ELECTRONICS TODAY

electronics today international

DECEMBER 1975

NEW SERIES: OP AMPS

30p

ETI HEATHKIT COMPETITION
THREE SCOPES MUST BE WON

ACTIVE CROSSOVER PROJECT

OTHER PROJECTS:

DIGITAL STOPWATCH
LOGIC PULSER
LOGIC PROBE

HEATHKIT SCOPE REVIEW
MULTIMETER GUIDE

ETI SPECIAL OFFER: NEW MEMORY SCIENTIFIC CALCULATOR FROM NOVUS £15.95

NEWS . . . CONSTRUCTION . . . DEVELOP

electronics today international

DECEMBER 1975 VOL 4. No. 12.

Main Features

Projects

Data Sheets

News & Information

Free Competition

Special Offer

EDITORIAL AND ADVERTISEMENT OFFICE
36 Ebury Street
London SW1W OLW
Telephone: 01-730 8282

HALVOR W. MOORSHEAD
Editor

ROBERT C. EVANS
Advertisement Manager

STEVE BRAIDWOOD, G3WKE
Assistant Editor

JEAN BELL
Production

INTERNATIONAL EDITIONS

COLLYN RIVERS
Editorial Director

AUSTRALIA
BRIAN CHAPMAN
Technical Editor
BARRY WILKINSON
Engineering Manager
Modern Magazine Holdings Ltd
Ryrie House, 15 Boundary Street
Rushcutters Bay 2011
Sydney, Australia.

FRANCE
DENIS JACOB
Editor in chief
CHRISTIAN DARTEVILLE
Editor
Electronique Pour Vous International,
17 Rue de Buci
Paris, France.

Electronics Today International is published on the first Friday of the month prior to the cover date.

PUBLISHERS
Modern Magazines (Holdings) Ltd
36 Ebury Street, London SW1W OLW.

DISTRIBUTORS
Argus Distributors Ltd

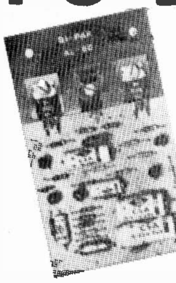
PRINTERS
GB Newspapers Limited, Colchester

READERS' QUERIES: These can only be answered if they relate to recent articles published in the magazine. Rarely can we supply information in addition to that published. Written queries must be accompanied by a stamped addressed envelope, and telephone queries must be brief, not before 4pm and can only be answered subject to the availability of technical staff.
BACK NUMBERS Back numbers of many issues are available for 35p each plus 10p postage.
SUBSCRIPTIONS Great Britain £5 00 per annum. Overseas £5 50.

SEE PAGE 59 FOR SOMETHING SPECIAL

PO BOX 6 WARE HERTS

VISIT OUR COMPONENT SHOP
18 BALDOCK STREET, WARE, Herts (A10)
Open Mon.-Sat. 9-5.30 p.m. Tel. 61593
Late night shopping till 7 p.m. Fri.

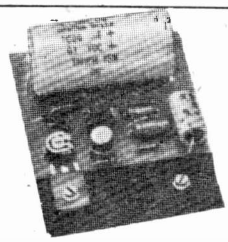


AL 60

ONLY £3.95

50w. PEAK (25w. R.M.S.)

● Max Heat Sink temp 90°C ● Frequency Response 20Hz to 100K Hz ● Distortion better than 0.1 at 1KHz ● Supply voltage 15-50 volts ● Thermal Feedback ● Latest Design Improvements ● Load — 3, 4, 5 or 16 ohms ● Signal to noise ratio 80dH ● Overall size 63mm x 105mm x 13mm. Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.



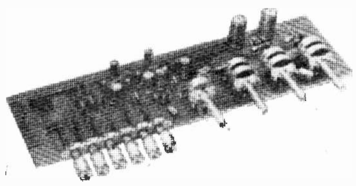
STABILISED POWER MODULE SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer BMT80, the unit will provide outputs of up to 1.5 amps at 35 volts. Size: 63mm x 105mm x 30mm.

These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including:—Disco Systems. Public Address Intercom Units, etc. Handbook available 10p.

TRANSFORMER BMT80 £2.60

PRICE £3.00



STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.

Three switched stereo inputs, and rumble and scratch filters are features of the PA100 which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

£13.20

GUARANTEE

SATISFACTION OR YOUR MONEY REFUNDED

MK 60 AUDIO KIT

Comprising: 2 x AL60, 1 x SPM80, 1 x BTM80, 1 x PA100, 1 front panel, 1 kit of parts to include on-off switch, neon indicator, stereo headphone sockets plus instruction booklets.

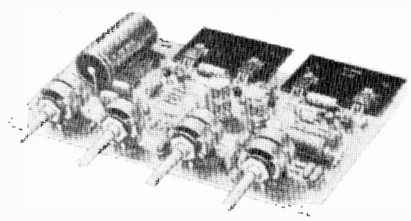
COMPLETE PRICE: **£27.55** plus 45p postage.

TEAK 60 AUDIO KIT

Comprising: Teak veneered cabinet size 16¾" x 11½" x 3¾", other parts include aluminium chassis, heatsink and front panel bracket, plus back panel and appropriate sockets, etc.

KIT PRICE: **£9.20** plus 45p postage.

PLEASE ADD V.A.T. AT 25% TO ALL ITEMS EXCEPT
*** ADD 8%**
 # NO V.A.T.
GIRO NUMBER 388-7006



STEREO 30 COMPLETE AUDIO CHASSIS

7 + 7 WATTS R.M.S.

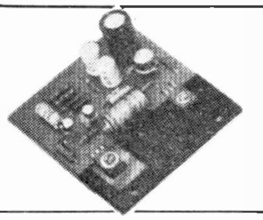
The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This with only the addition of a transformer or overwind, will produce a high quality audio unit suitable for use with a wide range of inputs, i.e. high quality ceramic pickup, stereo tuner, stereo tape deck, etc.

Simple to install, capable of producing really first-class results, this unit is supplied with full instructions, black front panel, knobs, mains switch, fuse & fuse holder and universal mounting bracket, enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available.

Ideal for the beginner or advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty. Can be installed in 30 mins.

PRICE £15.75 Plus 45p postage & packing

TRANSFORMER £2.45 plus 45p postage & packing **TEAK CASE £3.65** plus 45p postage & packing



AL 10/AL 20/AL 30

The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power devices has resulted in a range of output powers from 3 to 10 watts R.M.S.

The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

AL10 £2.30, AL20 £2.65, AL30 £2.95

SPEAKERS

E.M.I. LEK 350 Loudspeakers Enclosure kit in teak veneer, including speakers. Rec. retail price £4.50 per pair.
OUR SPECIAL PRICE
ONLY £27.75 per pair P&P £3
WHILE STOCKS LAST!

HEADPHONES

4-16 ohms impedance frequency response 20 to 20,000 Hz stereo/mono switch and Volume Control **£4.55**

FRONT PANEL

FOR PA100. Attractive matt silver. Finish with black trim and lettering. Adds that professional touch. **£1.10 only.**

M.P.A.30

Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new Bi-Pak M.P.A.30 which is a high-quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.

Used in the construction are 4 low noise, high gain, silicon transistors. It is provided with a standard DIN input socket for ease of connection.

Supplied with full, easy-to-follow instructions.

PRICE £2.65

STORAGE-CARRY CASES

RECORD CASES
7 in E.P. 18 3/8th in. x 7 in x 8 in (50 records) ***£2.48**
12 in L.P. 13¾in x 7 3/8th in x 12¾ in (50 records) ***£3.30**

CASSETTE CASES
Holds 15. 10in x 3¾in x 5in. Lock and handle ***£1.50**

8-TRACK CARTRIDGE CASES
Holds 14. 13in x 5in x 6in. Lock and handle ***£2.20**
Holds 24. 13 3/8th in x 8 in x 5 3/8th in Lock and handle ***£3.20**

CARTRIDGES

ACOS	GP91-1SC	200mV at 1.2cms/sec	£1.11
	GP93-1	280mV at 1cm/sec	£1.43
	GP96-1	100mV at 1cm/sec	£2.31
TTC	J—2005	Crystal/Hi Output	£0.97
	J—2010C	Crystal/Hi Output	£1.11
		Compatible	£1.52
	J—2006S	Stereo/Hi Output	£1.81
	J—2105	Ceramic/Med Output	
	J—2203	Magnetic 5mV/5cm/sec	£4.78
		including stylus	£2.88
	J—22038	Replacement stylus for above	
	AT—55	Audio-technica magnetic cartridge 4mV/5cm/sec	£3.06

DYNAMIC MICROPHONE

TYPE B1223 200 ohms impedance. Complete with stand, on/off switch and 2.5mm and 3.5mm plugs. Suitable for cassette tape recorders.
PRICE £1.67

JUST OUT!

STEREO FM TUNER

WRITE *NOW* FOR FULL DETAILS

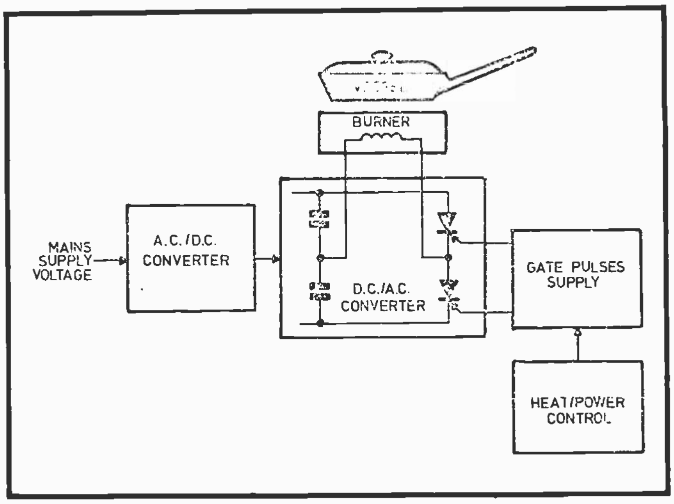
news digest

NEW INDUCTION COOKING CONCEPT

A new system of induction heating, designed for 'cool-top' electric cookers is currently being demonstrated by RCA. The system, which uses fast-turnoff thyristors operating at 30kHz, is estimated to halve electricity usage and to offer an efficiency of up to 70% compared to 35-45% using conventional elements.

The basic concept of the system depends on eddy currents generated in the base of a cooking vessel by the high-frequency current in an induction coil placed beneath the cooker surface. The coil itself does not heat up, so that the working area temperature is only as high as that of the vessel being heated. As a result, heat losses are kept to a minimum.

Unlike conventional electric heating systems, the induction method provides instant power regulation from zero to full power with an 'inertia' even lower than that of the most modern gas cooker.



CBM SCIENTIFIC

The new CBM SR 7919D features logs, trigs, inverse trigs a memory, , square root, power raising and exponent entry. This calculator costs £18.30 and is aimed at the 'student scientific' market.

The 8-digit display converts to a 5-digit mantissa plus 2-digit exponent display. It is battery operated with a mains adaptor as an optional extra at £2.50 + VAT. The calculator is guaranteed for 1 year.

DATA BOOKS

The autumn editions of DATA books are now available. The Transistor DATA book costs £31.60 (per year) for two issues and lists 19000 types from 128 manufacturers. The Linear IC DATA book is available for £27.60 (per year) for two issues and lists 7473 devices including 700 new types. The books are obtainable on trial from London Information, Index House, Ascot, Berkshire, SL5 7EU.

VIEWDATA TRIALS IN JANUARY

A pilot trial of the proposed Viewdata Service will start in January and if the results are satisfactory the service will be made available to the public in 1978. The system will be provided by the Post Office over the public telephone network, and will provide subscribers with data for display in the same format as Oracle and Ceefax. Information is to be provided by organisations independant of the PO, who could be provided with some of the revenue collected by the Post Office. Apart from the VDU, likely to be a colour TV with teletext decoder, the user would require some form of modem and Keyboard.

Compared to broadcast teletext the service will have unlimited capacity. The cost, however, is likely to be much higher - one will have to pay for phone calls and information in addition to the cost of the equipment.

SUPER-STABLE VOLTAGE REFERENCE

A monolithic temperature-stabilised voltage-reference IC, which out-performs standard Zener Diodes by a factor of 20, has been developed by National Semiconductor. The new precision reference, LM199 provides a 6.9V reference that offers an ultra-low temperature coefficient, excellent long term stability, and low noise. Drift is guaranteed to be less than 1ppm/^{o}C.

The LM199 is easy to use. Two leads are connected to the temperature stabiliser, which can be operated at any point between 9 and 40V. The other two leads are tied to an active Zener. Active circuitry lowers the Zener impedance to 0.5 and allows the LM199 to operate over a current range of 0.5 to 10mA with virtually no change in temperature coefficient.

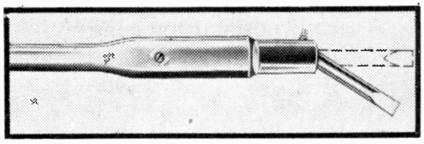
The low dynamic impedance makes the LM199 two orders of magnitude less sensitive to operating current than standard 7.5mA reference diodes. The device is packaged in a four-lead TO46 metal can.

SOLAR POWER ARRAYS'

The MST100 solar power module as used on Everest by the BBC Film Crew are available from the Electronic Components Division of Ferranti. With a one-off price of £60 per module, applications on boats and caravans are also anticipated.

The modules produce a typical output of 1.7W into a 6V battery system under the maximum earth surface insolation of air-mass one (approximately 100mW/cm^2) Each consists of 20 semi-circular silicon photo voltaic cells connected in series, mounted in a rugged glass metal sandwich, with a sealed edge, and with the cells embedded in transparent plastic. Ferranti Limited, Electronic Components Division, Gem Mill, Chadderton, Oldham, Lancs.

FOR READERS WHO FANCY A BIT ON THE SIDE?



A modification now available on the Solon 65W soldering iron is this adjustable-angle bit. It is claimed to improve accessibility or visibility in awkward applications. GEC-Henley Ltd., Gravesend, Kent.

PUSH BUTTON DIALLING IC

The D4037 from General Instrument Microelectronics is a MOS LSI device which converts keyed numbers into pulsed signals identical to those produced by a conventional dialler. The IC has a re-dial facility at the touch of a button, so the dialler can try again if his number was engaged. The device has provisional Post Office approval.

AMATEUR COMPUTER CLUB

A recent newsletter of the Amateur Computer Club describes a low cost mini computer project. The letter claims the WEENY-BITTER a 256 word 8 bit machine, can be built (without peripherals) for around £50. Future articles will describe in detail the hardware, programming techniques and upgrading. Enquiries to J.T.C. Aslett, Secretary of the Amateur Computer Club, 7 Doordells, Basildon, Essex.

CHRISTMAS HOLIDAY LECTURE

'Electronics in Crime Prevention' is the title of this year's Christmas Holiday Lecture to older school children. Geoffrey Philips, Director of Police Scientific Development Branch, will deliver the lecture at the Institution of Electrical Engineers (IEE), Savoy Place, London WC2R OBL on Tuesday 30th December and Wednesday 31st December 1975 at 2.30pm.

The lecture will include a number of demonstrations, short films and video tapes and a number of coloured slides.

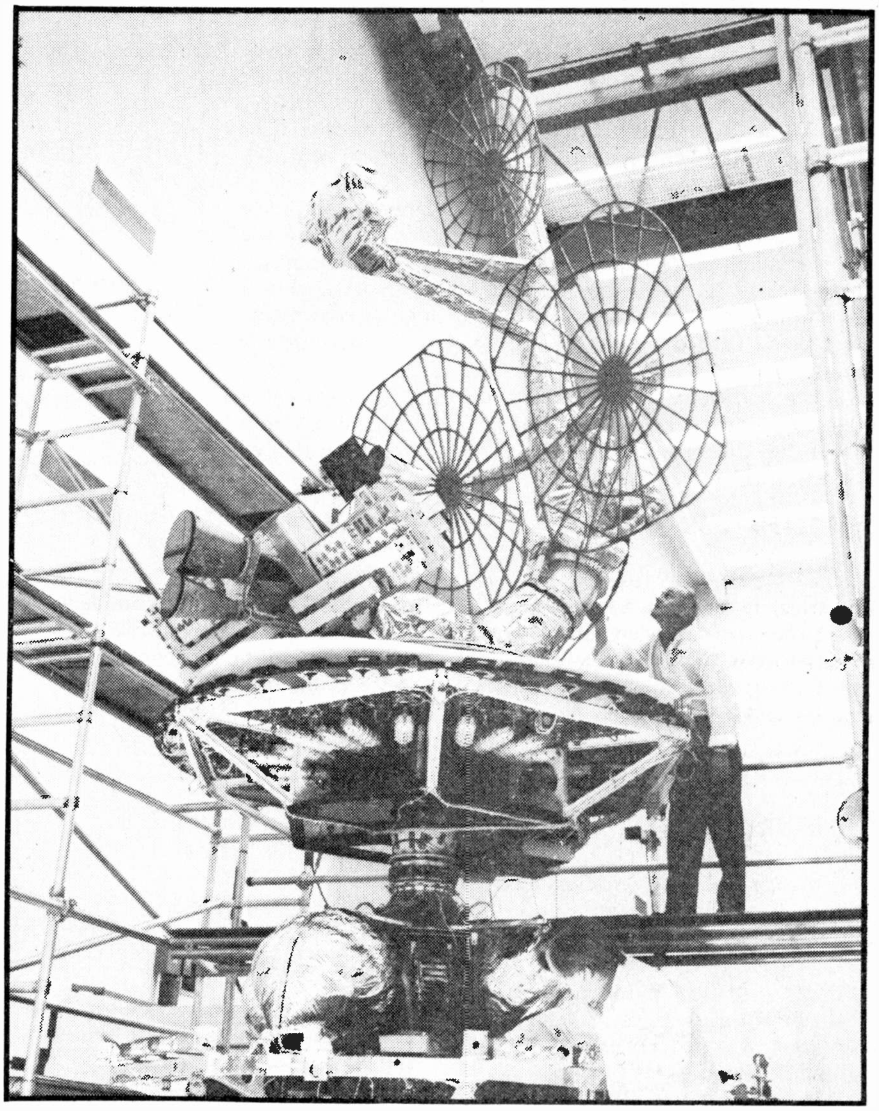
TIME ZONE WATCH

The latest watch module from National Semiconductor accurately tracks two time zones, and is designed to make a traveller's digital watch. The MM5880 is a 6 function device which drives four digit LED display. Hours, minutes, seconds and month-with-date are controlled by a single push-button.

A second push-button controls the display of time zone. Resetting the second zone time does not affect the time of the first zone.

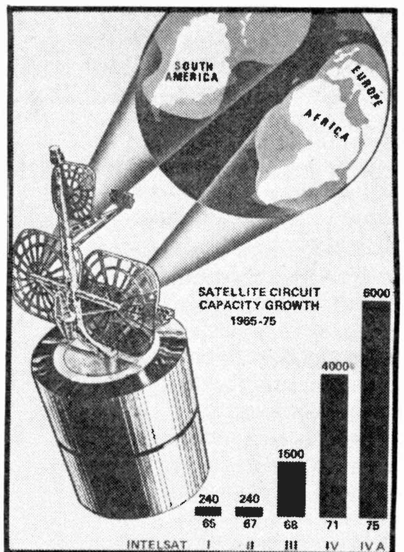
The MM5880 presents calendar information in the American style (month-date); the MM5860 presents it in European fashion (date-month). Either model can be connected to display 12 hour or 24-hour time.

INTELSAT IV SATELLITE



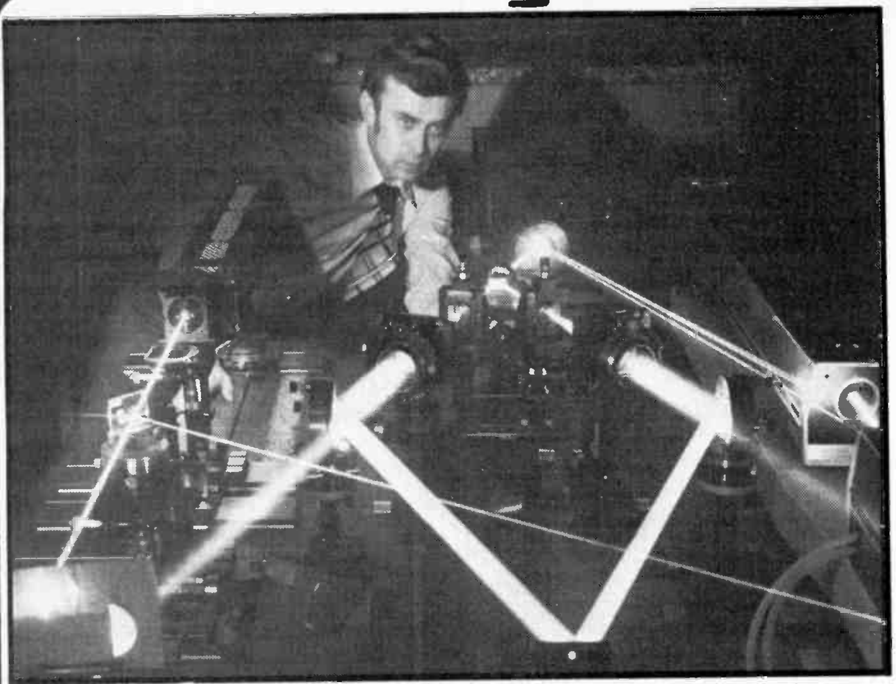
The first in a series of six new Intelsat IV-A communications satellites was launched on 25th September carrying new technology designed to handle global telecommunications traffic. The first satellite will carry telephone transmissions to and from the United States, Europe and West Africa.

The Intelsat organization is made up of 91 member-nations using the Intelsat global satellites over the Pacific, two over the Indian Ocean and three over the Atlantic. The new satellite will have an average assigned use of 6,000 circuits, or 20 colour television channels. Intelsat IV-A carries a newly-designed antenna that can concentrate signal beams like spotlights into world business centres on both sides of the Atlantic. The new satellite has an overall height of 6.97 meters and a diameter of



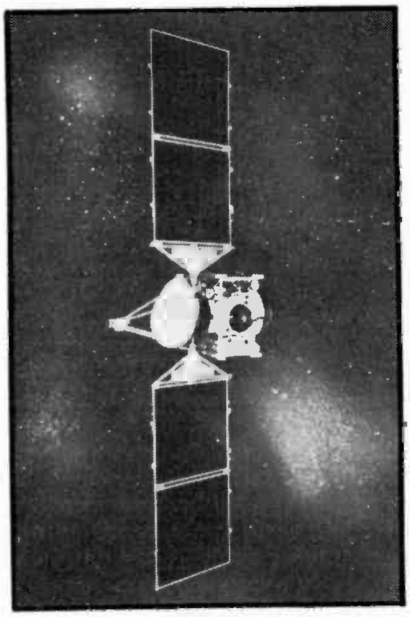
2.35 meters. Solar panels, covered with 17,000 solar cells, provide the craft with primary power of 600 watts. The satellite is designed to have an in-orbit life of seven years.

news digest



The Science Research Council will be providing a high power Laser for researchers from British Polytechnics and Universities. The Neodymium Glass Laser and associated equipment will initially cost £1 million. The photo above shows Laser research by Siemens who have succeeded in producing low-loss fibreoptic cable.

A new, high powered satellite space bus capable of fulfilling a variety of communication missions has been unveiled by General Electric Company of the USA's Space Division at the Telecom 75 World Telecommunications Exhibition in Geneva. The system is being built for the Japanese Government's experimental broadcast satellite



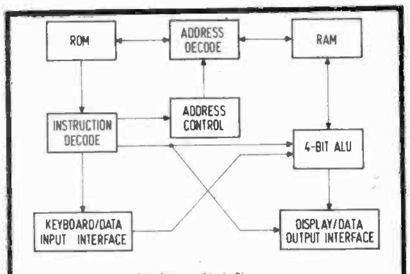
programme to prove the feasibility of transmitting a high quality colour television service to the entire Japanese terrirtory. This includes the offshore islands of Okinawa and Ogasawara, 1,500km and 1000km southwest and south of Tokyo, as well as the main island chain extending in an arc 2,600km long. Down-like transmission frequency will be in the 12GHz band, with two 100-ATT channels.

AMI MICROCONTROLLER

AMI Microsystems have introduced a microprogrammable display processor for low-cost processor and control applications. The S9209 contains in a single MOS/LSI chip all the essential elements of a computer's central processor: arithmetic and control system; program and data storage, and data input/output facilities. These elements fit the 9209 for a broad range of specialised calculator and non-calculator fixed program applications, such as in a credit verification terminal or special-purpose industrial timer. Other typical applications include portable data entry devices, low-cost point-of-sale terminals and appliance controllers. For applications requiring increased processing capabilities, several 9209 modules can be connected in tandem, using additional external hardware.

Incorporated in the 9209 is a 6k micro-instruction ROM organised as 756 x 8-bit words; a 256 bit RAM providing four 16 x 4-bit data registers, a 4-bit parallel binary adder; two 4-bit accummulators; 6-bit RAM and 10-bit ROM address registers; input,output and microinstruction decoding and control logic.

The instruction set includes



9209 General Block Diagram

33 basic instructions for arithmetic processing, data manipulation, testing, data transfer, addressing and I/O operations. Typical instruction cycle time is 15uS. The S9209 is available in either a 28- or 40-pin DIP, either plastic or ceramic. It has been pre-programmed into several standard special-purpose devices, and samples are available ex stock.AMI, 108A Commercial Road, Swindon, Wiltshire.

MORE EMI-SCANNERS

A further 15 hospitals in the United Kingdom are to be equipped with the EMI-Scanner brain X-ray system. These latest orders will bring the total of EMI-Scanner systems in use in UK hospitals to 22 making the National Health Service the largest user outside North America of this advanced British-made brain examination system.

The new Extel 8400 range of digital cassette tape recorders interface with most computer equipment, but with prices starting around £900, not many of us will be buying them to hook up to our calculators!

Continued on page 76

Marshall's

A. Marshall (London) Ltd Dept:ETI
42 Cricklewood Broadway
London NW2 3ET Tel: 01-452 0161/2
Telex: 21492
& 85 West Regent St Glasgow G2 2QD
Tel: 041-332 4133
& 1 Straits Parade Fishponds Bristol
BS16 2LX Tel: 0272 654201/2
& 27 Rue Danton Issy Les Moulineaux
Paris 92 Tel: 642 2985
Catalogue price 25p

Call in and see us 9-5.30 Mon-Fri 9-5.00 Sat

Trade and export enquiries welcome

Top 500 Semiconductors from the largest range in the UK

SN456	0.80	2N3390	0.45	2N5295	0.48	AF116	0.35	BC207	0.12	BF159	0.27	LM309K	1.88	OC42	0.50
2N456A	0.85	2N3391	0.28	2N5296	0.48	AF117	0.35	BC208	0.11	BF160	0.23	LM5TI	1.50	OC45	0.32
2N457A	1.20	2N3391A	0.29	2N5298	0.50	AF118	0.35	BC212K	0.16	BF163	0.32	LM380	1.10	OC71	0.17
2N490	3.16	2N3392	0.15	2N5457	0.49	AF124	0.30	BC212L	0.16	BF166	0.40	LM381	2.20	OC72	0.25
2N491	4.38	2N3393	0.15	2N5458	0.45	AF125	0.30	BC214L	0.18	BF167	0.25	LM702C	0.75	OC81	0.25
2N492	3.00	2N3394	0.15	2N5459	0.49	AF126	0.28	BC237	0.16	BF173	0.27	LM709T099	0.48	OC83	0.24
2N493	5.20	2N3402	0.18	2N5492	0.58	AF127	0.28	BC238	0.15	BF177	0.29	8DIL	0.38	ORP12	0.55
2N696	0.22	2N3403	0.19	2N5494	0.58	AF139	0.65	BC239	0.15	BF178	0.35	14DIL	0.40	R53	1.80
2N697	0.16	2N3440	0.59	2N5496	0.61	AF186	0.46	BC251	0.25	BF179	0.43	LM710	0.47	SL414A	1.80
2N698	0.82	2N3441	0.97	2N6027	0.45	AF200	0.65	BC253	0.25	BF180	0.35	LM3900	0.70	SL610C	1.70
2N699	0.59	2N3442	1.40	2N5777	0.45	AF239	0.65	BC257	0.15	BF181	0.36	LM723C	0.90	SL611C	1.70
2N706	0.14	2N3414	0.10	3N128	0.73	AF240	0.90	BC258	0.16	BF182	0.35	LM741T099	0.40	SL612C	1.70
2N706A	0.16	2N3415	0.10	3N139	1.42	AF279	0.70	BC259	0.17	BF183	0.55	8DIL	0.40	SL620C	2.60
2N708	0.17	2N3416	0.15	3N140	1.00	AF280	0.79	BC261	0.25	BF184	0.30	14DIL	0.38	SL621C	2.60
2N709	0.42	2N3417	0.21	3N141	0.81	AL102	1.00	BC262	0.25	BF185	0.30	LM747	1.00	SL623	4.59
2N711	0.50	2N3638	0.15	3N200	2.49	AL103	1.00	BC263	0.25	BF194	0.12	LM7488DIL	0.60	SL640C	3.10
2N718	0.23	2N3638A	0.15	40361	0.40	BC107	0.14	BC300	0.38	BF195	0.12	LM7805	2.00	SL641C	3.10
2N718A	0.28	2N3639	0.27	40362	0.45	BC108	0.14	BC301	0.34	BF196	0.13	14DIL	0.73	SN76003N	2.92
2N720	0.57	2N3641	0.17	40363	0.88	BC109	0.14	BC302	0.29	BF197	0.15	LM7805	2.50	SN76013N	1.95
2N914	0.39	2N3702	0.11	40389	0.46	BC113	0.15	BC303	0.54	BF198	0.18	LM7812	2.50	SN76023N	1.60
2N916	0.28	2N3703	0.12	40394	0.56	BC115	0.17	BC307	0.17	BF200	0.40	LM7815	2.50	SN76033N	2.92
2N918	0.32	2N3704	0.15	40395	0.65	BC116	0.17	BC308A	0.15	BF225J	0.23	LM7824	2.50	ST2	0.20
2N929	0.37	2N3705	0.15	40406	0.44	BC116A	0.18	BC309C	0.20	BF244	0.21	MC1303	1.50	TAA300	1.80
2N930	0.22	2N3706	0.15	40407	0.35	BC117	0.21	BC327	0.27	BF245	0.45	MC1310	2.92	TAA263	1.10
2N1302	0.19	2N3707	0.18	40408	0.50	BC118	0.14	BC328	0.28	BF246	0.58	MC1330OP	0.90	TAA350	2.10
2N1303	0.19	2N3708	0.14	40409	0.52	BC119	0.29	BC337	0.20	BF247	0.65	MC1351P	0.80	TAA550	0.60
2N1304	0.26	2N3709	0.15	40410	0.52	BC121	0.35	BC338	0.20	BF254	0.19	MC1352P	0.80	TAA611C	2.18
2N1305	0.24	2N3710	0.15	40411	2.25	BC125	0.16	BCY30	0.80	BF255	0.19	MC1466	3.50	TAA621	2.03
2N1306	0.31	2N3711	0.15	40594	0.74	BC126	0.23	BCY31	0.85	BF257	0.47	MC1469	2.75	TAA661B	1.32
2N1307	0.30	2N3712	1.20	40595	0.84	BC132	0.30	BCY32	1.15	BF258	0.53	ME0402	0.20	TBA641B	2.25
2N1308	0.47	2N3713	1.20	40601	0.67	BC134	0.13	BCY33	0.85	BF259	0.55	ME0404	0.13	TBA651	1.69
2N1309	0.47	2N3714	1.38	40602	0.61	BC135	0.13	BCY34	0.79	BFR39	0.24	ME0412	0.18	TBA810	1.50
2N1671	1.54	2N3715	1.50	40603	0.58	BC136	0.17	BCY38	1.00	BFR79	0.24	ME4102	0.11	TBA820	1.15
2N1671A	1.67	2N3716	1.80	40604	0.56	BC137	0.17	BCY39	1.50	BFS21A	2.30	ME4104	0.11	TBA920	4.00
2N1671B	1.85	2N3771	2.20	40636	1.10	BC138	0.24	BCY40	0.97	BFS28	0.92	MJ480	0.95	TIL209	0.30
2N1711	0.45	2N3772	1.80	40669	1.00	BC140	0.68	BCY42	0.28	BFS61	0,27	MJ481	1.20	TIP29A	0.49
2N1907	5.50	2N3773	2.65	40673	0.73	BC141	0.68	BCY58	0.30	BFS98	0.25	MJ490	1.05	TIP30A	0.58
2N2102	0.66	2N3779	3.15	AC126	0.20	BC142	0.23	BCY59	0.32	BFX29	0.30	MJ491	1.45	TIP31A	0.62
2N2147	0.78	2N3790	2.40	AC127	0.20	BC143	0.25	BCY70	0.17	BFX30	0.27	MJ2955	1.00	TIP32A	0.74
2N2148	0.94	2N3791	2.35	AC128	0.20	BC145	0.21	BCY71	0.22	BFX84	0.24	MJE340	0.48	TIP33A	1.01
2N2160	0.90	2N3792	2.60	AC151V	0.27	BC147	0.14	BCY72	0.15	BFX85	0.30	MJE370	0.65	TIP34A	1.51
2N2218A	0.22	2N3794	0.10	AC152V	0.49	BC148	0.14	BD115	0.75	BFX87	0.28	MJE371	0.75	TIP35A	2.90
2N2219	0.24	2N3819	0.37	AC153	0.35	BC149	0.15	BD116	0.75	BFX88	0.25	MJE520	0.60	TIP36A	3.70
2N2219A	0.26	2N3820	0.38	AC153K	0.40	BC153	0.18	BD121	1.00	BFX89	0.90	MJE521	0.70	TIP41A	0.79
2N2220	0.25	2N3823	1.42	AC154	0.25	BC154	0.18	BD123	0.82	BFY50	0.23	MJE2955	1.20	TIP42A	0.90
2N2221	0.18	2N3904	0.27	AC176	0.30	BC157	0.16	BD124	0.67	BFY51	0.23	MJE3055	0.75	TIP29c	0.80
2N2221A	0.21	2N3906	0.27	AC176K	0.40	BC158	0.16	BD131	0.40	BFY52	0.21	MP8111	0.32	TIP30c	0.85
2N2222	0.20	2N4036	0.67	AC187K	0.35	BC160	0.60	BD132	0.50	BFY53	0.18	MP8112	0.40	TIP31c	1.00
2N2222A	0.25	2N4037	0.42	AC188K	0.40	BC167B	0.15	BD135	0.43	BFY90	0.75	MP8113	0.47	TIP32c	1.25
2N2368	0.25	2N4058	0.18	ACY18	0.24	BC168B	0.15	BD136	0.49	BRY39	0.48	MPF102	0.30	TIP33c	1.45
2N2369	0.20	2N4059	0.15	ACY19	0.27	BC168C	0.15	BD137	0.55	BSX20	0.21	MPSA05	0.25	TIP34c	2.60
2N2369	0.22	2N4060	0.15	ACY20	0.22	BC169B	0.15	BD138	0.63	BSX20	0.21	MPSA06	0.31	TIP41c	1.40
2N2646	0.55	2N4061	0.15	ACY21	0.26	BC169C	0.15	BD139	0.71	BSX21	0.29	MPSA12	0.35	TIP42c	1.60
2N2647	0.98	2N4062	0.15	ACY28	0.20	BC170	0.15	BD140	0.87	BU104	2.00	MPSA55	0.26	TIP49	0.70
2N2904	0.22	2N4126	0.21	ACY30	0.58	BC171	0.16	BD529	0.80	BU105	2.25	MPSA56	0.31	TIP53	0.53
2N2904A	0.24	2N4289	0.34	AD142	0.57	BC172	0.17	BD530	0.80	C106D	0.65	MPSU05	0.65	TIP2955	0.98
2N2905	0.25	2N4919	0.95	AD143	0.68	BC177	0.28	BFR39	0.24	CA3180A	0.85	MPSU06	0.58	TIP3055	0.50
2N2905A	0.26	2N4920	1.10	AD149V	1.20	BC178	0.27	BFR79	0.24	CA3020A	1.80	MPSU55	0.63	TIS43	0.28
2N2906	0.19	2N4921	0.80	AD150	0.63	BC179	0.30	BDY20	1.05	CA3028A	0.79	MPSU56	0.80	ZTX300	0.13
2N2906A	0.21	2N4922	0.83	A0161	1.15	BC182	0.12	BF115	0.36	CA3035	1.37	NE555V	0.70	ZTX301	0.13
2N2907	0.22	2N4923	1.00	AD162	1.15	BC182L	0.12	BF117	0.55	CA3052	1.62	NE556	1.30	ZTX302	0.20
2N2907A	0.24	2N5190	0.92	AD161	pr	BC183	0.12	BF121	0.35	CA3046	0.70	NE560	4.48	ZTX500	0.15
2N2924	0.20	2N5191	0.96	AD162	1.05	BC183L	0.12	BF123	0.35	CA3048	2.11	NE561	4.48	ZTX501	0.13
2N2926	0.20	2N5192	1.24	AF106	0.40	BC184	o.13	BF125	0.35	CA3089E	1.96	NE565A	4.48	ZTX502	0.18
2N3053	0.25	2N5195	1.46	AF109R	0.40	BC184L	0.13	BF152	0.20	CA3090Q	4.23	OC23	1.35	ZTX530	0.23
2N3054	0.60	2N5245	0.47	AF114	0.35	BC186	0.25	BF153	0.25	LM301A	0.48	OC28	0.76		
2N3055	0.75	2N5294	0.48	AF115	0.35	BC187	0.27	BF154	0.16	LM308	2.50	OC35	0.60		

TTL Integrated Circuits — Quality & Prices you can't beat

														SN74174	1.25
										SN7495	0.72	SN74151	0.85	SN74175	0.90
SN7400	0.16	SN7410	0.16	SN7432	0.28	SN7451	0.16	SN7481	1.25	SN7496	0.75	SN74153	0.85	SN74176	1.44
SN7401	0.16	SN7411	0.25	SN7437	0.37	SN7453	0.16	SN7482	0.75	SN74100	1.25	SN74154	1.50	SN74180	1.40
SN7401AN	0.38	SN7412	0.28	SN7438	0.35	SN7454	0.16	SN7483	0.95	SN74107	0.36	SN74155	1.50	SN74181	1.95
SN7402	0.16	SN7413	0.35	SN7440	0.16	SN7460	0.16	SN7484	0.95	SN74118	1.00	SN74157	0.95	SN74190	2.30
SN7403	0.16	SN7416	0.35	SN7441AN	0.85	SN7470	0.33	SN7485	1.25	SN74119	1.92	SN74160	1.10	SN74191	2.30
SN7404	0.19	SN7417	0.35	SN7442	0.65	SN7472	0.26	SN7486	0.32	SN74121	0.37	SN74161	1.10	SN74192	1.15
SN7405	0.19	SN7420	0.16	SN7445	0.90	SN7473	0.36	SN7490	0.45	SN74122	0.50	SN74162	1.10	SN74193	1.15
SN7406	0.45	SN7423	0.29	SN7446	0.95	SN7474	0.36	SN7491	0.85	SN74123	0.60	SN74163	1.10	SN74196	1.60
SN7407	0.45	SN7425	0.29	SN7447	0.95	SN7475	0.50	SN7492	0.45	SN74141	0.85	SN74164	2.01	SN74197	1.58
SN7408	0.19	SN7427	0.29	SN7448	0.90	SN7476	0.35	SN7493	0.45	SN74145	0.90	SN74165	2.01	SN74198	2.25
SN7409	0.22	SN7430	0.16	SN7450	0.16	SN7480	0.50	SN7494	0.82	SN74150	1.50	SN74167	4.10	SN74199	2.25

LONDON — GLASGOW — PARIS
AND NOW

BRISTOL!

