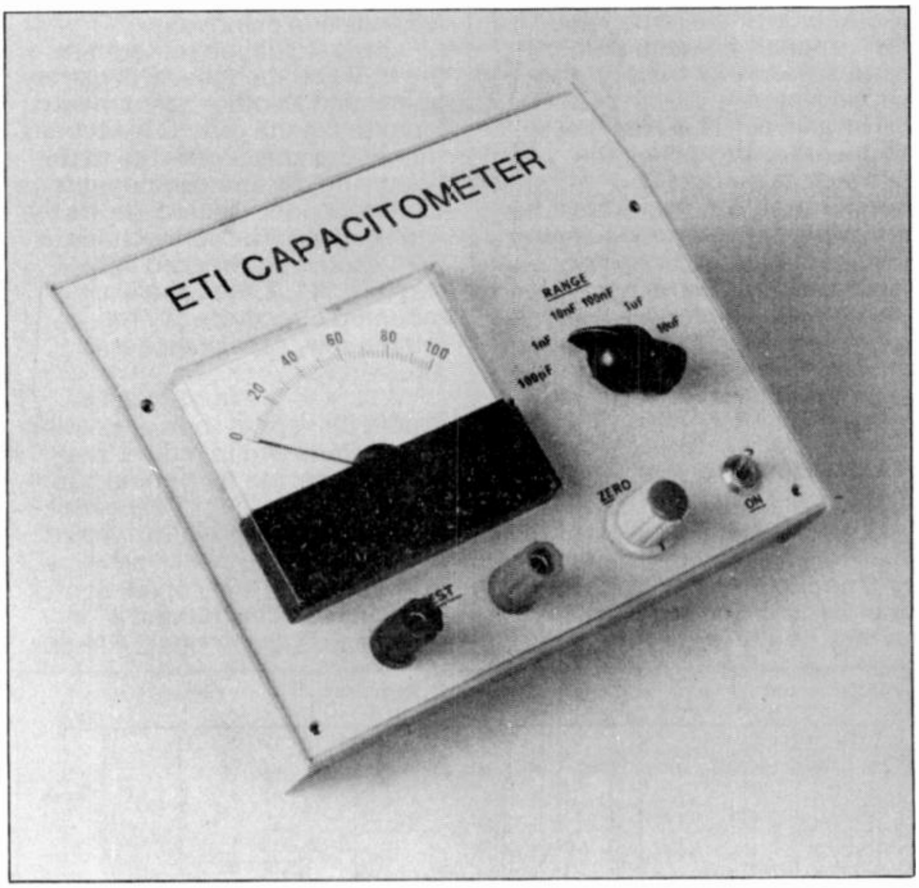
Mind your p's and μ's with Ray Bold's handy bench capacitance meter.

This instrument is designed to accurately measure capacitors from a few picofarads to ten microfarads on a forward reading linear scale. The meter is very sensitive and it incorporates a zero adjustment which is useful for cancelling the effects of stray capacitances on the lower ranges. This means the 0 to 100p range is exactly that and does not call for mental arithmetic.

However, the Capacitometer is simple and inexpensive to build, the most expensive component being the meter M1, although a spare or second hand meter can be used.

There are ten ranges available on the Capacitometer. The ranges are:

0 – 100pF
0 – 1nF
0 – 10nF
0 – 100nF
0 – 1μF
0 – 10μF



Theory

Figure 1 shows the complete circuit of the Capacitometer. Q1 is a unijunction oscillator producing a narrow pulse at B2 every three milliseconds (if R1 is selected) or every thirty milliseconds (if R2 is selected). The pulses are amplified and inverted by Q2 and used to trigger IC1.

IC1 produces a pulse every time it is triggered. The width of the pulse varies according to the formula T=1.1CR. For example: with SW1 in position three, R1 is selected to produce a pulse every three milliseconds, and R8 is selected. With a 10n capacitor connected to the terminals the pulse width will be:

$$1.1 \times (10 \times 10^{-9}) \times (100 \times 10^{3}) = 1.1 \times 10^{-3} \text{ seconds}$$

or 1.1 milliseconds every three milliseconds. These pulses are averaged to produce full scale deflection on M1.

Now if a capacitor of 100n is connected and SW1 switched to position four, R2 is selected to produce a pulse every thirty milliseconds and R8 is still selected. The pulse width will be:

$$1.1 \times (100 \times 10^{-9}) \times 100 \times 10^{3}) = 1.1 \times 10^{-2} \text{ seconds}$$

or 11 milliseconds every thirty milliseconds.

It can be seen that the average voltage is the same as in the previous example and full scale deflection is again produced on M1. Similar calculations apply to the other ranges.

Figure 2 illustrates the advantage of such a low full scale duty cycle. With a test capacitor at the top of the set range the duty cycle is 33% and the meter reads full scale (Fig. 2c). A slightly larger test capacitor produces a greater duty cycle and the meter correctly reads off the scale (Fig. 2d). A much larger capacitor will give overlarge pulse widths causing IC1 to miss alternate trigger pulses so the duty cycle is a little over 50% (Fig. 2e) and the meter still correctly reads off the scale.

If the full scale duty cycle were designed to be, say, 60% the capacitor with a value at the top of the set range produces the 60% mark-to-space ratio and the meter reads full scale deflection (Fig. 2f). However, if the much larger capacitor is tested, again alternate trigger pulses are missed and a duty cycle of just over 50% is produced (Fig. 2g). This causes the meter to erroneously read a value on the scale.

Designing the Capacitometer with a full scale duty cycle of only 33% increases the margin for error and allows capacitors well over the set range to be shown correctly for what they are.

After being clipped by ZD1 the pulses are applied to C2 which produces a steady voltage proportional to the pulse width. This is applied via calibration preset resistor PR1 to IC2's non-inverting input.

The gain of IC2 is arranged so that for full scale reading the voltage at its output is approximately 5V. Therefore it is impossible to overdrive the meter movement by a factor of more than about 1.8. This technique safeguards the meter without diode protection. In addition, the time constant of the C2 circuit keeps the pointer velocity below overload conditions.

Construction

The PCB overlay is shown in Fig. 3. Solder in the resistors and capacitors first and the semiconductors last. A suggested panel layout is shown in Fig. 4 but this may be altered as the dimensions of the meter dictate. However, the centre of the meter is indicated and this should suit the majority of meters.

The front panel of the case used will probably be supplied with a clear protective sheet on. This should be left on and marking carried out in ballpoint pen. Only when all drilling has been completed should the film be removed for lettering to be applied. Before applying lettering clean the surface of the front panel with methylated spirits or similar to remove any grease. Then be careful to handle the panel by its edges only. After lettering, the front panel should be finished with clear lacquer to protect the lettering and paintwork.

Leads should be soldered to the PCB and then the PCB, battery holder and all other components mounted in the case. Connections should then be completed to the battery holder and components on the front panel. Figure 5 shows the wiring layout. The connections to SW1 should be checked very carefully. R1, 2, 7, 8, and 9 are mounted directly on SW1 to reduce stray capacitance and interwiring.

Wiring to the front panel should be kept as short as possible for neatness and to reduce stray capacitance, but long enough to allow easy handling of the panel when assembling the instrument.

After carefully checking all assembly work and connections, make sure the instrument is switched off and connect a nine volt battery via a milliammeter. The prototype took 13mA on the 1μ and 10μ ranges and 5mA on the other ranges. Switch on and if there is a significant difference from these figures the meter should be switched off quickly and the cause investigated.

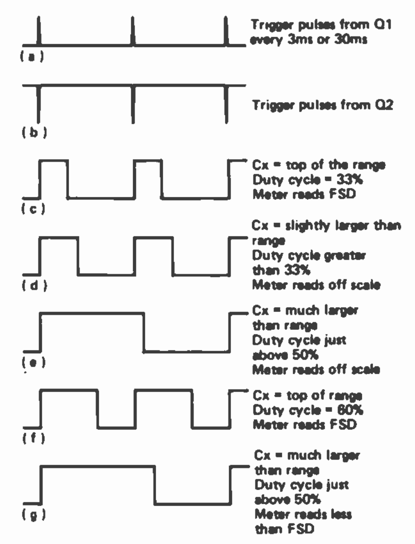


Fig. 2 The duty cycle for different test capacitances.

Calibration

It is suggested a close tolerance capacitor be obtained for calibration. Alternatively one could be measured on a piece of equipment of known accuracy. This capacitor should be set aside for periodic checks of the

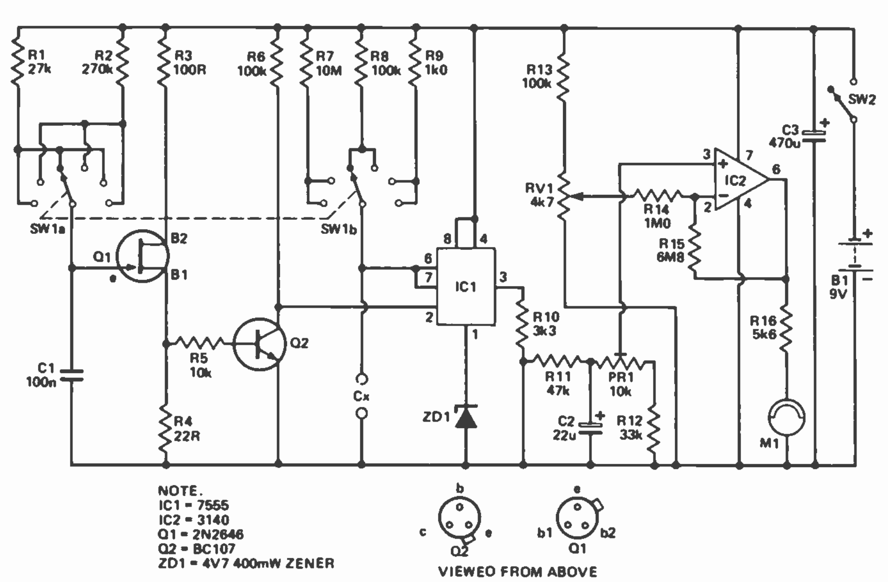


Fig. 1 The circuit diagram of the Capacitometer.