IT'S OUR SERVICE THAT MAKES US GROW

1 STRAITS PARADE
FISHPONDS
BRISTOL BS16 2LX
TEL: BRISTOL 654201/2

PW TELETENNIS KIT

As featured on BBC Nationwide and in the Daily Mail 2 Oct '74. Ideal game for whole family. No need to modify your TV set, just plugs in to aerial socket.
Parts list as follows: **A** Resistor Pack **£1.00** p & p 20p; **B** Potentiometer Pack **£1.25** p & p 20p; **C** Capacitor Pack **£3.10** p & p 20p; **D** Semi-conductor Pack **£14.50** p & p 20p; **E** IC Sockets **£4.00** p & p 20p; **F** Transformer **£1.15** p & p 25p; **G** PCB's **£7.50** p & p 20p; **H** Switches **£4.50** p & p 20p; **I** UHF Modular Kit **£7.50** p & p 20p.

Special Prices — complete kit excluding case **£42.00** p & p 50p. Sections **A-F** incl. **£23.50** p & p 30p. Assembly instructions with complete kit or **75p** on request.

P.C. Marker Pen Dalo 33PC **0.87p** **Zeners** 400MW—**11p**; IW — **17p**
IC Sockets 8DIL **16p**; 14DIL **17p**; 16DIL **20p.**
Resistors ¼w — **2p**; ½w — **3p**; 2½w — **9p**; 5w — **10p**; 10w — **12p.**
Scorpio Car Ignition Kit — £11.50 + VAT
IMF440V — **£1.10.**
RSTBO246 — **£1.20.** Transformer — **£3.00.**
OPTO & LED'S
Red, green and yellow
0.16 diameter, **31p**
0.20 diameter **33p**
DL707 **£2.35** or 4 for £8.00
Minitron **£1.55**

Cmos Circuits—CD Range

4000	0.36	4016	0.66	4030	0.87
4001	0.36	4017	1.72	4031	5.19
4002	0.36	4018	2.55	4037	1.93
4006	1.58	4019	0.86	4041	1.86
4007	0.36	4020	1.91	4042	1.38
4008	1.63	4021	1.72	4043	1.80
4009	1.18	4022	1.66	4044	1.80
4010	1.18	4023	0.36	4045	2.65
4011	0.36	4024	1.24	4046	2.84
4012	0.36	4025	0.32	4047	1.65
4013	0.66	4027	0.43	4049	0.81
4014	1.72	4028	1.50	4050	0.66
4015	1.72	4029	3.50		

Veroboard

	Copper		Plain	
	0.1	0.15	0.1	0.15
	£ p	£ p	£ p	£ p
2.5x3¾in	36	26	—	17
2.5x5in	40	39	—	19
3¾x3¾in	40	39	—	—
3¾x5in	45	47	—	32
3¾x17in	1.61	1.26	1.00	1.92
PINSx36	30	30		
x200	1.16	1.16		

Trade and Retail Supplied

Potentiometers

Linear or Log

	Single	Double
Rotary Pots	18p	45p
Rotary Switched	28p	—
Sliders	45p	75p

Full range of Capacitors stocked. See catalogue for details

Presets Horizontal or Vertical
IW **8p** 3W **10p**

Construction Kits

AV7	Aerial Amps	£2.04
UHS70	Transmitter	£2.74
MUE7	Receiver for above	£3.22
EW18	Electronics dice	£6.53
EW20	Electro. Dice + Sen	£7.79

TRY OUR NEW GLASGOW SHOP

VAT all prices exclusive

P&P 25p **Mail Order**

Spectral amplification is a new trend in Hi-Fi systems. Be one of the first to have a two or three way amplifier by using our simple design . . .

ACTIVE CROSSOVER

ETI project 433

Next month the second part of this article will describe a complete two-way filter amplifier – the INTERNATIONAL 435.

NO SINGLE loudspeaker can adequately handle the whole range of audio frequencies in high-fidelity reproduction. Thus to obtain the best possible fidelity we must resort to multiple speaker systems where each driver is designed to cover one portion only of the audio spectrum.

This means that some method must be used to divide the audio spectrum, from the amplifier, so that an individual driver only receives the band of frequencies for which it was designed. This is especially important for midrange and tweeter drivers for they are seldom capable of handling frequencies lower than a specified limit without being damaged.

PASSIVE CROSSOVERS

In simple systems a single capacitor may be used to block low frequencies and pass only highs to a tweeter. But unfortunately such a capacitor only provides 6 dB per octave attenuation. With some tweeters this attenuation is not sufficient to suppress the resonant frequency of the tweeter. The driver could thus be damaged when operated at high power levels. Additionally, the presence of frequencies other than those in the desired passband leads to high levels of intermodulation distortion and a general 'muddiness' of reproduction.

Hence all good multi-way systems use networks which provide at least 12 dB per octave attenuation, in the stop band, to control the audio band presented to each drive unit. A typical network for a three-way system is given in Fig.1. To keep power losses down in such networks the coils must have dc resistances of less than one ohm. This means that heavy gauge wire must be used, making the coils large and expensive. Additionally the high value of capacitance required would normally call for the use of non-polarized electrolytics, however, there are several disadvantages with these. Firstly, the tolerance on non-polarized electrolytics is plus or minus 50%! This means that a crossover using them could quite easily give a system which had peaks and/or deep holes in the response. Additionally such capacitors have disadvantages such as limited life, fairly low working voltages and problems due to leakage. Thus all good crossovers use polyester capacitors which, again, are rather expensive.

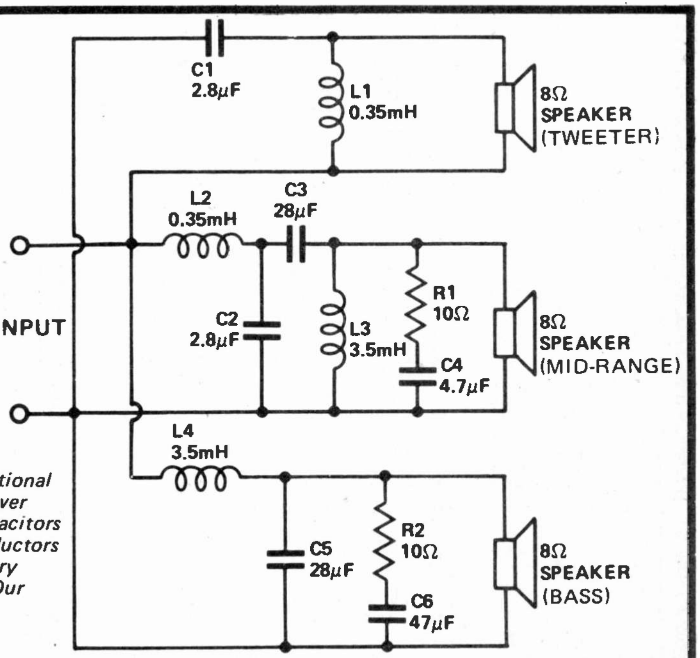


Fig. 1. A conventional three-way crossover system using capacitors and air-cored inductors is a bulky and very expensive unit. Our drawing shows a typical unit.

This all leads to the fact that, for a multi-way high-fidelity system, the crossover can and should be quite expensive. In fact it can cost almost as much as the bass driver!

Many people try to save money by trimming crossover cost – they use lighter wire and electrolytics—and then wonder why an otherwise expensive system does not sound right. *The crossover design is one of the most important features of the whole system – it is better to compromise on a less expensive woofer than to compromise on the crossover.*

(Main text continued on page 14)

ETI 433 ACTIVE CROSSOVER

SPECIFICATION

Cutoff Slope (High pass)	12 dB / octave
(Low pass)	6 dB / octave
Maximum Output	2 V rms.
Distortion (at 2 V out)	< 0.05%
Noise (Below 2 V)	86 dB
Cutoff Frequency	As required
Input Impedance	47 k
Output Impedance (Buffered)	< 10 ohm
Minimum Load (Buffered)	500 Ohm
Frequency Response (Sum of all ouputs) 20 Hz to 20 kHz	± 1 dB

ACTIVE CROSSOVER

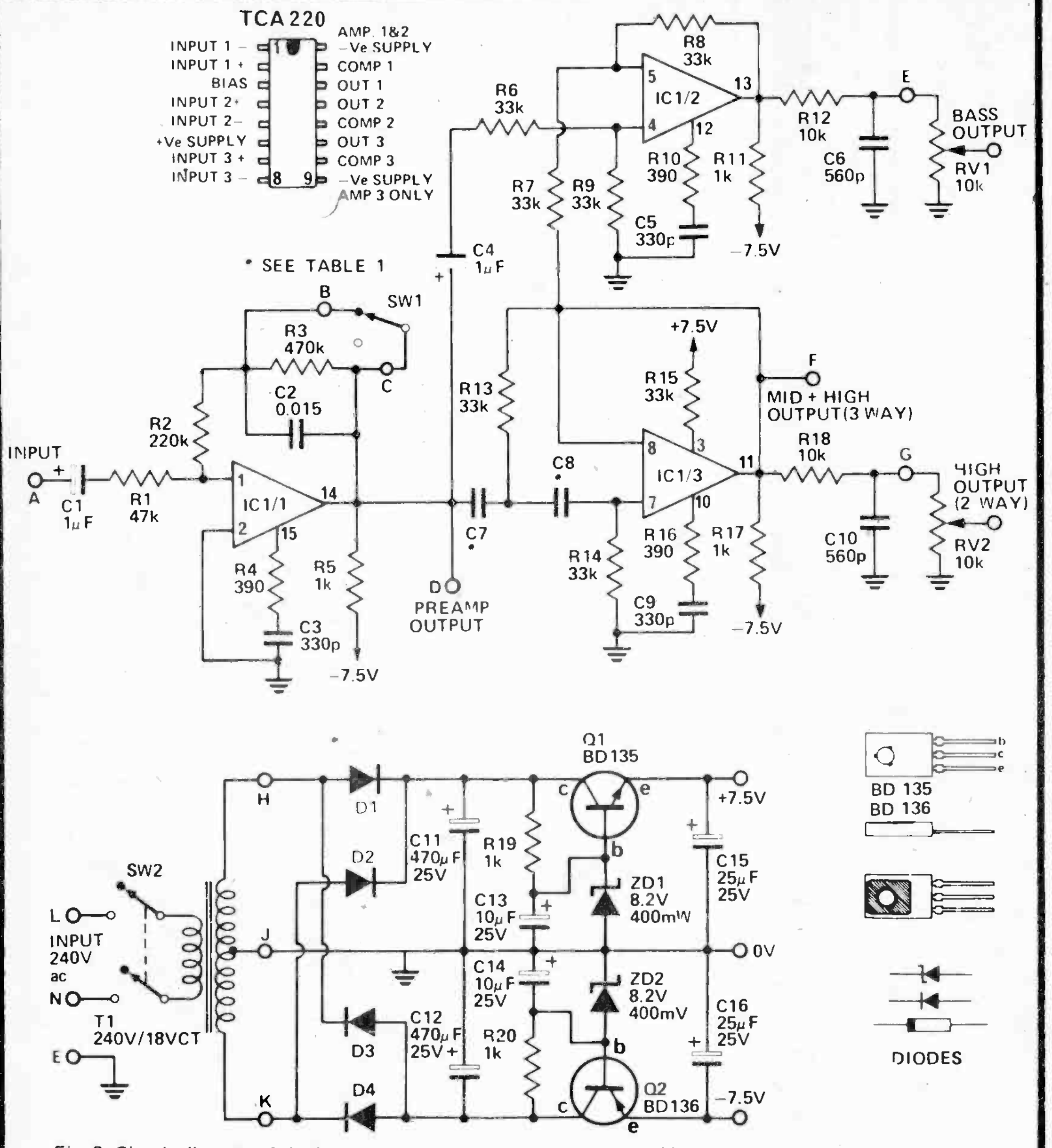


Fig. 2. Circuit diagram of the basic two-way electronics crossover and its power supply. These circuits are on board ETI433A.

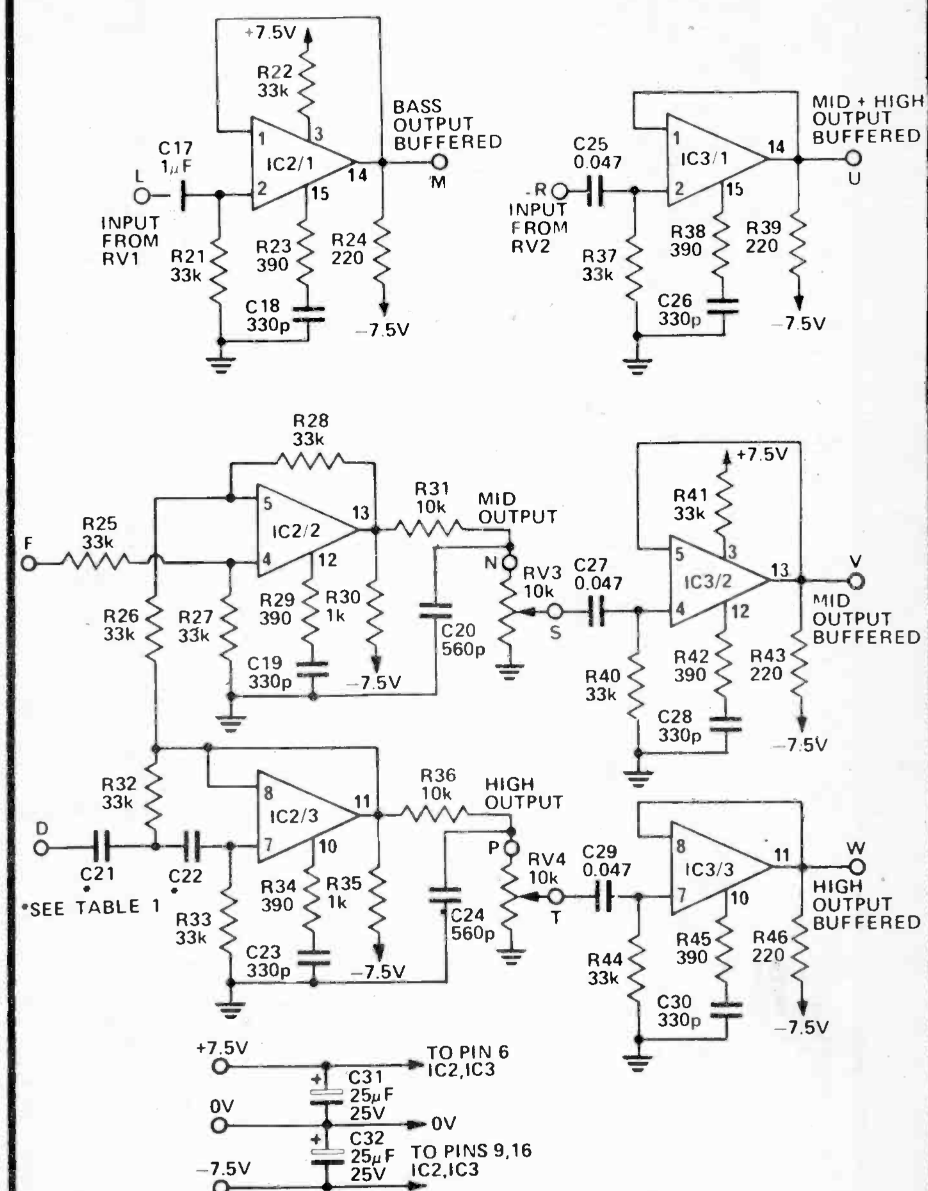


Fig. 3. Circuit diagram of the mid/high crossover board which provides four output buffer amplifiers. These circuits are on board ETI433B.

HOW IT WORKS – ETI 433

The input signal is initially amplified by IC1/1. Switch SW1 together with R3 and C2 provide a maximum of 10 dB of boost below 50 Hz at a rate of 6 dB per octave. The frequency at which the boost comes in may be altered by selecting a value of C2 such that its reactance is 220k at the frequency where the woofer is normally 3 dB down. Thus if the turnover frequency is required to be 100 Hz the value of C2 should be halved.

If the boost facility is not required R3, C2 and SW1 should be deleted and a link installed between points B and C. The mid frequency gain is set by R2/R1 to about 13 dB and the input impedance is equal to the value of R1, that is, 47 k.

The first high-pass filter consists of IC1/3 where R13, R14, C7 and C8 set the cut-off frequency. The values of C7 and C8 required may be found from Table 1. This output is the high range in a two way system, or the mid plus high of a three-way system. This signal, when subtracted from the input signal by IC1/2 gives the bass range output. A second high-pass filter, where C21, C22, R32 and R33 form the frequency determining network, gives the output for the tweeter in a three-way system. This when subtracted from the mid-plus-high signal leaves the mid only as required.

Each of these outputs goes to a level set potentiometer and then is buffered by amplifiers IC2/1 and IC3/1,2,3. These outputs are now capable of driving loads in excess of 500 ohms. If the crossover is to be used to drive a constant and known load (that is, it is to be used on only one type of amplifier) the buffer amplifiers may be omitted and the outputs taken directly from the potentiometers.

The full-wave power supply provides plus or minus 13 volts which is regulated down to plus or minus 7.5 volts, by series regulators Q1 and Q2, where zeners ZD1 and ZD2 provide the necessary reference. If the unit is to be powered from the power amplifier C11, 12, and D1 to D4 should be deleted. Resistors R19 and R20 are altered to suit as shown in Table 2. The collector of Q1 now goes to the positive supply rail of the amplifier and the collector of Q2 to the negative supply rail. If the amplifier supply rail is above plus and minus 20 volts, or if both printed circuit board are being used, (that is it is a buffered three way system) a heatsink must be added to Q1 and Q2.

PARTS LIST – ETI 433A

2-WAY SYSTEM

R4,10,16 Resistor	390	¼W	5%
R5,11,17 "	1k	¼W	5%
R19,20 "	1k	¼W	5%
R12,18 "	10k	¼W	5%
R6,7,8,9 "	33k*	¼W	2%
R13,14,15 "	33k	¼W	5%
R1 "	47k	¼W	5%
R2 "	220k	¼W	5%
R3 "	470k	¼W	5%

*These may be any value between 15k and 82k provided they are all the same value and preferably 2%.

RV1,2 Potentiometer 10k lin.

C3,5,9 Capacitor	330 pF ceramic
C6,10 "	560 pF ceramic
C2 "	0.015 μF polyester
C1,4 "	1 μF Tag tantalum
C13,14 "	10 μF 25V
C15,16 "	25 μF 25V

C11,12 Capacitor 470 μF 25V
C7,8 " See Table 1.
D1-D4 Diode 1N4001, 1N4005or similar
ZD1,2 Zener Diode 8.2 volt 400 mW
Q1 Transistor BD135 or similar
Q2 Transistor BD136 or similar
IC1 Integrated Circuit TCA220
T1 Transformer 240V/18V CT 150 mA
SW1 toggle or slide switch SPDT
SW2 Toggle switch DPDT 240V rated
PC Board ETI 433A

The TCA220 is available from Doram Electronics, P.O. Box TR8, Leeds, LS12 2UF.

PARTS LIST – ETI 433B

3-WAY WITHOUT BUFFERS
All 2-way system PLUS

R29,34 Resistor	390	¼W	5%
R30,35 "	1k	¼W	5%
R31,36 "	10k	¼W	5%
R25,26,27,28 Resistor	33k*	¼W	2%
R22,32,33 "	33k	¼W	5%

* These may be any value between 15k and 82 k provided all are the same value and preferably of 2% tolerance

RV3,4 Potentiometer 10k Lin

C19,23 Capacitor	330 pF ceramic
C20,24 "	560 pF ceramic

C21,22 See Table 1.
IC2 Integrated Circuit TCA220
PC board ETI 433B

3-WAY SYSTEM WITH BUFFERS ADD

R24,39,43,46 Resistor	220	¼W	5%
R23,38,42,45 "	390	¼W	5%
R21,37 "	33k	¼W	5%
R40,41,44 "	33k	¼W	5%

C18,26,28,30 Capacitor	330 pF ceramic
C25,27,29 "	0.047 μF polyester
C17 "	1 μF TAG Tantalum
C31,32 "	25 μF 25V electro

IC3 Integrated Circuit TCA220

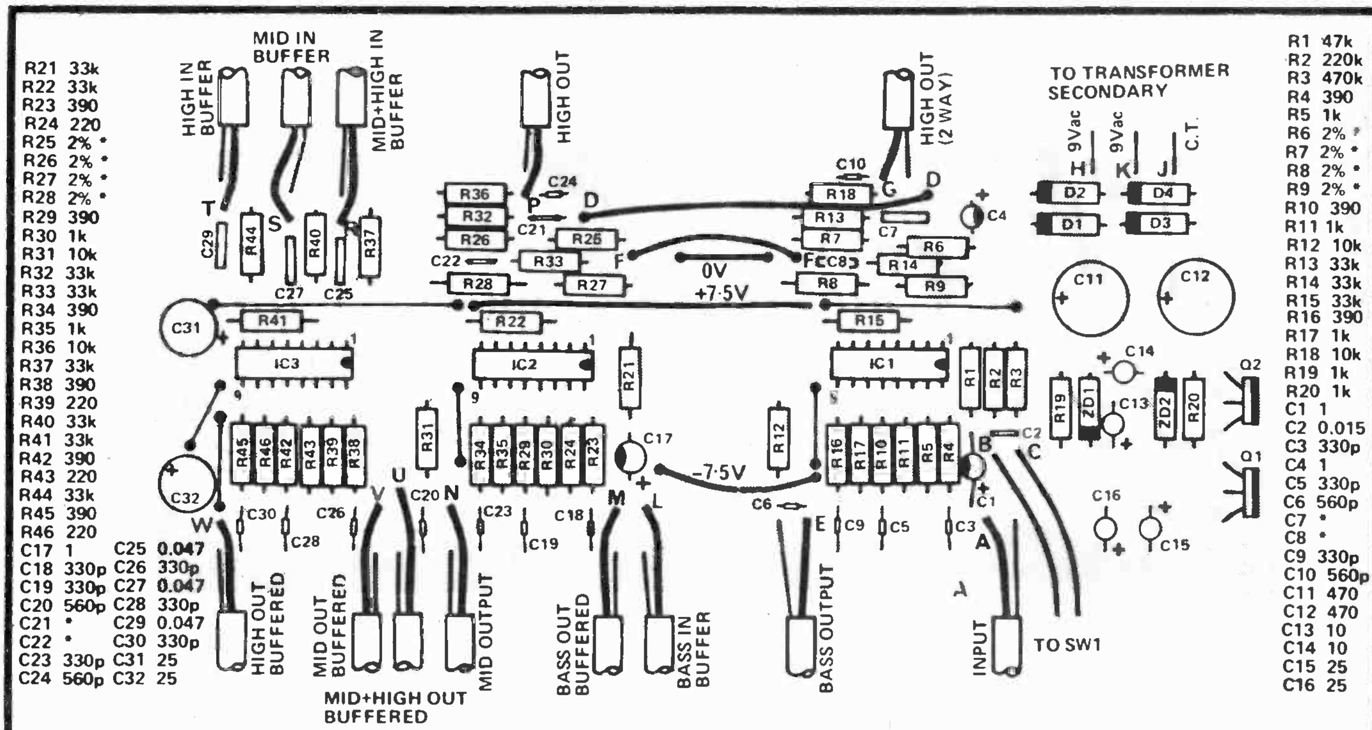
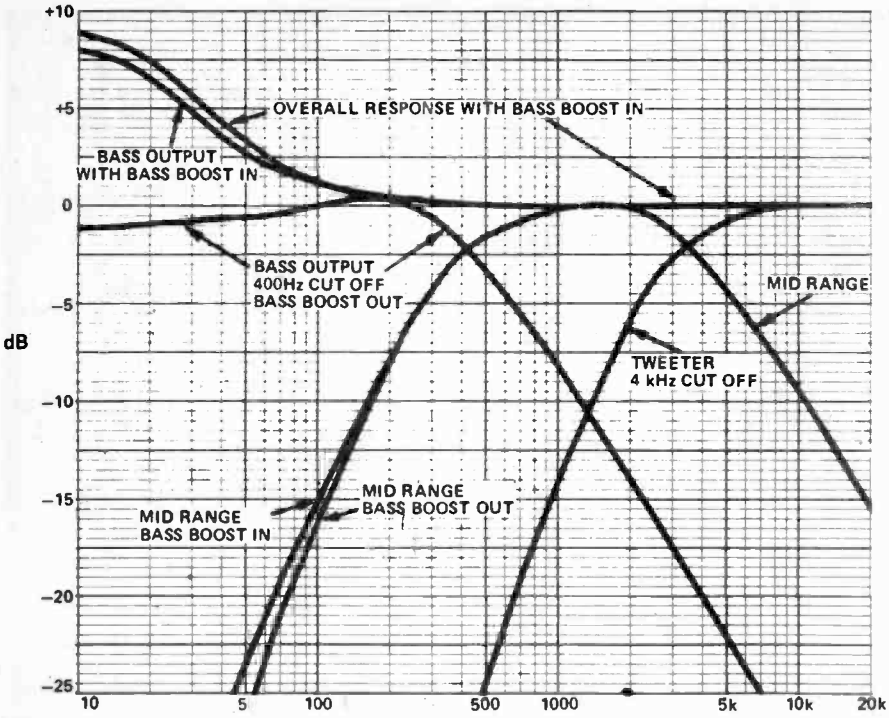


Fig. 4. Component overlay for complete three-way system. Capacitance values are in microfarads except where otherwise noted.



Response curves of the active filters.

TABLE 1

CROSS OVER FREQUENCY IN HERTZ	VALUE OF C7,8 or C21, 22 in μF
100	0.082
130	0.068
150	0.056
200	0.047
230	0.039
270	0.033
330	0.027
400	0.022
500	0.018
600	0.015
750	0.012
900	0.0082
1300	0.0068
1500	0.0056
2000	0.0047
2300	0.0039
2700	0.0033
3300	0.0027
4000	0.0022
5000	0.0018
6000	0.0015
7500	0.0012
9000	0.001

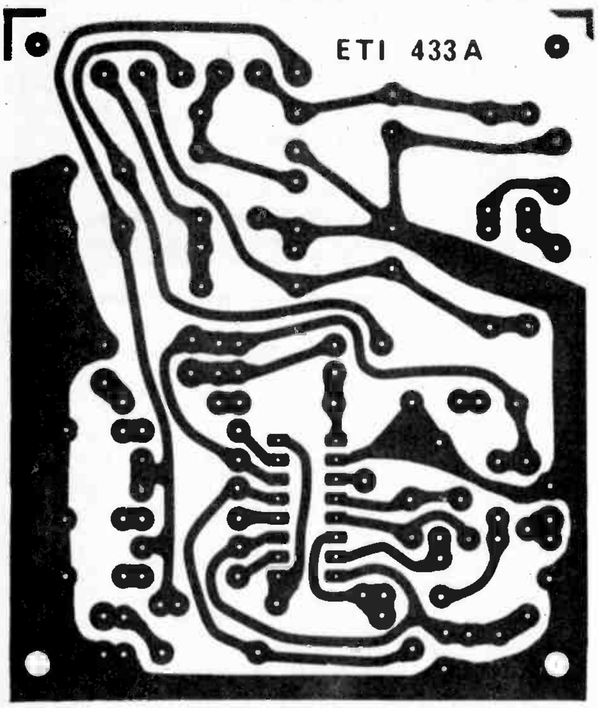


Fig. 5. Printed-circuit layout for the two-way board. Full size 77 x 90 mm.

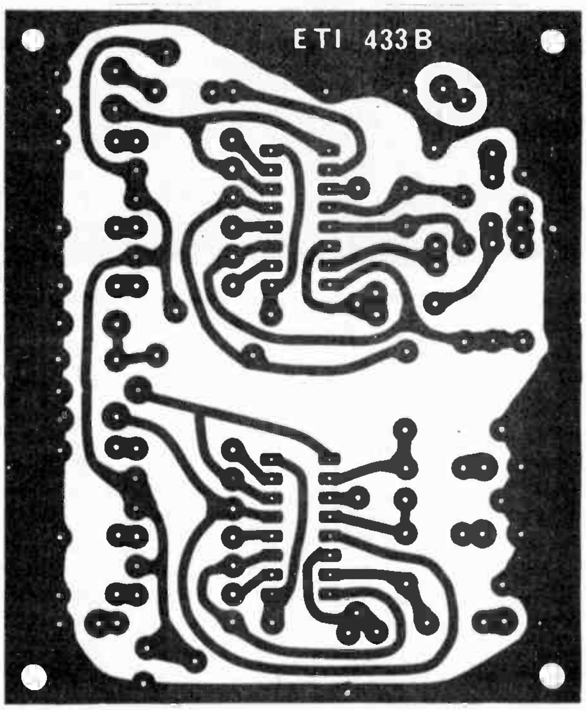
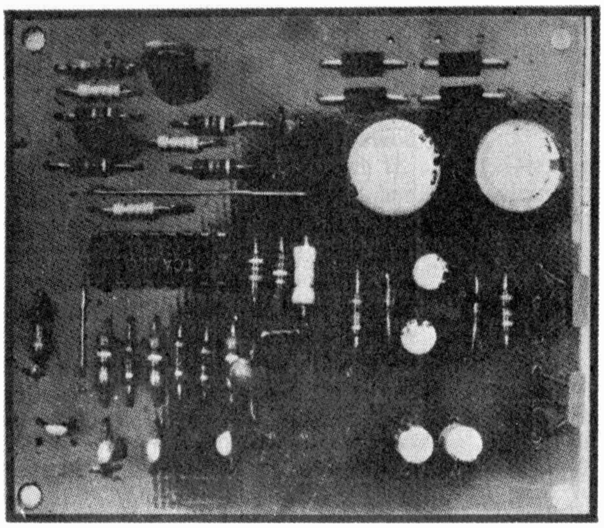


Fig. 6. Printed-circuit layout for the add-on three-way board. Full size 77 x 90 mm.

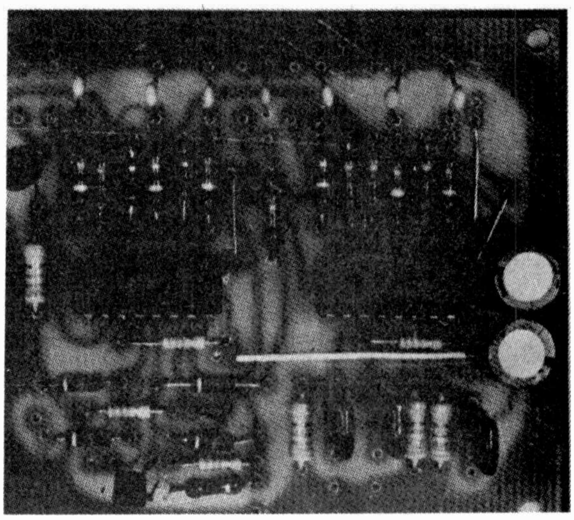
ACTIVE APPROACH

Having now established that effective conventional crossovers cost money, we may now wonder if that money could be spent in a better way by using a completely different approach. There is a better way, but until recently it has been much too expensive to be generally used. The method is to use an electronic crossover, after the preamplifier, followed by separate power amplifiers for each driver. This is feasible because a power amplifier can now be built at a cost which is about the same as that of the passive crossover. Indeed quite a few manufacturers are bringing out systems based on this principle.

Even well-designed crossovers have several serious disadvantages. As we have already said they are expensive, they waste power, they reduce damping factor (in the crossover region damping factor may drop to less than unity) and they only perform correctly into their designed load impedance. Practical drivers exhibit



The basic two-way electronic crossover.



This board provides three-way crossover plus output buffers if required.

their nominal impedance only over a very small portion of their passband, and impedance may well increase to several times the nominal value at the high end of the range. It is possible to compensate for this, to some extent, by using extra networks across the driver (the series RC networks in Fig. 1) — but this adds even more expense. Further, it is very difficult to alter the crossover frequency and also difficult to trim the crossover for best results.

However, if we were to use an electronic crossover incorporating active filters, we overcome most of the problems mentioned in a single stroke. The bulky and expensive inductors and the large and expensive capacitors are eliminated. Damping factor is restored (due to seperate amplifiers being used to drive each speaker directly) and it is quite easy to change or trim the crossover frequency as desired.

Further, as electronic crossovers may have gain, it is quite a simple matter to match the various drivers of the system for sensitivity. This can be only achieved, in passive designs, by attenuating the more sensitive units down to the level of the least sensitive unit. A process which can be quite wasteful of amplifier power.

Of course with active crossovers, as with anything, there are disadvantages. In active filters we generally use operational amplifiers to implement the filters and therefore, bandwidth and noise become considerations. Further, as said before, a separate amplifier is required for each driver or group of drivers — and this can be expensive.

Nevertheless the technique is now quite feasible and is certainly worthwhile. Consequently we have developed a minimum-expense method of building a very fine system based on active filter techniques. This month we describe a basic two or three way active filter system which may be incorporated into existing amplifiers. To follow next month will be an active filter/amplifier combination based on the 422 amplifier and later still we will be describing how a complete system, including a three-way speaker system, may be built.

For those interested in the design of active filters a full article on this subject will also be published in the near future.

DESIGN FEATURES

There are several different approaches which may be used in the design of active filters. The first and most commonly used method, is to use separate filters for the bass, mid and high range speakers. This method is capable of compensating for amplitude, if the components are chosen correctly, but not for phase. In fact there has to be a phase change of 180° between filters to eliminate the hole that would otherwise occur at the crossover point. This is the reason for the tweeter being reversed in phase when a conventional crossover is used in a two-way system.

Another design approach, and the one that we have elected to use, is to use an active high-pass filter to generate the signal for the tweeter, and to subtract this signal from the input signal in a differential amplifier in order to generate the bass output. This substraction process generates the required crossover characteristic with both amplitude and phase taken in to account.

Initially we were worried because the bass output had a slight peak before the cutoff point but the peak is necessary to maintain that response when phase is taken into account. When the output of all channels are summed the combined response is within plus or minus one quarter of a dB of being flat over the whole range.

With this type of active filter the initial slope can be varied by adjusting the feedback resistor (R13, R32) to give a slow rolloff (Bessel filter) or to give a slight peak and fast cutoff (Chebishev). The sharper the initial cutoff the greater the apparent peak in the bass response.

As several operational amplifiers are required to implement this design we elected to use the TCA 220 triple operational amplifier. This IC, as well as containing three op-amps in the same package, is cheaper than using three separate op-amps of the 741 type or similar. Unlike the 741 type of op-amp, the TCA 220 requires a pull-down resistor on each output and a compensation network. An additional resistor is required to bias each complete IC. The use of the TCA 220 simplifies and cheapens the construction of the filter system considerably.

With active filter crossovers it is a relatively simple matter to alter the gain-versus-frequency characteristic of the filter, within its pass-band, in order to compensate for non-linearities in the associated driver. An example of this kind of compensation is our inclusion of low frequency equalisation for the woofer. Most woofers begin to drop off in the 50 to 100 hertz region. This may be corrected to some extent by adding boost below this turnover frequency. In our design we have provided 6 dB of boost which may be switched in when desired and which is limited to a maximum of 10 dB. The 10 dB limit is necessary to prevent the amplifier being over driven at low frequencies even at fairly low average listening levels.

The turnover frequency may be

selected by means of a simple component change to suit the driver in use. This equalisation technique can effectively extend the low frequency response by another octave, eg, from 50 hertz down to 25 hertz.

CONSTRUCTION

The configuration of the electronic crossover used will depend very much on the system into which it is to be built. The prospective builder should therefore carefully determine his individual requirements before commencing to build a system.

If a fixed load is to be driven (ie, numbers of amplifiers) as would be the normal case, the buffer amplifiers are not required, and the output may be taken directly from the potentiometers.

It must also be decided whether you want a two-way or a three-way system. Rather than use three separate amplifiers to drive the woofer, mid and tweeter drivers separately, it may be better to use a conventional crossover for the mid/high crossover and a two-way electronic crossover for the bass/mid.

Mono or stereo? If a stereo unit is to be built only one power supply is required and the bass-boost switch and the level potentiometers can all be dual units.

If the amplifier has a dual power supply with voltages exceeding ± 10 volts it may be used to power the crossover. This course of action will save one transformer, four power diodes and the filter capacitors.

Mechanical layout is not given as the unit will most probably best be mounted within the amplifier case. Keep it well clear of the power transformer and mount it using insulated spacers. This is necessary to avoid the possibility of earth loops which will cause a high hum level.

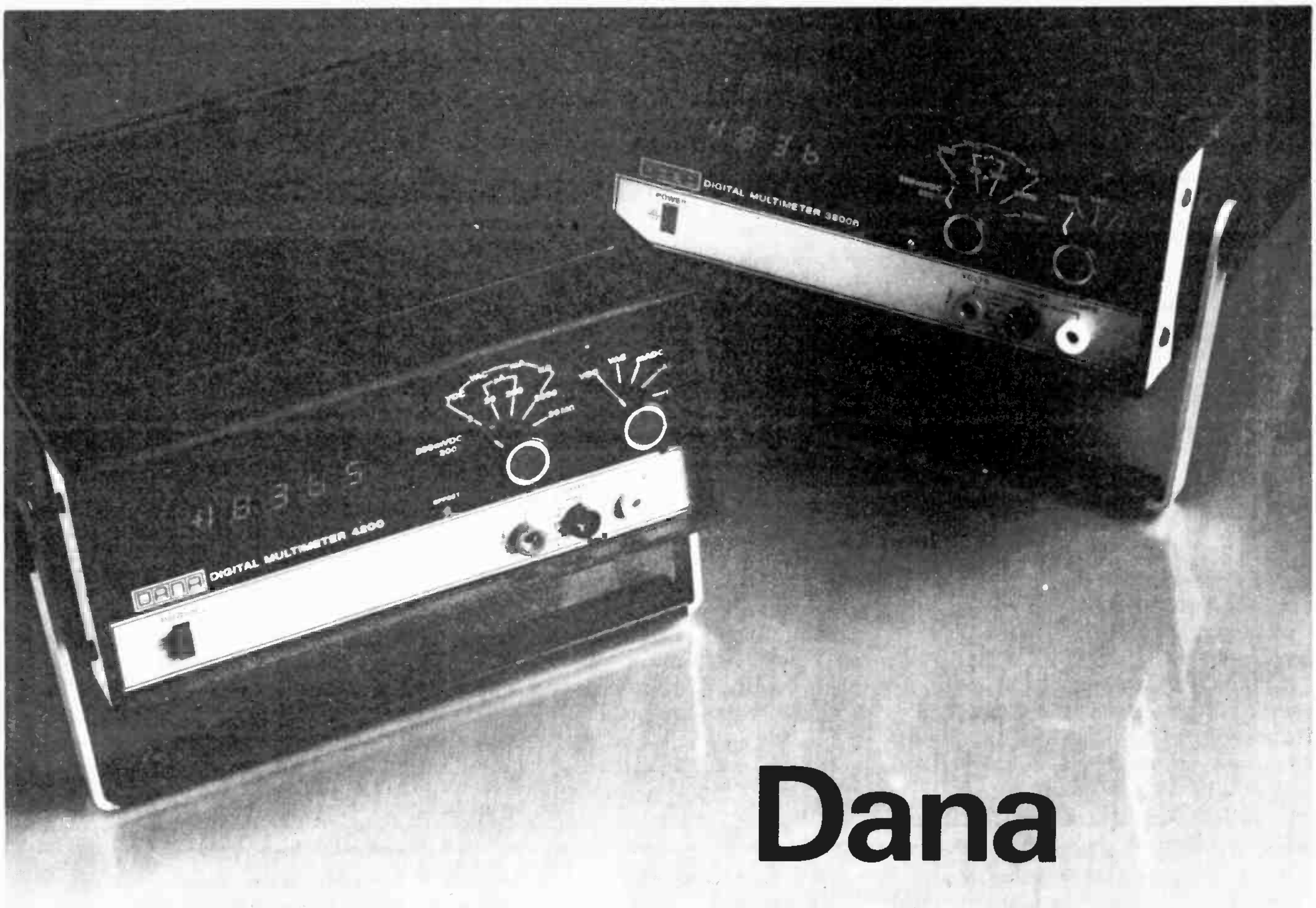
Full component overlays are given for all alternatives but only the circuitry required should be assembled. In a three-way system without buffers one section of IC2 is not used. In this case just leave out the components associated with the unused section in order to reduce power consumption.