HOW IT WORKS

Q1 and associated components form a pulse generator generating a narrow pulse every three milliseconds or thirty milliseconds depending on the resistor selected (R1 or R2). These pulses are amplified and inverted by Q2 and are used to trigger IC1, a 7555 CMOS timer connected as a monostable.

IC1 gives out a pulse every time it is triggered, the width of the pulse being dependent on the values of the resistor and capacitor connected to pins 6 and 7. The resistor is selected by SW1b and the capacitor is the capacitor to be measured.

ZD1 is used to chop these pulses to a constant amplitude and C2 acquires a voltage dependent on the pulse width and frequency from IC1. This voltage is fed to IC2 which forms a voltage amplifer with a gain of approximately eight. The amplifier is calibrated for full scale deflection by PR1 and incorporates a zero control, RV1.

M1 is used to indicate the voltage from IC1 pin 6 and therefore the value of capacitor.

instrument's accuracy.

With the instrument switched on and the appropriate range selected, the zero adjustment should be checked. The test capacitor should then be connected and PR1 carefully adjusted to obtain the correct reading. On the prototype it was noted that a change in supply voltage of plus or minus one volt causes a 2% increase or decrease respectively in full scale reading.

On the 0–100p and 0–1n ranges a reading will appear on the meter due to stray capacitances. On these ranges the zero control should be rotated anti-clockwise until the meter just reads zero. Adjusting the control carelessly will cause errors in later readings. It must also be remembered the control needs returning fully clockwise when using the higher ranges. It is advisable to use a marked knob so its position can be checked visually if required during a measurement. It may also be useful to mark the front panel with the correct settings for the 100p and 1n ranges.

The zero control is also useful when measuring short lead capacitors or the sweep of variable capacitors. Flying leads should be connected to the instrument and one of them left disconnected at the capacitor end. The instrument should then be zeroed and the lead connected to the other side of the capacitor. Direct readings can then be made.

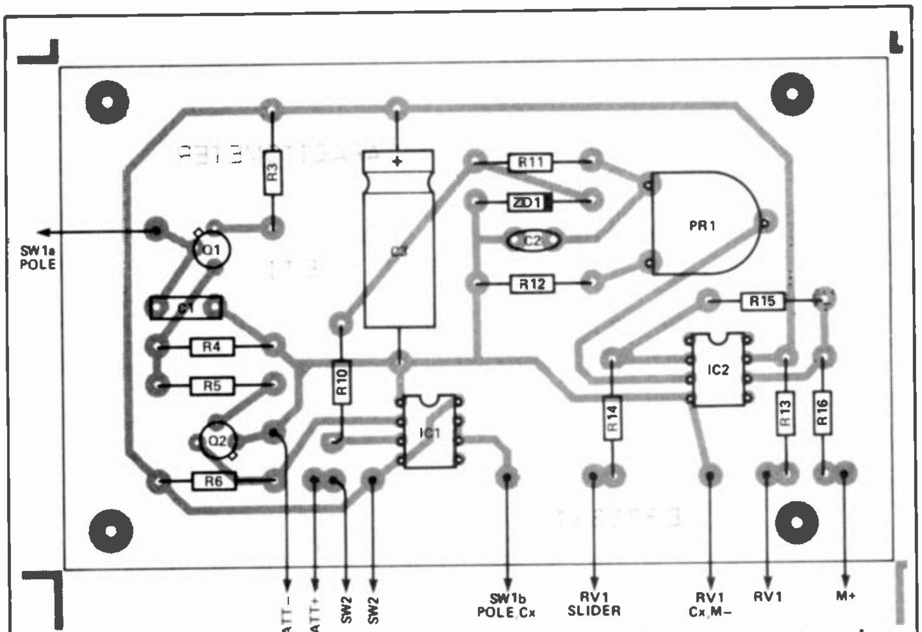


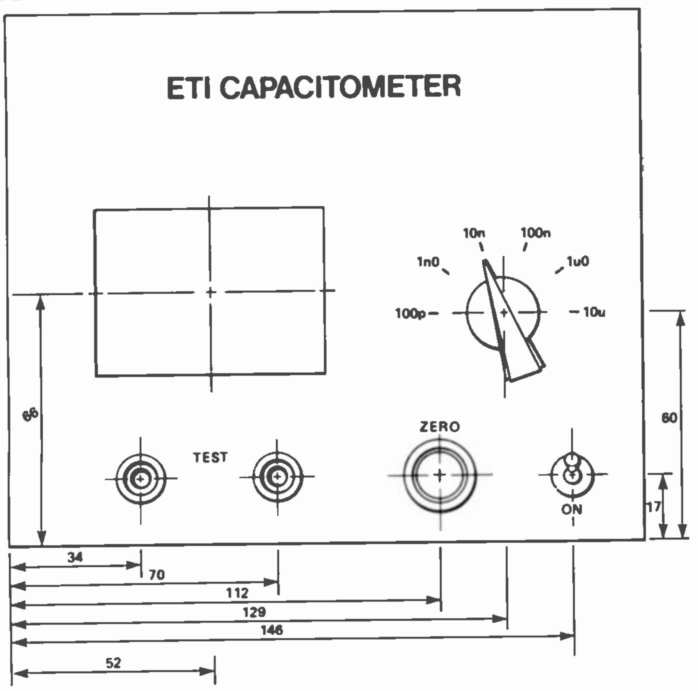
Fig. 3 The component overlay.

Alternative Meters

A wide range of meters can be used in this unit. The value of R16 should be altered to accommodate the meter chosen.

With a capacitor suitable for full scale deflection connected to the test terminals and PR1 set at its centre point, a voltage of approximately 5V is produced at IC2 pin 6. Using Ohm's law with this voltage and the full scale deflection current of the chosen meter, R16 can be calculated as follows.

Meter sensitivity eg
100μA FSD
internal resistance eg 580R



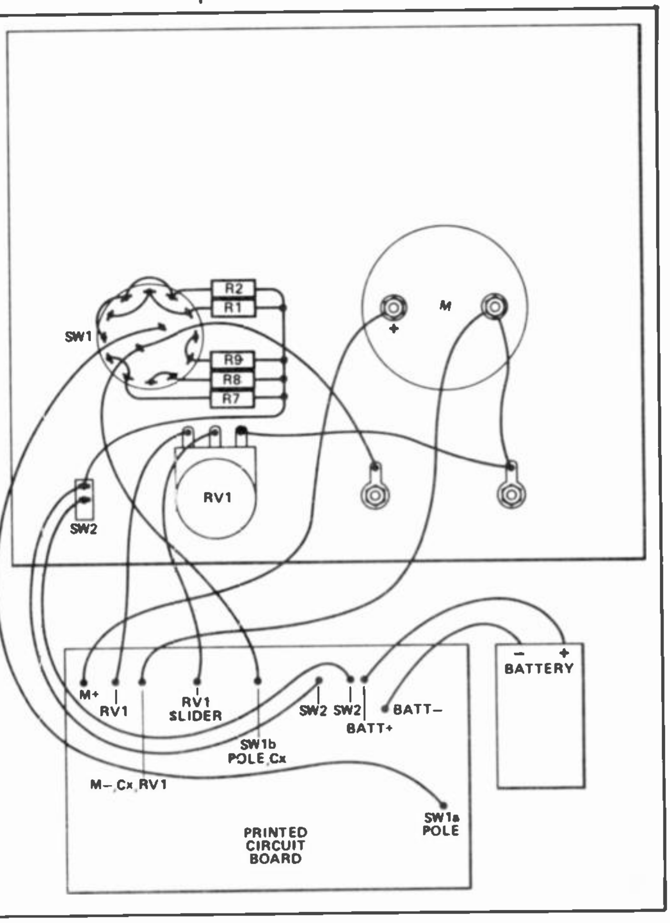


Fig. 4 The suggested front panel design.

Fig. 5. Wiring of the Capacitometer.

total resistance for 100μA =

$$\frac{V}{I} = \frac{5}{100 \times 10^{-6}} = 50k$$

In this case the meter's internal resistance is insignificant and a 51k resistor should be suitable for R16.

It is also possible to calibrate the instrument for use with an existing multimeter in a similar way.

ETI

BUYLINES

The case can be obtained from MS Components Limited, telephone number 01-670 4466. The catalogue number is 4108.

The battery holder was also from MS Components, as catalogue number 644.

The 10n capacitor with a 1% tolerance can be obtained from Maplin Electronics. All the other components are easily available and should cause no problems. A PCB will be available from the ETI PCB Service in due course.

PARTS LIST

RESISTORS All ¼W 5% unless stated		**C2**	**22µ 16V tantalum**
R1	**27k 1%**	**C3**	**470µ 16V electrolytic**
R2	**270k 1%**		**10n 1% polystyrene for calibration**
R3	**100R**		
R4	**22R**	**SEMICONDUCTORS**	
R5	**10k**	**IC1**	**7555**
R6, R13	**100k**	**IC2**	**3140**
R7	**10M 1%**	**Q1**	**2N2646**
R8	**100k 1%**	**Q2**	**BC109**
R9	**1k0 1%**	**ZD1**	**4V7 400mW zener diode**
R10	**3k3**		
R11	**47k**	**MISCELLANEOUS**	
R12	**33k**	**M1**	**1mA moving coil meter**
R14	**1M0**	**SW1**	**two pole, 6 way rotary switch**
R15	**6M8**	**SW2**	**SPST miniature toggle switch**
R16	**5k6 (see text)**		
PR1	**10k horizontal preset**		
RV1	**4k7 potentiometer**		
CAPACITORS			
C1	**100n polycarbonate**		

Red and black 4mm terminals; case; transfers; knobs; PP3 battery and carrier; PCB; connecting wire, screws, nuts and bolts.