If the unit is being powered from the main amplifier, or a three-way system with buffers is being used, a heatsink is required. The heatsink recommended is a piece of aluminium 60 x 85 mm bent into a 'U' shape and mounted vertically on the end of the board. The transistors should be insulated from the heatsink.

For a stereo system delete the power supply components on one of the boards (up to C15 and C16) and just link the two boards together. ●

TABLE 2

MAIN AMPLIFIER SUPPLY VOLTAGE	VALUE OF R19,R20
± 10-15 V	1 k
± 15-20 V	1.8 k
± 20-25 V	2.7 k
± 25-30 V	3.9 k
± 30-40 V	5.6 k
± 40-50 V	8.2 k



Dana

cut the cost of ownership

Dana offer the high-quality 3800B and 4200 DMMs at quantity prices — and savings only start there. Because they have a one-year specification the costs of calibration, and therefore the total running costs are reduced. What else?

A three-pole active filter and dual-slope integration ensure outstanding noise rejection. As a result you get what is practically unknown in an instrument in this price bracket: freedom from errors caused by all types of noise — not just mains hum.

The 3800B is a 3½-digit (2,000 counts) DMM, and the 4200 is a 4½-digit (20,000 counts) DMM. Both instruments measure resistance, a.c. volts, d.c. volts and d.c. current.

One-year stability is outstanding: a highly stable zener diode voltage reference guarantees the stability of both DMMs to be within their rated accuracies for at least a year after calibration. D.c. accuracy is assured by an extremely high input impedance: 1,000 megohms on the 2-volt range.

Both models have isolated b.c.d. outputs available, and the 3800B will feed data out at up 60 readings a second. At £145.00 for the 3½-digit DMM and £ 220.00 for the 4½-digit DMM one of these has to be the offer you can't refuse.

DANA®
Others measure by us.

Makers of High-quality Instruments : Frequency Counters
Digital Voltmeters
Waveform Generators
Communications Test Equipment
Microwave Counters
Frequency Synthesizers

Dana Electronics Ltd.,
Collingdon Street,
Luton, Beds. Telex : 82430
Telephone : 0582 24236

ETI PCB's

TITLE	PROJECT NO.	ISSUE	BOARD NO.	TOTAL
Int. Stereo Amp. 25 watts/chan.	Int. 25	Oct. 1975	Int. 25	£4.21
Dual Power Supply	105	Apr. 1972	014	£1.48
Wide Range Voltmeter	107	Top Project No. 1	022	£1.09
I.C. Power Supply	111	Jan. 1973	111	£1.43
Thermocouple Meter	113	Dec 1973	113	£1.57
Dual Beam Adaptor	114	Oct. 1974	114	£1.00
Impedance Meter	116	June 1975	116	1.01
Digital Voltmeter	117	Oct. 1975	117A	68p
			117B	68p
Simple Freq. counter	118	Nov. 1975	118	68p
The Revealer	213	Top Project No. 1	213	68p
Brake Light Warning	303	Oct. 1972	007	68p
Automatic Car Theft Alarm	305	Aug. 1972	019	99p
International Battery Charger	309	Nov. 1973	309	98p
Tacho Timing Light	311	Dec. 1974	311	80p
Electronic Ignition CDI/Tacho	312	May 1975	312	£1.72
Car Alarm	313	Mar. 1975	313	67p
Auto Amp	314	May 1975	314	75p
ET Four Input Mixer	401	Top Project No. 2	005A	67p
Super Stereo	410	Top Project No. 2	025	£1.51
100W Guitar Amp	413	Feb. 1973	413	£1.73
Master Mixer	414	Top Project No. 1	414A	£1.14
			414B	£1.52
			414C	£1.52
Stage Mixer	414	July 1975	414D	£1.89
			414E	£1.78
The Over L.E.D.	417	Nov. 1973	417	68p
Mixer Pre-Amp	419	Dec. 1973	419	91p
International 420 Four Channel Amp	420	Apr. 1974	420A	76p
			420B	£1.11
			420C	£1.21
			420D	£1.21

TITLE	PROJECT NO.	ISSUE	BOARD NO.	TOTAL
Discrete SQ Decoder	420E	June. 1974	420E	£1.69
Int. 422 Stereo Amp 50 watts/Chan.	422	Aug. 1974	422	£2.97
Plus Two Add on Decoder Amp	423	Nov. 1974	423	91p
Spring Reverberation Unit	424	Dec. 1974	424	£1.62
Stereo Rumble Filter	426	Jan. 1975	426	76p
Graphic Equaliser	427	Jan. 1975	427	£1.96
Colour Organ	428	Feb. 1975	428	£2.10
Simple Stereo Amp	429	Mar. 1975	429	76p
Line Amp	430	July 1975	430	76p
Fluorescent lamp dimmer	508	Nov. 1972	011	76p
Photgraphic Timer	512	Aug. 1972	023	76p
Tape Slide Synchroniser	513	Top Project No. 2	026	76p
Digital Stop Watch	520	Jan. 1974	520A	£2.05
			520B	50p
Low Cost Laser	524	Mar. 1974	524	£1.30
Push Botton Dimmer	427	Feb. 1975	527	96p
Electronic One Arm Bandit	529	Sept. 1975	529A	£2.32
			529B	£2.32
Temp. Controller	530	Mar. 1975	530	85
Photo Timer	532	Sept. 1975	532	87
Digital Display	533	Oct. 1975	533A	68
			533B	68
Music Synthesiser	601	Aug. 1974	Osc. 601A	£2.54
			Mixer 601B	£2.54
			Trans 601C	£1.62
			V.C.A. 601D	90p
			Key Board Cont: 601E	£3.72

TITLE	PROJECT NO.	ISSUE	BOARD NO.	TOTAL
Music Synthesiser	601	Aug. 1974	Noise Cont: 601F	£1.22
			Trans. 2 601G	£1.74
			V.C. 601H	£2.36
			601J	£2.54
			Ext. Input Mod. 601L	£1.06
			Key Cont. 601M	97p
			Power Sup. 601N	£3.04
			Aux. Board 601P	£1.54
			601R	
Radar Intruder Alarm	702		702	£1.13
Int. F.M. Tuner	751	Sept. 1975	751	£2.75
Light Dimmer		June 1975		68p
Print Timer		Top Project No. 2		68p
Inter Com.				68p
Intruder Alarm		Apr. 1975		94p
Digital Alarm Clock	Tim-tronic	Sept. 1973	5017 AA/BB	£1.24
Utiliboard		Nov. 1975		£1.68
Bicycle Speedometer		June 1975		68p

At the time of going to press we have stocks of all the above boards. Allow 7/10 days for delivery by post. Boards also available for other published designs at 6p a sq. inch + VAT and P&P. Large stocks of components also available.

CROFTON ELECTRONICS LTD.

Dept. C, 124 Colne Road, Twickenham, Middx. 01-898 1569

TTLs by TEXAS

7400	13p	7483	80p
7401	14p	7484	95p
7402	14p	7485	120p
7403	16p	7486	30p
7404	16p	7489	270p
7405	16p	7490	40p
7406	38p	7491	75p
7407	36p	7492	45p
7408	14p	7493	40p
7409	20p	7494	75p
7410	13p	7495	65p
7412	23p	7496	78p
7413	32p	74107	30p
7414	60p	74121	30p
7416	33p	74122	46p
7420	14p	74123	68p
7422	18p	74141	65p
7423	34p	74151	72p
7425	30p	74153	85p
7427	37p	74154	150p
7430	14p	74155	76p
7432	25p	74156	76p
7437	25p	74160	99p
7440	14p	74161	99p
7441	65p	74162	99p
7442	60p	74163	99p
7447	75p	74164	120p
7448	70p	74166	126p
7450	15p	74174	120p
7451	16p	74175	85p
7453	16p	74180	100p
7454	16p	74181	298p
7460	15p	74182	82p
7470	27p	74185	135p
7472	25p	74190	144p
7473	30p	74191	144p
7474	30p	74192	120p
7475	45p	74193	120p
7476	30p	74194	108p
7480	50p	74195	75p
7481	95p	74198	198p
7482	70p	74199	180p

C-MOS LOGIC I.Cs NEW LOW PRICES

CD4000AE	19p
CD4001AE	19p
CD4002AE	19p
CD4009AE	67p
CD4011AE	19p
CD4012AE	19p
CD4013AE	55p
CD4016AE	50p
CD4017AE	120p
CD4018AE	175p
CD4020AE	250p
CD4022AE	170p
CD4023AE	19p
CD4024AE	120p
CD4025AE	19p
CD4026AE	196p
CD4027AE	75p
CD4028AE	140p
CD4029AE	175p
CD4030AE	55p
CD4042AE	137p
CD4043AE	202p
CD4046AE	140p
CD4047AE	154p
CD4049AE	63p
CD4054AE	196p
CD4055AE	196p
CD4056AE	135p
CD4060AE	229p
CD4069AE	37p
CD4071AE	27p
CD4081AE	19p
CD4082AE	27p
CD4510AE	130p
CD4511AE	200p
CD4528AE	120p

OP. AMPS

1458	Dual Op Amp Int Comp	8 pin DIL	70p
301A	Ext Comp	8 pin DIL	36p
3130	COSMOS/Bi-Polar MosFet	8 pin DIL	100p
3900	Quad Op Amp	14 pin DIL	70p
536T	FET Op Amp	TO-99	275p
709	Ext Comp	8/14 pin DIL	30p
741	Int. Comp.	8/14 pin DIL	25p
747	Dual 741	14 pin DIL	70p
748	Ext. Comp	8 pin DIL	36p
776	Programmable Op Amp	TO-5	140p

LINEAR I.C.s

CA3028	Diff. Cascade Amp	TO5	90p
CA3046	5 Transistor Array	14 pin DIL	50p
CA3048	Quad Low Noise Amp	16 pin DIL	200p
CA3089E	FM IF System	16 pin DIL	200p
CA3090	FM Stereo Multi. Dec.	16 pin DIL	160p
ICL8038CC	VCO Fun Gen	14 pin DIL	275p
LM380	2W Audio Amp	14 pin DIL	90p
LM381	Stereo Preamp	14 pin DIL	160p
M252	Rhythm Generator	16 pin DIL	900p
MC1310P	FM Stereo Dec.	14 pin DIL	175p
MC1312			
MC1314	SQ Quad. Dec	14 pin DIL	1100p
MC1315			
MFC4000B	1/4W Audio Amp	PCB	70p
MFC6040	Electronic Attenuator	PCB	90p
NE555	Timer	8 pin DIL	45p
NE556	Dual 555	14 pin DIL	100p
NE561	PLL with AM Demod.	16 pin DIL	325p
NE562	PLL with VCO	16 pin DIL	325p
NE563	PLL FM/IF Demod	16 pin DIL	300p
NE565	PLL	14 pin DIL	200p
NE566	PLL Fun. Gen.	8 pin DIL	150p
NE567	PLL Tone Dec	8 pin DIL	200p
2567	Dual 567	14 pin DIL	370p
SN72733	Video Amp.	14 pin DIL	120p
TBA800	5W Audio Amp	QIL	90p
TBA810	7W Audio Amp	QIL	100p
TBA820	2W Audio Amp	QIL	80p
XR2240	Prog Timer/Counter	16 pin DIL	370p
ZN414	TRF Radio Receiver	TO-18	110p

Basic data sheets on above at 10p each +S.A.E.

VOLTAGE REGULATORS FIXED PLASTIC — 3 Terminals

1 Amp	+Ve		–Ve		200mA	(TO5)
5V	7805	140p	7905	200p	—	—
12V	7812	140p	7912	200p	7812	99p
15V	7815	140p	7915	200p	7815	99p
18V	7818	140p	7918	200p	—	—
24V	7824	140p	7924	200p	—	—

VARIABLE
723 14 PIN DIL 45p

Data sheets on regs at 10p each + s.a.e.

OPTO-ELECTRONICS

OCP70	30p
OCP71	90p
ORP12	50p
ORP60	60p
ORP61	60p
2N5777	40p

SEVEN SEGMENT DISPLAYS

3015F	0.3 in	DIL	120p
MAN3M	0.127 in	PCB	110p
DL704	0.3 in	DIL	135p
DL707	0.3 in	DIL	135p
DL747	0.6 in	DIL	225p

LEDS: TIL209 Red 14p; TIL211 Green 30p

LOW PROFILE DIL SOCKETS BY TEXAS

8 pin **13p**, 14 pin **14p**, 16 pin **15p**, 24 pin **50p**.

INSULATORS Mica + 2 Bushes for TO3 & TO66 5p

TRIACS

	100V	400V	500V
3 Amp	85p	99p	120p
6 Amp	88p	120p	150p
10 Amp	109p	154p	165p
15 Amp	145p	180p	220p

OTHER

40430	99p
40486	99p
40669	95p
BR100 Diac	21p

SCR-THYRISTORS

1A 50V	TO5	40p
1A100V	TO5	42p
1A400V	TO5	52p
1A600V	TO5	70p
3A100V	Stud	49p
3A400V	Stud	75p
7A100V	TO5+HS	84p
7A400V	TO5+HS	90p
8A 50V	Plastic	130p
12A400V	Plastic	160p
16A100V	Plastic	160p
16A400V	Plastic	180p
16A600V	Plastic	220p

BT106 1A/700V	Stud	140p
C106D 3A/400V	Plastic	55p
MCR101 0.5A/15V	TO-92	25p
2N3525 5A/400V	TO-66	90p
2N4444 8A/600V	Plastic	185p
2N5060 0.8A/30V	TO-92	34p
2N5062 0.8A/100V	TO-92	37p
2N5064 0.8A/200V	TO-92	40p

TRANSISTORS

AC126	11p	BF182	33p	ZTX502	18p	2N4060	13p
AC127	12p	BF184	22p	2N697	13p	2N4289	20p
AC128	11p	BF185	22p	2N698	30p	2N4347	130p
AC141	18p	BF194	10p	2N706	12p	2N4348	160p
AC142	18p	BF195	9p	2N708	18p	40360	40p
AC176	11p	BF196	14p	2N918	40p	40361	38p
AC187	13p	BF197	15p	2N928	20p	40362	40p
AC188	12p	BF200	32p	2N930	18p	40364	120p
AD149	43p	BF257	32p	2N1131	18p	40409	55p
AD161	36p	BFR39	30p	2N1132	18p	40410	55p
AD162	36p	BFR40	30p	2N1304	21p	40411	225p
AF114	18p	BFR79	30p	2N1305	21p	40594	75p
AF115	18p	BFR80	30p	2N1306	28p	40595	85p
AF116	18p	BFR88	30p	2N1307	28p		
AF117	18p	BFX30	30p	2N1308	28p		
AF139	33p	BFX84	26p	2N1309	28p		
AF239	38p	BFX85	25p	2N1613	20p		
BC107	9p	BFX86	25p	2N1711	20p		
BC108	9p	BFX87	20p	2N1893	30p		
BC109	10p	BFX88	24p	2N2218	21p		
BC109C	12p	BFY50	16p	2N2219	20p		
BC147	7p	BFY51	15p	2N2220	19p		
BC148	7p	BFY52	16p	2N2221	20p		
BC149C	8p	BRY39	34p	2N2222	20p		
BC157	11p	BSX19	16p	2N2369	14p		
BC158	10p	BSX20	18p	2N2484	30p		
BC159	11p	BU105	140p	2N2904	20p		
BC169C	12p	BU108	250p	2N2905	20p		
BC177	18p	MJE340	45p	2N2906	20p		
BC178	17p	MJE2955	99p	2N2926R	7p		
BC179	18p	MJE3055	65p	2N2926B	7p		
BC182	10p	MPSA06	30p	2N29260	8p		
BC183	10p	MPSA12	50p	2N2926Y	9p		
BC184	11p	MPSA56	32p	2N2926G	9p		
BC187	30p	MPSU06	62p	2N3053	18p		
BC212	11p	MPSU56	78p	2N3054	40p		
BC213	10p	OC28	55p	2N3055	50p		
BC214	14p	OC35	48p	2N3439	67p		
BC478	30p	OC36	56p	2N3442	140p		
BCY70	18p	OC41/2	15p	2N3702	11p		
BCY71	22p	OC45	11p	2N2703	11p		
BD123	100p	OC71	20p	2N3704	11p		
BD124	65p	TIP29A	40p	2N3705	11p		
BD131	36p	TIP30A	48p	2N3706	10p		
BD132	40p	TIP31A	52p	2N3707	11p		
BD135	43p	TIP32A	58p	2N3708	9p		
BD139	63p	TIP33A	90p	2N3709	9p		
BD140	70p	TIP34A	115p	2N3773	220p		
BF115	22p	TIP35A	290p	2N3866	90p		
BF167	23p	TIP36A	370p	2N3903	18p		
BF170	23p	TIP41A	65p	2N3904	18p		
BF173	25p	TIP42A	70p	2N3905	18p		
BF177	26p	TIP2955	70p	2N3906	18p		
BF178	28p	ZTX108	10p	2N4058	15p		
BF179	33p	ZTX300	13p	2N4059	10p		
BF180	33p	ZTX500	15p				
BF181	33p						

FETs

BF244	25p
MPF102	30p
MPF103	30p
MPF104	30p
MPF105	30p
2N3819	22p
2N3820	57p
2N3823	50p
2N5457	30p
2N5458	30p
2N5459	30p

MOSFETs

3N128	85p
3N140	85p
3N141	85p
40603	58p
40673	58p

UJTs

TIS43	27p
2N2160	80p
2N2646	38p
2N4871	30p

PUJT

2N6027 48p

OA90	7p
OA91	7p
OA95	7p
OA200	8p
OA202	10p
IN914	4p
IN4148	4p

RECTIFIER

BY100	25p
BY126	12p
BY127	12p
BYZ10	45p
BYZ11	45p
BYZ12	45p
BYZ13	45p
IN4001	5p
IN4004	6p
IN4007	7p

ZENER
3.3V to 33V
400mW 9p
1W 18p

TUNNEL
AEY11 50P

VARICAP
BB105 25p

NOISE
ZIJ 90p

DIODES

SIGNAL

OA47	7p
OA70	9p
OA81	8p
OA85	10p

BRIDGE RECTIFIERS

.25A 100V	20p
1A 50V	22p
1A 100V	24p
1A 400V	27p
1A 600V	30p
2A 50V	30p
2A 100V	35p
2A 400V	45p
6A 50V	60p
6A 100V	65p

VAT RATES

ALL ITEMS AT 8% **EXCEPT** where marked which are rated at 25%.

Fully branded devices by Texas, RCA Motorola, National, Mullard, etc.

Minimum Order £2
P&P 20p
Please add VAT to total

All first grade devices
Visitors, by appointment, welcome.
Govt., Colleges, etc. orders accepted

TECHNOMATIC LTD.

54 SANDHURST ROAD, LONDON, NW9
Tel: 01-204 4333

INPUT GATE

LETTERS FROM OUR READERS

ELECTRONIC IGNITION (ETI APRIL 1975)

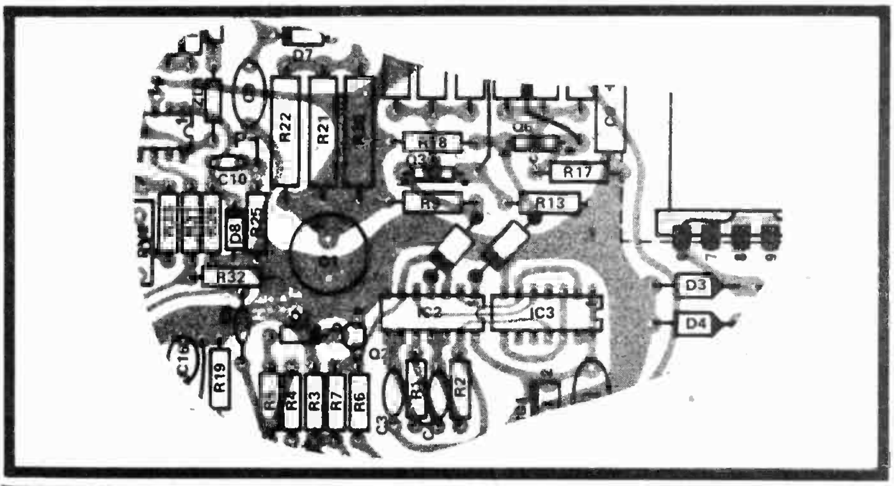
I built the ETI electronic ignition according to your articles in April and May this year and found that IC2/3 and IC2/4 (Nand Gates of the 7402) packed up after a short while. Can you offer any help?

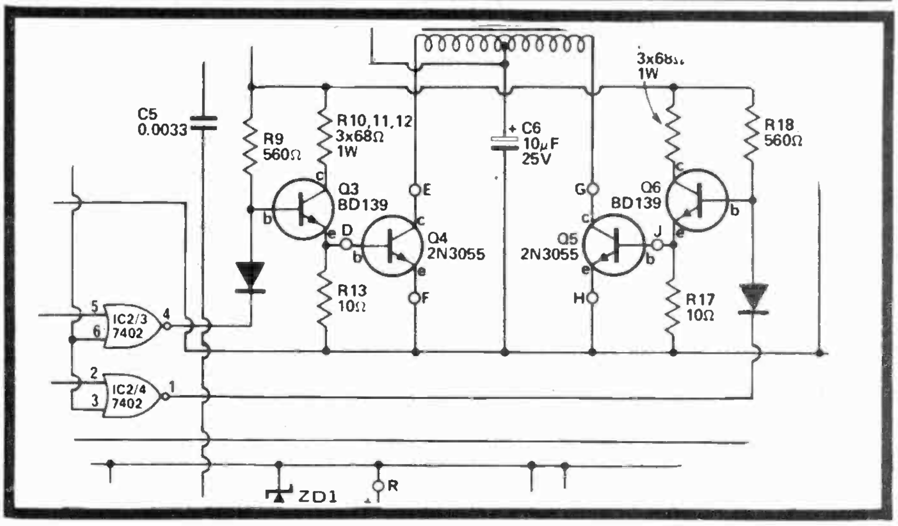
Also could you tell me if the waveform on the outputs of these two gates should be symmetical.

— H. F. Slough

The failure of the 7402 may be due to the loading (in the 1 state), l y transistors Q3 and Q6. This can be cured by adding two diodes in series with output of IC2/3 and IC2/4 as shown in the diagram. These diodes should be 1N4005 or germanium transistors used as diodes (bases and collectors joined). The use of silicon diodes increases slightly (about 150mA) the input current, due to not turnings off the output transistor as hard. Germanium transistors do not alter it. Germanium diodes have too high a voltage drop at the 20mA required. Adding these diodes reduced the current of the 7402 from 30mA to 19mA (our prototype).

The waveform on the output of IC2/3 and IC2/4 should be symmerical except that it is being gated on and off due to the regulation.





TEXAS REPLIES

May I comment briefly on the 'Electronics Tomorrow' column in your August issue. Your author suggests that it is Texas Instruments' policy to 'sell the ideas, get the orders and then think about designing the product'. Specific reference was made to the TMS 3952 clock IC and passing reference to the TIFAX Decoder system.

The TMS 3952 was, in fact, never released and has still not been. As your author says, "TI have never made a noise about it' so we cannot really be accused of selling the idea too aggressively. With any CI product it is necessary to make pre-production samples for evaluation and it is inevitable that these sometimes get into the hands of those who are not quite as discreet about them as we ourselves try to be.

Turning to the TIFAX Decoder system, your very comprehensive article (in the July issue) on Teletext referred to our press conference on 6th May in which we stated our positive commitment to designing and producing a set of LSI devices dedicated to Teletext decoding-well in advance of getting any orders! Since then we have adhered to our commitment and we shall shortly begin to sample, to manufacturers, the first part of the system which is a very fast, high capacity, character-generating ROM.

In the final analysis, of course, it is essential to get the orders. The life of any product must depend on this as does the profitability and, indeed, the life of the company which makes the product.

— Richard B. Mann, Market Communications Manager, Texas Instruments Ltd, Manton Lane, Beds.

CALLING ALL SWIMMING POOL OWNERS

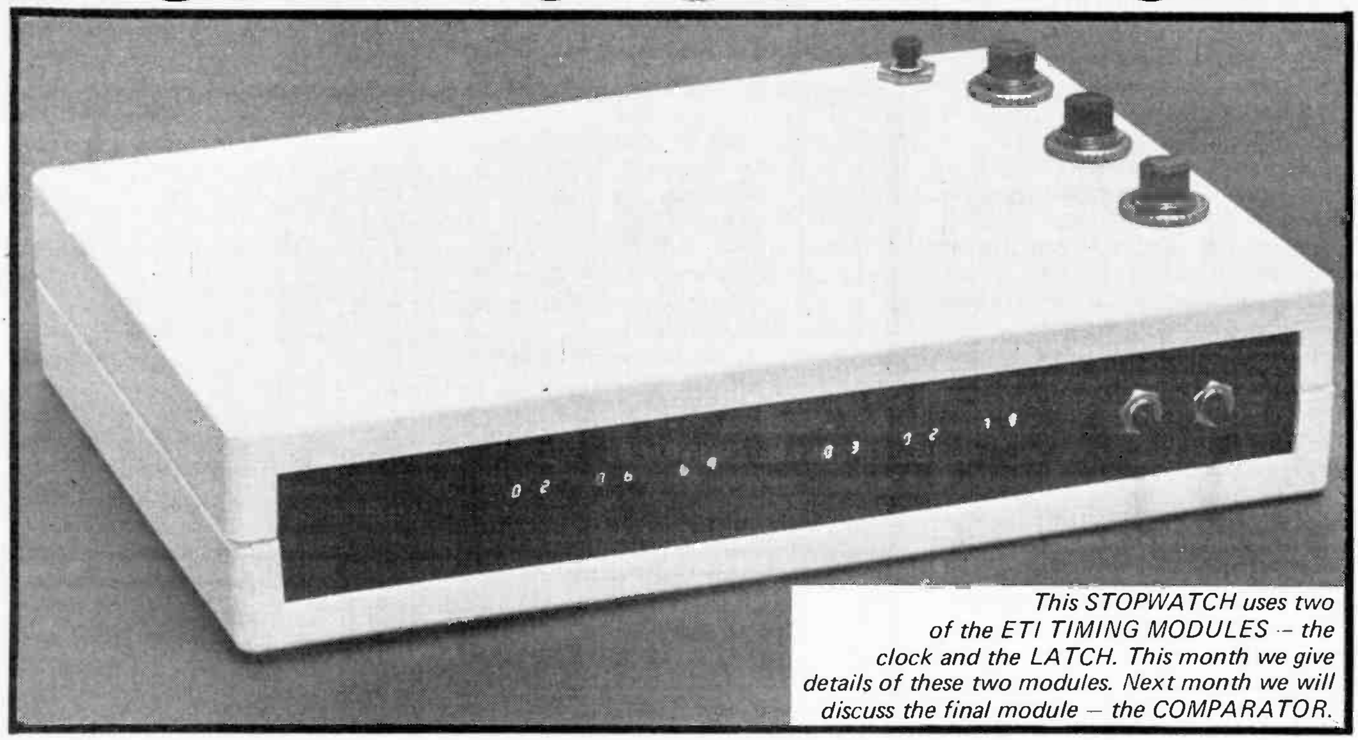
My Son-in-law wrote to me from the States saying that over there they use automatic, mains operated plants that produce chlorine and all that they add is common salt. The unit has a power pack giving 7.5V D.C. and all the operator does is to see that if the ammeter drops back in reading, and then he simply adds salt. He could not find out what is used for the electrodes and where such materials can be obtained, and this is what I want to know so that I can experiment to produce an automatic unit for myself.

Possibly some of your readers will have the answers?

— T.P.S. Dixon, Yellowell House, Horley, Banbury, Oxon.

Use ETI TIMING MODULES to build this

DIGITAL STOPWATCH



This STOPWATCH uses two of the ETI TIMING MODULES – the clock and the LATCH. This month we give details of these two modules. Next month we will discuss the final module – the COMPARATOR.

CLOCK MODULE ETI 551

The main module is a nine digit crystal-controlled clock with an easily varied counting format — it can count in "hrs hrs, mins mins secs secs, 1/10th, 1/100ths, 1/1000ths," or in 000,000.000 secs, or, with slight modifications, in some other formats such as hours, minutes and fractions of minutes, or in 00.0000000 hrs.

LATCH MODULE ETI 552

The second module of which any number may be added to one basic clock module, is a nine digit latch which can either contain the same data as the clock module, or can store the number in the latter when a switch is pressed or a control pulse received. This enables one to 'freeze' the time in the clock module without interrupting counting — a stopwatch 'split' facility.

COMPARATOR MODULE ETI 553

The third module can give out a pulse, set a Flip-Flop or reset the clock module to zero. Any number of these modules may be connected to one basic clock module. One comparator could be used to sound an alarm after a preset time, or several could be connected together to switch a video tape recorder on and off at preset times, or to control some machine or an industrial process. (This will be described next month.

WHAT IF NINE DIGITS IS TOO MANY?

Although the counter, latches and comparators can all accommodate nine digits, those who only need to 'see' a few digits should not be put off. Because of the elegance of the SR (shift register) counting system used a nine digit counter requires nearly the same number of components as a six digit counter. In fact, on the PCB layouts we have only provided sufficient components to drive 6-digit displays. Those who require more will have to use a few additional components.

The 6 digits to be displayed can be chosen from any of the 9 digits: laboratory timers usually display minutes down to milliseconds; stop-watches can display hours to tenths of seconds, or tens of minutes to hundredths of seconds, whilst owners of video and other tape recorders could choose tens of hours to seconds. As yet we know no perfectionist who wants tens of hours to milliseconds!

COUNTING WITH A SHIFT REGISTER

The conventional design for a multi-digit counter used to be a chain of BCD counters, and a large arrangement of switches which sequentially feed the data from each stage of the counter to a single 'multiplexed' BCD output, suitable for driving the displays. This is the system found in most clock ICs, in some watch ICs and in nearly all circuits for clocks which used TTL.

However, as first realised three years ago, it is more efficient to make multi-digit counters by storing a number in a shift register and 'circulating' it through a binary adder adding one to a digit or setting it to zero at the required times. This system is found in most timing ICs designed in the last few years (e.g. the Mostek MK5030).

Figure 1 shows a block diagram of an SR counting system. The main advantages of the system are that as the data is handled sequentially (digit by digit) it is already in a format suitable for interfacing to multiplexed displays, and that increasing the size of the counter only requires increasing the shift register capacity and slightly modifying the control circuitry.

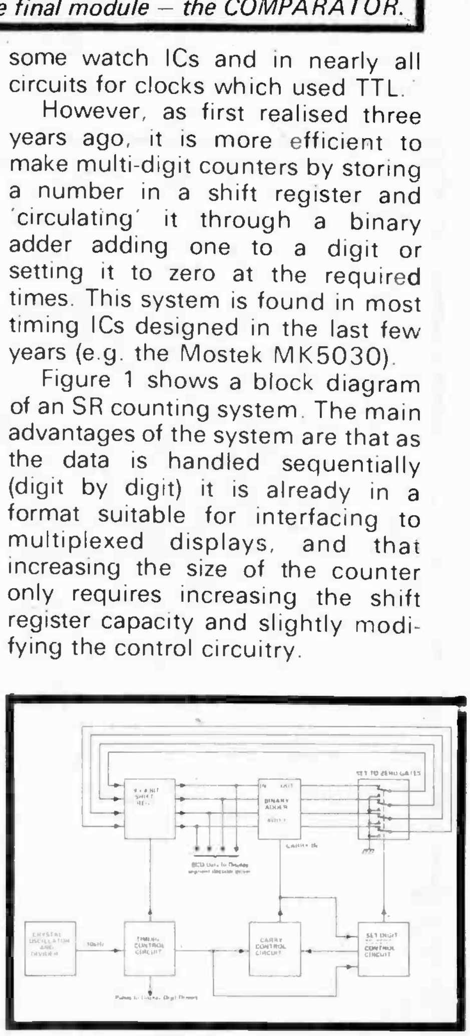


Fig. 1. An SR counter.

THE CLOCK MODULE

Figure 2 is identical to Fig 1 but the circuit blocks are filled in with actual components. For simplicity we will first discuss a clock using the "hrs hrs, mins mins, secs secs, 1/10th, 1/100th, 1/1000ths" format. This project does not have a separate "How it works" section; rather this is explained as we cover the various design options. The number in the counter is stored in a 9 x 4 bit shift register (4006 (1) and (2)). The output of the SR is returned to its input via a 2 digit and carry, 4 bit, binary adder (4008 (1)), and a set of 4 AND gates (4081 (1)). In one pass around the loop any digit may be left unchanged, incremented by one, or reset to zero. All that needs changing is the carry input to the adder and the common control to the 4 AND gates.

A 10kHz signal goes to the clock input of a 4017 decade counter and the 4017 produces 10 consecutive output pulses on its 10 output pins, Q0 to Q9, such that only one output is 'high' at any one time. One in ten of the 10kHz pulses which clock the 4017 is blanked by the Q9 output using a two input NOR gate (¼ of 4001 (1)). This signal is used to clock the shift register.

Thus in one millisecond the number in the SR is circulated once, and the 4017 goes through a complete cycle. The clock polarities are such that the SR is clocked (that is, new data is latched into its first stage, and new data appears at its output) at the same instant as a change occurs in the 4017 outputs.

The data present at SR outputs during the time in which Q0 is high is defined as the value of the least significant digit, called D0, that present while Q1 is high defines the value of D1, and so on. Q0 to Q8 can be used to drive display "digit drivers", and the SR outputs drive the display segments via a 4511 BCD-to-seven-segment decoder-driver.

"SET DIGIT TO ZERO"

A digit is recirculated unchanged until there is a 'carry' from the previous (less significant) digit. At this point it is incremented by '1' by the adder, and the new value recirculated. If however the digit in

PARTS LIST
CLOCK MODULE ETI551

CAPACITORS
Sixteen 10nF — All ceramic
One each 27pF, 47pF, 68pF
one trimmer 2-22pF
two 100μF 2V electrolytics

RESISTORS
Nine 150Ω — All 1/8th W
Five 120k
One each 560 ohm, 1k, 8.2k, 15k

DIODES
Seven 1N914 1N4001

CMOS
4000 4006 4017 4050 4511
4001 4008 4020 4081 75492
4006 4008 4027 4081
BC184 transistor
2N3704 "
5.12MHz crystal
ETI551 pcb
Seven 16 pin DIL sockets
Ten 14 pin DIL sockets*
(One 24 pin LSI socket)*
Two soldercon pins for Xtal socket
DIL Pin Header

DISPLAY MODULE ETI551D
Three DL33 3-Digit packs
One ETI551D pcb
6" 14 way flat cable
(14 pin DIL plug)*

LATCH MODULE ETI552
RESISTORS
Eight 150Ω Five 120k
CAPACITORS
Eight 10nF
DIODES
Four diodes (1N914)
CMOS 4006 4019 4050 75492
4006 4011 4027 4511
2N3704 transistor
ETI552 pcb
Five 16 pin DIL sockets
Five 14 pin DIL sockets*
(One 24 pin LSI socket)*
DIL Pin Header

DIGITAL STOPWATCH
One ETI551 One ETI552 Two ETI551D
One connector (6" of 24 way flat cable; with optional LSI plugs)*
Two miniature toggle switches
Three microswitches
One push-to-make switch
Battery connector
3 PCB mounting pillars
193x29x2.5mm red perspex
Verocase 751410J

* A couple of pounds can be saved if the connections are soldered in rather than using plugs and sockets.

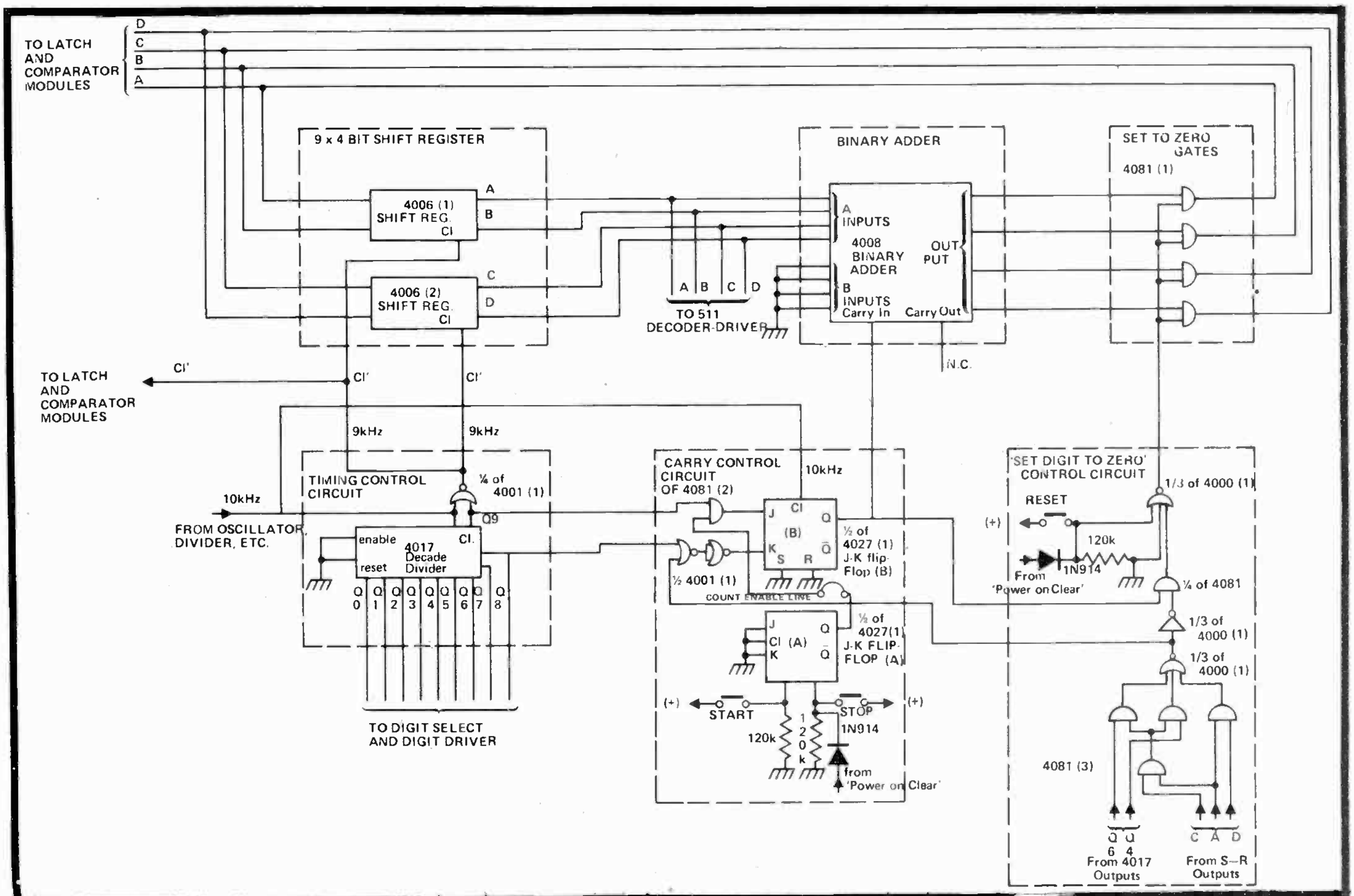
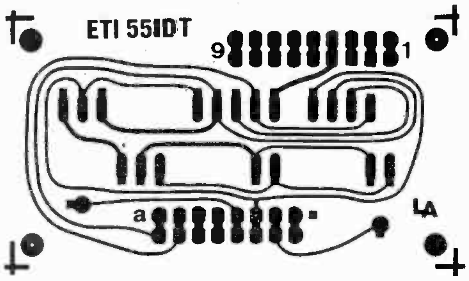


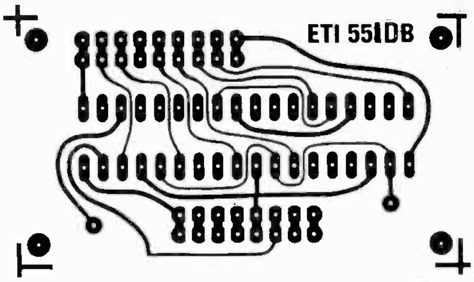
Fig. 2. Circuit diagram of the clock. Figs. 3,4,5,6 and 7 show other circuitry on the clock board.

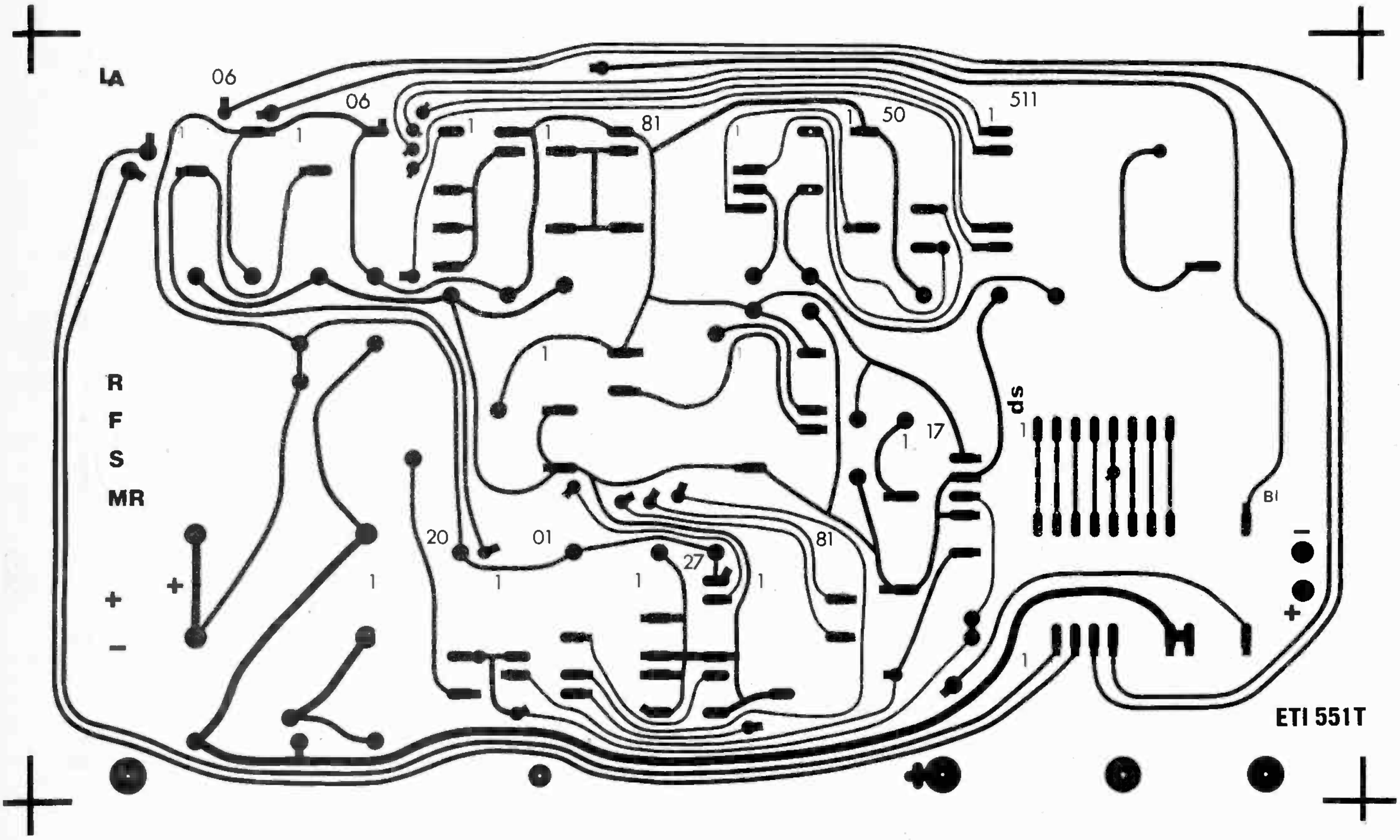
ETI TIMING MODULES

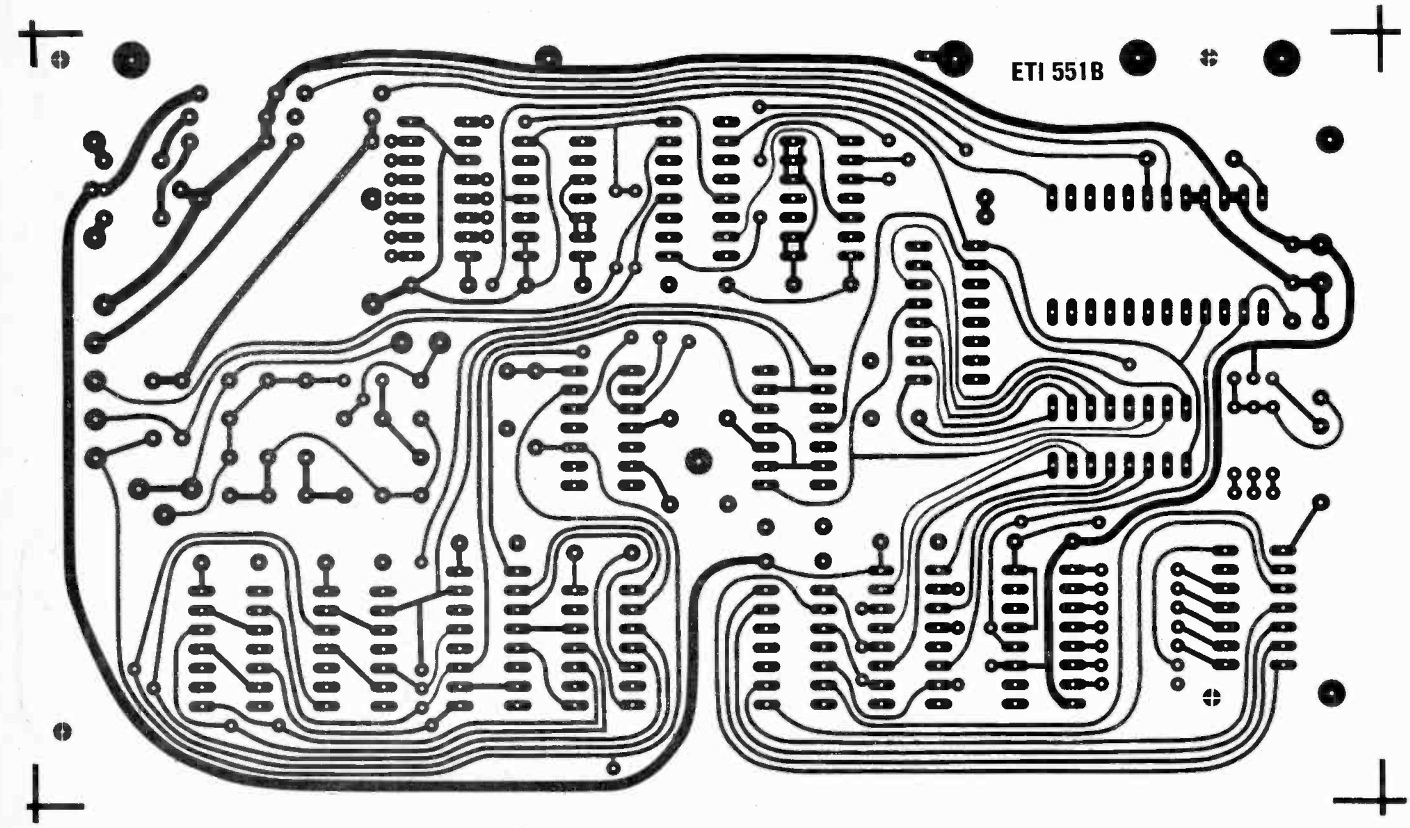
DIGITAL STOPWATCH

Main text continues on page 24









NOTE: Double sided PCBs are used in these projects. The suffix T refers to the top (component side) and B to the bottom.

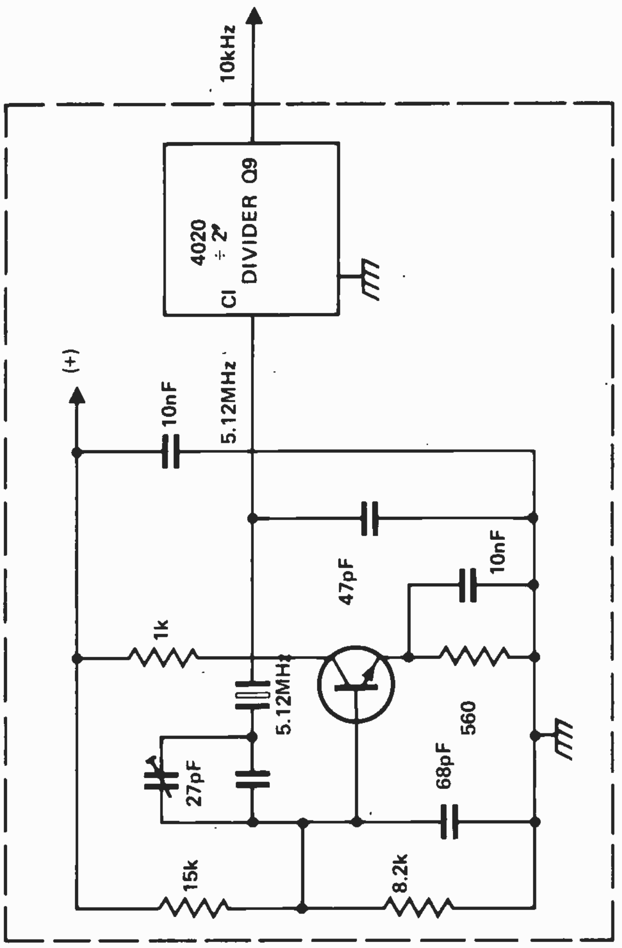


Fig. 3. Crystal oscillator and divider.

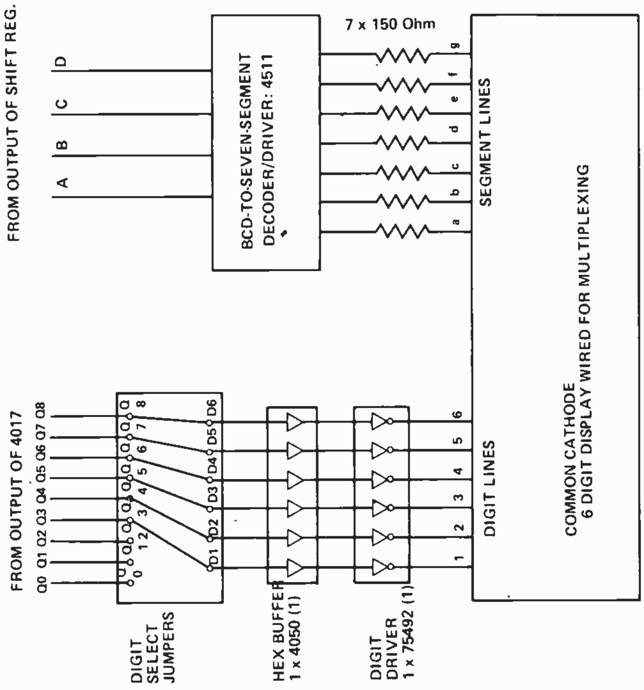
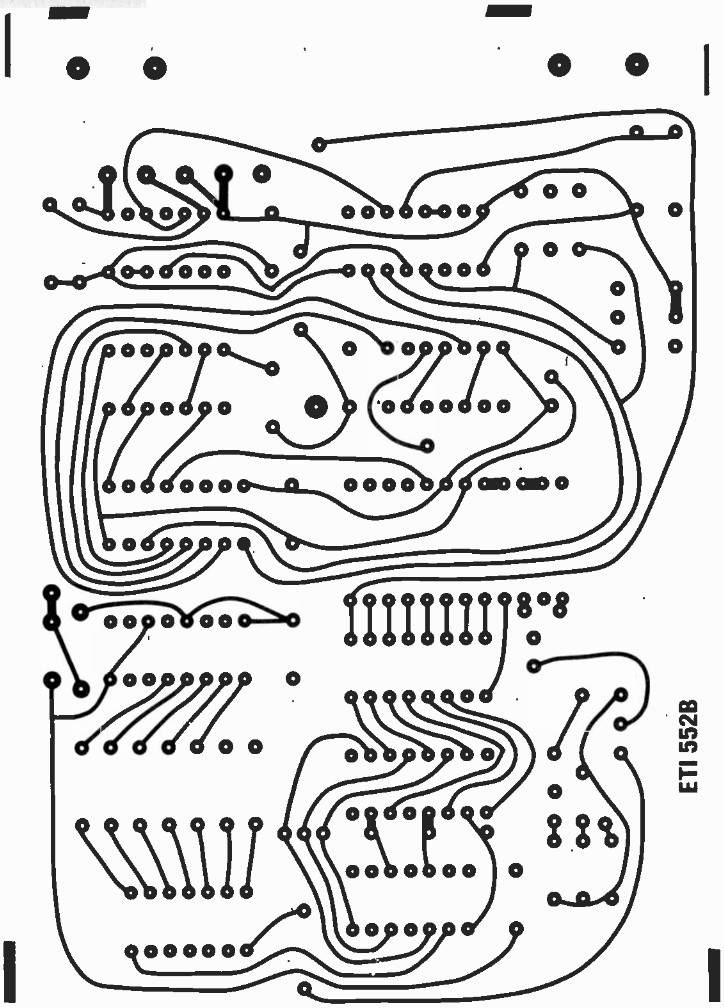
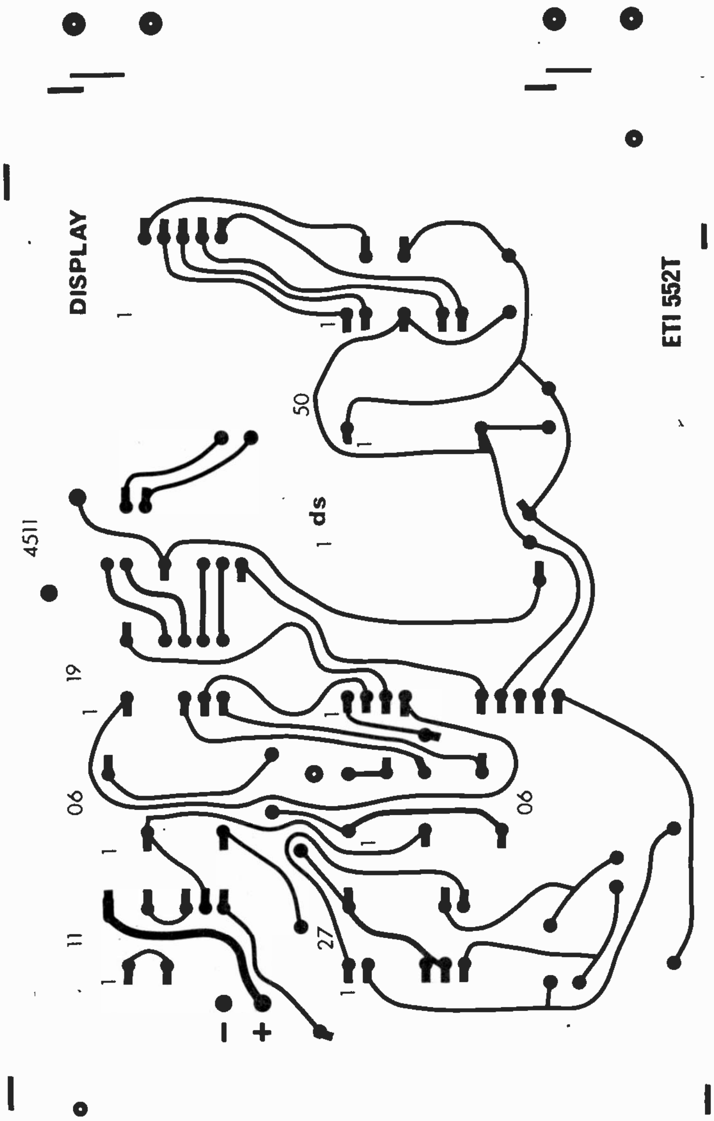


Fig. 4. Display Driving Circuitry.





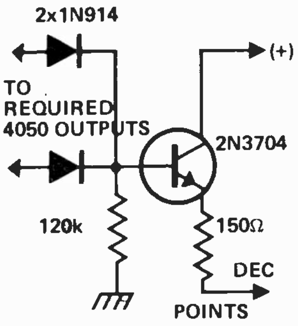


Fig. 5. Decimal Point Driver.

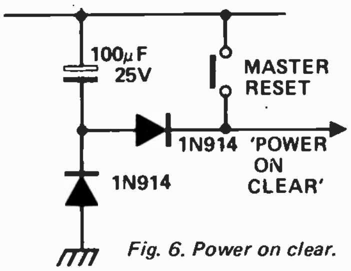


Fig. 6. Power on clear.

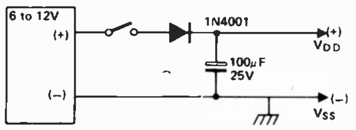


Fig. 7. Battery Power Supply.

DIGITAL STOPWATCH

question had already reached its maximum value ('5' for the tens mins and tens secs digits, '9' for all the others), instead of the value being incremented, it should go to zero, and a carry be transmitted to the next digit. This "Set to Zero" signal is derived from various gates as shown. In addition, pushing the Reset button for more than one millisecond sets all digits to zero.

"CARRY"

Before describing this part of the circuit it is worth looking at the operation of the 4027 J-K Flip-Flop. The J and K inputs are used to set (logical '1') or clear (logical '0') the Q output as follows:

If Q is '0', and J is '1', Q will go to '1' a few nanoseconds after the clock input goes from '0' to '1'. This occurs whether the K input is '1' or '0'.

If Q is '1', and K is '1', Q will go to '0' just after the clock input goes from '0' to '1' (irrespective of the state of the J input.) This a '1' on the J input will set the Q output on the positive edge of the clock pulse; a '1' on K will similarly clear it. If J and K are both '1', Q will toggle between '1' and '0', changing at every positive transition of the clock pulse. Q can be independently set or cleared by a '1' on the set or reset inputs.

The Q output of Flip-Flop A (½ of 4027 (1)) is set to '1' by pressing the Start button. This '1' is then used to set the Q output of Flip-Flop B (½ of 4027 (2)) to '1' at the start of Q0 time (the period during which Q0 of the 4017 is high). This Q output is the 'carry' signal, and when D0 (the digit whose value is present at the SR outputs during Q0 time) is clocked back into the SR at the end of Q0, it is incremented by 1 once every loop of the SR, i.e. once every milisecond.

Until D0 has reached its maximum value, D1 must not be incremented, and the carry must be 0, every time D1 is clocked back into the SR (at the end of Q0 time.) The condition that D0 is not at its maximum value is indicated by a '1' on the MAX output of the "Set to Zero" circuit, which goes to the K input of Flip-Flop B and cancels the carry at the beginning of Q1 time. If D0 has reached its maximum value, then MAX is low during Q0 time, the carry is not cancelled and increments D1 at the end of Q1 time.

If both D0 and D1 have their maximum values, the carry will propagate to Q2 time, etc. Thus if the counter is counting, the carry is set during Q0 time, and propagates 'down' the number until cancelled. It is also cancelled by Q8 at the beginning of Q9 time so that the counter behaves itself if it overflows.

10 kHz SOURCE

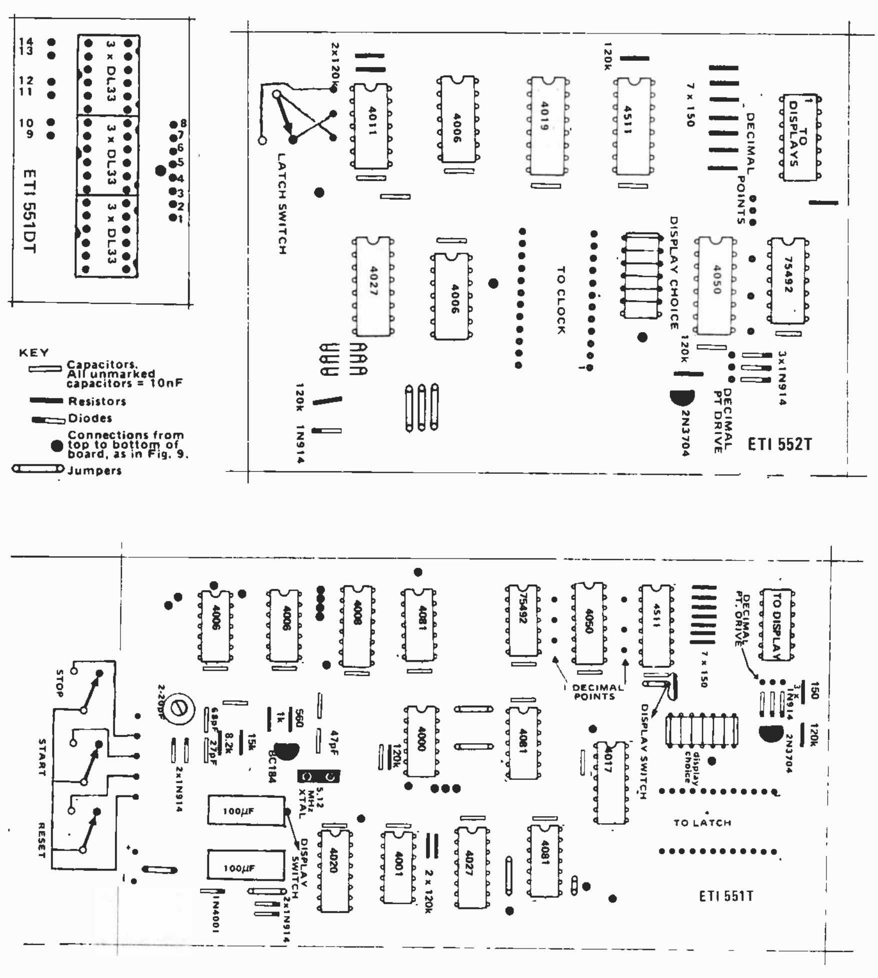
The 10 kHz signal is obtained by dividing the output of a 5.12 MHz crystal oscillator by 512 (2^9) using the first nine stages of a 4020 14 stage binary counter (see Fig 3.) The disadvantage of using a crystal of this frequency is that a transistor oscillator has to be used rather than a CMOS inverter oscillator (which doesn't have enough gain at this frequency to sustain oscillation). The advantages are that crystals over 5 MHz are cheaper, inherently more stable, and physically smaller than lower frequency crystals.

DISPLAY DRIVING

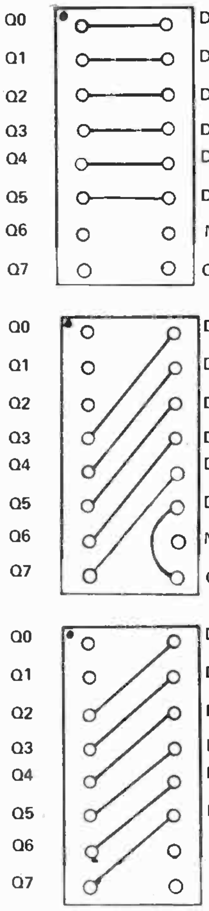
The digit and segment driving circuits are straightforward (Fig. 4). The SR outputs are fed to a 4511 BCD-to-seven-segment decoder-driver, which drives the display segment lines through current-limiting resistors. The maximum recommended continuous output current per segment on the 4511 is 25 mA, and with a 8V supply (typical output voltage of a 9V battery) the resistor value required is 150 Ohm.

The digit driver as shown will drive 6 digits. The digits required are selected by wiring jumpers between six of the nine Q0 to Q8 outputs and the six 4050 hex buffer inputs. For convenience on the PCBs these connections have been laid out in a standard DIL format so that the jumpers can be wired onto a pin-header and the required selection 'plugged in'. Q0 corresponds to the least significant digit, i.e. milliseconds, and Q8 to the most significant, i.e. tens of hours.

The component layouts for the clock, latch and display boards.



Here are three examples:



(a) is wired to display
mins D5
secs D4
secs D3
1/10 D2
1/100 D1
1/1000D0

(b) is wired to display
hrs D5
hrs D4
mins D3
mins D2
secs D1
secs D0

(c) is wired to display
hrs D5
mins D4
mins D3
secs D2
secs D1
1/10 D0

The 4050 buffers are needed to drive the 75492 hex digit driver. The latter contains six Darlington Pair NPN transistors with the required resistors and can supply digit currents up to 250mA per digit.

Decimal points may be lit if required by wiring jumpers from the required 4050 buffer output to the decimal point driving circuit (Fig. 5). Thus decimal points are wanted after hrs and mins on a display (hrs hrs . mins mins . secs secs) for right-hand decimal point digits, the Q5 and Q7 time dec pts have to be lit, and jumpers are connected from the outputs of the 4050 buffers corresponding to Q5 and Q7 (D2 and D4) to two of the diodes in the dec pt driving circuit.

DISPLAYS

The driving circuitry will drive any common cathode LED displays, such as the DL33MMB (0.08in), DL704 or DL704E (0.3in) and FND500 or DL750 (0.5in and 0.6in).

POWER ON CLEAR

A simple circuit is provided which sets the counter to '0' and puts it into the stop mode when power is turned on (Fig. 6).

THE LATCH MODULE

The essence of the latch module is that it contains a shift register and display driving circuitry identical to that of the clock module. There is also switching circuitry to enter into the latch SRs the same data as is entered into the clock SRs, or to circulate the data unchanged. Finally there is circuitry to time the change between these two states. The data routing is accomplished by a 4019 Quad AND-OR gate which is basically a 4 pole 2-way switch which routes data from the inputs of the clock SR to the inputs of the latch SR when KA is '1' and KB is '0'. It connects the latch SR input to its output when KA is '0' and KB is '1'.

The 4027 J-K Flip-Flops time the changeover of the 4019 switch. These Flip-Flops can be wired in two modes. In the 'hold-transparent' mode the latch starts 'transparent' (the data it contains follows the contents of the clock module). When the latch push-button is pressed the latch stays transparent until the beginning of the next word (until the next Q0 time occurs) and then the 4019 switches over and the number in the SR is circulated

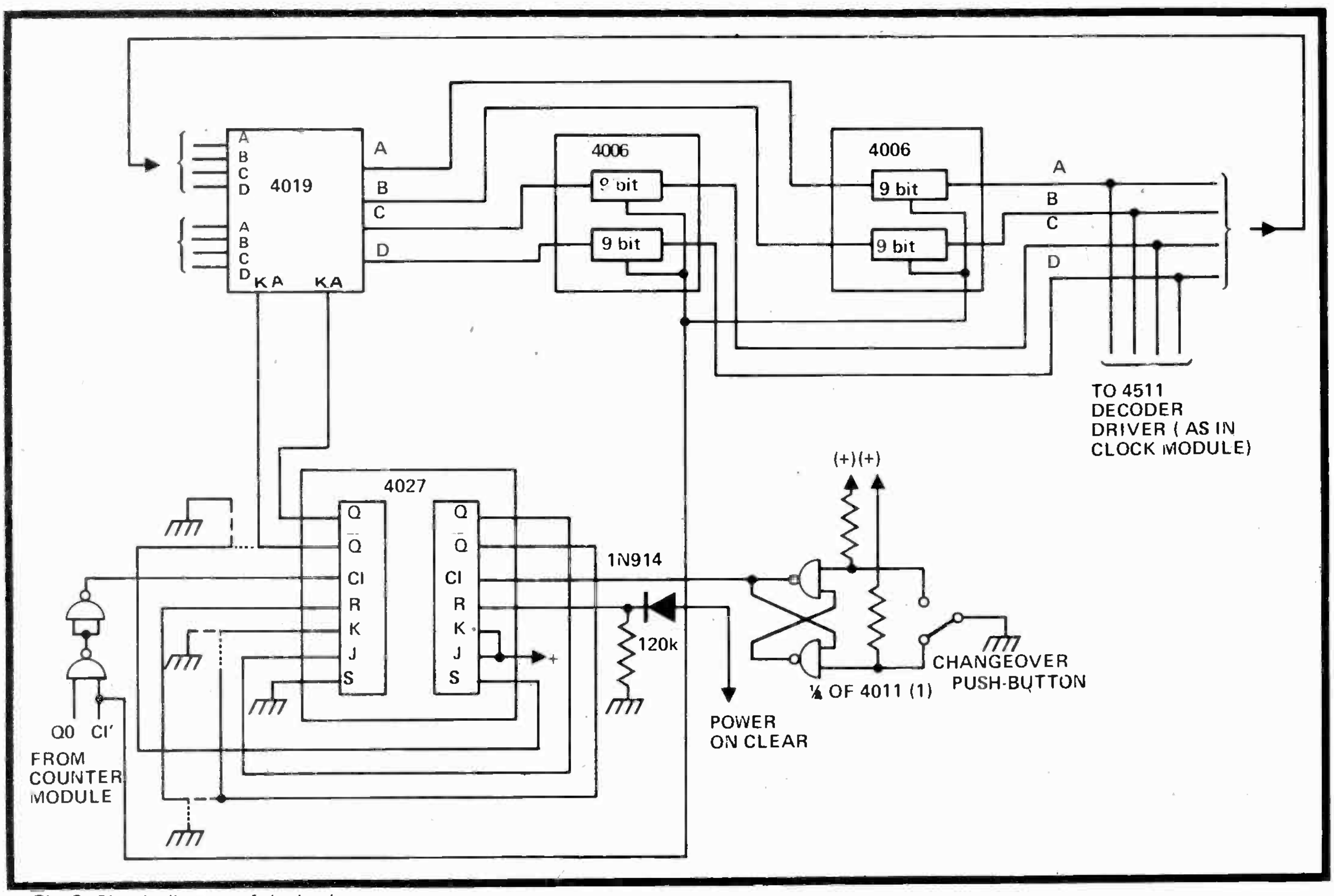


Fig. 8. Circuit diagram of the latch.

DIGITAL STOPWATCH

and displayed: the latch 'holds' the time at which the button was pressed, accurate to within +1msec. Further pressing of the latch button causes the module to alternate between the 'transparent' and 'hold' states.

Wiring the J-K Flip-Flops the second way makes it operate in the 'hold-hold' mode. In this mode the latch starts off 'holding' its contents. If the latch button is pressed, in the middle of the next Q0 time the 4019 is switched to loading new data into the SR. In the middle of the following Q0 time the 4019 switches back to recirculating and holding the data. Thus in this mode the display always appears 'frozen', but each time the latch button is pressed the contents of the latch are 'updated' to show the number in the clock module at that moment. This mode is expected to be found most useful in applications where the latch is controlled by an external source. In either mode the "Power On Clear" circuit is connected so that when power is switched on, or when the Master Reset button is pressed, the latch is loaded with zero, and in the first mode it is set to its 'transparent' state. In both modes, two NAND gates (½ of 4011 (1)) eliminate any effect of contact bounce in the push-button switch.

Selection of one mode or the other is governed by wiring up three jumpers or switches. On the PCB there are holes for three horizontal jumpers and three vertical jumpers. If the horizontal ones are connected (indicated by faint dotted lines in Fig. 8) the latch will operate in the hold-hold mode. If the vertical ones are connected (indicated by bold dashed lines in Fig. 8) it will operate in the hold-transparent mode. The display selection and driving circuitry used in the latch modules are identical to those used in the counter module.

Some users may find it best to attach a display to only the latch module, thus saving cost while still obtaining a Stop-watch 'split' action. As mentioned earlier, any number of latch modules may be connected to one clock module. The outputs from the clock module are simply attached to several modules instead of just one.

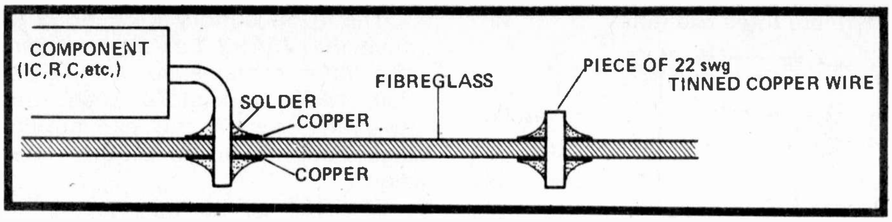


Fig. 9. How to make connections through the board.

CONSTRUCTION

The modules are best assembled on double-sided PCB's as shown, due to the circuit complexity. Connections between copper on the top and bottom of the boards are made using component leads where possible. Otherwise small pieces of tinned copper wire are used (see fig 9 above).

The recommended method of mounting the CMOS IC's is to use Soldercon pin sockets which can be soldered to both sides of the board (and are inexpensive). The ICs may be soldered in but this makes fault-finding very difficult. On the component side of the board, care must be taken only to apply solder to the flat side of the Soldercon Pins.

Connections between modules are made very simple, and easy to check, using flat cable and 24 pin plugs and sockets (using 24-way pin-headers and Soldercon pins in a 24-pin DIL layout). Connections between modules and display PCBs are also made using flat cable and 14-way DIL pin-headers and IC pin sockets.

The PCB's were designed so that one clock module, one latch module and either two DL33 6 digit displays or one DL704 or FND500 8 digit display, with batteries, switches, etc, would all fit into the smallest of the new Vero plastic cases, using a transparent red perspex front window in the space normally occupied by an aluminium panel. If greater complexity is required, one of the larger boxes in the same range may be used.

EXTRAS

A stop-watch which gives time to millisecs is great but the average human finger can't do much better than 1/20th of a second. We expect some constructors will need to actuate their modules using electronic, rather than mechanical, pulses.

ELECTRONIC START-STOP

Electronic starting and stopping can

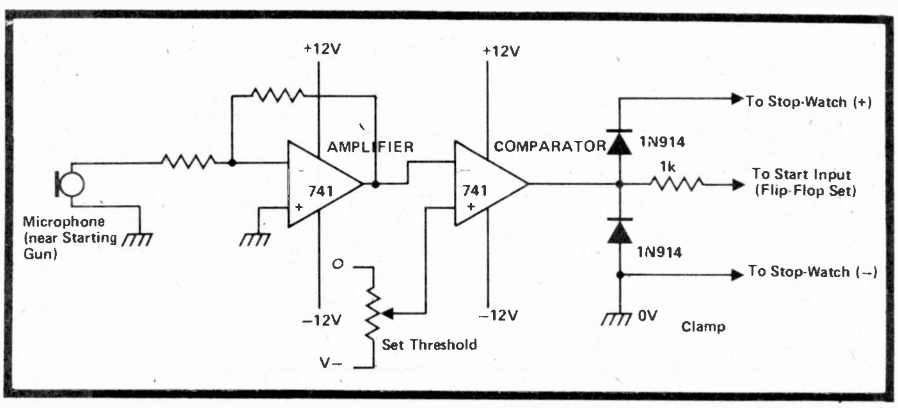
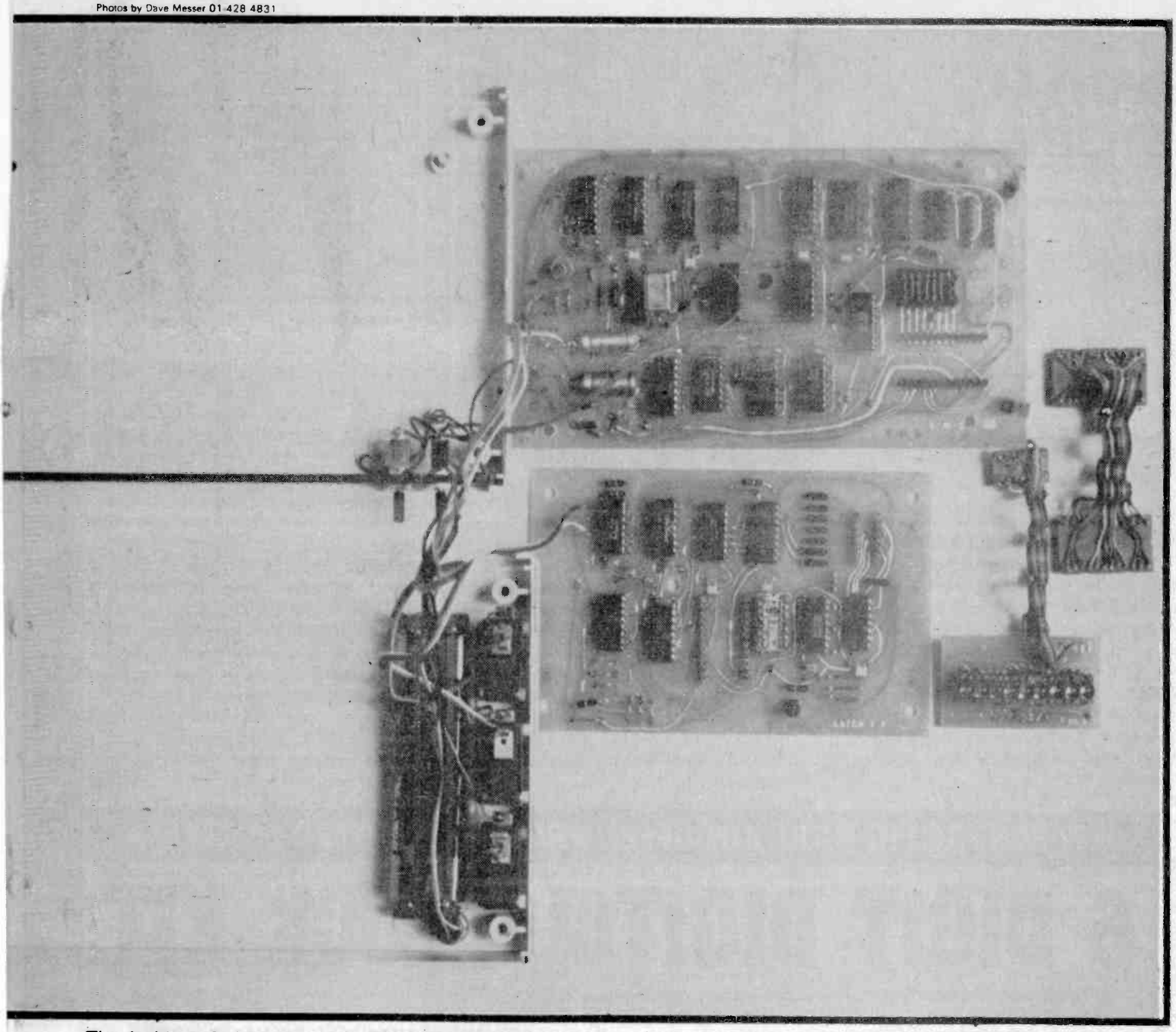


Fig. 10. A simple circuit for using the sound of a starting gun to start the Stopwatch.