CREDIT CARD CASINO

Paul Chappell risks all with ETI's tiny answer to Las Vegas.

Since the advent of the 1960 Betting and Gaming Act there has been a huge upsurge in the volume of gambling in Britain. It is estimated some 75% of the population now indulge in some regular form of betting, whether it be football pools, bingo, horse racing or casino type games — cards, dice, roulette.

If you include the occasional 10p in an arcade slot machine and your special personal numbers which may already have won you a holiday for two in Acapulco (if you subscribe for seven years to Illiterate Indigestion) then probably everybody who is not an Archbishop or a miser has a flutter at some time or other.

The Credit Card Casino is a pocket gambling machine which will play roulette, craps, and several other games of chance. The case measures only 3in x 2in x ½in, so although it may not be quite as slim as a credit card, it's certainly small enough to slip into your pocket.

Construction

The component overlay for the project is shown in Fig. 2. To allow the switch button to protrude through the front panel, none of the components must be higher than the switch body.

This means mounting the transistors as close as possible to the PCB, and choosing the tantalum capacitors for minimum body length — 16mm or less if possible. Most 6.3V devices will be suitable. If they are a little too tall when standing upright, you can lean them towards R2 and R3. C3 should also be chosen with care. Radial leads with a 5mm pitch and a case that can be mounted flat against the PCB are the main requirements. Ceramic or metallised film types of suitable proportions are both equally suitable.

Don't solder in the LEDs at this stage — wait until the case top has been drilled and you can judge the lead length needed.

The batteries we used were Duracell RM13H mercury cells, sold as hearing aid batteries in most chemists. The PCB is drilled to fit the body of the cells, roughly 8mm in diameter. The positive contacts consist of strips of phosphor-bronze, 5mm x 10mm, cut from a draught excluder strip. These are soldered to the pads on the rear of the PCB on either side of the battery holes (Fig. 3).

A small kink in the middle of each strip helps to keep pressure on the cells to maintain good contact. The negative terminals are made from stiff wire — we used a paper clip bent to shape with long nosed pliers! Be careful when bending the wire. Excessive strain on the soldered end can lift the tracks from the PCB.

Assembling The Case

Using the fascia as a template, mark out the positions for the LEDs and switch on the lid of the case. The LED holes should be made with a 5/64in drill. Check the positions after against the fascia — if any holes are not quite central, you can widen them slightly with a larger drill or a reamer. The fascia will disguise any slight errors!

A square hole is needed for the switch button. If you have a 7/16in square punch, or can afford a few pounds to buy one, mark the drilling point by drawing an X between the corners of the square hole, making sure to keep it parallel to the sides of the lid.

If you haven't got a punch the alternative is to mark out the square and drill several holes around the inside. Use a sharp knife to cut out the waste plastic then tidy up the hole by filing it to size or by gradually paring away the remaining waste with a knife.

Insert the LEDs into the PCB, then hold the PCB against the drilled lid so that the switch button is in its hole. Adjust the positions of the LEDs so they all poke through their respective holes with the PCB parallel to the lid. Now solder the LEDs in place and crops the leads.

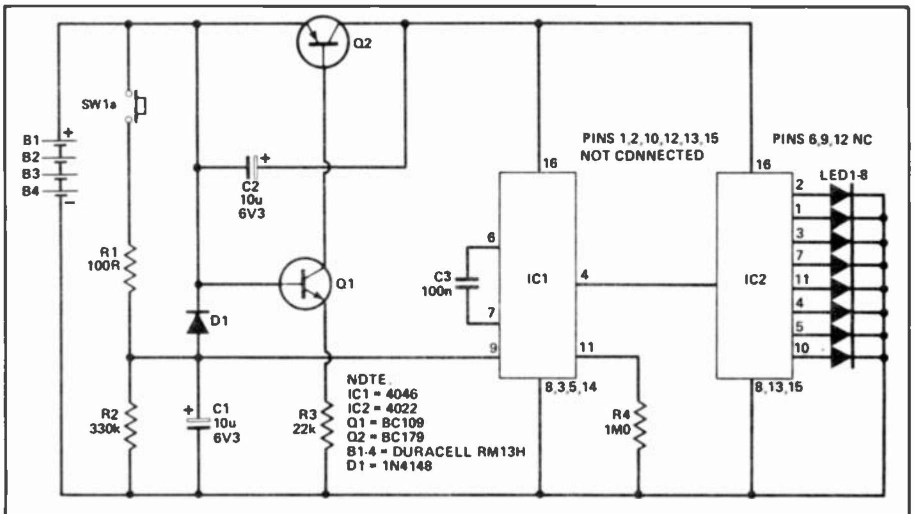
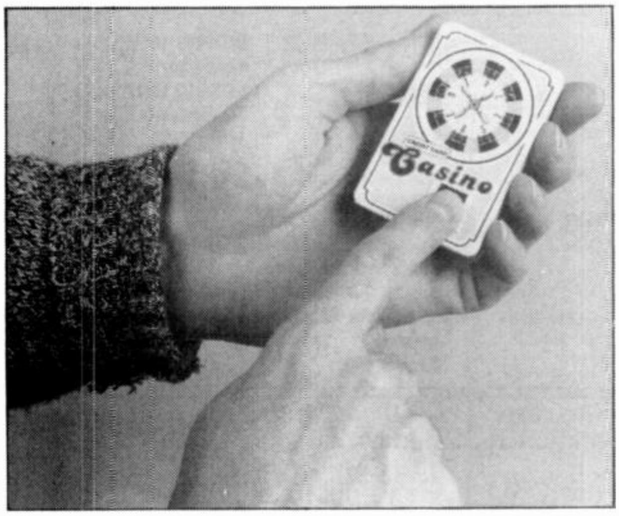


Fig. 1 The circuit of the Credit Card Casino.



The complete Credit Card Casino. A pocket sized flutter.

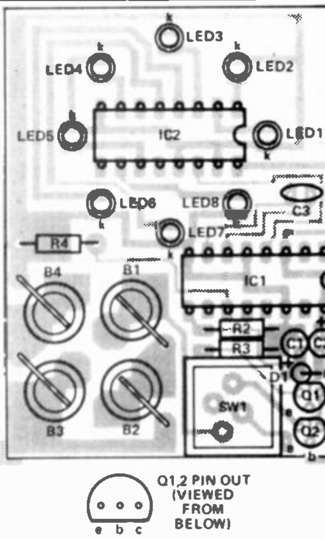


Fig. 2. Component overlay for the Credit Card Casino.

At this point you can either finish the casino the easy way or the hard way. The easy way first. Line the bottom of the case with a piece of ¾in stiff foam plastic. Put on the lid of the case with the foam holding the PCB in place, cover the front with the self-adhesive fascia, and you've finished.

If you prefer the PCB can be held in place by gluing the switch body and LEDs to the lid but in this case you'll have to unsolder the phosphor-bronze strips when you want to change the batteries. The casino finished in this way will be about 1in deep.

If you are keen to make the slim version, you've still got some work ahead of you. The first thing to do is to mark the body of the case all around, ½in from the rim.

By far the easiest way to do this is to spend a few minutes making yourself a simple marking gauge. You'll need a length of ¼in wood baton, a panel pin and some glue. Cut a 1in length and a 6in length from the baton. Knock the panel pin through one end of the 6in length so that the point just protrudes through the wood. Fix the 1in piece at right angles to the 6in one, ½in from the pin. Now hold the longer baton so that the point is against the side of the case and the short length rests on the rim. Keeping the short piece flat against the top at all times, score a line all the way around the case with the point. If you have a steady hand, the line will be ½in from the rim all the way around.

Cut off the top part of the case with a hacksaw, just above the line you have marked, then file down the rough edges. Place a piece of fine grained sandpaper on a flat surface and place the case upside down on it. Rub the case on the sandpaper with a gentle circular motion until it is perfectly smooth and has worn right down to the marked line. Be patient. If you try to rush it, you'll end up with a lop-sided case.

Since the case is slightly tapered, you'll now find that the lid won't fit. The raised area on its underside will be too wide. Your next job is to file away the edges of the raised area until the lid fits flush with the top of the case.

You'll also find that there are no screw holes. You'll have to drill the pillars (carefully!) with a 5/64in drill, using the lid as a template to mark the drilling positions. Now screw the lid in place and gradually pare away the overhanging edges with a sharp knife. Don't use a file or sandpaper, or you'll scratch the sides of the case. It's best to take off the waste plastic a little at a time rather than trying to remove the entire depth with one cut — you'll have more control over the knife.

The final problem is that the PCB will no longer fit. You'll have to widen the case! After some

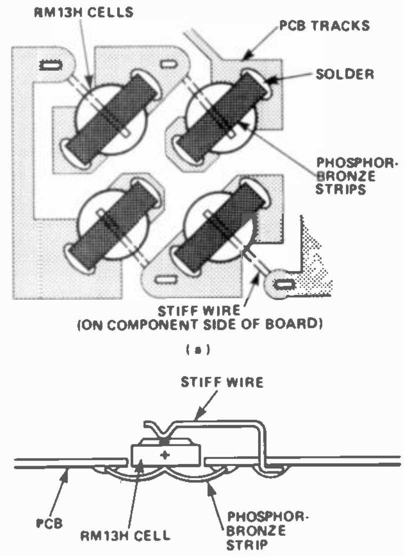


Fig. 3. Some hints on construction. (a) the position of the phosphor bronze strips and the wire for the battery contacts. (b) a side view showing the 'kink' in the phosphor bronze strip and the shape of the wire contact.