Photos by Dave Messer 01-428 4831



The insides of the stopwatch. The clock board is at the top, the latch beneath. Here we show one display, but a second display module will plug in directly. A small saving can be made by soldering the flat cable directly onto the boards rather than using the LSI plugs as shown.

be achieved by feeding positive going pulses to the set and reset inputs of the clock module 4027 A Flip-Flop. These pulses do not have to be 'clean' but it should be noted that the state of this Flip-Flop is not determined if both these inputs are high simultaneously.

Obvious electronic timing systems would be ones where the start time is derived from a signal driving a solenoid operated starting gun, or from sound pulses. Below is a simple circuit of a suggested sound operated start system (see fig 10).

A simplified suggested light operated start or stop is as shown in fig 11.

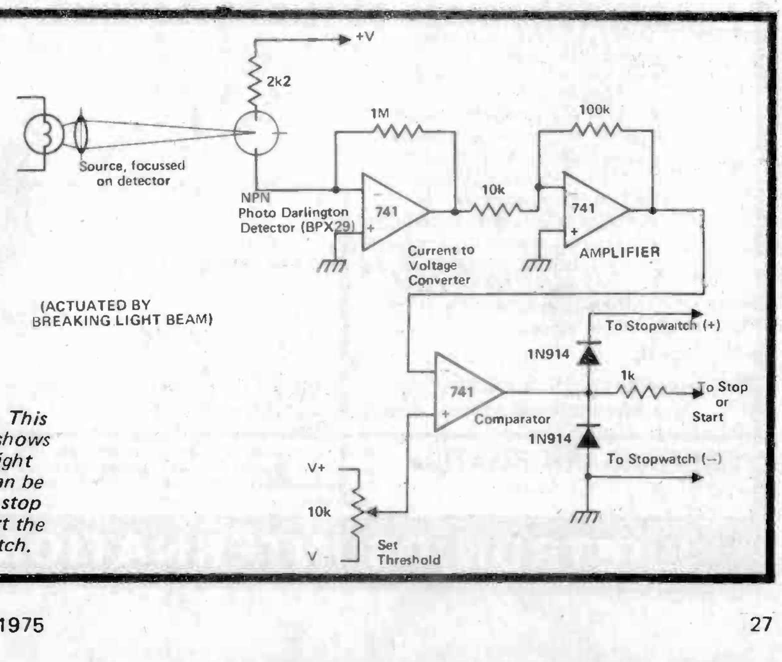


Fig. 11. This circuit shows how a light beam can be used to stop and start the Stopwatch.

DIGITAL STOPWATCH

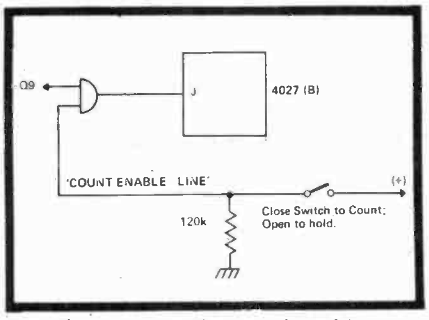


Fig. 12.Controlling the counting with a toggle switch.

COUNTING CONTROLLED BY TOGGLE SWITCH OR CONTINUOUS SIGNALS

If the count enable line (normally driven by the Q output of the 4027 A Flip-Flop, on the clock module) is high the module will count, if it is low it will hold its value. Thus the counting can be controlled by driving this line from an external signal instead of from the flip flop output. For example the counting can be controlled by a toggle switch:

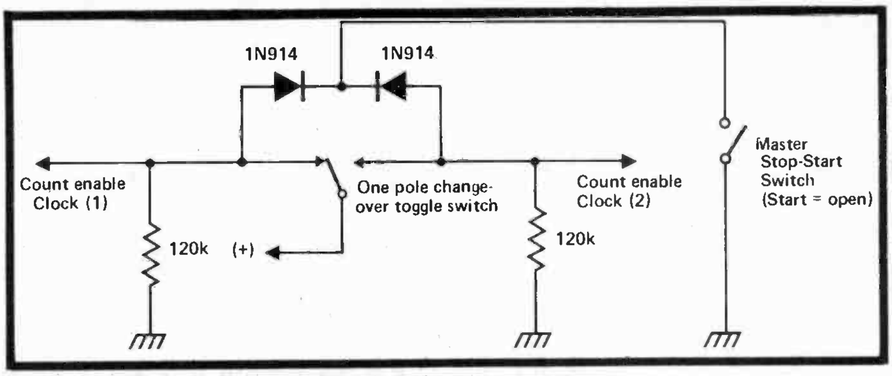


Fig. 13. Two clock modules can be wired up to give a chess clock.

CHESS CLOCK

To build up a system which compares the accumulated time spent in each of two states, such as a chess clock; one could use two clock modules with their count enable lines connected like this:

They should also have their reset lines connected together. When using more than one clock module in one system, such as this chess clock, considerable savings can be made by constructing the crystal oscillator and 4020 divider on only one of the modules, and taking the 10KHz signal from this to the other boards.

ENDLESS POSSIBILITIES

Virtually any timing necessity can be satisfied using a system made up from the ETI TIMING MODULES. In our clock we used two displays — but we could have used just one display show the contents of the latch). We could have made a more complicated Stopwatch by adding more and more latches. With ten latches and ten switches you could give individual times to the first ten runners, swimmers, racing cars ......

The possibilities mushroom when you consider the comparator module as part of a system. A clock becomes an alarm clock or timer. If you use the output to reset the clock you have a programmable pulse generator with a period ranging from milliseconds to tens of hours. ●

ETI REVIEW

THIS NEW 'SCOPE is likely to replace the IO-102 as Heathkit's most popular scope. The IO-4540 is long and low and looks really up-to-date with its flashy blue and white front panel and bigger screen. The case is big — 8 inches high, 13 wide and 17 deep — but it is easy to stack equipment on top (the handle is recess-mounted).

The IO-4540 really is a new scope—our model was one of the first in the country. In fact it was only a week before we had to send this article to the printers when we received the big box from Heathkit! Consequently we have not given the scope much of a trial, but as far as we can see the spec given is accurate.

The scope offers a bandwidth of 6MHz with a sensitivity of 20mV/cm. The FET front end gives an input impedance of 1mΩ with low capacitance (38pF). The attenuator provides sensitivities between 20mV and 10V/cm in nine ranges (1-2-5 steps).

A front panel control gives variable attenuation between calibrated points. Up to 400V dc can be handled. The risetime and overshoot are quite good for a 'scope in this bracket.

Horizontal sensitivity is 0.25V/cm and the front panel socket will accept frequencies up to 100kHz; attenuation of x1, x10, and variable is provided.

Seven timebase ranges, calibrated in a 1-2-5 sequence between 200mS/cm and 2μS/cm, can be switched into variable control. The input signal is routed to the trigger circuits direct (for DC), via a capacitor (for AC) or through a low pass filter. This filter enables the scope to trigger on the frame pulses of a complex TV waveform for signal tracing. Trigger level control and a socket for external trigger are also provided on the front panel.

TTL ICs are used in the trigger and sweep circuits; other circuitry is all transistor. Four main boards (see photos on the right) carry 80% of the electronics. These sections are the vertical amplifier, the horizontal amplifier, the trigger and sweep circuits, and the power supply and c.r.t. drive. A tuner section wafer switch and tag strip mounted behind the front panel holds the time base oscillator. The only other components off the PCB's are switches and pots, transformers, one big electrolytic can and the c.r.t.

The power supply section provides stabilised voltages for the sweep and vertical amplifier boards so the instrument remains accurate with changing mains voltages.

10-540 SPECIFICATIONS—

VERTICAL:
Bandwidth: DC to 5 MHz ±3 dB.
Attenuator: 1, 2, 5 sequence, calibrated and variable.
Rise Time: 70 ns.
Overshoot: 5% at 1 kHz.
Impedance: 1M /38 pF.
Sensivity: 20 mV/cm.
SWEEP:
Type: Triggered.
Range: 200 ms — .2μs, 7 steps plus variable.
Trigger Source: Int/Ext/Line.
Trigger Modes: AC/DC/TV; + / — Slope; Auto/Norm.

HORIZONTAL:
Sensitivity: .25 V/cm.
Bandwidth: DC to 100 kHz.
Impedance: 1MΩ/50 pF.
Ext. Horiz. Input: XI and X10 attenuator
GENERAL:
CRT: 5DEP31F, 8 x 10 cm, green, medium - persistence phosphor, 5in round, flat-face tube.
Accelerating Potential: Approx. 1.5 kV.
Graticule: Painted, 8 x 10 cm.
Power Requirements: 110-130 VAC or 220-260 VAC, 50/60 Hz, 35 watts.
Dimensions: 8in H x 13in W x 17in D.
PRICE KIT: £99.90 inc VAT and delivery
ASSEMBLED: £174.96 inc. VAT and delivery.

Full details available upon request from:

Heath (Gloucester) Ltd.,
Bristol Road,
Gloucester GL2 6EE.

or

The London Heathkit Centre,
233 Tottenham Court Road,
London W1P 9AE.

CONSTRUCTION

At the top of the kit package is a 155 page manual to help with building up the kit. The manual tells us not to unpack anything except pack 1, the components for the first board. One by one each of the components has to be located and ticked off individual. Heathkit go carefully at one side of the bench.

Then the "Step-by-Step" assembly begins. Each component is inserted one by one, and again ticked off individually. Heathkit go to great lengths to be unambiguous

HEATHKIT IO-4540 SCOPE

—most parts have *four* references: the part number (e.g. Q103), the device number (EL 131), the Heathkit number (417-241) and a drawing of what it looks like. This method, however, does lead to confusion. The simple steps are made to appear difficult and much time is spent working out the instructions when a look at a good diagram can say everything in one glance.

Heathkit's method means that building up the kit is a little boring and takes twice as long as it would if the instructions were less detailed.

Building the boards took, including time for ticking the manual, about eight hours (including coffees and distractions) but building the chassis and wiring up the controls and boards took over twice as long again!

The only tools needed are a soldering iron, wire cutters, pliers, and screwdrivers. The quality of the components is very high. The only instrument needed for setting up the scope is a high impedance multimeter, but a low capacity probe and signal generator make things easier. The three boards carrying presets are mounted above the chassis with lots of access, and diagrams in the manual explain clearly all steps of calibration. The two transformers are mounted in a cage which can be swivelled to minimise hum on the trace.

IF IT DOESN'T WORK

If the project doesn't work first time there's lots of help in the manual. There are several Trouble Shooting Charts and each board has an "X-Ray View" diagram. The circuit diagram is big (2ft across) and each board has a voltage diagram. Heathkit even tell you how to check the transistors and diodes for faults.

The scope costs £99.90 in kit form.

If you do come to build up an IO-4540 start at the back of the manual and read how it works first. Then you can learn quite a lot by following the circuitry as you build up the scope.

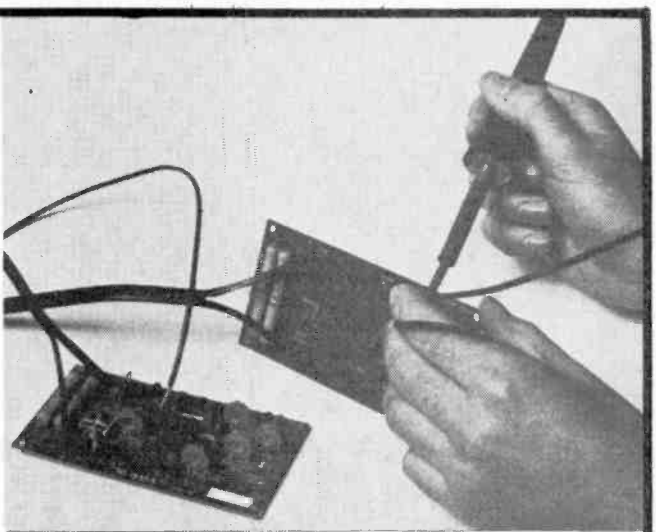


PHOTO 2: The board shown on the left holds all the vertical amplification circuitry. The other board contains the horizontal amplification circuits. This uses a basically similar circuit to that of the first board but it is a little simpler.

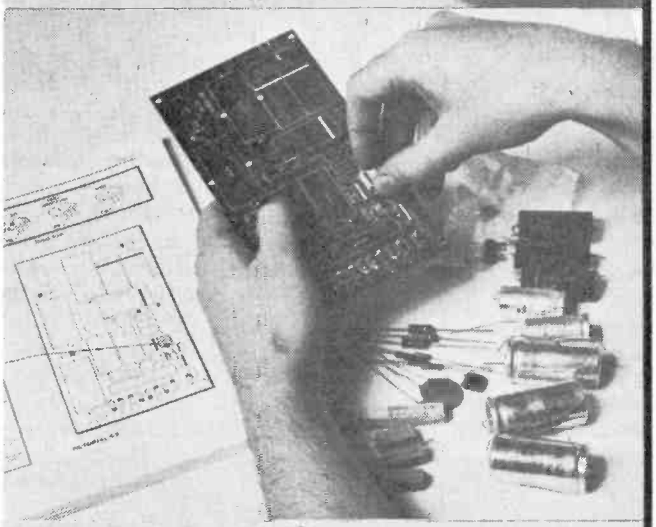


PHOTO 3: The third board carries the trigger and sweep circuits. Despite the complexity of the circuits the board is easily built up using the manual. There are twelve transistors and four ICs (TTL) on this board.

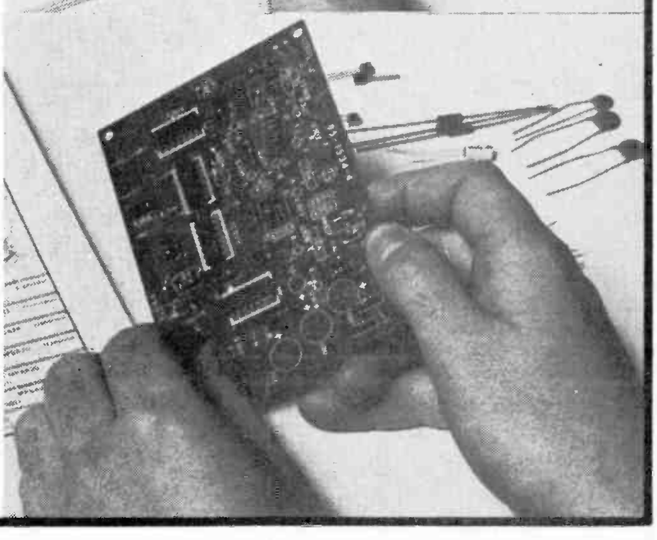
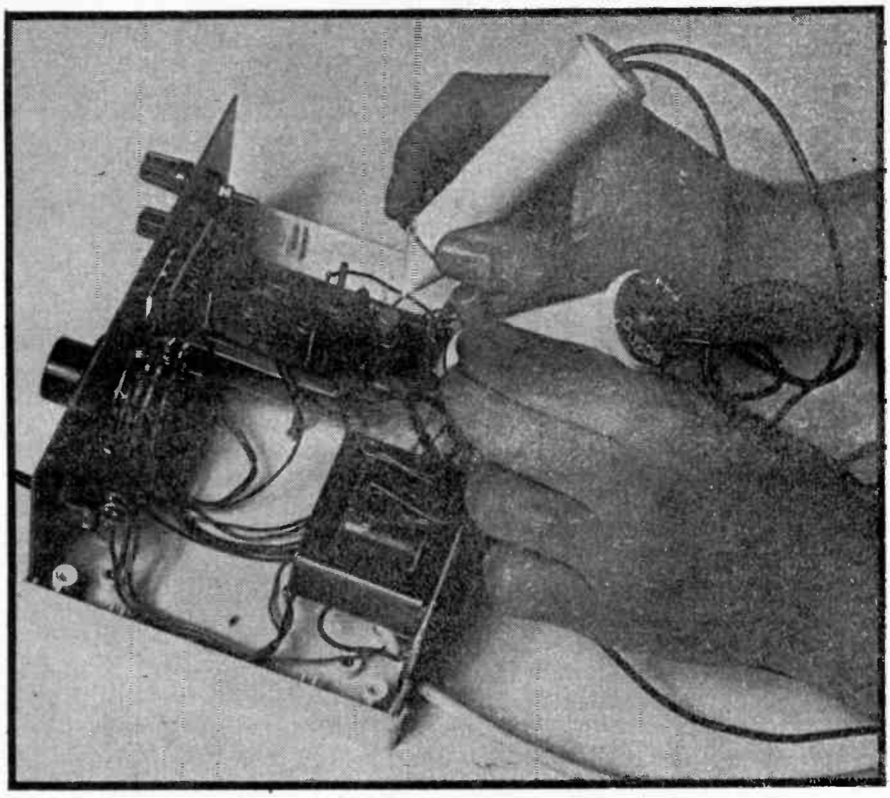


PHOTO 4: The final board carries the small components of the power supply. You can see how each step illustrated in the manual. Most parts have a Heathkit coding stamped on them so that identification is no problem.



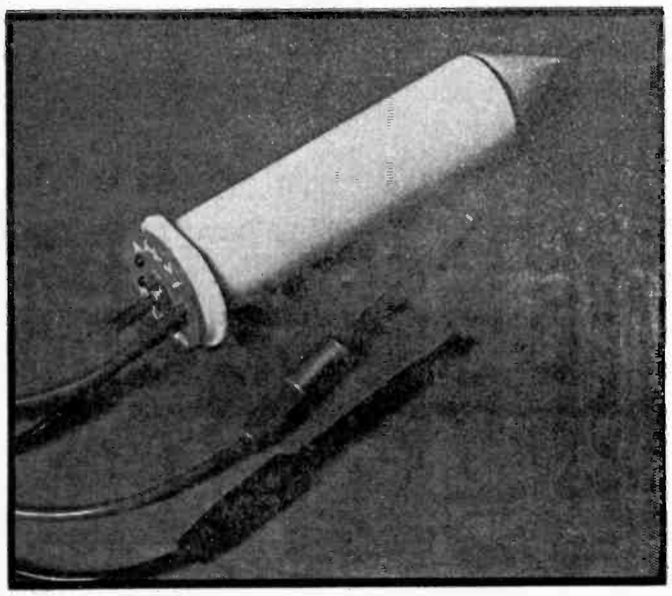
LOGIC PROBE

A basic tool for digital servicing.

THE SERVICING of digital equipment is greatly simplified by the use of a logic pulser and logic probe, for these two instruments enable one to follow circuit operation stage by stage.

THE PROBE

The probe must be capable of detecting pulses as short as 50 nanoseconds (for TTL operation) and make them visible. It was found that readily available linear ICs were not suitable as they are too slow and required dual supply voltages. Neither could CMOS be used as it also is too slow, for testing TTL gates, and its threshold voltages are not consistent. Further, TTL could not be used as it cannot withstand the voltages used with CMOS logic. This virtually means that the only devices that are suitable are discrete transistors.



The logic probe we built in a solder tube.

HOW IT WORKS

The probe consists of two independent voltage level detectors which, via pulse stretching monostables, drive light-emitting diodes to give a visual indication of the logic state being monitored. Transistors Q1 and Q4 form the low level or '0' detector, transistors Q5 and Q6 the high level or '1' detector whilst the remaining components form the pulse stretching monostables and visual indicators.

The high level detector works as follows. If the input level is below about 2.5 volts (1.3 volts above the level set on R17 by transistor Q5) transistor Q6 will be cut-off. When the input level rises above 2.5 volts, transistor Q6 will turn on, as will Q7, causing LED 2 to light – indicating a '1'. The transition at the collector of Q7 will, at the same time, be passed to Q8 turning it off. The current which was flowing through Q8 will now flow via R22 in to the base of Q7 holding it on even though Q6 may by now have stopped conducting. After fifty milliseconds the charge on C2 will leak away via R19, 20 allowing Q8 to conduct. When Q8 conducts it robs the current from the base of Q7 turning it and the LED off. However should the voltage at the tip of the probe still be present Q6 will still be turned on holding on in turn Q7 and the LED.

Resistors R11, 12, 13 and 14 set the operating conditions of Q5 such that the threshold voltage is optimized for either TTL or CMOS. As CMOS logic works on supply voltages ranging from five to fifteen volts, transistor Q5 has been arranged to track the supply so that the correct threshold is maintained at all times.

The low level detector works in exactly the same fashion except that it is inverted in order to detect pulses which approach within 0.45 volts of the negative line (TTL only). Each PNP transistor and each NPN transistor have been replaced with their complements. In this case Q4 sets the thresholds and the circuit operates exactly as stated for the high detector. Note that the diodes have also been reversed.

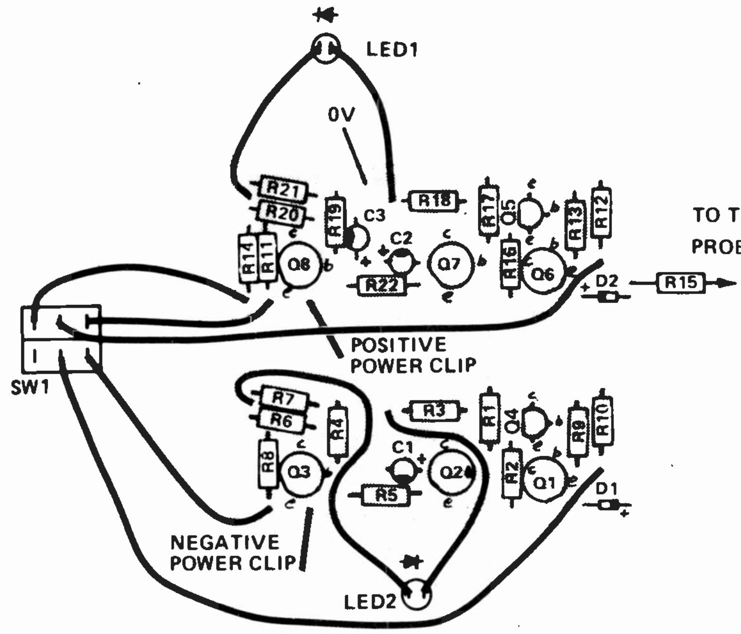


Fig. 3. Component overlays for the two comparators showing interconnection wiring.

PARTS LIST – ETI 120

R3,18	Resistor	680	¼ W	5%
R4,15,19	"	1 k	"	"
R10,13	"	1 k8	"	"
R1,9,12,17	"	2 k7	"	"
R5,14,22	"	3 k3	"	"
R2,16	"	8 k2	"	"
R7,21	"	10 k	"	"
R8,11	"	27 k	"	"
R6,20	"	100 k	"	"
C1,2	Capacitor	0.47 µF	25 V tantalum	
C3	"	10.0 µF	25 V "	
D1,2	Diode	IN914 or similar		
Q1,7,8	Transistor	BC177		
Q2,3,6	"	BC107		
Q4	"	BC179		
Q5	"	BC109		
SW1	Switch	Two pole, two position miniature toggle		

PC boards 2 off ETI 120
Probe case (see text)
LED 1, 2 Light emitting diodes TIL209 or similar
2 Alligator clips or Ezy-hooks

CHARACTERISTICS

PULSER – ETI 121

- Will source, or sink, up to 500 mA.
- Operates on supply voltages from 5 to 15.
- Suitable for both TTL and CMOS.
- Power supply drain less than 15 mA under worst case conditions.
- Press for '1' release for '0'. High impedance at other times (>1 M).
- Will drive capacitive loads up to 1000 pF.
- Protected against accidental reversal of supply leads.
- Duration of pulse 500 nanoseconds.

PROBE – ETI 120

- Pulses as narrow as 50 nanoseconds will be detected.
- Stretches narrow pulses to 50 milliseconds for ease of detection.
- Operates on supply of 5 to 15 volts.
- Suitable for TTL or CMOS.
- True '1' and '0' level detectors. Neither LED is alight if the circuit is faulty or the probe is not making contact.
- Current drawn from the circuit is less than 20 microamps.
- Current drawn from power supply (one LED alight) 12 mA on 5 volts, 35 mA on 15 volts.

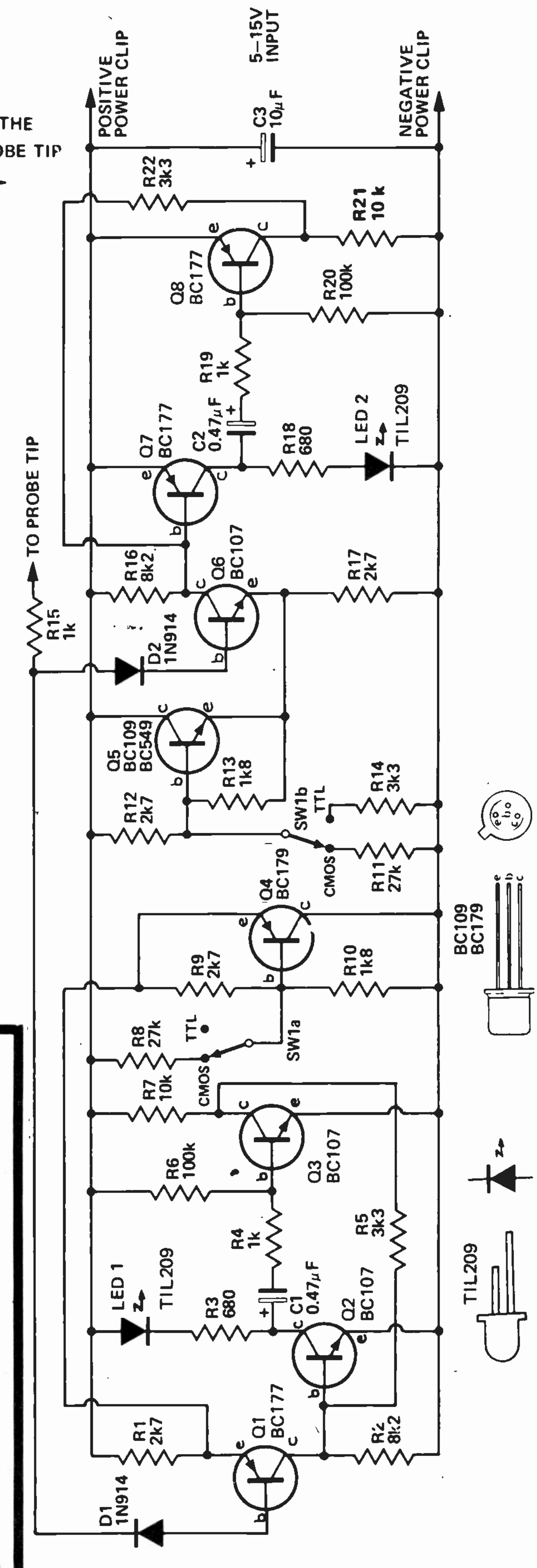


Fig. 1. Circuit diagram of the logic probe

LOGIC PROBE

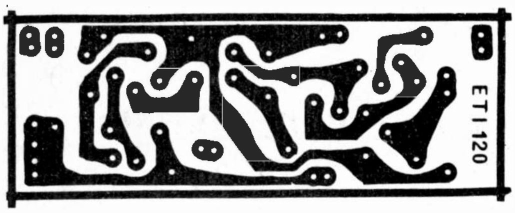


Fig. 2. Printed circuit board for the logic probe (2 required). Full size 23 x 66 mm.

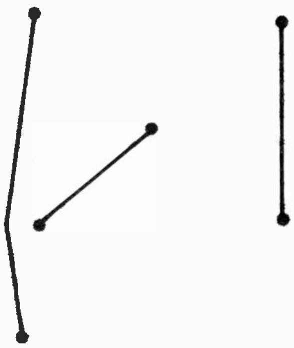


Fig. 4. Linking required between the two boards.

As both high and low logic states must be detected, a discrete transistor voltage-comparator circuit was designed to detect each state separately. These comparators must not load the circuit under test as CMOS is sensitive to current and capacitive loading. In our prototype the current drawn was a maximum of 19.7 microamps for a high, and 10 microamps for a low.

In both comparators the transistors associated with the pulse detector are turned on by an input level that exceeds the comparator threshold.

As transistor turn-on time is much faster than turn-off time, using the transistors in this way ensures the highest possible speed of operation for the particular types of transistors used. Additionally, the delay in turning off assists by lengthening the pulse, thus ensuring more reliable triggering of the monostable on very short pulses.

The input transistors Q1 and Q6 are protected against breakdown, due to excessive base-emitter voltage, by diodes D1 and D2. The diodes are also required to ensure that Q1 and Q6 remain conducting even when the probe tip is taken to the supply voltage.

Transistors Q3 and Q8 are also protected against reverse base-emitter voltages by R4 and R19 respectively.

In operation the probe will light LED 1 if a low level is detected, LED 2 for a high, neither LED if the point being monitored is at ground potential or a poor contact is made with the tip, and both LEDs will light if there is a pulse train present.

A single pulse input will be lengthened, by the monostables, to 50 milliseconds with the pulse polarity being indicated by the LED which is illuminated. Thus even single pulses as short as 50 nanoseconds may readily be detected.

CONSTRUCTION

We assembled our probe in a case made from a solder tube. This is commonly available from component shops for about 35p (containing Ersin Multicore Solder). Any probe case or tubing with a diameter of 23mm and a length at least 90mm (excluding nozzle) will do. The solder tube has a detachable plastic end-cap which supports SW1 and the LEDs. SW1 is used to hold a small name-plate in position as shown in Fig. 6. Two LEDs are mounted into the end plate, together with SW1, and after soldering leads to the LEDs they should be passed through the holes in the plate, and the plastic end-piece, and secured in position with a drop of epoxy cement. Another hole is drilled in the stopper through which is passed the two supply-voltage leads.

A removeable nozzle has to be made and for this we used a polyester resin filler (Isopon or any of the car body repair fillers is ideal). First saw of the original nozzle and line the inside of the tube with grease or cow gum. This stops the filler making a permanent joint. Then mix some filler and spread it for about 25mm down the inside of the tube. Roughly mould the nozzle shape around the polythene tubing which comes with the solder and bed this firmly in the end of the tube. After a couple of minutes the nozzle can be whittled into shape. After hardening remove the nozzle and clean up the inside face (saw off the rough moulding). Remove the polythene tubing and in the hole R15 and the probe tip can be fixed with more filler. Use a darning needle or one of the needles made for sewing up knitting as the tip. Do not leave more than 15mm protruding or the needle is likely to break. Finally the nozzle can be filed and sanded to give a neat appearance.

The electronics are built on two printed circuit boards. The two boards are identical and care should be taken to use the correct overlay for each board as different transistors are used and some components are reversed on the two boards. Note particularly diodes D1 and D2 and capacitors C1 and C2. Also note how the two boards are linked together and that the supply rails are reversed. No difficulty should be experienced if the printed-circuit boards and the component overlay as specified are used.

Connect the leads from the stopper assembly to the boards. Position the boards together, copper side to copper side, with a piece of insulating material between them. Make sure that the board assembly will fit into the tube without bending the sides. Cut a piece of cardboard or plastic 75 x 85mm, roll it into a tube and fit in the probe body. Now fit the board assembly into the tube – it may be necessary to dress the sides of the boards with a file to obtain a neat fit.

The tip may now be connected and both ends screwed into position. Finally, alligator or, better still, Ezy-hooks clips should be fitted to the supply leads.

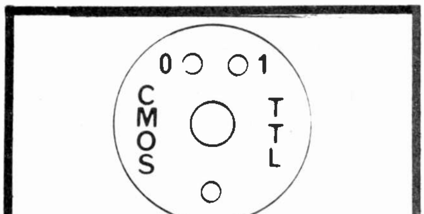


Fig. 5. Artwork for the nameplate on the probe.

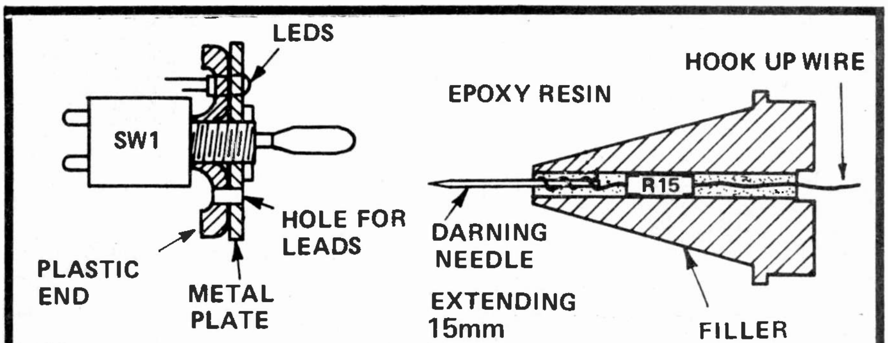


Fig. 6. How the probe ends are constructed.

Electronic timekeeping
Sintel delivers: designs – kits – components

Parts for the ETI Stopwatch System:

— See this month's article

STOPWATCH

Complete Kit for Stopwatch without Latch
Conents: Verobox 75/410J — Red perspex front panel — Manganese batteries — clips — Transistors — Diodes — Wiring Pins — Screws — Sockets — 14 pin Pin-Header — CMOS — Resistors — Capacitors — Crystal — PCBs — Trimmer — 3 x DL33MMB displays — Full instructions **£34.39**
As above except for Displays and Display PCB **£27.82**
(for other display options see below).

STOPWATCH with one LATCH

Complete Kit for Stopwatch with one Latch ('Split'-'display free') facility
With two sets of c x DL33MMB displays, etc **£52.89**
With one set of 3 x DL33MB displays **£46.32**
Without Displays (see other options below) **£39.75**

LARGE DISPLAY OPTIONS

The Stopwatches may be used with larger displays — DL704E (0.3") or FND500 (0.5") N.B. When using larger displays we recommend that a segment current boosting circuit be used to obtain higher brightness; details supplied with any parts ordered.

Displays (each)		Display PCBs (will hold up to 8 digits):	
DL704E	**85p**	For DL704Es	**£1.35**
FND500	**£1.50**	For FND500s	**£1.35**

Note that only one of these display PCBs, together with displays, can fit in the 7510J Verobox supplied with the complete kits.

FURTHER APPLICATIONS

For those who want to vary or extend the Stopwatch design, components are available from us in various sub-divisions — see box by article for 'PCB Module Kits'. Send a large s.a.e. for fuller list. Some possibilities suggested are:

— Multiple Latch Systems
— Multiple Counter Systems
— Alarm Systems
— Mains Power Supplies
— Chess Clocks

ADD VAT at 8% to all Prices in this advertisement.

15p p&p on orders under £3. Free on orders over £3. Orders sent by 1st Class Post.

Exports: No VAT. 35p (Europe), £1 (Overseas) for Air Mail p&p

Full Price List and Data with any order, or on request (a large s.a.e. helps)

Official Orders welcomed; written, phoned or telexed, from Univs., Polys., Nat. Inds., Govt., Companies, etc. **Fastest Delivery for R & D.**

SINTEL

53a Aston Street, Oxford
Tel. 0865 43203
Telex: 837650 A/B ELECTRONIC OXFD

ALARM CLOCK KITS

Complete kits including slim attractive case for 6 digit alarm clocks with bleep alarm, snooze and intensity control, using MK50253 IC and LED displays. Kits also include PCBs — active and passive components — IC socket — min. transformer — switches — flat cable — loudspeaker
6 digit Alarm Clock Kit with 0.3" DL704E displays **£22.80**
6 digit Alarm Clock Kit with 0.5" FND500 Displays **£26.70**

CLOCK CRYSTAL TIMEBASE

32.768 kHz Quartz Crystal: High accuracy/stability for clock and watch timebases. Can be used with CMOS divider and logic to provide stable 50 cps **£3.60**
'50 cps Kit' — will provide 50 cps for clock ICs, giving time accurate to within a few seconds a month; contains small pcb, 32.768 kHz crystal, 4011, 4020, 4025, trimmer, C's, zener, R's, IC skts. Also ideal for car or boat clocks **£6.28**

IC's

MK50253 12 or 24 hour, 4 or 6 digit alarm clock with alarm tone on chip, snooze, reset to zero; proven high reliability **£5.60**
MK50250 Identical to MK50253 except that it is 24 hr. only **£5.00**
MK5030M CMOS LED watch IC with date and seconds **£19.50**
AY1202 4 digit clock with simplest interface to 5LT01 .... **£5.60**
AY1224 4 digit clock **£4.25** MM5314 4 or 6 digit clock **£4.44**

DISPLAYS

FND 500 Very attractive 0.5" Red Common Cathode LED — only **£1.50**
DL704E 0.3" C. Cathode LED **85p** MAN3M 0.13" C. Cathode LED **48p**
5LT01 4 digit clock display — 0.″ green phosphor diode **£5.80**
ILIXCO 3½ digit 0.5" Liquid Crystal display, with socket **£9.40**

DISPLAY PCBs — each of the four display PCBs below is **£1.35**
For clocks with 4 or 6 displays: PCB for DL704E's; PCB for FND500's
For counters; up to 8 digits: PCB for DL704E's; PCB for FND500's

VEROBOXES

Two from the range of the attractive and functional cases from Vero:
75-1410L 205 x 140 x 40mm **£2.64** 75-1411D 205 x 140 x 75mm **£2.94**
Red or Green Perspex for front panel of Box J **30p**; Red for box D **40p.**

ETI DVM and Frequency Meter

MC14511CP **£1.95** MC14553CP **£4.07** MC14518CP **£1.03**
CA3130 **88p**

CMOS

CMOS from the leading manufacturers only — at new low prices.

CD4000AE	**0.17**	CD4027AE	**0.46**	CD4051AE	**0.77**	CD4081BE	**0.18**
CD4001AE	**0.17**	CD4028AE	**0.74**	CD4052AE	**0.77**	CD4082AE	**0.18**
CD4002AE	**0.17**	CD4029AE	**0.94**	CD4053AE	**0.77**	CD4085BE	**0.59**
CD4006AE	**0.97**	CD4030AE	**0.46**	CD4054AE	**0.95**	CD4086BE	**0.59**
CD4007AE	**0.17**	CD4031AE	**1.82**	CD4055AE	**1.08**	CD4089BE	**1.27**
CD4008AE	**0.79**	CD4032AE	**0.88**	CD4056AE	**1.08**	CD4093BE	**0.66**
CD4009AE	**0.46**	CD4033AE	**1.14**	CD4057AE	**20.35**	CD4094BE	**1.53**
CD4010AE	**0.46**	CD4034AE	**1.56**	CD4059AE	**10.64**	CD4095BE	**0.86**
CD4011AE	**0.17**	CD4035AE	**0.97**	CD4060AE	**0.92**	CD4096BE	**0.86**
CD4012AE	**0.17**	CD4036AE	**1.82**	CD4061AD	**16.43**	CD4099BE	**1.50**
CD4013AE	**0.46**	CD4037AE	**0.78**	CD4062AT	**7.33**	MC 4501CP	**0.32**
CD4014AE	**0.83**	CD4038AE	**0.88**	CD4063BE	**0.90**	MC14502CP	**0.98**
CD4015AE	**0.83**	CD4039AE	**2.86**	CD4066AE	**0.58**	MC14508CP	**3.58**
CD4016AE	**0.46**	CD4040AE	**0.88**	CD4067BD	**9.31**	ME14510CP	**1.26**
CD4017AE	**0.83**	CD4041AE	**0.69**	CD4068BE	**0.18**	MC14511CP	**1.95**
CD4018AE	**0.83**	CD4042AE	**0.69**	CD4069BE	**0.18**	MC14516CP	**1.03**
CD4019AE	**0.46**	CD4043AE	**0.83**	CD4070BE	**0.18**	MC14518CP	**1.03**
CD4020AE	**0.92**	CD4044AE	**0.77**	CD4071BE	**0.18**	MC14520CP	**1.03**
CD4021AE	**0.83**	CD4045AE	**1.15**	CD4072BE	**0.18**	MC14532CP	**1.18**
CD4022AE	**0.79**	CD4046AE	**1.10**	CD4073BE	**0.18**	MC14553CP	**4.07**
CD4023AE	**0.17**	CD4047AE	**0.74**	CD4075BE	**0.18**	MC14555CP	**0.74**
CD4024AE	**0.64**	CD4048AE	**0.46**	CD4076BE	**1.27**	MC14556CP	**0.74**
CD4025AE	**0.17**	CD4049AE	**0.46**	CD4077BE	**0.18**	MC14566CP	**1.21**
CD4026AE	**1.42**	CD4050AE	**0.46**	CD4078BE	**0.18**	MC14585CP	**1.45**

RCA 1975 CMOS Databook: 400 pages of data sheets and 200 pages of circuits, applications, etc. .... **£2.30** (no VAT) + 37p p&p
New Motorola McMOS Databook .... **£2.30** (no VAT) + 47p p&p

HARDWARE

SOLDERCON DIL SOCKETS for IC's, displays, CMOS, TTL.
The sensible low cost way for providing sockets. As they can be soldered on the conductor side of the board, they are ideal for use with double-sided PCB.
Strip of 100 pins for **50p.** 400 for **£2.** 1,000 for **£4.** 3,000 for **£10.50**
7-way Boss Switch: 7 ultra-min. toggle switches in 14 pin DIL **£2.60**
20-way Colour Coded Flexible Flat Cable .... **£1** per metre; **£8.50** per 10

eti project 121

LOGIC PULSER

Companion instrument to the logic probe.