HOW IT WORKS

IC2 is a Johnson counter, which lights each of the LEDs in turn as it is clocked. The clock signal is derived from the VCO section of a phase locked loop, IC1. The output frequency of IC1 is determined by the voltage on pin 9.

When the spin button is pressed, C1 is charged to virtually the full positive supply voltage via R1. When the button is released, the charge leaks away via R2 over a period of several seconds.

The result is that the light spins rapidly around the circle of LEDs while the button is held down then when the button is released it gets slower and slower and eventually comes to rest.

Transistors Q1 and Q2 serve to cut off the supply when the casino is not in use. When the spin button is pressed Q1 draws current via R3 and turns on Q2, allowing the circuit to operate.

When the button is released the negative end of C2 is at almost the full supply voltage. C2 gradually charges via the base current supplied to Q1 and the voltage across R3 drops.

After a minute or so, Q1 can no longer draw enough current to keep Q2 hard on. The voltage at Q2 collector falls slightly, causing Q1 base voltage to fall, leading to an even lower current from Q1.

This regenerative action causes the current to be shut off almost instantly, and the casino remains in a standby state drawing only Q2's leakage current until the spin button is pressed again.

experiment, we found that the best way to do this is to use the edge of a file at 45° to the case wall — it takes off the plastic fairly quickly, but it's hard work! You can also file down the edges of the PCB slightly, but be careful not to cut into any of the tracks.

From now on, it's easy! Line the bottom of the case with a layer of ¼in foam plastic, put the PCB against the front panel so that the switch and LEDs are in their respective holes, then bring the two halves of the case together. You'll probably find it easier to do this upside down — that is, hold the lid face downwards in the palm of one hand with the PCB above it, then lower the body of the case over the top. Then, holding the two halves of the case together, put it on your workbench and put in the screws. Finally, remove the backing from the fascia and stick it to the top of the case.

If you've had the patience and dedication to follow this through, you deserve a little relaxation, so we've put together some games you can play on the Credit Card Casino.

PARTS LIST

RESISTORS	
R1	100R
R2	330k
R3	22k
R4	1M0
CAPACITORS	
C1, 2	10u 6.3V tant.
C3	100n any type. See text
SEMICONDUCTORS	
IC1	4046
IC1	4022
Q1	BC548L or equivalent
Q2	BC558L or equivalent
LED1 to 8	3mm LEDs, 4 red, 4 green.
D1	IN4148

MISCELLANEOUS
Switch: push-to-make keyboard switch; four Duracell RM13H mercury cells; T3 plastic case (white), self-adhesive fascia; strips of phosphor-bronze; paper clip; printed circuit board.

Roulette

Short of tossing a coin, this must be one of the simplest gambling games in existence. Players bet on numbers or combinations of numbers by placing their betting slips in certain positions on the roulette table. A single spin of the wheel decides the winers and losers. The croupier collects any losing stakes, pays the winners, and the betting begins again ready for the next spin.

Figure 4 shows the layout of the roulette table, which you can make from a sheet of card, and the positions where stakes would be placed to bet on certain combinations of numbers. Table 1 lists the possible bets and the odds that should be paid on them in a fair casino (one with no advantage to the bank). It is conventional in gambling to state odds in terms of the winnings you receive. You also get your stake back again, so if you bet 5 at 7 to 1 you would get back *eight* pounds; seven pounds winnings and the return of your £1 stake. Next time you put 10p into a fruit machine and get £2 out, you'll know not to say 'I won £2', but 'I won £1.90 and got my 10p stake back again!' The sum of your winnings and the stake money is known as your *returns* from the bet.

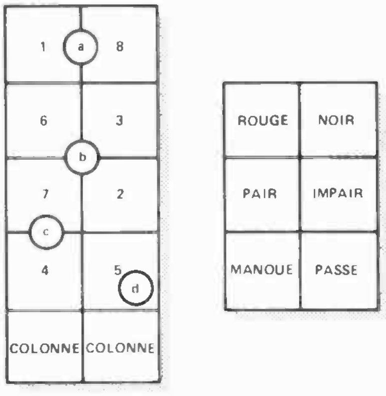


Fig. 4 The markings for the roulette table. Squares should be large enough so that bets can be placed without obscuring the numbers, and so that they can be placed on the border between squares without ambiguity. A *cheval* and *carre* bets only apply to the numbered section. You cannot, for example, place a bet on the border between *pair* and *manque*.

The top bet in Fig. 4 will win on either 1 or 8; it is a *cheval* bet and pays 3:1. The next bet down is a *carre* bet on the numbers, 2, 3, 6 and 7. It pays evens. Next comes another a *cheval* bet on 4 and 7, and finally an *en plein* bet on number 5, paying 7 to 1. If the wheel happened to stop on 7, bets 6 and 3 would win. The others would lose.

Breaking The Bank At Monte Carlo

Every gambler has daydreams about inventing the perfect system to beat the roulette wheel. It's impossible, but then by the laws of aerodynamics a bumble bee can't fly, so just maybe ...

The best known and simplest system is just to double your bet each time you lose. This is how it works. Begin by betting £1 on black. If you win — great! Pocket the winnings and start again with £1 on black. If you lose, bet £2. If you win this time your total stake will have been £3 — £1 on the first go (which you lost) and £2 on the second. The return will be £4 leaving you with £1 winnings. Start again with £1 on black.

Let's suppose you have some bad luck this time, and get four reds in succession before black comes up. Your total stake will have been £1 + £2 + £4 + £8 + £16 = £31. The returns from the fifth spin of the wheel when black eventually came up (on which you bet £16) will be £32 leaving you with £1 profit. As long as you double your bet each time you lose, you will *always* end up £1 ahead each time black comes up! As soon as it does, you go back to a bet of £1. If the wheel is spun once a minute, and black comes up 50% of the time on average, that makes your earnings £30 an hour! The presence of a zero (in a casino this is the house number: all the stakes go to the bank and nobody wins except the casino!) does not affect the results. You just double your bet as if the outcome had been red.

Of course, such systems have their disadvantages, otherwise casinos would be out of business overnight. With the credit card casino you can try out this sytem and any others you may dream up without risking your money. If you come up with something good and win a fortune, don't forget to take out a subscription to ETI. We may be able to suggest a few add-ons for your executive jet!

Bet	Meaning	Odds
En plein	Bet on a single number	7 to 1
A cheval	Bet on two adjacent numbers	3 to 1
Pair	Bet on any even number	evens
Impair	Bet on any odd number	evens
Passe	Bet on any number from 5 to 8	evens
Manque	Bet on any number from 1 to 4	evens
Rouge	Bet on any red number	evens
Noir	Bet on any black number	evens
Carre	Bet on any number in a square of 4	evens
Colonne	Bet on any number in a column	evens

Table 1: The types of bets allowed on the credit card casino. These are the same as for a standard roulette wheel, except that Passe would represent 19 to 36 and manque would be 1 to 18. The odds are different, of course.

BUYLINES

The only item likely to cause any difficulty is the switch. This is a Preh 75120-008 low profile keyboard switch; you may have to phone a few computer hardware shops to locate a source. The UK distributors for Preh (pronounced 'pray') are Eardley Electronics Ltd, 182-4 Camden Hill Rd, London W8.

The phosphor bronze strip can be obtained from hardware shops. It is sold as draught excluder strip for door frames. As you will probably have to buy it in lengths of several yards, the rest can be used to draught-proof your front door!

The batteries for this project are sold by chemists as hearing aid batteries. The type is not important, but the cell diameter must be about 8mm to fit the cut-out in the PCB. The cell voltage should be about 1.4V, but the circuit is not fussy about variations in voltage. If you are unable to obtain the specified RM13H, try others from watch or calculator shops. Take a ruler with you!

A complete set of parts for this project including PCB, case, self-adhesive fascia, phosphor bronze strips, and even a paper clip, is available from: Specialist Semiconductors, Founders House, Redbrook, Monmouth, Gwent. The price is £5.90 + 60p postage and packing. The self-adhesive fascia is available separately from the same source for 90p + a stamped, self-addressed envelope.

The PCB will be available from our Readers Services in due course.

CREDIT CARD GAMES

Casino Craps

One player is chosen to be the shooter — in this case, the person who presses the button on the Casino. He places his stake on the table, and all other players put down the same amount. The shooter presses the casino button, records the number that turns up, then presses the button again.

If the two numbers total 9 or 15, this is known as a 'natural' and the shooter immediately wins all the money on the table. If they total 2, 3 or 16, this is called 'craps'. The shooter immediately loses and the player on his left takes the casino and becomes the new shooter. If the shooter makes any number other than natural or craps, this number becomes his 'point'.

Now the game becomes a little more complicated. The shooter presses the casino button again and adds the resulting number to the outcome of the previous spin. If the result is a nine, he loses. If he makes his point again, he wins. If neither of these occur, he just keeps spinning until one or the other turns up.

To make this a little clearer Table 3 shows some winning and losing sequences of spins.

Sequence A: The shooter loses because his first two spins add up to three, which is craps.

Sequence B: The shooter wins because his first two spins total nine — a natural. Note that although his first spin is one of the craps numbers, he doesn't lose because it's the total of the first two spins that counts.

	A	B	C	D	E	F
1st spin	2	2	6	6	6	4
2nd spin	1	7	4	4	4	7
3rd spin	–	–	3	3	5	8
4th spin	–	–	2	6	–	3
5th spin	–	–	8	–	–	–

Table 2: Some winning and losing sequences in a game of Casino Craps. See text for explanation.

Sequence C: The first two spins add up to 10. This is neither a natural, nor craps, and so becomes the shooter's point. The fourth and fifth spins also add up to ten. The shooter has made his point and wins.

Sequence D: The shooter's point is again ten but his third and fourth spins add up to nine, which is the losing number.

Sequence E: The shooter loses for the same reason as above. The second and third spins add up to nine.

Sequence F: In this sequence, the shooter's point is 11 and the shooter wins through making his point on spins three and four. Note he does not win through making 15 on spins two and three. You can only have a natural on the first two spins. The other natural (nine) is a winner on the first two spins and a loser thereafter.

If the shooter loses, the casino passes to the player on his left. All stakes remain on the table and another round of betting must take place before the new shooter spins. For every loser, the total pool to be won increases!

Knock

This is a game of nerves and judgement. Spin the casino and as soon as you think the light has finally come to rest, tap on the table. Anybody who knocks before the light comes to rest loses. The winner is the first person to knock when the light has stopped. This game is usally played for fun — very popular at children!s parties! If you wish, it can be played for money. All players put in a fixed stake and the winner takes all.

The Ultimate Game

A book published in 1972 describes how a disillusioned psychiatrist decided to hand over his entire life to the whim of the Casino. Whenever he had a decision to make, however trivial, he would write down a number of options and then spin the Casino to choose between them.

For some reason, the book refers to the Casino as a die, but we won't let that bother us — it was probably a Casino-inspired decision anyway!

We join the story at the point where our hero, Dr. Rhinehart, has just forged the signature of the director of a mental hospital to take a coach load of loonies to see the rock musical Hair, and has forgotten to bring them back again. Why? Because the Casino told him to, of course. He has admitted everything to the police (you guessed it — because the Casino told him to), but the interview with Inspector Putt is still not going quite the way the detective would wish.

'Does it not occur to you, Inspector, that in tellling you I forged Dr. Mann's signature I may be lying because the Die has told me to?'

'What –'

'That in fact my original statements of innocence may be the true ones?'

'What? What are you suggesting?'

'Simply that yesterday when I heard that you wished to question me again, I created three options for the Die to choose from: that I tell you I had nothing to do with the order to go to Hair; that I tell you that I initiated the excursion and forged the orders; and thirdly that I tell you I conspired with Eric Cannon to help him escape. The Die chose the second. But which is the truth seems to me to be still an open question.'

'But — What are you saying?'

'The Die told me to tell you that the Die told me to take the patients on an excursion to Hair'

'But is that story the truth?' asked Inspector Putt, his face somewhat flushed.

Dr. Rhinehart shook a die onto the little coffee table in front of him. He examined the results.

'Yes,' he announced.

Full instructions on how to lead the dicelife, and its advantages when being questioned by the police, can be found in: 'The Dice Man', by Luke Rhinehart, published by Panther Books.

ETI

TECH TIPS

Auto Battery Charger

Andy Armstrong
Leighton-Buzzard

This is a car battery charger which can be trusted to charge the battery faster than the standard four amps because it will switch to a low charge rate when the battery is almost fully charged. In addition, it is protected against damage if connected the wrong way round.

Assuming that the battery is connected the right way round, the sensing circuitry is energized via D2. If the battery voltage is below the preset end-of-charge point then the relay switches on and connects the battery directly to the rectified output of the transformer. Charging proceeds at maximum rate.

When the voltage of the battery rises sufficiently, the op-amp switches over and the relay is switched off. The relay will not switch just because the peak of the charging current takes the battery voltage up for a few milliseconds because R7 and C1 average it out. D3 protects C1 in case of reversed polarity.

The battery voltage will then fall to some extent, but the relay should not switch back on because there is about 1V of hysteresis applied to the op-amp (referred to the battery voltage). The voltage is unlikely to fall to this extent because it remains under charge, albeit at a lower rate.

If a 24W car bulb is used in place of R1, the lamp will start to glow dimly once the relay has switched off. This will serve as a visible reminder that the battery is charged.

It is a wise precaution to switch on after connecting, and switch off before disconnecting the charger, to prevent sparks, and hence the possibility of explosion.

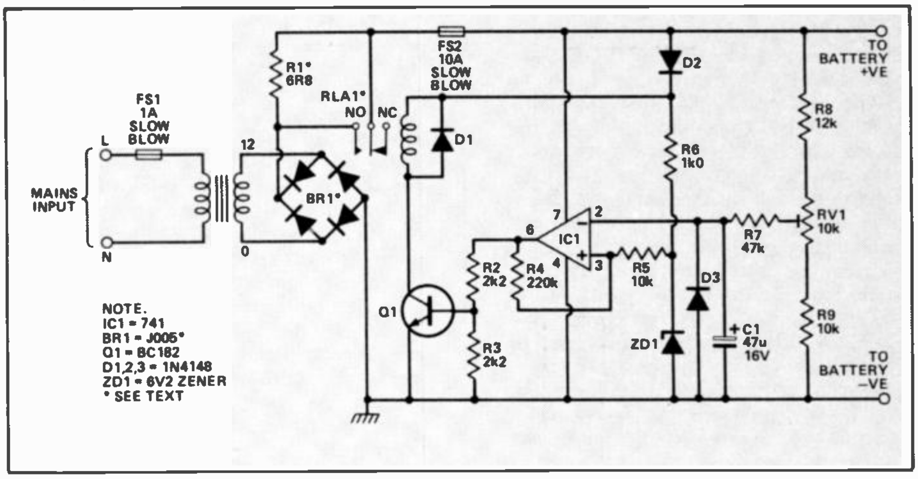
No particular transformer is specified, because constructors can choose what wattage to use. If a tractor or lorry battery is to be charged, then a high current rating is required.

A 50VA transformer would be the minimum useful size. This will not give a particularly fast charge rate. If more than 10A charging current is anticipated, a more substantial bridge rectifier will be required. Also, the relay contacts must be rated for the maximum rated current expected.

The circuitry shown here may, of course, be added to an old, standard-type battery charger simply to prevent harmful overcharging, or to keep a battery topped up for occasional discharge cycles.

A good way to adjust the cut-off point of the circuit is to connect it to a car battery which is well charged. Adjust RV1 so that the relay switches on for two or three minutes. If the battery is well charged this should be long enough to raise the voltage to its maximum value, without being long enough to damage the battery. Then adjust RV1 so that the relay just switches off. The unit should now work perfectly.

If there is any problem with the relay switching back on when the battery is well charged, then the hysteresis can be increased slightly by lowering R4 to 180k or 150k. If it seems necessary to lower it further, suspect the battery of being below standard — maybe it has a high resistance cell.



Versatile DRAM Interface For The 6502

Keith Howell
Keele

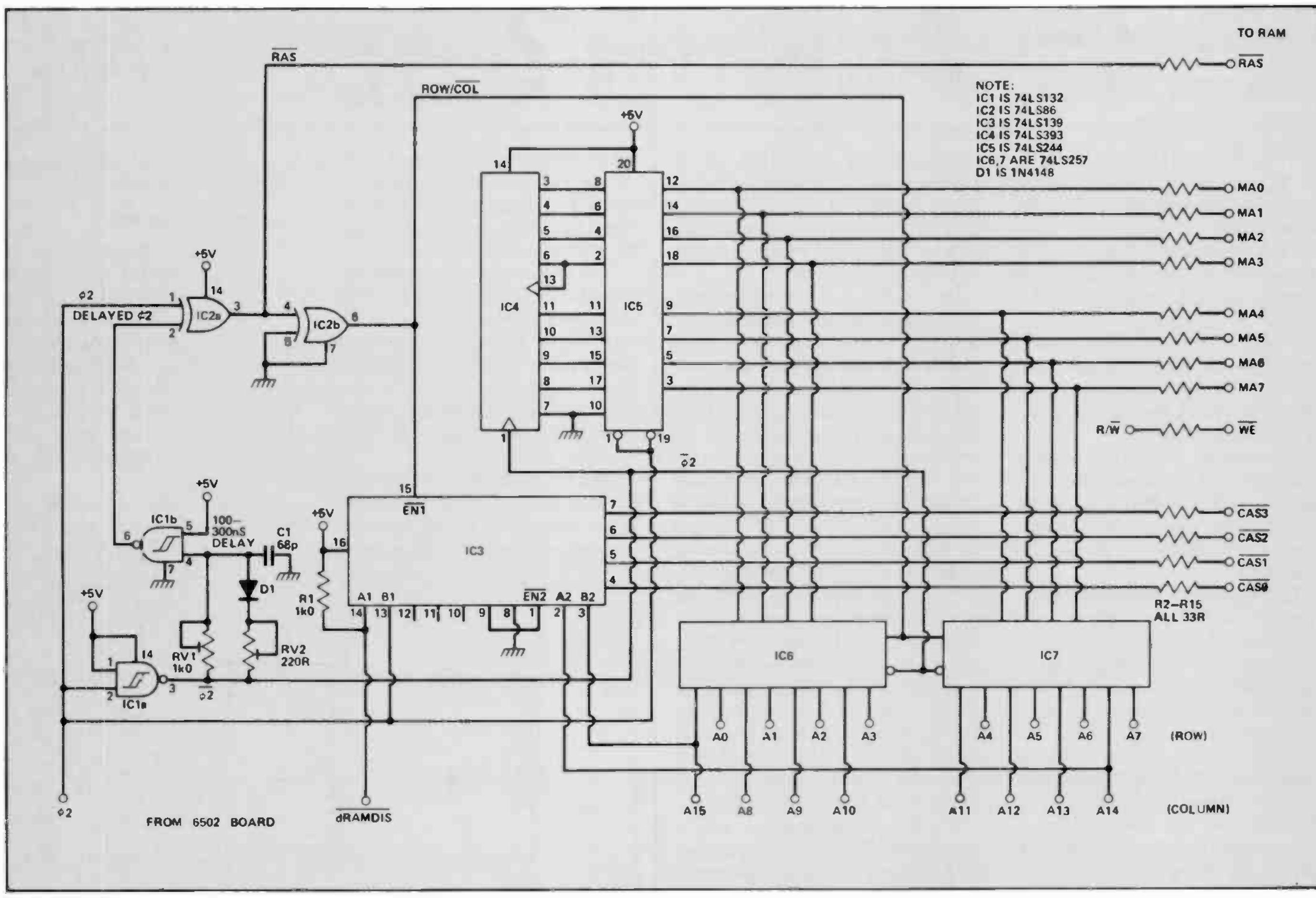
This interface uses few chips yet is extremely adaptable. It has been tested on a 1MHz Acorn Atom with two 4416-150ns DRAMs without the 33R damping resistors, although these and adequate decoupling capacitors are recommended for fewest errors. I see no reason why it should not work with 6809 processors and with 4164 (1 x 64K) or 41254 (4 x 64K) DRAMs.