ALTHOUGH the logic probe used alone is a very valuable piece of digital test equipment, it is limited by the fact that it can only observe the logic states that occur naturally within the piece of digital equipment under test.

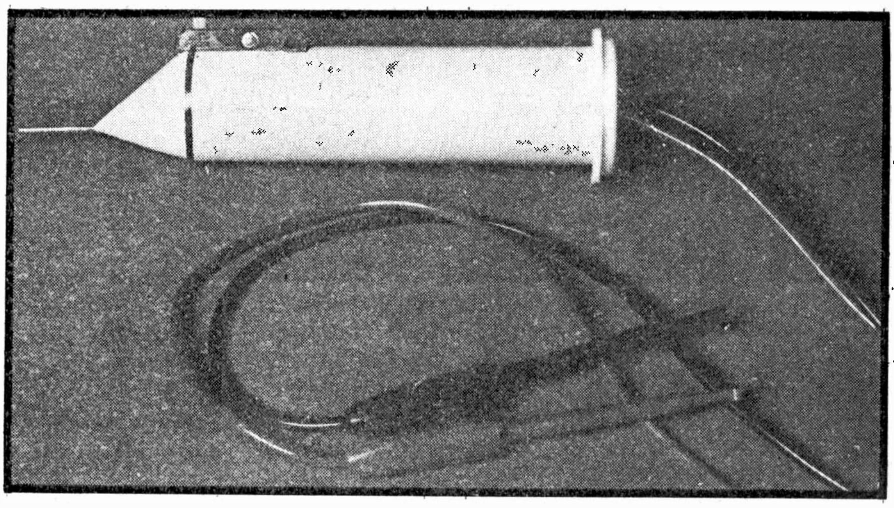
The logic pulser is a further valuable tool that is used in conjunction with the logic probe. It's function is to override the naturally occurring state at the particular circuit node under test. That is, if the circuit node is normally at the '1' state, the pulser will drive that node to a '0' for a very short period when the microswitch is pressed. If the circuit node is normally at a '0', the probe will drive it to a '1' for a very short period when the microswitch is released. Thus it puts a short pulse into the circuit node regardless of it's normal state when SW1 is pressed and released.

A fairly powerful pulse is required to override the normal logic state of a circuit node and care must be taken to ensure that the devices either driving, or being driven from that node are not damaged. This is achieved by making the pulse of very short duration. In our probe the pulse width is 500 nanoseconds. Thus although the pulse is of high current the energy released is insufficient to damage normal logic devices.

The probe must be suitable for driving either TTL or CMOS that is, it must operate from a supply ranging from 5 to 15 volts, it must be capable of operating into loads having a capacitance as high as 1000 picofarads and must supply a current pulse of around half an amp. All these conditions are fulfilled in the ETI 121 Pulser and the prototype has been tested by causing it to generate several hundred thousand half amp pulses without any problems. The probe is quite capable of pulling two (in parallel) high-power TTL 'zeros' to a '1' level and this is the most severe condition it has to meet.

At the same time as providing high level pulses, the pulser should not draw too much supply current as some CMOS supplies may not have much additional capability. Under worst-case conditions the ETI Pulser drew a maximum of 10 mA.

The probe is capable of overriding a normal logic state but is not capable of overriding a point that is connected to ground or to a supply rail. Thus by pulsing a node and at the same time looking at that point with the logic probe it is possible to tell if that point is shorted to either rail.



A basic tool for digital servicing.

The logic pulser combined with the logic probe is thus capable of performing stimulus — and — response testing of both TTL and CMOS logic and of determining the exact nature of a fault at a particular circuit node.

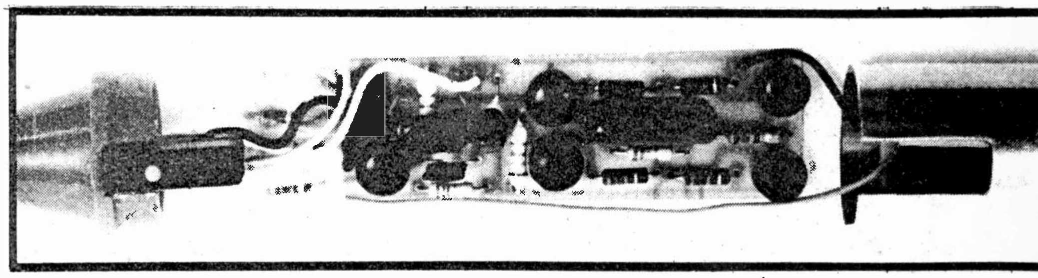
CONSTRUCTION

Construction is greatly simplified if the printed circuit board of Fig. 2, is used. This should have the components assembled to it in accordance with the component overlay. Note particularly the polarity of C1, and the connections of the microswitch such that the normally-closed terminal of the switch is connected to the base of transistor Q1. Also make sure that a red lead is connected to the positive rail of the board, and a black lead to the negative rail, to facilitate later connection.

We used the same probe case for the pulser as for the logic probe. The probe tip again uses a darning needle and the microswitch SW1 is mounted into the plastic filler tip as follows. First check switch to determine what the contact arrangement is. Attach colour coded wires to the switch, to aid later identification. If you use a solder tube as a case you have to saw off the nozzle and cut a slot for the microswitch. Keep the switch as far forward as possible to give more room for the pcb. Line the tube end with grease so that the filler will not stick. Wire or tape the switch into position and fill the end of the tube with filler. Make sure there is a hole, for fixing the probe tip by inserting the polythene tubing which comes with the solder. Roughly mould a nozzle. After a couple of minutes this can be carved with a knife. Then remove the polythene tubing and insert the needle. Fix this into the correct position using more filler. When the filler is hard the nozzle can be removed for filing and sanding into shape.

Connect the probe tip and microswitch leads to the board and, after insulating the inside of the case with cardboard or plastic as previously described, insert the board into the case. Pass the supply leads through the plastic end piece and then fit both end pieces and secure them in position. Finally attach Ezy-hooks or crocodile clips to the supply leads.

Keep the supply leads as short as is reasonably possible as excessively long leads will degrade the performance of the pulser.



Internal construction of the pulser.

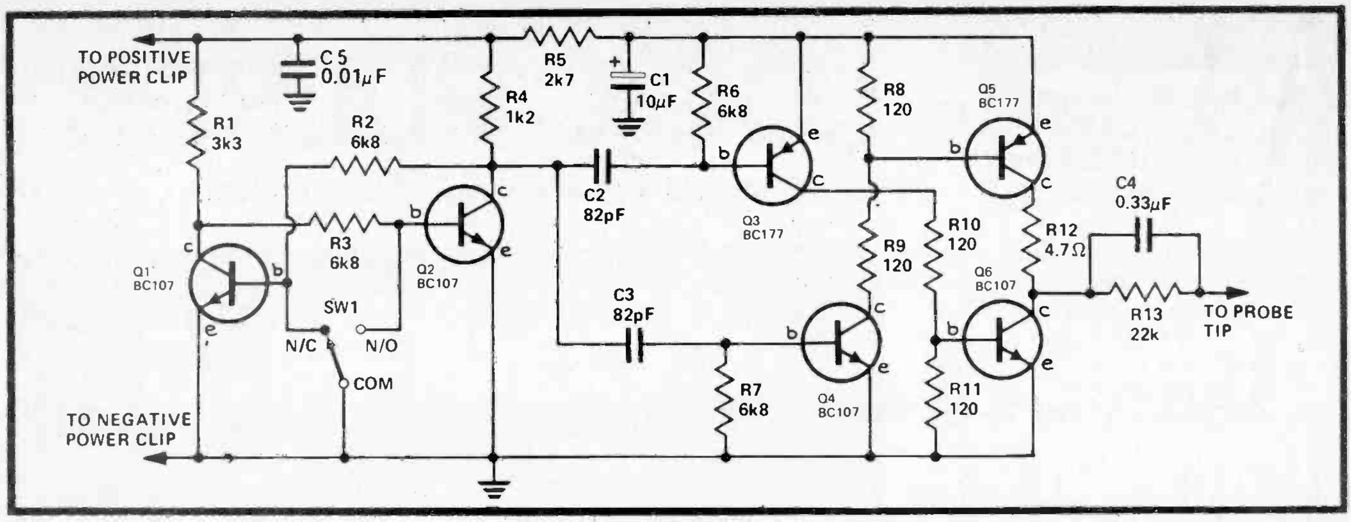
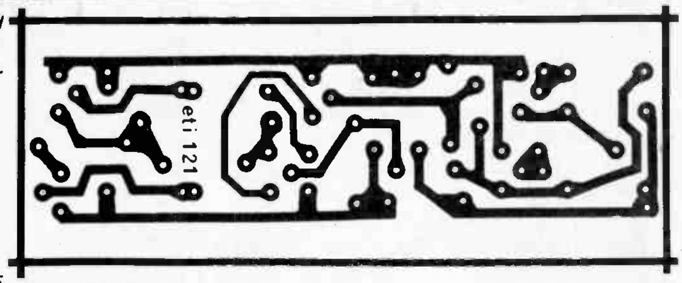


Fig. 2. Printed circuit board for the pulser. Full size 23 x 65mm, or 23 x 85mm. If this board is made to 23 x 85mm (same scale as shown here) it will not fit into a solder tube case. In this case the board should be reduced to 65mm in length (as shown below). To save confusion when ordering the board ask for ETI121–85 or ETI121–65.



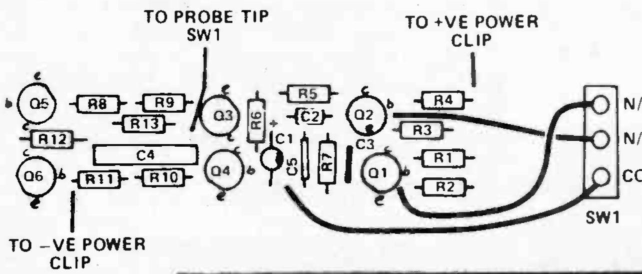


Fig. 3. Component overlay for the pulser.

HOW IT WORKS

The pulser is activated whenever microswitch SW1 is pressed. This switch controls the state of a flip-flop formed by transistors Q1 and Q2. The flip-flop is necessary to prevent contact bounce of the microswitch from having effect.

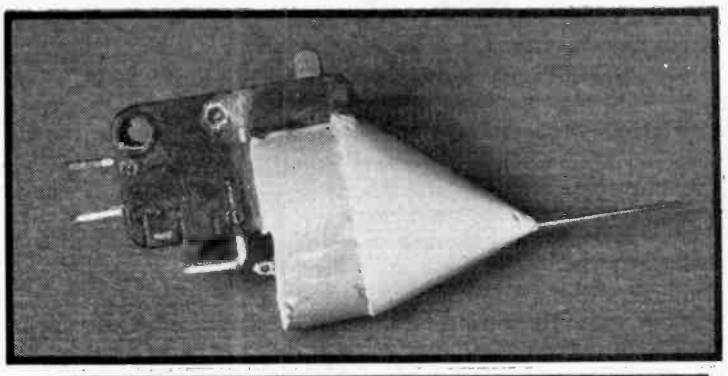
The output transistors of the probe, Q5 and Q6, which in turn are controlled by Q3 and Q4 are both normally off. However when the microswitch is pressed Q2 turns off and the rising voltage on its collector is coupled, via C3, to the base of Q4 turning it on. This in turn, turns on Q5 pulling the output to the positive rail. This generates a '1' pulse if the point under test was at a '0' level. Resistor R12 provides a current limit of around 500 milliamps. Due to the small value of C3 the pulse output is only about 500 nanoseconds long, short enough so that there is insufficient energy to damage the device under test.

When the switch is released Q2 turns on and the negative-going edge is coupled to Q3 by C2 turning it on. This turns on Q6 causing the output to be pulled to the negative rail. This gives a '0' pulse which, like the '1' pulse, is only 500 nanoseconds long.

The output from the probe is taken via the paralleled combination of R13 and C4 where C4 carries the current and R13 discharges C4 between pulses. This network protects the probe against the condition where the probe is inadvertantly connected to a voltage which is above or below the logic supply rails.

Resistor R5 isolates the high current pulse from the power supply, capacitor C1 providing the actual current needed.

Fig 4. The tip of the logic pulser, made from a darning needle, a microswitch, and a small quantity of car body filler.

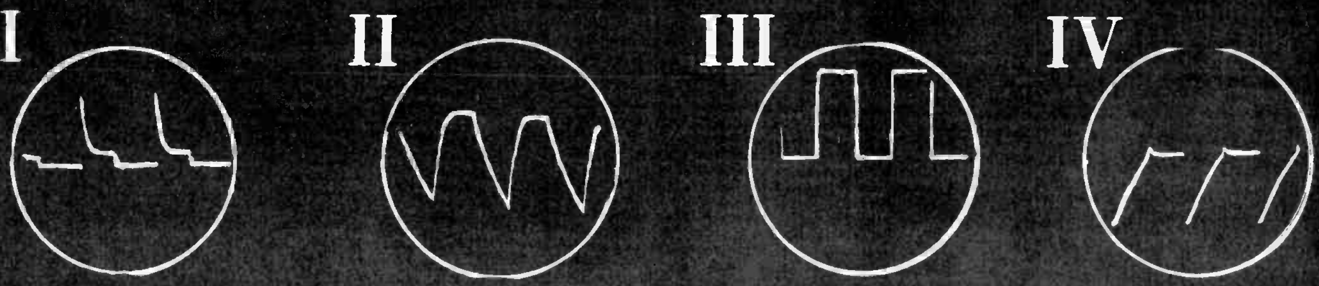


PARTS LIST

R12	Resistor	4.7 ohm	¼W	5%
R,8,9,10,11	"	120 ohm	¼W	5%
R4	"	1k2	¼W	5%
R5	"	2k7	¼W	5%
R1	"	3k3	¼W	5%
R2,3,6,7	"	6k8	¼W	5%
R13	"	22 k	¼W	5%
C2,3	Capacitor	82 pF	ceramic	
C5	"	0.01 µF	polyester	
C4	"	0.33 µF	polyester	
C1	"	10 µF	25 V tantalum	
Q1,2,4,6	Transistor	BC107 or similar		
Q3,5	"	BC177 or similar		

1 micro switch
2 crocodile clips, Ezy-hooks or Doram probes
PC board ETI 121
probe case (see text).
polyester filler (from a car accessories shop).

SPECIFICATION
See page 33.



ETI/HEATHKIT COMPETITION

WIN A SCOPE!

FIRST PRIZE

THE NEW HEATHKIT 10-4540 OSCILLOSCOPE

See the review on page 30.

SECOND PRIZE

A HEATHKIT 10-4560 OSCILLOSCOPE

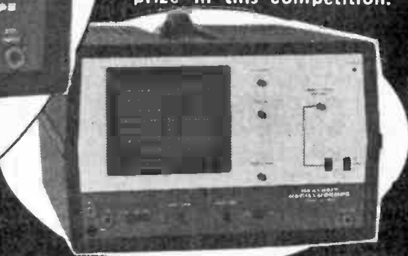
THIRD PRIZE

ANOTHER 10-4560 SCOPE

THE HEATHKIT 10-4540 (£99.90 IN KIT FORM)

MORE DETAILS FROM HEATH (GLOUCESTER) LTD. BRISTOL ROAD, GLOUCESTER, GL2 6EE

SHOWN BELOW IS THE 10-4560 OSCILLOSCOPE This has a sensitivity of 100mV up to 5MHz. It costs £69.90 in kit form and is second and third prize in this competition.



RULES

This competition is open to all U.K. and Northern Ireland readers of Electronics Today except employees of the magazine, their printers and distributors and employees of Heath (Gloucester) Ltd, and their advertising agents.

All entries must be on the coupon cut from the magazine, photostats are not acceptable. As long as the correct coupon is used, readers may submit as many entries as they wish.

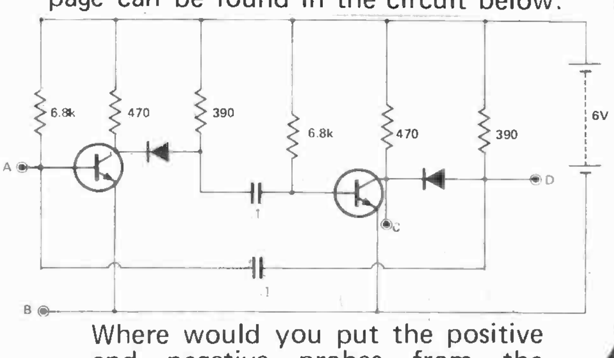
The First Prize will be awarded to the first correct entry drawn after the closing date, the Second Prize to the second correct entry, etc. No correspondence can be entered concerning the competition. It is a condition of entry that the judges decision in all matters is regarded as final.

The winners will be notified by post. The answers and a list of prizewinners will appear in a future issue of ETI.

Entries should be sent to: ETI/Heathkit Competition, 36 Ebury Street, London SW1W 0LW to reach us by 30th December 1975.

HOW TO ENTER

The four waveforms at the top of the page can be found in the circuit below:



Where would you put the positive and negative probes from the vertical input (y axis) to get these traces? Mark your answers in the boxes on the coupon. Use the letters A, B, C and D in your answers.

Send this coupon to ETI/Heathkit Competition, ETI Magazine, 36 Ebury Street, London SW1W 0LW.

FREE CATALOGUE!

TO ALL ENTRANTS WHO TICK THE BOX BELOW.

☐

'VERTICAL' PROBES

WAVEFORMS	+	— earth
I		
II		
III		
IV	A	B

The catalogue contains SPECIAL OFFERS open only to readers who send for the catalogue with this coupon!

Name. . . . .

Address . . . .

. . . .

. . . .

ON SALE DECEMBER 5th

JANUARY ETI

16 EXTRA PAGES

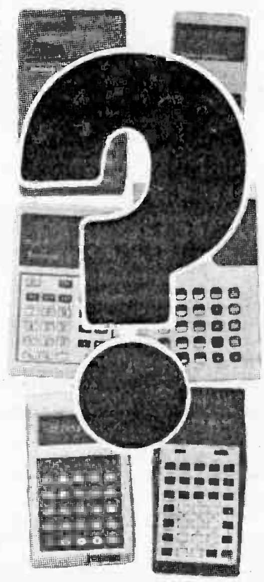
Have you noticed how your ETI is going up in size? There have been 76 pages for two years — until recently. In November we added 16, in December 8, and January's issue will be another bumper issue. The reason? ETI's rapidly rising sales and advertising enable us to do this without increasing the price. And ETI readers seem to be enthusiastic and Tech-Tips have been flooding in, so in the January issue there will be a super large:

TECH-TIPS SPECIAL

SCIENTIFIC CALCULATORS

Just over a year ago the cheapest scientific calculator cost over £50. Today there are a vast number available for a fraction of the price — and with far, far more facilities. This is a rapidly moving field, so we've arranged for a thorough survey of the market and give you "instant comparison" tables on the models now available.

We also explain the terms being used to describe the calculations that can be made.



LOGIC TESTER

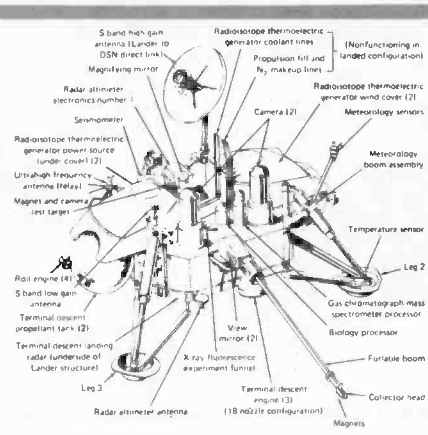
Until recently the most commonly used family has been TTL. But CMOS is rapidly gaining widespread usage and any tester, to be of value these days, must be able to test both these families. Our unit is able to test both families, and is capable of being used to breadboard and test simple circuits based on single ICs.

CROSSOVER AMPLIFIER

The follow-up to this month's feature on the Active Crossover Unit and how to couple it up to the 50W amplifier module

IS THERE LIFE ON MARS ?

NASA's Viking landers will soon be on Mars. These remotely controlled probes of superb sophistication will carry out a whole series of tests to find out if there is, or ever has been, life on Mars. In January's issue we explain the mission and tests to be made.



50W AMPLIFIER MODULE

An updated version of our 50W unit (r.m.s. of course) which can be used to increase the power (and quality?) of your existing amplifier.

At the time of this issue going to press, the features mentioned here are in an advanced state of preparation. However, circumstances, including highly topical news, may affect the final contents.

ORDER A COPY FROM YOUR NEWSAGENTS

electronics today international

ETI DATA SHEET

TCA210 AUDIO AMPLIFIER AND PRE-AMPLIFIER — MULLARD

The TCA210 is a monolithic integrated circuit comprising two amplifiers for use in intercoms and other audio systems. The first is a high-gain pre-amplifier with differential input and a class A output stage which can deliver 2.5mW into an 800Ω load. The second is a power amplifier with a class B output stage capable of delivering 500mW into a 25Ω load. Up to 800mW can be delivered into a 15Ω load for short periods. When there is no signal, the current consumption is 8mA. Squelch provision incorporated in both amplifiers can be used to ensure maximum battery life.

SPECIFICATION

Supply voltage (V_P)	12V
Total current drain (I_{tot})	8mA
PRE-AMPLIFIER	
Open loop voltage gain (G_V)	10,000
Input bias current (pins 1 and 15) ½(I_1+I_{15})	2.5μA
Unity gain bandwidth (with 6dB/oct compensation) (B)	>10MHz
Noise figure at (R_S=500Ω ; B= 300 to 4000Hz (F)	4dB
Total current (pin 14) I_{14}	4.0mA
Current of current sink I_C input stage	>2.5mA
Bias current (pin 2) (I_2)	>200μA
OUTPUT AMPLIFIER	
Open loop voltage gain (G_V)	500
Input bias current (pins 5 and 13) ½(5+I_{13})	2μA
Unity gain bandwidth (with 6dB/oct compensation) (B)	1MHz
Total current (dc; no signal; pin 10) (I_{10})	4mA
Bias current (pin 7) (I_7)	>150μA
PERFORMANCE	
Pre-amplifier	
Output power (R_{L1}=800Ω) (P_o)	2.5mW
Bandwidth (−3dB) (B)	4kHz
Total current (I_{14})	4mA
Input signal (V_{i1})	1.5mV
Input impedance (|Z_i|)	500Ω
Output amplifier	
Output power	
(R_{L2}=25Ω ; d_{tot}=5%) (P_o)	500mW
(R_{L2}=15Ω ; d_{tot}=5%) (P_o)	800mW
Bandwidth (−3dB) (B)	4kHz
Total distortion (P_o=50mW) (d_{tot})	1.5%
Input signal (V_{i2})	260mV
Input impedance (|Z_i|)	1.3kΩ
Total current (dc; no signal; pin 10) (I_{10})	4mA

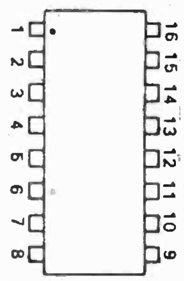
ABSOLUTE MAXIMUM RATINGS

Voltages (pin 8 must be externally connected to pin 16)

Pins 3, 9, 10, 14	17V
Pins 1, 15, 5, 13	17V or V_P
Pins 1, 5	5V
Currents	
Pin 10	550mA
Pin 9	550mA
Pin 8	550mA
Pin 14	20mA
Pin 3	20mA
Pins 2, 4, 6, 7, 11, 12	5mA
Pins 1, 15, 5, 13	0.5mA

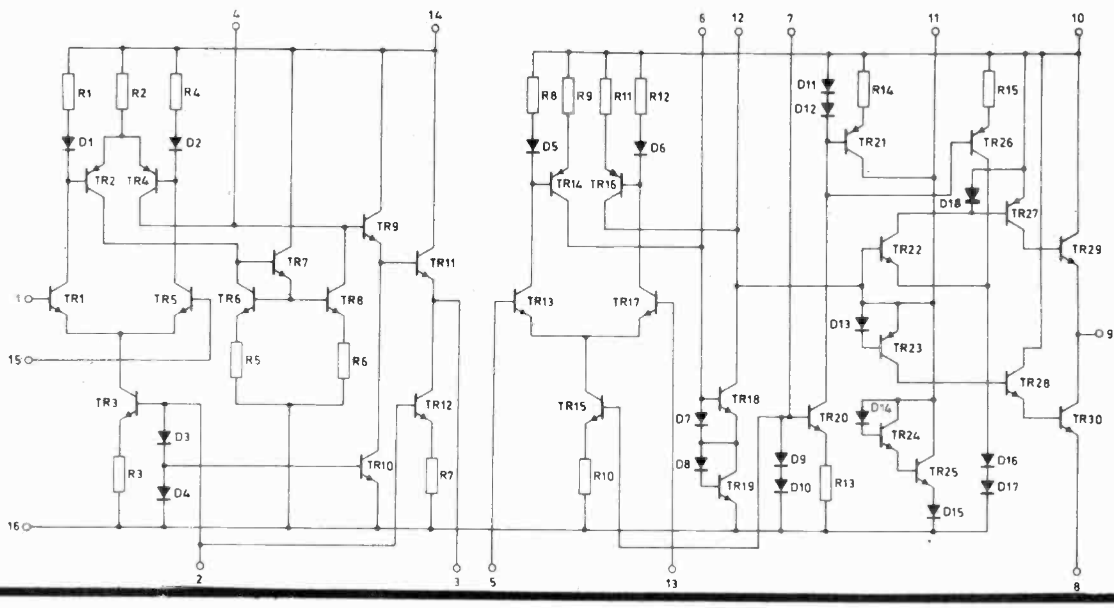
PACKAGE

16 lead plastic DIL

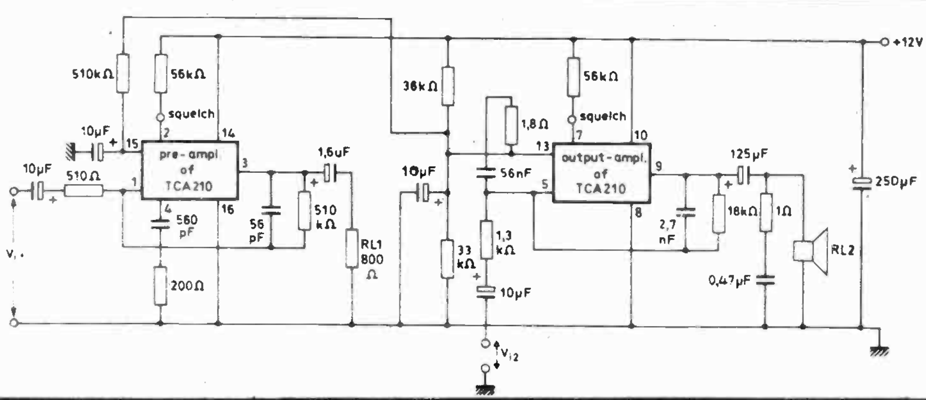


Typical advertised price £1-70.

CIRCUIT DIAGRAM



AMPLIFIER FOR INTERCOM SYSTEMS



AY-5-1224A 4 DIGIT CLOCK

GENERAL INSTRUMENT

The AY51224A is a P channel MOS IC containing all the logic necessary to make a 4 digit, 12 or 24 hour clock operating from a 50 or 60Hz input. It has multiplexed BCD or 7-segment outputs and will drive LED, Fluorescent and Gas discharge displays with the minimum of interfacing. The package has only 16 leads. It features zero blanking in the 12 hour mode.

The chip needs a single 15V supply and the clock reads zero until the time is set. The IC carries it's own multiplex oscillator.

SPECIFICATION

Clock input frequency	50/60Hz
Clock input logic '0'	+0.5V to −2V (Note 1)
Clock input logic '1'	−8V to V_{DD}
Multiplex clock frequency	DC to 50kHz (Note 2)
Interdigit Blanking	150μS at 6.67 kHz) (Note 3)
Control inputs logic '0'	+3V to −1.5V
Control logic '0'	−6V to V_{DD}
Outputs logic '0' (Vout= 2V, Iout=4mA)	500Ω
Outputs logic '1' (leakage) (Vout=−18V)	10μA
Power consumption (V_{DD} = 15 volts)	10mA

Note 1 The clock input pin may be taken positive with respect to V_{SS} provided that the current is limited to 100μA. The input will behave like a forward biased silicon diode in this condition.

Note 2 The frequency is determined by an external capacitor.

Note 3 At 6.67kHz multiplex frequency the digit ON time is 450μS and the OFF time is 150μS.

ABSOLUTE MAXIMUM RATINGS

Voltage on any pin with respect to V_{SS}	+0.3 to −20V
Operating temperature range	0°C to + 70°C
Storage temperature range	−65°C to + 150°C
Power dissipation (total) at 70°C ambient	500mW
(per output)	50mW

ELECTRICAL CHARACTERISTICS

V_{SS}	=	0V
V_{GG}	=	−12 to −18V
Tamb	=	0°C to + 70°C

PACKAGE 16 Lead DIL

16 15 14 13 12 11 10 9

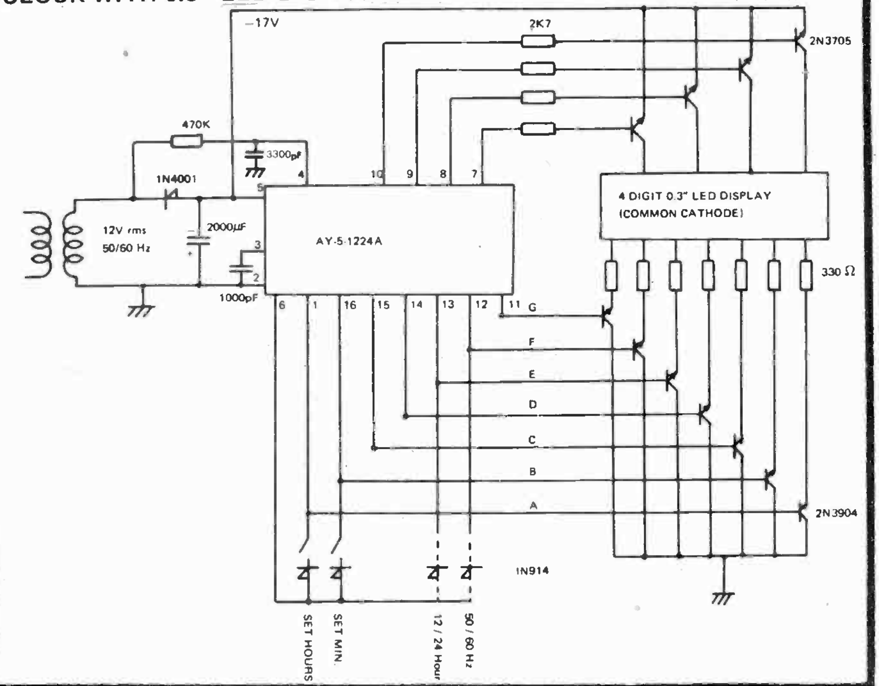
1 2 3 4 5 6 7 8

PIN CONNECTIONS

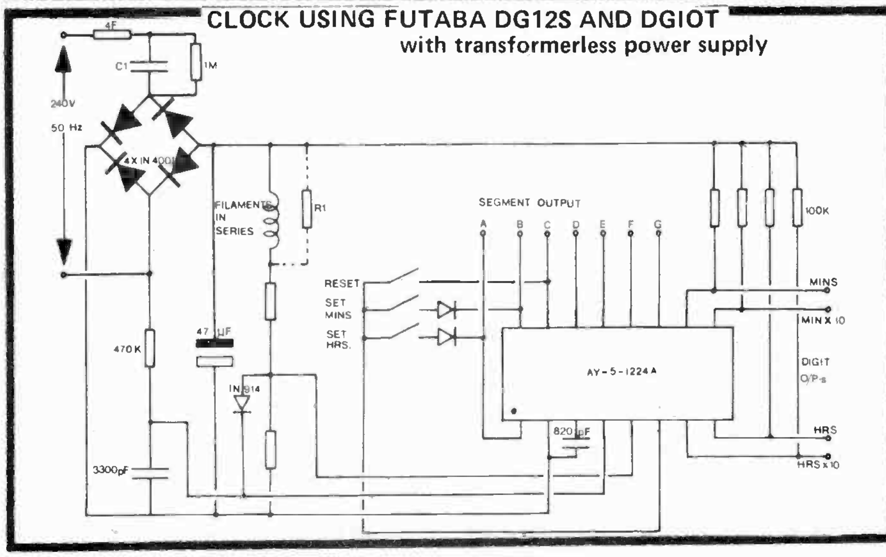
1. Segment A output/2^0 output/Set Hours input
2. V_{SS}
3. Multiplex oscillator
4. 50/60Hz input
5. VGG
6. Strobe output
7. Mx 4 output (Ten Hours)
8. Mx 3 output (Unit Hours)
9. Mx 2 output (Ten Minutes)
10. Mx 1 output (Unit Minutes)
11. Segment G output/BCD or 7 segment select
12. Segment F output/50 or 60Hz select
13. Segment E output/12 or 24 hour select
14. Segment D output/2^3 output/ Complement input
15. Segment C output/2^2 output/ Reset input
16. Segment B output/2^1 output/ Set minutes input

Typical Advertised Price £3.10 inc. VAT
Data supplied by General Instrument.

CLOCK WITH 0.3" LED DISPLAY



CLOCK USING FUTABA DG12S AND DGIOT
with transformerless power supply



PIN FUNCTIONS

Pins 1 and 11 to 16 (Segment output A-G) are multifunction. During multiplex times 1 to 4 they function as data outputs, either 7 segment code or BCD according to the display mode selected. During multiplex time 5 (Strobe) they function as inputs.

Segment Outputs A-G (Pins 1 and 11 to 16). In 7 segment mode the digits are multiplexed out on to these pins. Normally the outputs are at logic '0' (positive to display). Interdigit blanking for ¼ the digit time is incorporated for gas discharge displays.

BCD Outputs 2^0-2^3 (Pins 1, 16, 15, 14). In BCD mode the digits are multiplexed on to these pins in BCD code. Normally the outputs are at logic '0' (positive) i.e. code 0=0000.

Multiplex Outputs 1-4 (Pins 10, 9, 8, 7). These pins are successively switched to logic '0' to select the appropriate digit display. A fifth multiplex time (Strobe) is used to enable the control inputs. These outputs have interdigit blanking. The multiplex rate is 1/20th the multiplex clock frequency.

Strobe Output (Pin 6). This pin is used to enable the control input keyboard, it goes to logic '0' to enable.

Set Hours Input (Pin 1). When taken to logic '0' during strobe time this input causes the hours counter to advance at the rate of 1 hour per second.

Set Minutes Input (Pin 16). When taken to logic '0' during strobe time this input causes the minutes counter to advance at the rate of 1 min per second and the hours counter to advance at the rate of 1 hour per minute.

Reset Input (Pin 15). When taken to logic '0' during strobe time this input causes the clock to reset to zero.

Complement Input (Pin 14). When left open the segments and BCD outputs will have normal polarity. When connected to Strobe output via a diode the 7 segment and BCD outputs will be inverted.

12/24 hour select (Pin 13). When left open the clock will run in the 12 hour mode, when connected to strobe via a diode 24 hour operation will result.

50/60 Hz Select (Pin 12). When left open a 50 Hz clock will be accepted. When connected to strobe via a diode 60 hz operation will result.

BCD/7 Segment Select (Pin 11). When left open 7 segment outputs will be provided, when connected to strobe via a diode BCD outputs will be provided.

50/60Hz Input (Pin 4). The master clock (50 or 60 Hz) is input to this pin. Hysteresis is provided on the input so that the input wave form is not criticial.

Multiplex Oscillator (Pin 3). An external capacitor is used to set the multiplex frequency. If required this input can be driven by an external oscillator.

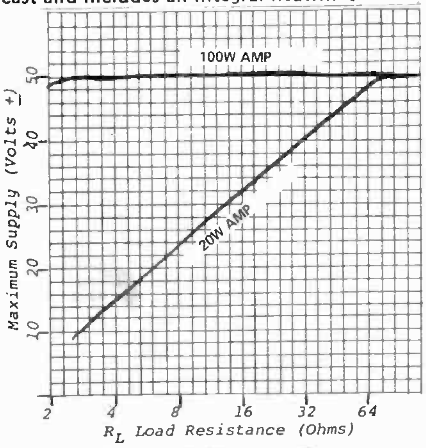
V SS (Pin 2). Positive supply line nominally 0 V.

VGG (Pin 5). Negative supply line nominally -15V.

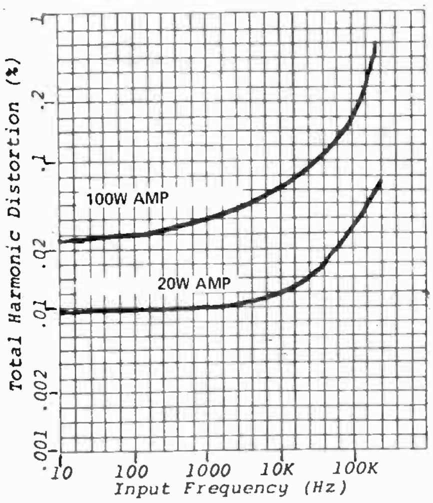
Power on Reset. At power ON the chip is reset to zero. Counting will not start until either Set Hours or Set Minutes has been pressed.

A 20W RMS (MAX) IC! The yanks have managed it with the 303D Power Driver. This is an operational transconductance amplifier intended for use as the driver of a complementary pair of output transistors (see the 400W circuit below!). The 303D can itself drive loads down to 4 ohms with appropriate supply voltages. Virtually any complementary output pair can be driven; then the full supply of ± 50 volts is allowed. In this mode the total amplifier power is limited only by the volt-amp ratings of the output devices.

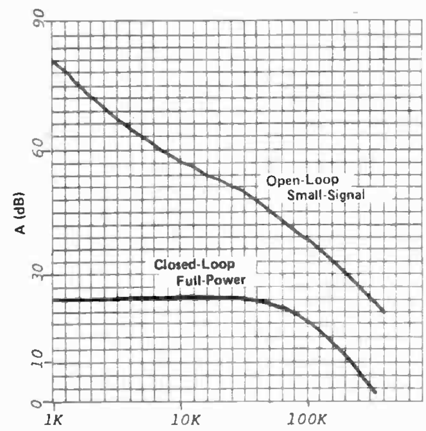
The device features internal compensation and a wide bandwidth. Crossover bias terminals (T and T') are provided but they can be left open if crossover behaviour is not critical. The construction is epoxy-cast and includes an integral heatsink.



Graph 1: Maximum Allowable Supply (V±) versus load for Sinusoidal Output.