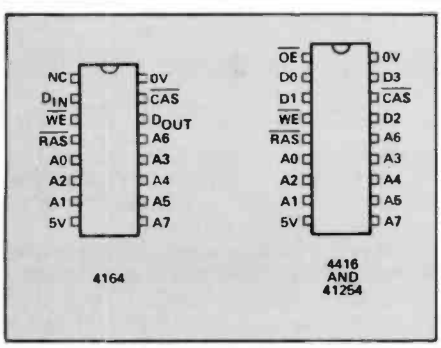
The timing diagram shows a single memory access cycle, with the 6502 requiring data valid on the falling edge of 02, the main timing signal. The refresh row address is enabled in the first half of the cycle (02 high).

The timing signal is exclusive-ORed with a delayed version of itself to produce the Row Address Strobe (RAS) at twice the access rate. The first falling edge of RAS is used to latch in the refresh row address from the 8-bit counter, IC4, and the tristate buffer, IC5. The second falling edge of RAS latches in the CPU row address (A7-A0).

IC2b adds one TTL gate delay to RAS, producing ROW/COL. This signal allows 20ns for the row address to be latched before selecting the CPU column address. IC3b is enabled by ROW/COL low. Input B1 disables the output if 02 is low which prevents a memory access during refresh. Input A1 can be used by a separate device to disable access at any other time and provide its own data to any memory address. For instance, a boot EPROM can be switched in if its chip select, CS, is tied to dRAMDIS at A1. This will prevent bus contention.

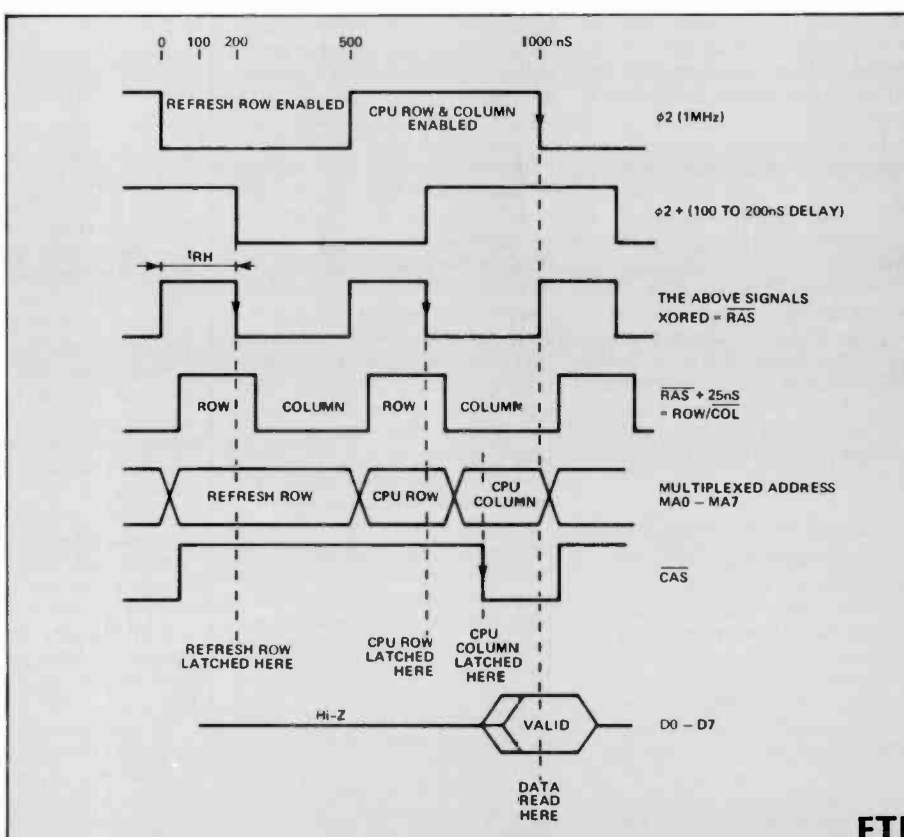
IC1a inverts 02 for the tristate address multiplexers, IC6 and 7. It also drives an RC delay network before IC1b is used to square up the waveform. Because the TTL schmitt trigger thresholds aren't symmetrical about 2.5V, RV2 and D1 have been added to the basic network, RV1 and C1, to give equal delays to rising and falling edges. After trying to calculate values for the delay resistors and finding they didn't work, I gave up and used a couple of presets. If an oscilloscope is unavailable for setting-up, adjusting the presets to the middle of the error-free range should do just as well.





Conventional wisdom says 6502 address lines aren't guaranteed valid until 200ns after the rising edge of 02. If so, RAS ought not go low until after 200ns. In practice, RAS high times as short as 90ns sec seem to work.

A 2MHz clock would allow 500ns for two DRAM cycles. The data sheet for 150ns DRAMs quotes a minimum cycle time of 256ns. The method I have used should not, therefore, work at 2MHz since there is not enough time between CPU accesses to allow refresh. In practice the DRAM may be fast enough for the method to work. Most memories are actually tested at twice their nominal speed.



OPEN CHANNEL

The old Band III 405-line television band, recently redesignated as a mobile radio band, is in the news at the moment. Prospective operators of mobile radio services in the band can't seem to agree on specification to be used.

GEC is proposing a system known as *full off-air call set-up* in which the speech channel is not taken up until the call is completely connected.

Compared with the nearest existing comparative service — cellular radio — this is an enormous benefit to a mobile radio system with a limited number of channels.

Call set-up on the cellular radio system can take anything up to 20 or 30 seconds, and a channel is used throughout this period. In congested areas that means there is one less channel for communications purposes.

GEC is one of two national operators of Band III mobile radio systems. The other national operator, headed by Pye and Racal, does not intend to introduce full off-air call set-up.

This difference wouldn't make equipment on the two services completely incompatible. A GEC mobile phone could be used on lower spec systems, but not vice versa.

Elsewhere on the system, regional operator National Radiofone is joining forces with British Telecom and Motorola to form a company called National Mobile Radio.

It's interesting to note that when applications were first invited for Band III operators last year, the Department of Trade and Industry refused permission for BT to even apply. Also, Motorola had its application turned down by the DTI. If at first you can't succeed ...

Illegal Cordless Telephones

A large number of the cordless telephones available (those phones which you carry around the house or garden with you so that you can make or take calls without having to return to a fixed point) are actually illegal to use.

Illogically, they are not illegal to import and sell. If you are contemplating buying one soon, you would be wise to ensure that the model of your choice is not in this category.

The general use and operation of illegal and legal types are identical. So what *is* the difference and why would you want to buy one of the illegal models rather than a legal version?

In terms of user-advantages, legal cordless phones have a typical range of no more than about 100 metres or so, depending on the local environment. The illegal units on the other hand are capable of a range of miles — up to 20 miles or so, depending on the model. To actually obtain distances of this range you might need to mount a loft or roof-top aerial instead of the small aerial supplied with the base station.

This extra distance will obviously make the illegal phones more attractive to potential users. After all, if you stayed within the law and wanted to have a portable phone with such a great range you would need to have a cellular radio phone — at around five times the cost to buy and around three times the call charge rate.

It's the extra distance which these illegal cordless telephones give the user over the legal types which causes the problems. Such high powers of transmissions may cause interference to emergency service transmissions (police, ambulances, fire services, etc). Secondly, the high powers could interfere with legal models.

The situation has deteriorated to the extent that the Department of Trade and Industry is currently in the process of producing legislation against the import and sale of illegal cordless telephones, but there are still a large number of them in service.

If you are worried that your cordless phone is an illegal type, check to make sure it has one of the 'green circle' BT approval labels. If not, or if it has a 'red triangle' unapproved label, don't touch it with a bargepole!

If nothing else, sale of these telephones has highlighted the need for a *legal* service to do the same job. Opponents of such a legal service use the argument that there is not enough free radio spectrum available. To them I point out my previous story, above and the new part of the radio spectrum which is being reallocated. Shouldn't we be making a move to use part of this to provide the service?

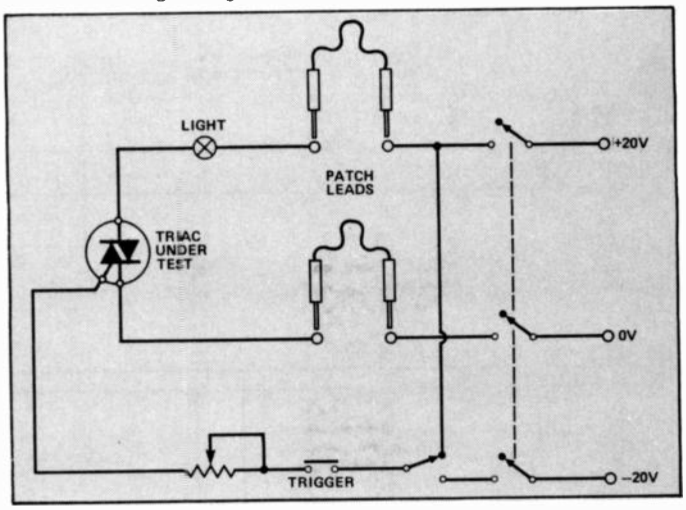
Keith Brindley

ALF'S PUZZLE

This month Alf has been buying packs of unmarked, untested, unwanted and unloved components. He is very proud of the test rig he built to check out the triacs.

Triacs are basically bi-directional SCRs. They provide a high resistance until a trigger pulse is received at the gate when they can conduct in either direction. Once triggered, a triac will continue to conduct until the current through it is reduced to less than a 'holding' current.

Alf's triacs could be fitted into his test rig and using the patch leads conduction in either direction could be checked. The trigger push button switch provides the trigger pulse and the two way switch enables either positive or negative pulses to be applied to the triac gate. The gate current could be adjusted using the potentiometer.



Alf plugged the first triac into the test socket, taking care to follow the pinout given in his data book, and turned on the power. The light came on immediately, showing the triac was conducting, before he had even thought about pressing the trigger button. 'Short circuit,' said Alf to nobody in particular, and dropped the faulty triac into the bin.

With the next triac, exactly the same thing happened. 'Oh well,' said Alf, 'You've got to expect a few duds.'

By the time the twenty-third triac had failed, Alf was beginning to get a little worried. On the fifty-ninth failure he was certain something was wrong — but what?

Were all Alf's triacs faulty? Is there something wrong with his test rig? Will Alf discover the answer by next month?

January's Answer

The January puzzle was inspired by a circuit in a certain magazine, which shall remain nameless to spare their blushes and to avoid writs for libel!

The author admitted his chosen op-amp only had a gain of 10^5 but he claimed that by using the resistor values shown he could force it to have a gain of 10^8!

By the same reasoning, we could force a piece of wire, which has an open-loop gain of 1, to have a gain of 1000 simply by connecting suitable feedback resistors across it.

Just think: an amplifier consisting only of wire and resistors!

The answer is that the usual formula for determining the gain of an amplifier with feedback resistors is just a rule of thumb.

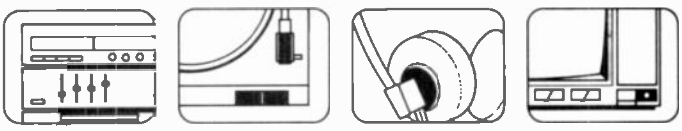
It is a very accurate rule of thumb when the closed-loop gain is a small fraction of the open-loop gain, but becomes increasingly inaccurate as the closed loop gain is increased.

Eventually, when the closed loop gain aimed for is comparable with the open loop gain of the amplifier, it becomes a complete nonsense.

This is why Alf's teacher at the evening classes said an op-amp's gain should be as high as possible, to make the feedback formula meaningful (when it is used in the normal way).

Alf's circuit will, in fact, have a marginally worse performance than the unmodified circuit.

PLAYBACK



The realism of stereo reproduction from records, tapes and radio is something all hi-fi users now take for granted. Until now, the same effect with TV has only been achievable by simultaneous broadcasts on stereo radio. Soon though, stereo sound on TV looks like becoming a reality.

Both BBC and ITV have agreed on a system called 'Nicam 728' (Near Instantaneous Compansion). This augurs well as rivalry between the two organisations has in the past delayed the acceptance of either of their respective technical offerings until they could be thoroughly tested against each other.

However, the Nicam system *has* been field tested. Transmissions from Wenvoe and Crystal Palace have proved very encouraging. As a result, the system has been approved by the Government and it is expected transmissions could start as early as 1988. Of course we have all heard these over-optimistic predictions before, but the nearness of this one does suggest some certainty.

Other countries have got in first. However, as with colour TV systems, they might live to regret it. Canada is using the 'MTS' system developed by Zenith. This is similar to the ordinary FM stereo radio signal except it is DBX encoded. There are reports of problems such as mono being received from supposedly stereo programmes and some stations using a stereo synthesizer instead of genuine stereo material.

Germany has been transmitting stereo with the 'Zweiton' system for the last two years but both sound and vision reproduction is said to be poor as a result.

So what is special about Nicam 728? The main thing is it encodes the signals digitally, eliminating noise, fading, distortion and other transmission ills. This permits another ploy. The existing mono sound signal remains unchanged, spaced at 6 MHz higher than the vision signal, while the additional digital stereo carrier is spaced 0.552 MHz above mono sound.

The mono sound transmitted power level is one fifth (–7 dB) that of peak vision, but the digital stereo carrier will be –10 dB or one tenth, half that of the normal mono signal. This low level greatly reduces the possibility of interference or intermodulation with either vision or mono sound carriers, which has been a problem with other systems.

This lowered level is only possible by using a digital signal.

Technically it looks like the UK will have a much superior system to that used elsewhere. It's only a pity it couldn't have been made a world standard.

It is the aesthetic side of the stereo TV that will have to be watched. The present combination of stereo radio and TV throws up many anomalies. When there is a close up shot of an instrument the sound remains the same. So the visual image is probably well to one side of the sound. Should the stereo balance be altered or should close-ups be avoided?

Come to that, as the TV screen width is so small, does stereo image really matter? If not, then why have stereo at all?

Vivian Capel

BIRD'S EYE VIEW

For some years now my magazine diet has consisted mainly of high protein, low fat trade mags. It was therefore with great interest that I read through the parcel of ETI back issues, kindly supplied by the Editor in preparation for this column.

My first impression was that the standard of features and circuits is generally very high (with a few unfortunate exceptions).

Apart from the lighter approach and the obvious bias towards what is interesting rather than what is necessarily commercially viable, the main difference between ETI and my usual fare can be summed up as: lack of engineering content.

Engineering

The term 'engineering' is not easy to define. I'll try to clarify what I mean by way of an example. If you take any logic circuit from the pages of ETI (you choose!), the chances are you will find little in it that is essentially 'electronic'.

That is to say, exactly the same result could be achieved by interpreting each IC box in the circuit diagram as an equivalent hydraulic component and each line as a pipe rather than a conductor.

If this sounds unlikely, you have only to remember that any logic system whatsoever can be constructed entirely from NOR gates (although you'll need an awful lot of them to make a microprocessor!)

So, as long as it is possible to make a hydraulic NOR gate (and it is), it is also possible to imitate any electronic logic circuit with hydraulics.

Indeed 'fluidics', as this science is called, is well developed and hydraulic control systems are in use in environments hostile to conventional electronics, such as nuclear power stations.

Naturally there are differences between electronic and fluidic circuits. The electronic implementations are much faster, smaller and usually cheaper, which is the very reason that electronics is used. However, that does not alter the fact that the underlying logical structure is not essentially 'electronic'.

Lego

This joining together of functional blocks to make a circuit I call the 'lego' aspect of the design (with a small 'l' to distinguish it from the manufacturer of toy bricks).

This aspect of design is by no means confined to digital circuits. It is quite feasible to cobble together analogue circuits from standard building blocks such as amplifiers, filters and the like. The only difference is that the analogue blocks themselves usually consist of a number of components rather than just a single IC.

Engineering (I've got around to it at last!) is any consideration which goes beyond the functional block approach. It's what makes electronics *electronics* rather than fluidics.

Good, Bad and Ugly

If a designer uses a BCD counter and a BCD to one-of-ten decoder where a Johnson counter would do, then that is bad lego. However, if he exceeds the fan-out of a logic gate or builds a VHF radio on Veroboard, that is bad engineering.

The ratio of lego to engineering in ETI (and other similar but unmentionable magazines) varies widely from circuit to circuit. I think it is fair to say that most ETI logic circuits are lego designs — the engineering content is minimal and incidental.

This is in no way to disparage the authors. Some very fine and beautiful structures can be built with lego.