Graph 2: THD versus frequency (typical) for 20 and 100 watt amplifiers at full power.

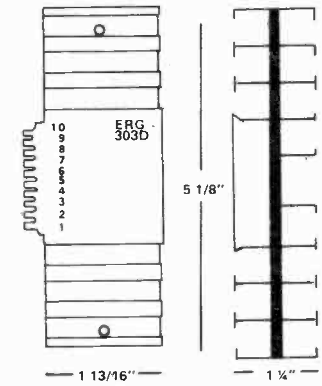


Gain Versus frequency. (20W Amp).

SPECIFICATION

Supply Voltage	±9V to ±50V see graph 1
Supply Current	adj. to 15mA
Input Offset	20mV max.
Input Bias Current	5µA max.
Slew Rate (R_L = 8)	15V/µ sec.
1kHz Harmonic Distortion 15W RMS (R_L = 8)	0.01% see graph 2
Power Bandwidth (R_L = 8)	80kHz
Small-Signal Bandwidth	200kHz
Input Impedance	200kΩ
Open-Loop DC Gain (R_f = ∞)	80dB
Input Noise 20Hz — 20kHz	10µV
THD at 1kHz when driving a MJ802/MJ4502 pair at 100W into 8Ω	0.02% (0.1% max)

PACKAGE



ABSOLUTE MAXIMUM RATINGS

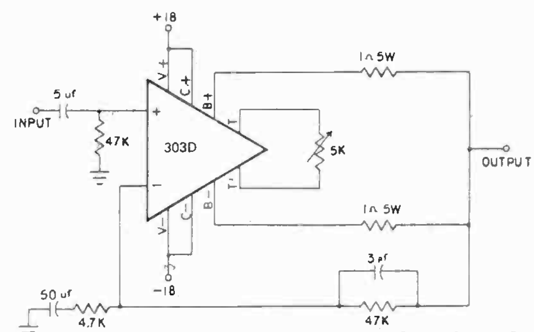
Supply Voltage	±50V DC
Output Current	7 Amps peak
Internal Dissipation	20W in still air 25°C.

Shortly to be available from Ambit International, 37 High Street, Brentwood, Essex.
The price will be about £25.

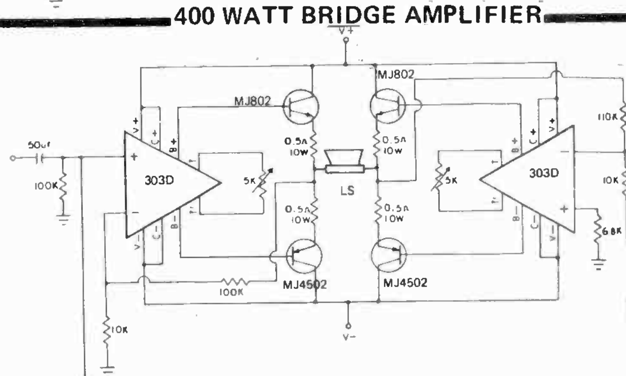
PIN CONNECTIONS

1. (+) Input
2. (—) Input
3. V+ Supply
4. V— Supply
5. T' } Crossover
6. T }
7. C— Negative Bias
8. B— (Negative Base Drive)
9. C+ Positive Bias
10. B+ (Positive Base Drive)

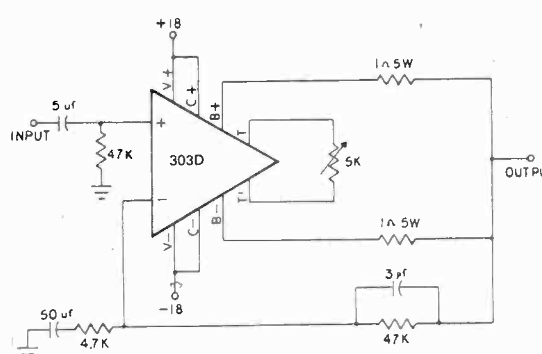
20 WATT AMPLIFIER



400 WATT BRIDGE AMPLIFIER



DYNAMIC SHORT-CIRCUIT PROTECTION



The resitors in series with C± terminals provide current limiting at 1 = V+/R3 for B± outputs. Adjust R2 (200—900Ω) for current limiting.

ETI • READER • OFFER •

NOVUS 3500 electronic sliderule

RECOMMENDED RETAIL PRICE: £22.95

ETI OFFER PRICE

£15.95!

INCLUDING VAT & CARRIAGE

At ETI we get enthusiastic about most of the calculators that we see and have made three available on offers in the past. We make no apologies for introducing yet another type — a brand, spanking new model which is due to be announced only after this issue goes to press! The Novus 3500 Electronic Sliderule offers facilities that, even at today's cut-throat prices, makes it a bargain at the suggested selling price of £22.95 but we have been able to arrange for ETI readers to make a massive saving from the word go on this fabulous model. Compare the facilities with other models available — it'll convince you of the bargain you'll get!

MAIN FACILITIES

1 8-digit LED display.
2 RPN (Reverse Polish Notation) with 3-level stack.
3 Full memory.
4 Operates with natural **and** common logs.
5 Full trig facilities operating directly in degrees.
6 y^x function.
7 Direct square root key.
8 Instant reciprocals.
9 x-y key: interchanges stacks.
10 Change-sign key.
11 π key: 3.1415926.
12 Usual arithmetic functions.

OTHER FEATURES

13 Display converts to decimal points after 30 seconds (if no key is pressed) to save battery — contents unaffected.
14 About 15 hours from 9V alkaline battery; low battery indicator (Battery supplied).
15 Exceptionally clear 44-page instruction manual.

(This specification may mean little to readers unfamiliar with current scientific calculators — and remember that a 44-page manual is necessary to explain all the operations it can handle!)

AVAILABILITY

ETI's offers in the past have sometimes been so successful that the initial estimate has proved wildly wrong. 2,000 units are being stocked for this offer initially. If orders exceed this every effort will be made to meet orders promptly but delays may result and it may be necessary to return money if it looks as though over long delivery dates will result. See next month's ETI for the current situation.

For security reasons, stocks of this calculator are not being held at ETI offices for callers.

The 3500 can be used with Novus Mains Adaptor, available from all Novus retailers for £3.95 (Mains Adaptor **not** available through ETI).

CUT COMPLETE COUPON

To: ETI/Novus Offer
Electronics Today,
36 Ebury Street,
London SW1W 0LW

Please find enclosed a cheque/PO for £15.95 (payable to Electronics Today International) for my Novus 3500.

This coupon will be used to dispatch your calculator. The offer is strictly limited to one Novus 3500 per coupon. Orders will be despatched as soon as possible but please allow 35 days for delivery and read note on availability.

Offer closes December 31, 1975

FOR OFFICE USE

NAME ....
ADDRESS ....
....
....

PLEASE USE BLOCK CAPITALS

NAME ....
ADDRESS ....
....
....

THERE ARE TWO WAYS TO MAKE PROJECTS

BOTH WORK. . .
SOMETIMES.

Here you can see one way. The chap in the picture is trying to get his home made radio to work. He might succeed.

The other way is to take regular copies of ETI. The only sure ways to do this are (i) place a regular order with your newsagents, or (ii) send us the coupon below. And may you have successful projects for years to come.

- - - - - -Cut- - - - - - -

To ETI Subs, Electronics Today, 36 Ebury Street, London SW1W OLW.

Please send me the next 12 issues of ETI, I enclose £5.00 (£5.50 overseas).

Name . . . .

Address . . . .

. . . .

. . . .

Dec. 75

MACK'S for MOTOROLA McMos®

MC14001CP	Quad 2 Input NOR	18p
MC14002CP	Dual 4 Input NOR	20p
MC14011CP	Quad 2 Input NAND	18p
MC14015CP	Dual 4 Bit Static Shift Register	£1.26
MC14017CP	Decade Counter	£1.22
MC14021CP	8 Bit Static Shift Register	£1.26
MC14023CP	Triple 3 Input NAND	20p
MC14027CP	Dual J-K Flip-Flop	86p
MC14042CP	Quad Latch	£1.26
MC14046CP	Phase Locked Loop	£1.85
MC14049CP	Hex Invertor Buffer	61p
MC14510CP	BCD U-Down Counter	£1.40
MC14511CP	BCD 7 Segment Latch Decoder Driver	£2.12
MC14528CP	Dual Monostable	96p

TEXAS TTL
74 SERIES

SN7400N	Quad 2 Input NAND	16p
SN7402N	Quad 2 Input NOR	16p
SN7404N	Hex Invertor	19p
SN7413N	Dual NAND Schmitt Triggers	32p
SN7447AN	BCD To 7 Segment Decoder Driver	95p
SN7472N	J-K Master-Slave Flip-Flop	26p
SN7473N	Dual J-K Master-Slave Flip-Flop	30p
SN7475N	8 Bit & 4 Bit Bistable Latches	50p
SN7490N	Decade Counter	50p
SN7493N	4 Bit Binary Counters	50p
SN7495N	4 Bit Right Shift Left Shift Registers	70p
SN74121N	Monostable Multivibrators	35p
SN74122N	Monostable Multivibrators	45p

723 FAIRCHILD
14 Pin DIL Var. Voltage Regulator **55p**

LM 1303 NATIONAL SEMICONDUCTOR
14 Pin DIL Stereo Pre-Amp. **£1.65**

MC 1310P MOTOROLA
14 Pin DIL Coiless Stereo Decoder **£2.10**

741 FAIRCHILD
8 Pin DIL Op-Amp. **30p**

ALL PRICES INCLUDE VAT
Please allow 20p to cover P&P

MFC 4000 B MOTOROLA
¼ Watt Audio Amp. **75p**

ZN 414 FERRANTI
Radio Chip **£1.25**

SIGNETICS
8 Pin DIL Timer **60p**

LM 380 N NATIONAL SEMICONDUCTOR
14 Pin DIL 1 Watt Audio Amp. **£1.20**

LM 3900 N NATIONAL SEMICONDUCTOR
14 Pin DIL Quad Amp. **69p**

MM 5314 NATIONAL SEMICONDUCTOR
24 Pin DIL Clock Chip **£4.35**

E 1109 EUROSIL
24 Pin DIL Clock Chip **£7.78**

EMI CASSETTE TAPES

SOUNDHOG

	5	10	20
C60	£2.30	£4.50	£8.46
C90	£3.18	£6.25	£11.20

HI DYNAMIC

	5	10	20
C60	£2.79	£5.43	£10.18
C90	£3.68	£7.18	£13.46
C120	£5.22	£10.15	£19.03

14 PIN DIL SOCKETS 16p

I.C. INSERTION TOOL

Aligns pins for direct insertion

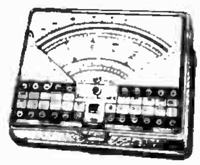
£1·45

EXTRACTION TOOL **45p**

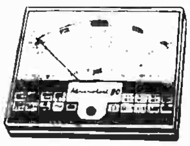
LITRONIX

7 Segment LED Displays
DL707 common anode DP left
DL704 common cathode DP right
£1.80 each. 4 for £7.
6 for £10

ICE 680R
Compact Precision multi-meter 20KΩ/V. 10 fields f measurement and 80 Ranges 1% accuracy. Damped movement. Mirror Scale. Supplied with Leads, Accessories and shatterproof case.
£19.98



Microtest 80
Pocket Precision Multimeter 20KΩ/V. 2% Accuracy. 40 Ranges. Shatterproof Case. Mirror Scale Auto-zeroing ohms range.
£11.88



MOTOROLA SMALL SIGNAL PLASTIC TRANSISTORS (TO 92)

Type No	Polarity	Vceo Vdc	IcMAX mA dc	hFE @Ic—2mAdc Vce—5Vdc	Price
BC237	NPN	45	200mA	120-460	15p
BC238	NPN	20		120-800	12p
BC239	NPN	20		120-800	15p
BC307	PNP	45	200mA	70-460	15p
BC308	PNP	25		70-460	13p
BC309	PNP	20		120-460	15p
BC317A	NPN	45	150mA	110-220	18p
BC318B	NPN	30	cont	200-450	18p
BC319C	NPN	20	300 Pk	420-800	20p
BC320A	PNP	45	150mA	110-220	20p
BC321A	PNP	30	cont		20p
BC322B	PNP	20	300 Pk	200-450	20p
BC327	PNP	45	1A	40 Min	20p
BC328	PNP	25	Peak	@Ic—300mA	18p
BC337	NPN	45		Vce—1V	18p
BC338	NPN	25			16p
BC347	NPN	45			13p
BC348	NPN	30	100mA	40-450	12p
BC349	NPN	20			12p
BC350	PNP	45			15p
BC351	PNP	30			15p
BC352	PNP	20			15p

AMTRON KITS

UK105/C	FM Microtransmitter	£8.07
UK220	Signal Injector	£3.53
UK230	AM/FM Antenna Amplifier	£4.16
UK285	UHF/VHF Antenna Amplifier	£8.87
UK302	4Ch. Radio Control Transmitter	£17.50
UK345/A	Superhet R/C Receiver	£8.81
UK325	GXC 2Ch. R/C Splitter 1000Hz. & 2500Hz.	£8.34
UK330	GXC 2Ch. R/C Splitter 1500Hz. & 2500Hz.	£8.34
UK555	Radio Control Strength Meter	£9.65
UK780	Electronic Metal Detector	£11.65
UK875	Capacitive Discharge Electronic Ignition Kit Neg. Earth	£17.33

MACK'S ELECTRONICS

283 Edgware Road, London W2.
Tel. 01-262 8614
Hours of business 9.30 - 6.00
Monday to Saturday   Callers welcome
ALL PRICES INCLUDE VAT   PLEASE ADD 20p P & P

PART 1

Op Amps

In this down-to-earth series, J. T. Neil explains the basic theory and practical applications of op amps.

OPERATIONAL AMPLIFIERS are small in size, provide very high, stable voltage gains, and are readily available at well under 50p each.

Unfortunately these immensely practicable devices tend to be described by their manufacturers and countless technical writers in terms that are virtually meaningless to the home constructor.

The purpose of this short series of three articles then, is to show, with the minimum of theory and mathematics, how to extract the essential information from data sheets and how to apply it to practical designs.

The units to be described, each using a single operational amplifier, are a compact sine-wave audio-signal generator, a high-impedance audio amplifier (with various switched frequency-responses available) and a dc amplifier to increase the effective sensitivity of an ordinary 1 mA meter to 10 μA fsd.

Each of these units can be run from batteries or any other suitable source; however, since operational amplifiers usually require dual supplies (which could become expensive if batteries were used for long) the first actual constructional project will be a power supply unit giving ± 12 V fully stabilised and short-circuit protected. This latter feature is rather important, for the operational amplifiers to be used have their lead out wires only 2.5 mm apart which, in experimental setups, will, sooner or later, lead to short circuits of the supply rails by solder blobs, touching wires etc.

Accordingly, a protected power supply, specifically designed for use with op amps and which automatically reverts to correct operation on removal of an unwanted short-circuit is essential.

WHAT IS AN OPERATIONAL AMPLIFIER?

Originally, the term was used to describe an amplifier suitable for performing mathematical operations in analogue computers. It has since come to include almost any high-gain dc amplifier capable of having its actual performance, in terms of gain, frequency response and input impedance, determined by external components arranged to provide feedback (usually negative feedback).

An *ideal* op. amp. has the following characteristics:—

1., Infinite gain
2. Infinite bandwidth
3. Infinite input impedance
4. Zero output impedance
5. Constant phase shift between input and output.

Obviously, such a device is impossible in the real world, but it *is* possible to manufacture amplifiers that have gains etc. So large, and output impedances so low, that any departures from the ideal have little effect in practical circuits.

For example, if a working gain of 100 is required and the op. amp. to be used has a gain (without feedback) of 50 000 then 50 000 ÷ 100 (500) is such a large margin that we can say that, for practical purposes, the reserves of gain available are so large that the gain is infinite. Similar reasoning applies to the other parameters whose ideal values were mentioned earlier.

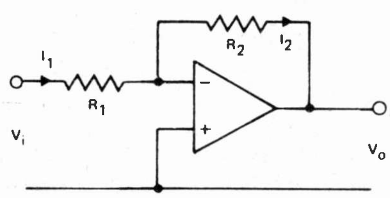


Fig. 1a. Inverting amplifier.

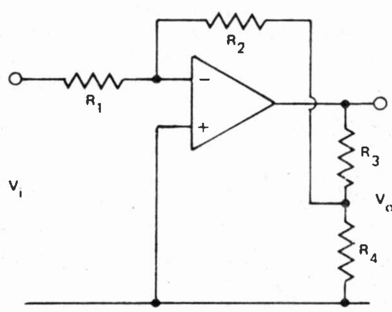


Fig. 1b. Inverting amplifier (high gain).

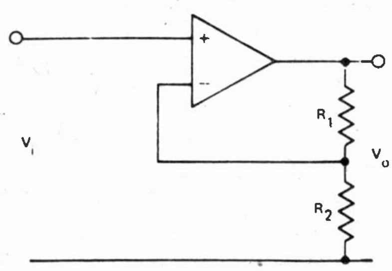


Fig. 1c. Non-inverting amplifier.

FEEDBACK

Operational amplifiers are most often arranged to function with negative feedback applied, although there are cases where either no feedback, or indeed *positive* feedback, is employed. The op. amps. we shall be considering have, in fact, two input terminals, and feedback is considered to be either negative or positive according to which of these inputs it is connected.

The two input terminals are arranged in the following manner. Consider that one input terminal is earthed; then if the application of a positive going signal to the other input results in a *positive* going output signal, then that latter input terminal is termed the "+ve" input terminal. Conversely, again with one input earthed, if the application of a positive going signal to the other input results in a *negative* going output signal, then that latter input terminal is termed the "−ve" input terminal. Sometimes the +ve input is called the "non phase inverting" input and the −ve input is called the "phase inverting" input.

By convention, the op. amp. itself is shown as a triangle, with the output being taken from the righthand apex; the two inputs are on the left, one input being the −ve and the other the +ve.

The arrangement of Fig. 1a will result in a phase reversal of the signal, while that of Fig. 1c will not. Accordingly, the first configuration is called an "inverting amplifier" and the second a "non-inverting amplifier".

TERMINOLOGY

Op. Amps have their own terminology which need expanation. These are frequently used when dealing with op. amps and without explanation could cause confusion. The terms are necessary because these devices do not have the ideal characteristics referred to earlier.

Open loop gain is the voltage gain of the amplifier at low frequencies with no feedback applied, ie with the feedback loop open. The value of 50,000 used as an example earlier is the open loop gain of the amplifier discussed.

Closed loop gain is the voltage gain of the amplifier when negative feedback is applied, ie with the feedback loop completed. It is thus the gain of the whole circuit and is analogous to the stage gain of valve and discrete-transistor circuits. The value of x2 we use below is the closed loop gain in that case.

Input bias current is that current that must be fed into the input terminals in order to make the output voltage zero. The current is necessary since the input transistors of the op. amp require some base current, however small, in order for them to conduct and so amplify.

Input Offset Voltage is that voltage that must be applied across the input terminals to make the output voltage zero. It is not usually as important as input bias current in the type of application that we shall be considering.

Common Mode Rejection is a measure of how good the amplifier is in rejecting signals applied to both inputs together. Once again, we will not need to pay great attention to this characteristic in our applications.

Frequency Response is usually quoted by stating the frequency at which the voltage gain falls to unity; it is then normally assumed that, as the frequency is reduced, the gain rises at a rate of 20dB per decade (i.e. the voltage gain rises by a factor of 10 for a ten-fold change in frequency) until it reaches the open loop value. It is then possible, with a knowledge of the open loop gain, to sketch the frequency response, see Fig. 2. Operational amplifiers have a response down to zero frequency, that is, they are dc amplifiers.

Towards the top end of the frequency range, slewing rate becomes important.

Slewing rate is the fastest rate of change of output voltage that the op. amp. can generate. Provided that the output voltage swing is small, say 1V peak-to-peak, the slewing rate limitation is unlikely to be a problem, even at a frequency close to the op. amp's maximum. However, if a large output voltage swing is called for, say 20V peak-to-peak at the same frequency, then slewing rate limitation can give rise to distortion; for clearly, at the zero crossing a large-amplitude signal will be changing its voltage as a faster rate than a signal of smaller amplitude.

For example the popular 741 IC may have a bandwidth of 100kHz to a small signal but the maximum slew rate of 1 volt/microsecond will limit bandwidth to 10kHz, if an output swing of 20V peak-to-peak or more is required, or to 40kHz at four volts peak-to-peak.

Slew rate thus limits the ultimate output swing available at high frequencies and is also a source of high-frequency distortion at high output levels.

The use of negative feedback will not cure the distortion for it is inherent in the op. amp. itself.

Each configuration has its own properties, which we shall now consider.

INVERTING AMPLIFIERS

Referring to Fig. 1c, consider an input, V_i at, say 1 kHz. Imagine that the input resistance of the op. amp. itself is so large compared to the values of R_1 and R_2 that it can be said to be infinite. This will be the case if R_1 is, say, 1 k, for the input resistance of a typical op. amp. is 1 M. Imagine also that the gain of the op. amp. is very much larger than the final gain of the whole circuit. Once again this will be so, for the gain of a typical op. amp. is 50 000 and the overall gain of the whole circuit will be very much less than this extremely high value, as will be shown.

This latter assumption is very important, for it means that the actual level of signals at the –ve input terminal will be so close to nothing that we can consider it to be zero. By Ohm's Law

$$I_1 = \frac{V_1}{R_1} = I_2 = \frac{V_2}{R_2}$$

where

V_1 is voltage across R_1

V_2 is voltage across R_2

But with zero signal at the –ve input

$V_1 = V_i$ and $V_2 = V_o$

so that the gain, A, is

$$A = \frac{V_o}{V_i} = \frac{V_2}{V_i} = \frac{R_2}{R_1}$$

which is independent of the actual gain of the op. amp., provided that the latter is very much larger than the value of A – very likely in practice.

It will be instructive at this point to consider the level of signal actually present at the –ve input of the op. amp. With an input signal of 1 volt and a circuit gain of x2, there will be an output of 2 volts. If the op amp gain is 50 000, then the level at the –ve input must be

$$\frac{2}{50\,000}.1 = 40\ \mu V,$$

quite close to the zero level assumed.

Note that when the amplifier output is fed back to the –ve input, the output voltage adjusts itself to such a value that the actual voltage between the two inputs becomes so close to zero that the difference can be neglected. The greater the gain of the op amp itself, i.e. the better it approximates to the ideal of infinite gain, the less the voltage at the –ve input becomes.

Since the –ve input has such a low level signal present, it is virtually at earth potential, and consequently the input resistance of the whole circuit is equal to R_1. Such an arrangement as illustrated in Fig. 1a is sometimes called a "virtual earth amplifier".

If a very high value of gain is required, complications can arise if a high input impedance is called for at the same time, for if R_2/R_1 is large, either R_2 will need to be such a high value that it is impracticable or R_1 will be too low for the required input impedance.

In that case, the configuration of Fig. 1b can be used. An analysis of this circuit gives, for the voltage gain

$$A = \frac{R_2}{R_1} \cdot \frac{(R_3 + R_4)}{R_4}$$

provided that R_2 is large compared to R_4.

Now R_1 can be kept at a reasonably high value (to raise the input impedance) with R_3 and R_4 making up the gain to the required level).

NON-INVERTING AMPLIFIERS

Now consider the non-inverting amplifier of Fig. 1c. As before, imagine that, due to the high gain of the op. amp., there is virtually zero signal between the two inputs and that the input resistance of the amplifier is very much greater than either R_1 or R_2.

Then $V_2 = V_i$ where V_2 is the voltage across R_2

$$\text{But } V_2 = \frac{R_2}{(R_1 + R_2)} . V_o$$

$$\therefore V_o = \frac{R_1 + R_2}{R_2} \cdot V_2$$

so that gain A is

$$A = \frac{V_o}{V_i} = \frac{(R_1 + R_2)}{R_2} \cdot \frac{V_2}{V_2} = \frac{(R_1 + R_2)}{R_2}$$

which again is independent of the actual gain of the op. amp. itself.

The input resistance of a non-inverting amplifier is very high, being determined largely by the impedance from the two input terminals to earth. Typically, it is of the order of 200 – 400 M at low and medium gain levels. It is this extremely high value of resistance that makes the non-inverting amplifier so useful, although, of course, there are disadvantages. For example, it might appear that a non-inverting amplifier would be ideal to accept the output from a high resistance source, but in

Op Amps

that case the resistance seen by the op. amp +ve input would be that source resistance, while the resistance seen by the −ve input will be R_1 and R_2 in parallel (Fig. 1c). The input bias currents (see later) at each input would then give rise to a voltage difference across the inputs and hence, of course, unwanted voltage offset at the output.

These two circuit configurations, namely, the inverting and the non-inverting, form the basis of all op amp circuitry and are well worth remembering. In a number of uses, the simple resistors used in the examples quoted are replaced by complex impedances of one kind or another in order to modify the frequency response in some way. By such means it is possible to make op amps respond as frequency selective amplifiers, integrators etc.

Examples of this tailoring of frequency responses will arise in the case of the audio amplifier to be described in part 3.

FREQUENCY COMPENSATION

Figure 2 shows the frequency response of a type 741 op amp it can be seen that the open loop gain starts to fall at frequencies above about 10 Hz. This is not to say that at higher frequencies useful gain cannot be obtained – it most certainly can. At 100 kHz for example, a closed loop gain of 20 dB is possible. However, the response of the 741 can be a limitation in some applications and then the 709 type amplifier is possibly preferred. The 709 is *never* used without some form of frequency compensation – it readily oscillates at around 10 MHz if none is employed – but does have the advantage that the values of the components used can be varied to provide various bandwidths, (Fig. 3). In practice, the values of the frequency compensation components are chosen to give just sufficient bandwidth for the application being considered. There is no real objection to employing values to give a greater bandwidth, but instability probems may then arise, and the noise level is liable to be greater.

As a point of historical interest, the 709 came before the 741 (it was itself preceeded by other op amps of reduced performance) and the need for the provision of external components proved irksome. Advances in technology enabled manufacturers to incorporate capacitors on the integrated circuit chip itself and so

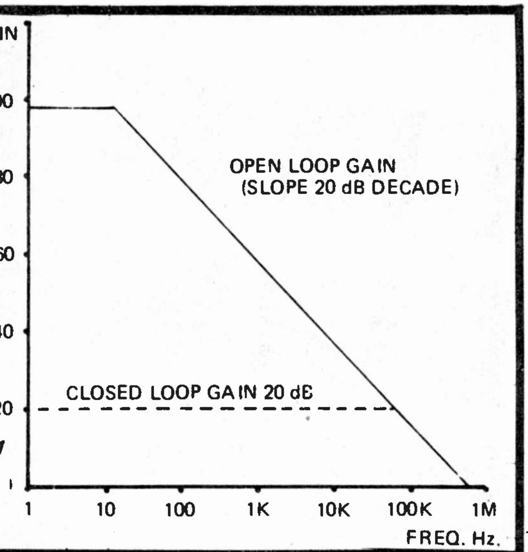


Fig. 2. Open loop gain of type 741 op amp and response with closed loop gain of 20 dB.

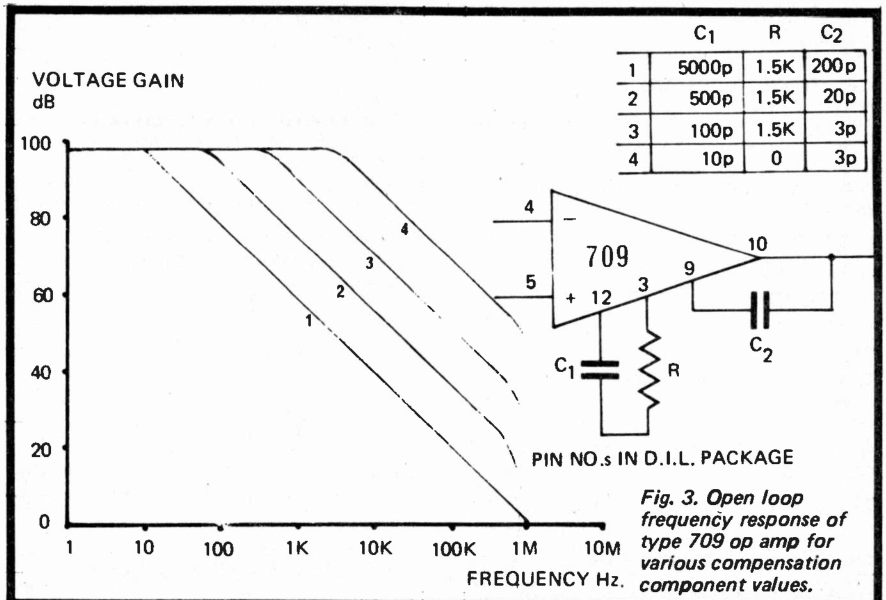


Fig. 3. Open loop frequency response of type 709 op amp for various compensation component values.

provide an op amp. that was stable without the need for large external components – thus the 741.

At the same time, the designers were able to provide protection at the input terminals, so that should either input have either supply rail connected to it (by a wiring error for example) no damage would be caused. The 709 in such circumstances, would have burned out its input transistors.

Further improvements were incorporated in the 748 op amp which is in some respects between the 709 and the 741, in that it requires one small external capacitor but provides a greater gain-bandwidth product than the 741.

With so many external connections – two supply rails, two inputs, one output and perhaps terminals for frequency compensation components – a special form of packaging was required and in fact there are two in common use. One, the T099, is similar to the common T05 transistor encapsulation in size of can but has eight lead-out wires. The other is the dual-in-line (DIL) package and it is recommended that the constructor uses this style, together with the appropriate holders. This will make it possible to check, to some extent, the dc conditions of the circuit when first wired up. This is done before the op amp itself is inserted thus perhaps preventing catastrophic failure of the device due to a wiring fault. Further, in those cases where a 709 is called for, it is possible to use a 741 for initial testing (although of course full performance in respect of frequency response might not then be obtained). Should an important wiring error have been made, damage is less likely to be caused to a 741 due to the built-in overload protection at its input terminals.

This for the average experimenter is all the theory that need be covered at the moment. Hence next month a start will be made on practical circuits, with details of the power supply and of the compact sine wave audio oscillator. ●

SELECTED BOOKS FROM ETI

Please list titles (with price) separately. Cheques, etc., to be payable to Electronics Today International and sent to:

ETI BOOK SERVICE, 25 Court Close, Bray, Maidenhead, Berks.

All prices include Postage and Packing.

ELECTRONICS SELF-TAUGHT WITH EXPERIMENTS AND PROJECTS
J. Ashe — **£2.20**
Covers basic principles of electronics. Projects include a large number of simple circuits.

TEST INSTRUMENTS FOR ELECTRONICS
M. Clifford — **£2.05**
How to build and use test instruments.

ELECTRONIC MUSICAL INSTRUMENTS
N. Crowhurst — **£2.05**
This book looks at the fascinating subject of electronic music from almost every angle.

EXPERIMENTING WITH ELECTRONIC MUSIC
R. Brown and M. Olsen — **£1.85**
Practical Experiments offer scope for originality and research.

BASIC MATHS COURSE FOR ELECTRONICS
H. Jacobowitz — **£1.70**
Ohms Law and all maths for electronics written in an easy, understandable way.

ELECTRONICS UNRAVELLED
J. Kyle — **£2.20**
A new commonsense approach to the basic principles of electronics.

DIGITAL ELECTRONIC CIRCUITS AND SYSTEMS
N. M. Morris — **£2.60**
The ideal book for the enthusiast confused by logic and digital techniques.

INDUSTRIAL ELECTRONICS
N. M. Morris — **£3.20**
The book concentrates mainly on semiconductor devices and circuits solutions to the many numerical problems are given, S.I. units are used throughout.

LOGIC CIRCUITS
N. M. Morris — **£3.10**
Aids the understanding of logical problems, discusses circuit principles including integrated circuits.

INTRODUCING AMATEUR ELECTRONICS
I. R. Sinclair — **£1.60**
The book for the complete novice of any age, as no previous knowledge is assumed.

BEGINNERS GUIDE TO ELECTRONICS
T. L. Squires — **£2.25**
A short cut for those wishing to obtain a quick acquaintance with modern electronics.

I.C. OP-AMP COOKBOOK
W. G. Jung — **£8.15**
Covers the basic theory of IC OP-Amp in great detail, also includes 250 practical circuit applications liberally illustrated.

TTL COOKBOOK
D. Lancaster — **£5.80**
Complete and detailed guide to TTL, how it works, how to use it and practical applications.

110 OPERATIONAL AMPLIFIER PROJECTS FOR THE HOME CONSTRUCTOR
R. M. Marston — **£2.10**
Outlines the essential characteristics of the OP AMP and presents 110 useful projects.

110 SEMICONDUCTOR PROJECTS FOR THE HOME CONSTRUCTOR
R. M. Marston — **£1.90**
This book introduces the reader to useful new devices such as the FET, SCR and IC, with full constructional details of many useful circuits.

UNDERSTANDING CMOS INTEGRATED CIRCUITS
R. Melen — **£3.25**
Begins with basic digital IC's, covers semiconductor physics, CMOS fabrication technology and design.

INTEGRATED ELECTRONICS
J. Millman — **£5.00**
Using an integrated circuits approach this text leads the reader step by step from semiconductor physics to devices, models, circuits and systems.

LINEAR IC PRINCIPLES, EXPERIMENTS AND PROJECTS
E. M. Noll — **£5.80**
An intro to one of electronic's most exciting devices.

DESIGNING WITH TTL INTEGRATED CIRCUITS
Texas Instruments — **£5.55**
Covers the entire family of TTL and practical applications of the circuits in digital systems.

OPERATIONAL AMPLIFIERS DESIGN AND APPLICATION
G. Tobey (Burr-Brown) — **£4.70**
Completely up to date, this work covers the entire field of operational amplifiers.

BEGINNERS' GUIDE TO TRANSISTORS
J. A. Reddihough — **£2.15**
Covers the basic theory and practice of modern transistors.

COLOUR TV THEORY
G. F. Hutson — **£4.65**
PAL Systems, principles and receiver circuitry for engineers, technicians and students.

TV SERVICING HANDBOOK
G. King — **£4.30**
Thoroughly practical handbook, deals in detail with modern receivers.

COLOUR TELEVISION SERVICING
G. King — **£4.90**
A practical handbook, dealing with all modern receivers.

MAZDA BOOK OF PAL RECEIVER SERVICING
D. Seal — **£5.30**
A practical handbook with over 200 illustrations.

THE OSCILLOSCOPE
G. Zwick — **£2.10**
Starts from the first principles and takes the reader to an advanced level

HOW TO USE VECTORSCOPES, OSCILLOSCOPES AND SWEEP SIGNAL GENERATORS
S. Prentiss — **£1.95**
It goes into the whole subject deeply, in 250 heavily illustrated pages

99 WAYS TO USE YOUR OSCILLOSCOPE
A. Saunders — **£1.80**
Describes how to solve practical problems using a scope.

WORKING WITH THE OSCILLOSCOPE
A. Saunders — **£1.85**
A book devoted to circuits and illustrations of waveforms that should be present.

HOW TO USE YOUR VOM VTVM AND OSCILLOSCOPE
M. Clifford — **£1.80**
This book aims to give you knowledge and help you perform a wide variety of essential tests on many different kinds of sets, appliances and equipment

Now...the most exciting Sinclair kit ever

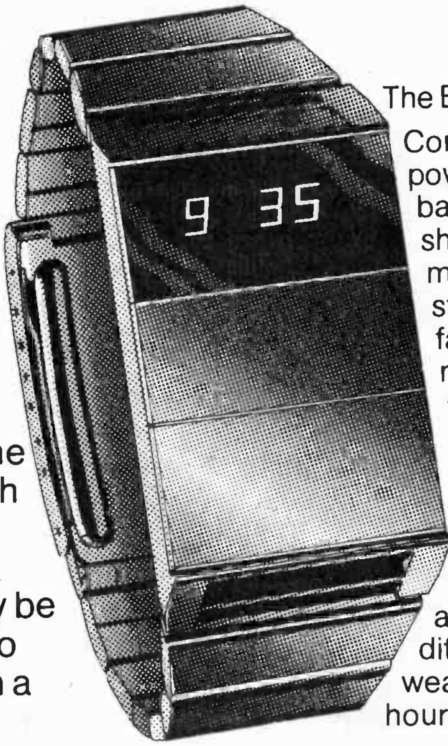
The Black Watch kit

At £17.95, it's

★ **practical** – easily built by anyone in an evening's straightforward assembly.

★ **complete** – right down to strap and batteries.

★ **guaranteed.** A correctly-assembled watch is guaranteed for a year. It works as soon as you put the batteries in. On a built watch we guarantee an accuracy within a second a day – but building it yourself you may be able to adjust the trimmer to achieve an accuracy within a second a week.



The Black Watch by Sinclair is unique. Controlled by a quartz crystal... powered by two hearing aid batteries... using bright red LEDs to show hours and minutes and minutes and seconds... it's also styled in the cool prestige Sinclair fashion: no knobs, no buttons, no flash.

The Black Watch kit is unique, too. It's rational – Sinclair have reduced the separate components to just four.

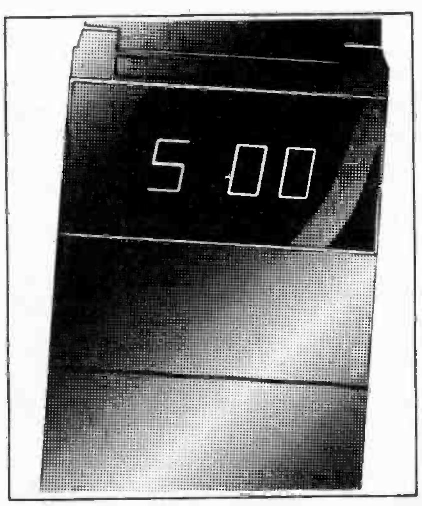
It's simple – anybody who can use a soldering iron can assemble a Black Watch without difficulty. From opening the kit to wearing the watch is a couple of hours' work.

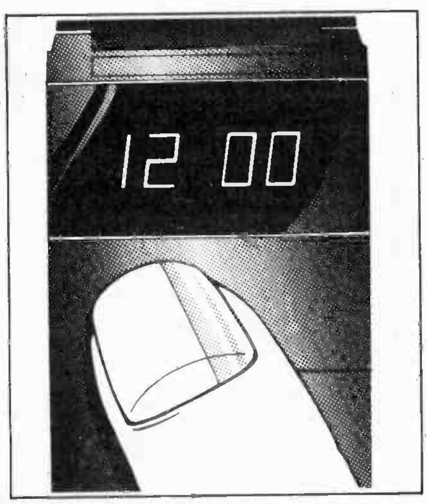
The special features of The Black Watch

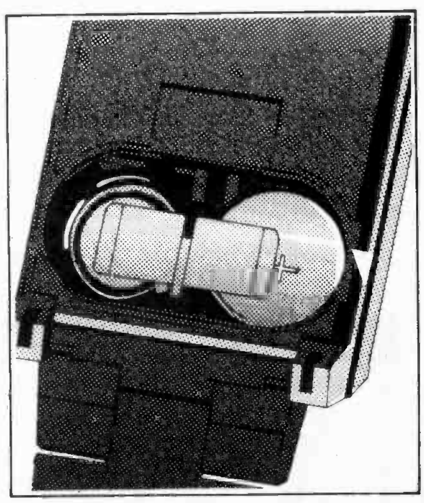
Smooth, chunky, matt-black case, with black strap. (Black stainless-steel bracelet available as extra – see order form.)

Large, bright, red display – easily read at night.
Touch-and-see case – no unprofessional buttons.

Runs on two hearing-aid batteries (supplied). Change your batteries yourself – no expensive jeweller's service.