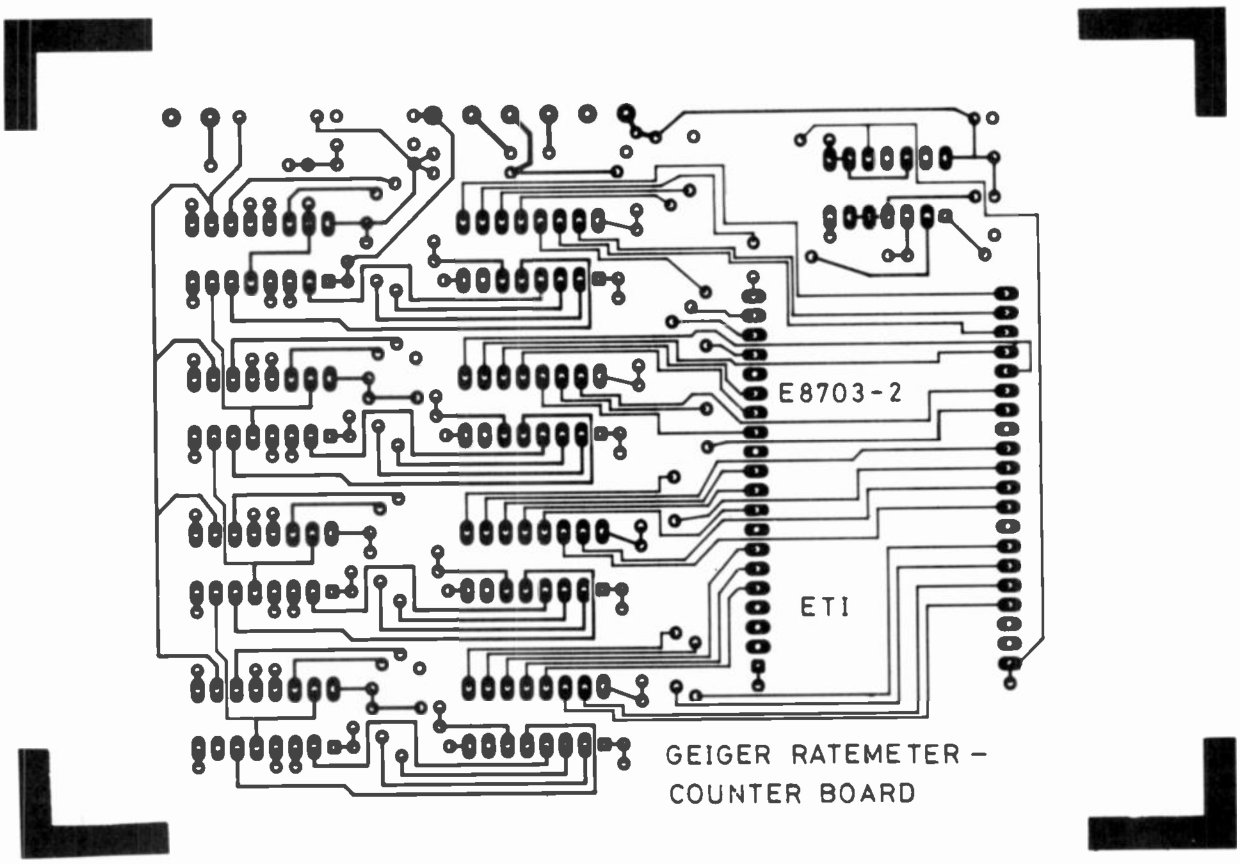
Designing with lego has its own problems, the solutions to which can be elegant or clumsy depending on the skill of the designer. My point is that, admirable though these skills may be, they are not *electronics* skills.

The means and results of taking logic design beyond the lego stage are being covered by Mike Barwise's excellent series and I have no wish to encroach on his territory here.

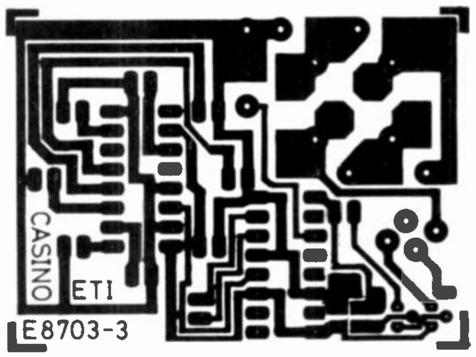
Some ETI circuits *do* have a substantial engineering content. Most of the audio amplifier designs, for instance. Whether or not they embody *good* engineering principles is an entirely different kettle of pirhanas, and one which I will look into another day.

John Bird

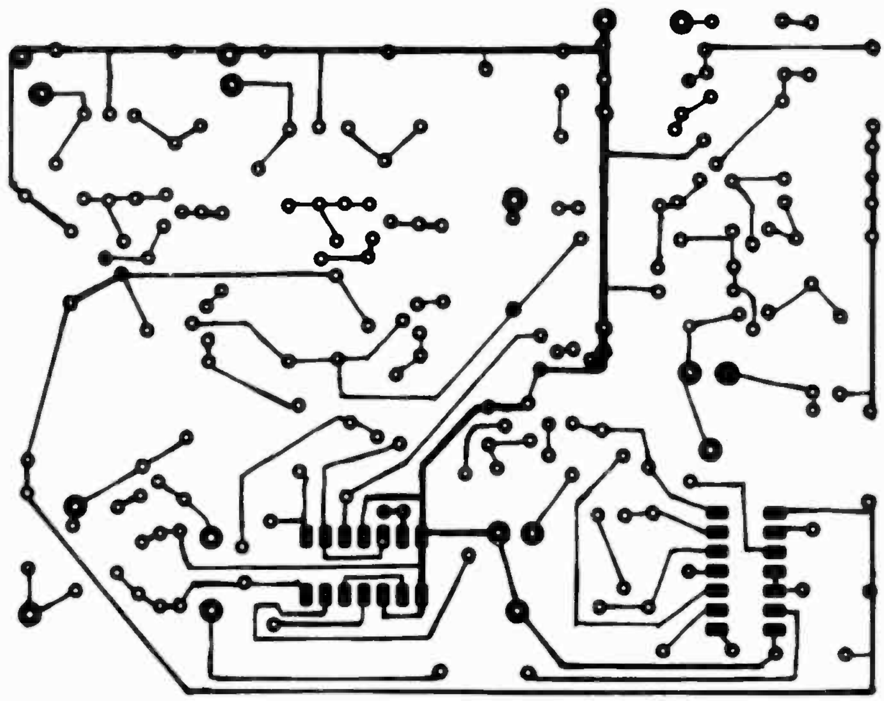
PCB FOIL PATTERNS



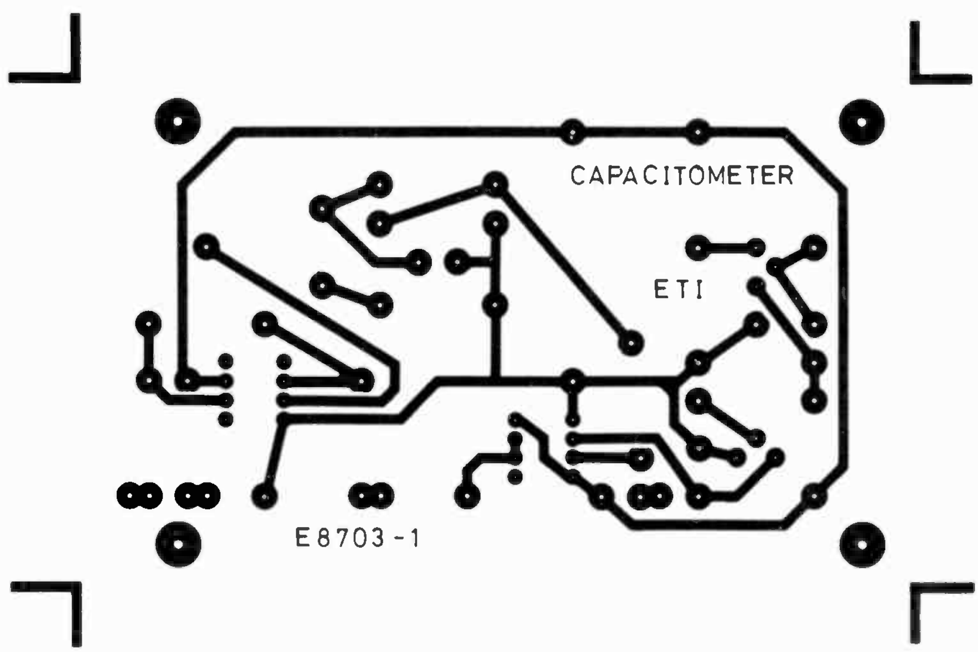
The Geiger Ratemeter counter board.



The Casino board foil pattern.



The foil pattern for the Stereo Decoder Board, held over from last month.



The foil pattern for the Capacitometer board.

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E8703-1	Capacitometer	F
E8703-2	Geiger Counter	L
E8703-3	Credit Card Casino	E

OOPS!

Microlight Intercom (May, 1986)
In Fig. 1 the link between pins 2 and 3 of PL3 is not shown. C13 is shown as a polarised capacitor. The battery check contact on SK1 should be shown as normally closed. The PCB foil pattern on p.59 is shown as from the component side. It should be reversed. The miniature loudspeakers mentioned in the article cost £2.50 each, not per pair as incorrectly noted in buylines. The author of the article suggests it is advisable to insert a suitable capacitor between R9 and IC3, pin 3.

Baud Rate Converter (May, 1986)
In Fig. 4 some confusion has crept in to the ins and outs of the circuit diagram. IC6a and IC5c need to be turned round and pins 20 and 25 of IC2 swapped round. In Fig. 5, D4 and D3 are shown the wrong way round on the overlay. This could of course lead to the destruction of C10 as well as the presence of second +12V rail instead of the required −12V. In Fig. 6, SK4.3 and SK3.3 must be swapped over. In the Parts List, C10 should be 1000µF, not 100µF.

RF Oscillators (June, 1986)
Fig. 12 does not, infact, show a working oscillator. For a series fed arrangement, take the link from CV1a,b junction to R3 and Q1 emitter junction and not 0V, remove C1 and move C2 to shunt R2. For a shunt-fed arrangement, break the link between L1 and Vcc and take Q1 collector to Vcc via a 4k7 resistor.

Speaking Alarm Clock (August, 1986)
In the circuit diagram, Fig. 2, diode D3 and resistor R14 shoudl be in parallel not series as shown. The link from IC10, pin 1, to battery positive should be removed.

Biofeedback Monitor (December, 1986)
The capacitor C4 is shown the wrong way around in the component overlay diagram (Fig. 4).

The Intelligent Call Meter (December, 1986)
The hex dump listing of the ROM for this project (Table 3) was badly printed with the byte at location BF missing. This should read 7F.

The Better Flanger (January, 1987)
In the circuit diagram (Fig. 2) D1 is not labelled. This is connected to Q1. In the component overlay (Fig. 5) several components are missing. A link should connect the two pads to the left of C1. Q1 is situated next to D1 and connection point P4 is situated between R16 and R33. In addition, the positions of R16 and C11 should be swapped.

Aerial Without Holes (In-Car Tech Tips, January, 1987)
Using enamelled wire of only 0.5mm diameter for the bifilar coils could cause overheating problems and even a fire risk with some cars. A much thicker wire (1.5mm should be sufficient) should be used.

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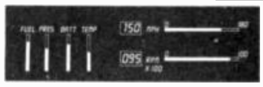

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