The Black Watch–using the unique Sinclair-designed state-of-the-art IC.

The chip...
The heart of the Black Watch is a unique IC designed by Sinclair and custom-built for them using state-of-the-art technology–integrated injection logic.

This chip of silicon measures only 3 mm x 3 mm and contains over 2000 transistors. The circuit includes

a) reference oscillator
b) divider chain
c) decoder circuits
d) display inhibit circuits
e) display driving circuits.

The chip is totally designed and manufactured in the UK, and is the first design to incorporate *all* circuitry for a digital watch on a single chip.

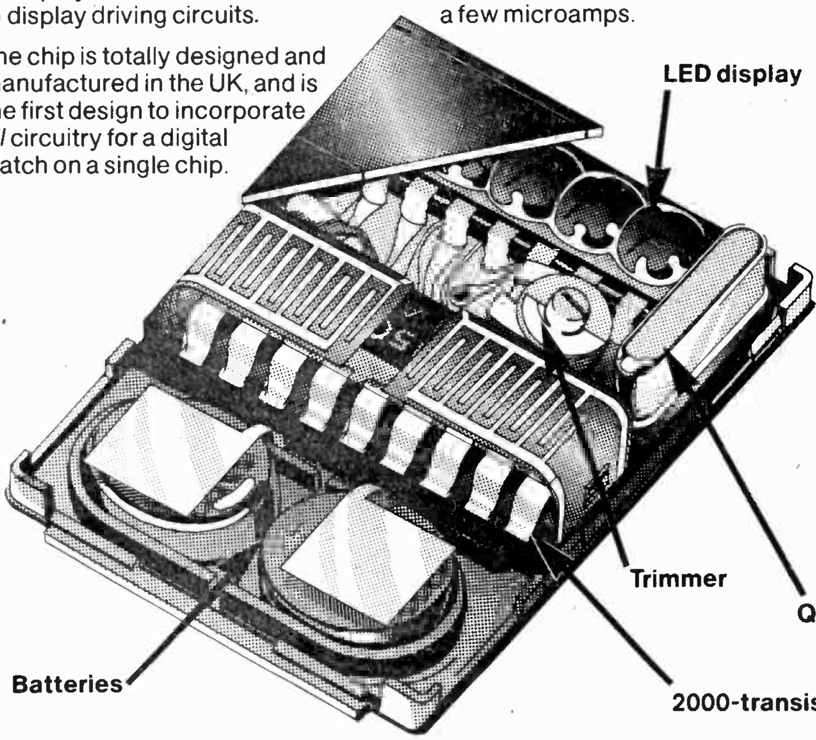
...and how it works
A crystal-controlled reference is used to drive a chain of 15 binary dividers which reduce the frequency from 32,768 Hz to 1 Hz. This accurate signal is then counted into units of seconds, minutes, and hours, and on request the stored information is processed by the decoders and display drivers to feed the four 7-segment LED displays. When the display is not in operation, special power-saving circuits on the chip reduce current consumption to only a few microamps.

Complete kit £17.95!

The kit contains

1. printed circuit board
2. unique Sinclair-designed IC
3. encapsulated quartz crystal
4. trimmer
5. capacitor
6. LED display
7. 2-part case with window in position
8. batteries
9. battery clip
10. black strap (black stainless-steel bracelet optional extra–see order form)
11. full instructions for building and use.

All you provide is a fine soldering iron and a pair of cutters. If you've any queries or problems in building, ring or write to the Sinclair service department for help.



Take advantage of this no-risks, money-back offer today!

The Sinclair Black Watch is fully guaranteed. Return your kit within 10 days and we'll refund your money without question. All parts are tested and checked before despatch–and correctly-assembled watches are guaranteed for one year. Simply fill in the FREEPOST order form and post it–today!

Price in kit form: £17.95 (inc. black strap, VAT, p&p).

sinclair

Sinclair Radionics Ltd,
London Road, St Ives,
Huntingdon, Cambs., PE17 4HJ.
Tel: St Ives (0480) 64646.
Reg. no: 699483 England. VAT Reg. no: 213 8170 88.

To: Sinclair Radionics Ltd, FREEPOST, St Ives, Huntingdon, Cambs., PE17 4BR.

Please send me — Total £

.... (qty) Sinclair Black Watch kit(s) at £17.95 (inc. black strap, VAT, p&p). ....

.... (qty) black stainless-steel bracelet(s) at £2.00 (inc. VAT, p&p). ....

* I enclose cheque for £................................., made out to Sinclair Radionics Ltd and crossed.

* Please debit my *Barclaycard/Access/American Express account number

....

Name ______________________________

Address ______________________________

____

______________________________ ETI 12

Please print. FREEPOST–no stamp required. *Delete as required

MULTIMETER GUIDE

How to choose a meter to suit your needs

THE BUDDING experimenter, after purchasing a basic set of tools, commences building small circuits at the earliest opportunity. Very rapidly he meets the situation where a circuit, as built, does not work. So what now? If all wiring has been done correctly then it must be a faulty component — but which one? The simplest way to find out is to use a meter to measure voltages around the circuit.

Thus the first instrument that an electronics experimenter will buy will be some kind of multimeter capable of measuring the common ranges of voltage, current and resistance found in usual circuitry.

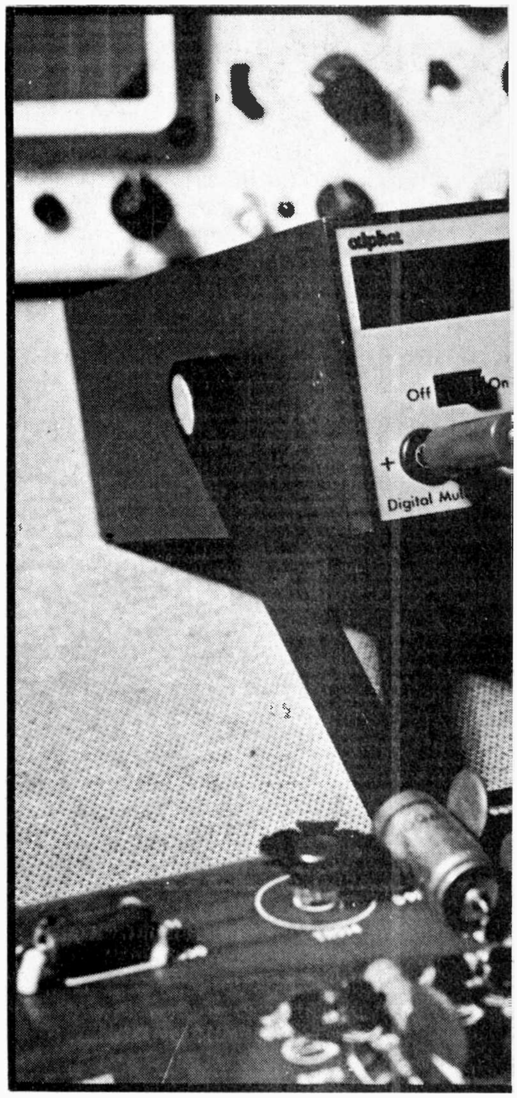
Upon investigating what is available the experimenter discovers that multimeters range in price from simple analogue meters at £4 to sophisticated, highly-accurate digital instruments costing several hundreds of pounds.

The experimenter must ask himself — which is the most suitable for his class of work? Is it really necessary to spend several hundred of pounds? Are £4 multimeters worth having at all?

In this article we examine the factors which must be considered when selecting a multimeter in order to satisfy the conflicting requirements of minimum expense and suitability.

When selecting a multimeter the following factors are of importance:

Input impedance
Accuracy
Resolution
Ruggedness
Number of ranges
Frequency response
Portability.



INPUT IMPEDANCE

A multimeter must have as high an input impedance as possible if the circuit under test is not to be severely loaded. Loading leads to substantial errors in the measurement and, if severe, may even damage components.

The input impedance of analogue meters is usually expressed in ohms per volt. Thus the impedance depends on the voltage range selected. Typical inexpensive meters have impedances of 1000 to 100,000 ohms per volt. Thus when measuring voltage a multimeter is in effect a resistor in parallel with the resistor (across which the voltage is being measured) within the circuit and it reduces the effective value of both — to something lower than the value of either. Thus, as a voltmeter is in effect a resistor, connecting it across a circuit will inevitably change the resistance of that circuit, and the meter must shunt current away from the circuit.

This brings us back to the reason for quoting the sensitivity of voltmeters in ohms per volt. Multiplying the sensitivity by the fsd range in use, gives the resistance of the meter circuit that will be shunting the component. Cheaper multimeters will have sensitivities ranging from as low as 1000 Ω/volt to as high as 100k Ω/volt

To illustrate loading effects, consider the circuit in Fig.1. By Ohms law we know that the voltage between points A and B is 0.75 volts.

Now let us see what happens when we use a 1000 ohms/volt meter on the 1 volt range to measure this voltage. The 1000 ohms of the meter in

THE MOVING-COIL METER

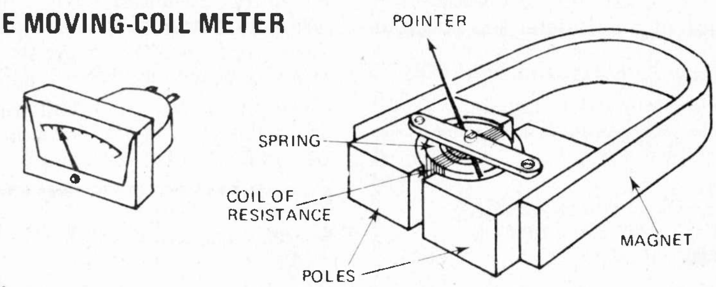


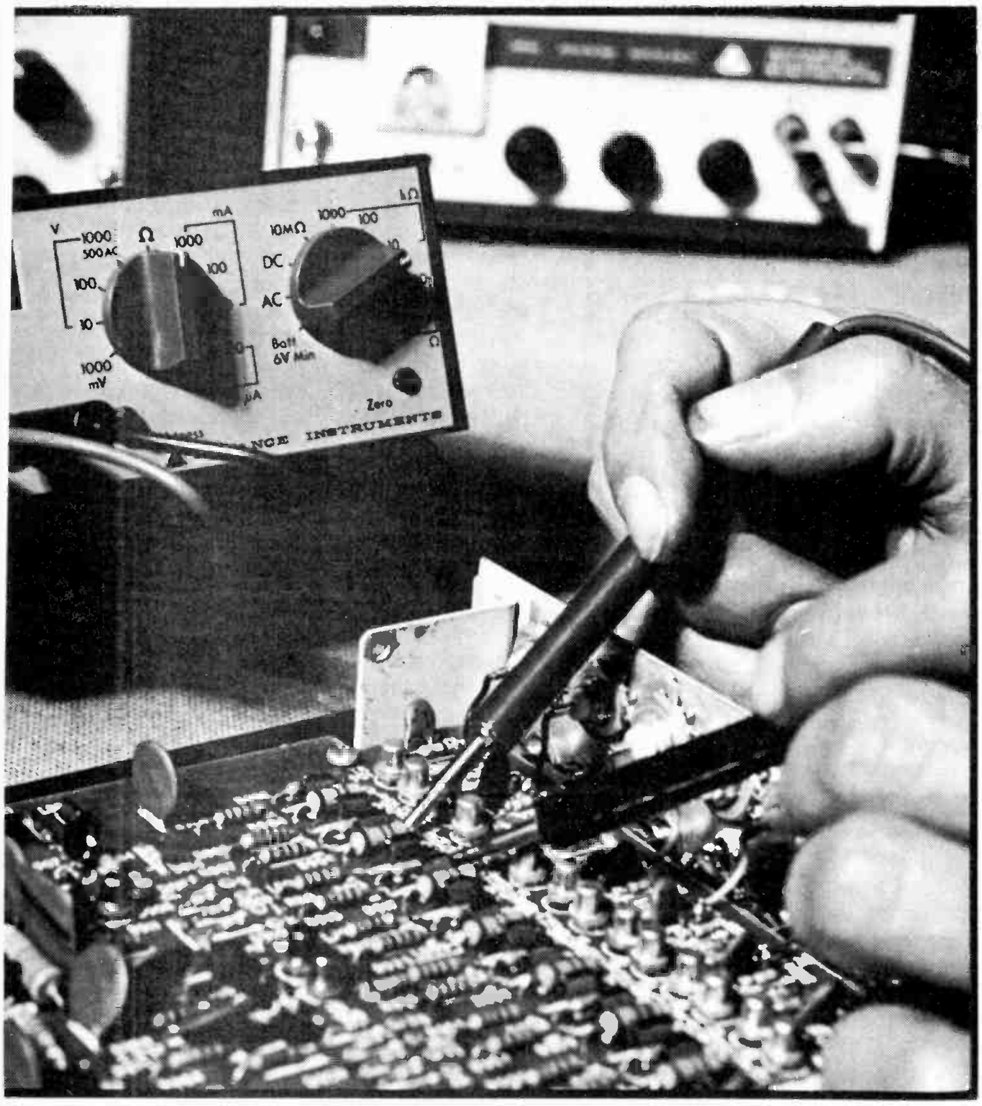
Fig. A.

If an electromagnetic coil is suspended in the field of a permanent magnet, it will be caused to rotate, when energized, by a force proportional to the energizing current.

In the moving-coil type of meter, as Fig.A shows, the field of the permanent magnet is arranged to pass across a cylinder in which hangs the coil of the meter. A fine spiral tension-spring restrains the rotation by providing a linearly increasing torque as the coil rotates. Attached to the coil is a pointer that moves across a scale, thus indicating current.

As the number of turns is increased, to improve sensitivity, the designer must use finer wire to keep the mass of the coil small. As a consequence of this requirement, sensitive meters usually have a higher resistance, and are more delicate.

When using any meter with switched ranges, always start off by selecting a meter range much higher than your estimate of the quantity to be measured.
This precaution safeguards the meter should the quantity be much larger than expected.



parallel with R2 will produce a combined value of 500 ohms. Thus the voltage read by the meter will be 0.5 volts instead of 0.75 volts — an error of 33 per cent!

It is the degree of this shunting effect that is important — in theory it can never be completely avoided, for some energy must flow into the measuring system from that being measured. In electronic measurements the rule of thumb is that for accuracy, the resistance of a voltmeter should be at least ten times that of the circuit — a hundredfold is better still.

However with the simple moving-coil type of meter a higher input impedance also requires a delicate meter movement which is relatively easily damaged. A good compromise would seem to be a meter having an ohms/volt rating of between 10 000 and 50 000.

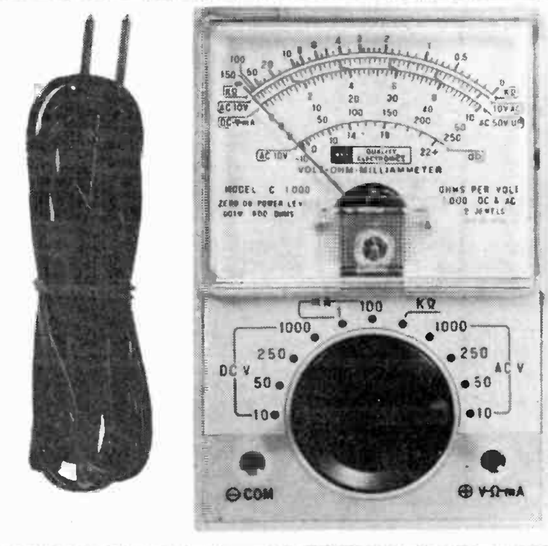
In more expensive meters — those employing electronic amplifiers and those using digital techniques, input impedances are usually at least one megohm and hence loading of the circuit is seldom a problem.

ACCURACY

The typical cheap multimeter has an accuracy of the order of 3 to 5% and this is further reduced by parallax reading errors. Better quality analogue instruments have 1% accuracy and mirror backed scales to reduce parallax reading errors.

Digital multimeters are at least 1% or better, with 0.2% being typical. Sophisticated units costing several hundreds of pounds may well have accuracies down to 0.001%. The way accuracy for a digital meter is quoted is far from being as simple as given here, but for our present purposes the simple statement given suffices.

As to what accuracy is needed, it is seldom that an experimenter, even one at fairly advanced level, needs an accuracy better than 1% and, mostly, even the 3 to 5% of a simple meter is good enough. So don't get carried away by accuracy, if you can afford 1% or better — great. But you will not be too badly off if you can't.



Typical of the inexpensive multimeter available this 1000 ohm/volt unit is suitable for general electrical work.

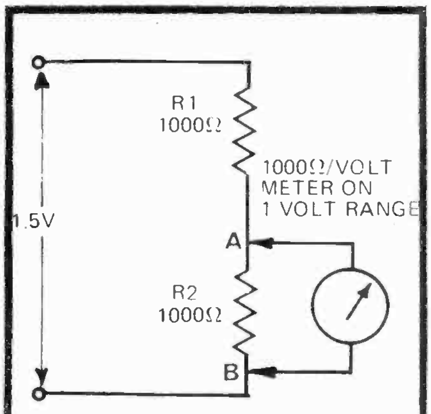
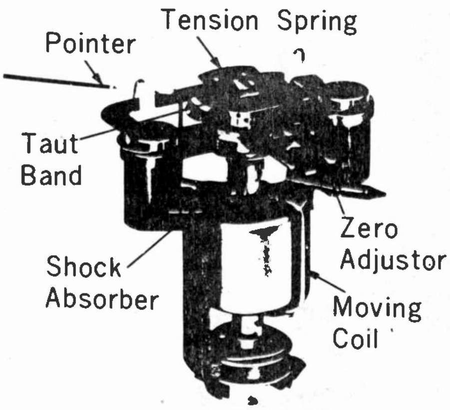


Fig. 1. Meter loading of the circuit can drastically increase reading error.

MULTIMETER GUIDE

TAUT BAND SUSPENSION SYSTEM



Better quality analogue multimeters usually employ a taut band suspension system in the meter movement. This system, although more expensive, has several important advantages over conventional moving coil movements.

The movement still employs the moving coil principle but now the coil is suspended by means of a platinium alloy band. Since, now, no pivots, jewels or hair springs are used errors due to pivot friction and roll of the jewel are completely eliminated. Additionally the meter will maintain correct reading regardless of orientation.

A shock absorber is usually fitted to the movement that incorporates dual bumper stops. Thus the movement is rendered insensitive to mechanical shock.

The use of a taut band movement ensures good linearity, freedom from backlash, freedom from effects of vibration and shock and much greater instrument reliability.

RESOLUTION

Resolution is often more of a limitation than is accuracy for, if the meter movement is small, it is difficult to read accurately. For example, when trying to read 1.5 volts on a 10 volt full scale meter, it may only be possible to say that it is somewhere between 1 and 2 volts. Hence the bigger the movement the better.

In the case of a digital meter the resolution is a function of the number of digits in the display. Thus a three digit display (999) can resolve to one part in 1000 and hence the accuracy must be better than 0.1% to make full use of the available resolution. Conversely it is little use having more than three digits in the display if the accuracy is only 1%.

RANGES

Any meter must be able to measure dc volts and current, ac volts and current and resistance to really qualify as a full multimeter. Some instruments also include dB calibration and the facility to measure capacitance.

DC voltage should have ranges from 1 to 2.5 volts full scale to 500 and preferably 1000 volts full scale. AC volts should cover from 2.5 volts full scale to at least 300 volts full scale. The lowest current range should be 1 mA full scale, or better, and the maximum reading should be at least one ampere.

Resistance scales should enable you to read from one ohm to at least one megohm with reasonable accuracy. Note that on cheaper meters cramming at the top of the ohms scale will prevent reading values in excess of 100k ohm at all.

Finally the ranges should ascend in the 1, 3, 10 ratio at least. Ten to one scale ratios lead to some difficulty in reading voltages that are just in excess of one range. For example assume a meter has 1, 10 and 100 volt ranges and is quoted as having an accuracy of 3% of full scale. Now let us suppose we are trying to measure 1.1 volts. We cannot read it on the one volt scale as the meter would read over range. On the ten volt scale we read about one volt but our accuracy on the ten volt range is 3%, that is, ± 0.3 volts. So the best we can say is that the voltage is between 0.7 and 1.3 volts. Hardly satisfactory for working on transistor amplifiers for, with this measurement, we would not be sure whether it was one or two base emitter junctions (0.6 to 0.7 volts per junction for silicon).

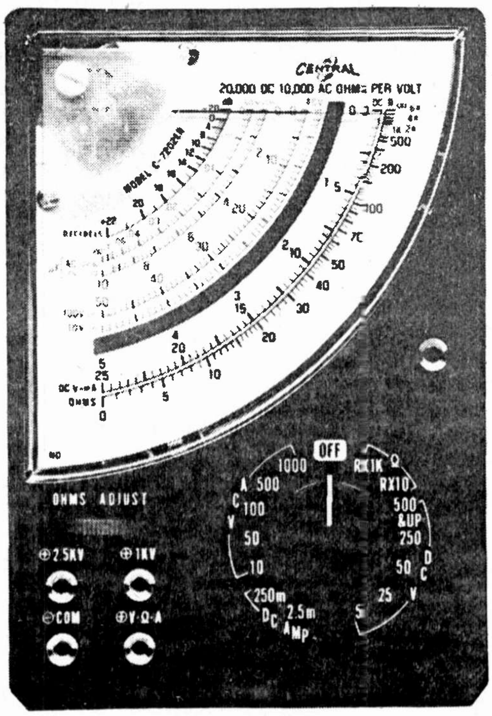
Had we a meter with a 3 volt range we would have read around 1.1 volts with an accuracy of ± 0.09 volts and the degree of ambiguity would have been vastly decreased.

RUGGEDNESS

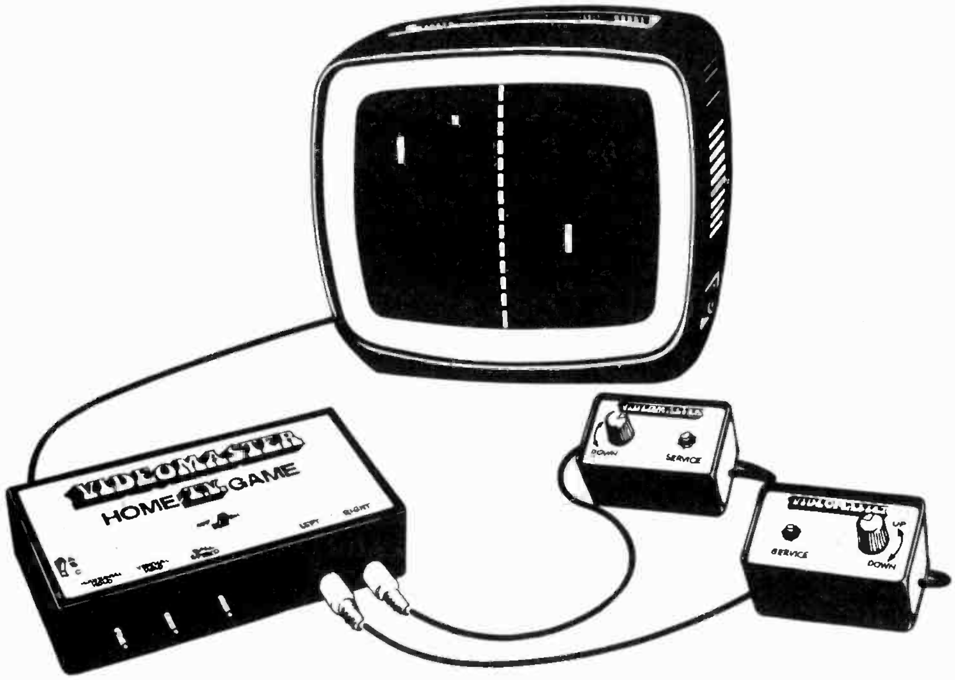
Drop a £4 multimeter and you may as well not bother to pick it up. The case will probably shatter and the meter movement will almost certainly be ruined. The more expensive units have poly-carbonate cases which could be bounced off a concrete floor (if you are game enough). The more expensive units will also probably use a taut-band meter movement rather than the simple moving-coil variety. Taut-band movements are virtually impervious to shock.

Some years ago we bounced such a

Continued on page 59



This 20,000 ohms/volt unit has a corner meter movement which allows a much greater scale length to be obtained in a small meter.



Videomaster urge all good electronics enthusiasts to play the game

The best thing about the Videomaster Home T.V. Game Mk. III is that the sheer pleasure of building it is immediately followed by the excitement of playing three fascinating games.

The famous Videomaster is now available for you to make. It plugs into any standard UHF 625 line TV set, and it shouldn't take you longer than a few hours to build.

In detail . . . The Videomaster Mk. III has eleven integrated circuits . . . four transistors . . . eleven diodes . . . is easy to build . . . with no alignment necessary because with ready-built and tested transistorized UHF modulator, is complete with all parts . . . including fully drilled and prepared p.c.b. . . . handsome plastic box . . . control leads . . . complete step by step assembly instructions . . . Runs on a PP7 9 volt battery . . . and has logic and analogue "state of the art" circuitry all with National Semiconductors CMOS devices . . . with full specification.

The cost? Only **£19.95** (+ VAT)

POST TODAY TO:

Videomaster Ltd

119/120 Chancery Lane, London WC2A 1QU

Please send me . . . . (insert no.) Videomaster Mk. III kits at £21.55 ea. inc. VAT. P & P

I enclose my cheque/money order for £. . . . .

Tick if VHF Modulator required ☐ –£1 extra

NAME

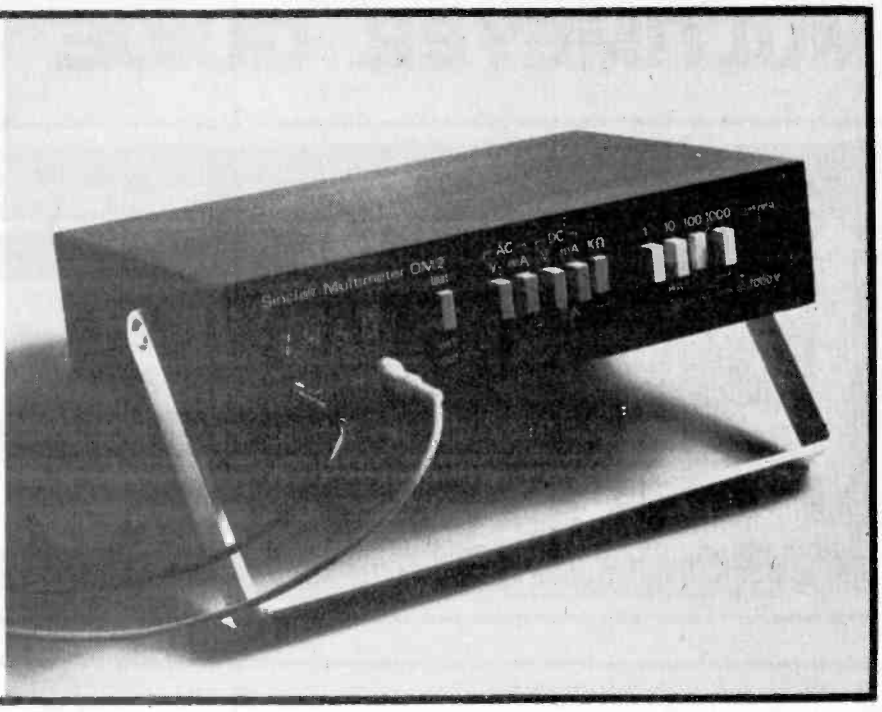
ADDRESS

ETI/3

ALLOW 14 DAYS FOR DELIVERY

IMPORTANT: PLEASE SEE ANNOUNCEMENT P.80

MULTIMETER GUIDE



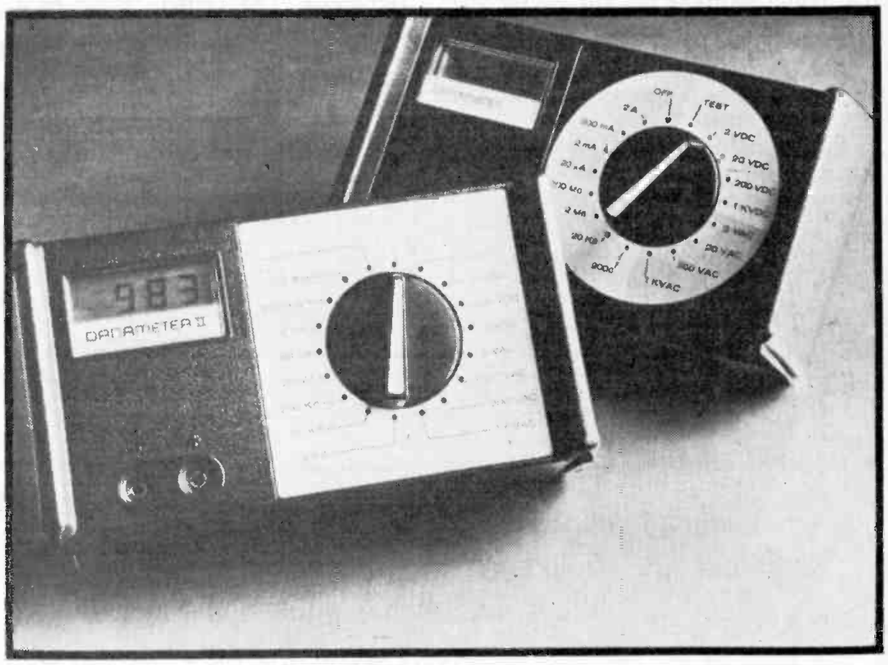
The Sinclair DM2 Multimeter is powered by a single 9V battery which gives up to 60 hours life. It features automatic dual polarity, automatic over-range and overload indication. The carrying handle doubles as a support for bench top use. Cost is around £65.

Continued from page 56

taut-band meter off the floor hundreds of times (in order to take photographs) without any damage occuring to the meter whatsoever (a Weston 660 series multimeter).

Ruggedness is very much a function of price. The more you pay the better the case and the movement used. The switches will also be larger, more robust and with silver-plated contacts. So although a £4 meter may appear to offer the same facilities as a more expensive unit it will certainly not last as long.

Steer clear of ultra-miniature meters. These are very fragile as well as being difficult to read. If you can afford it buy a meter with a taut-band movement – they are expensive but will be worth the money.



These Danameters are the cheap end of the range from Dana Laboratories. AC accuracy is 1.15% (Danameter) and 0·6% (Danameter II); prices are £135 and £168.50.

FREQUENCY RESPONSE

The ac ranges of a multimeter are of little value if the frequency response of the instrument only extends to a few hundred hertz. Such an instrument would only be useful for measuring 50 Hz mains voltages.

If possible obtain a meter that has a frequency response that at least covers the audio spectrum. This is almost indispensable if you are working on audio equipment and do not have a cathode-ray oscilloscope.

PORTABILITY

Most multimeters are portable as the simple kinds only require a couple of dry cells to power the resistance measurements. Multimeters that have amplifiers built in are sometimes restricted to mains only operation.

For the experimenter a multimeter should definitely be capable of battery operation. Therefore if a transistorized or digital multimeter is to be purchased make sure that it has rechargeable cells or is capable of running for extended periods on dry cells. Mains only types are fine for the laboratory but not for the hobbyist.

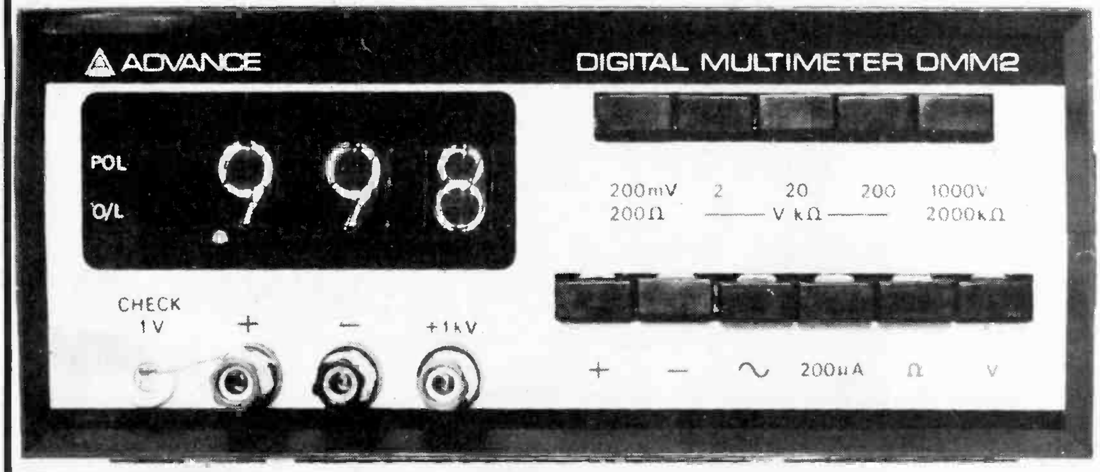
ANALOGUE OR DIGITAL

An analogue measurement is essentially one that is made continuously. A digital measurement on the other hand is made in a series of discrete steps.

The same basic quantities can be measured by both digital and analogue methods. For example, a conventional clock has a pair of hands which traverse a calibrated dial in a continuous sweep, and there is a theoretically infinite number of steps between any two calibrated points on the clock face – measurement is continuous and is therefore an analogue process.

A digital clock on the other hand indicates the time in discrete steps, each of one minute (or one second).

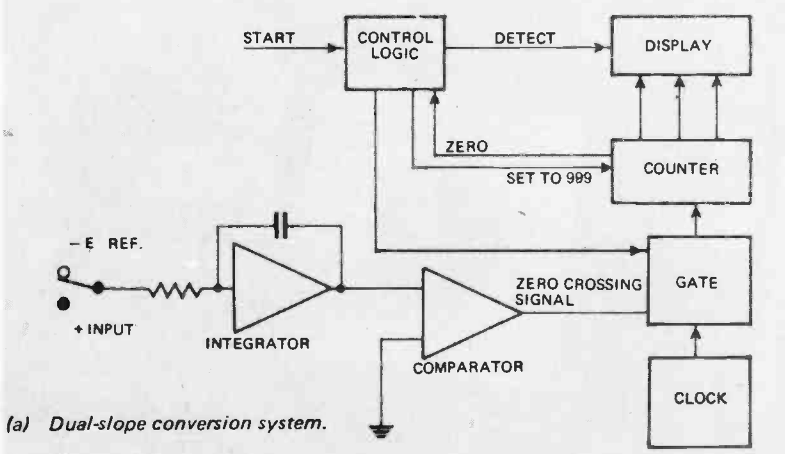
MULTIMETER GUIDE



For £121 you can have this digital mulitmeter from Advance. It has 0.2% accuracy.

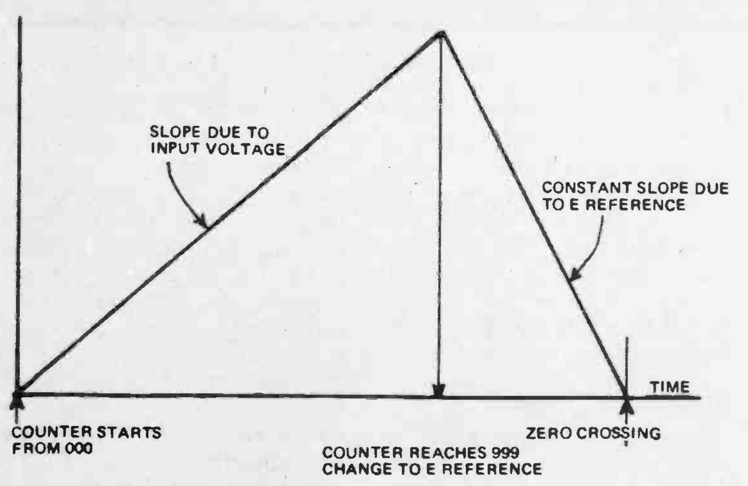
DUAL SLOPE A/D CONVERSION

There are several modes of operation of digital multimeters but by far the most commonly used in cheaper instruments is the DUAL SLOPE technique. The system, assuming a 3 digit display, works as follows: –



(a) Dual-slope conversion system.

(b) The counting procedure.



Initially when an unknown voltage is applied to the input a 'start conversion' pulse is generated and simultaneously all the counters are set to zero.

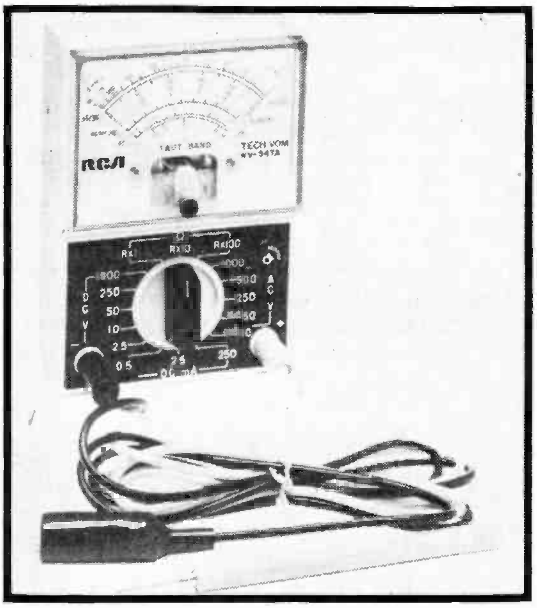
The integrator, which may be a simple operational amplifier design, begins to ramp up with a slope which is proportional to the magnitude of the input voltage. At the same time clock pulses are gated to the counters which commence to count up.

Control logic detects when the count reaches 999 and gates off the input voltage and gates on a reference voltage. The reference voltage is opposite in polarity to the input voltage and the integrator therefore begins to ramp down with a slope proportional to the reference voltage and the counter reverses. The process continues until zero voltage is reached.

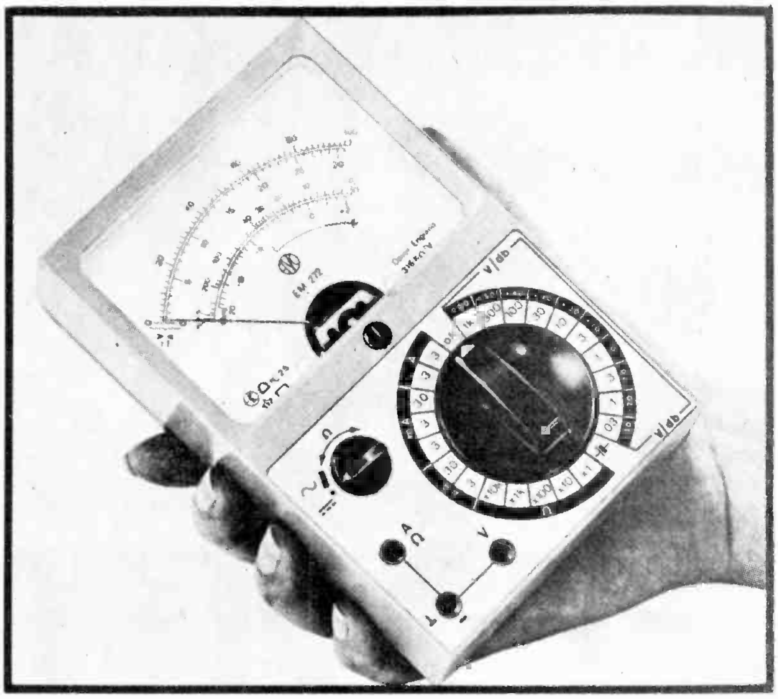
At this zero point a comparator closes the clock pulse gate, the counter stops and now holds a count proportional to the input voltage.

Design requirements for the integrator and clock accuracies are much less stringent with this technique than with others because both input ramp and reference ramp use the same circuitry. Hence component inaccuracies tend to cancel out and accuracy becomes dependent mainly on the stability of the reference voltage and, if used, the input attenuator and amplifier. The dual slope method provides good rejection of normal-mode noise.

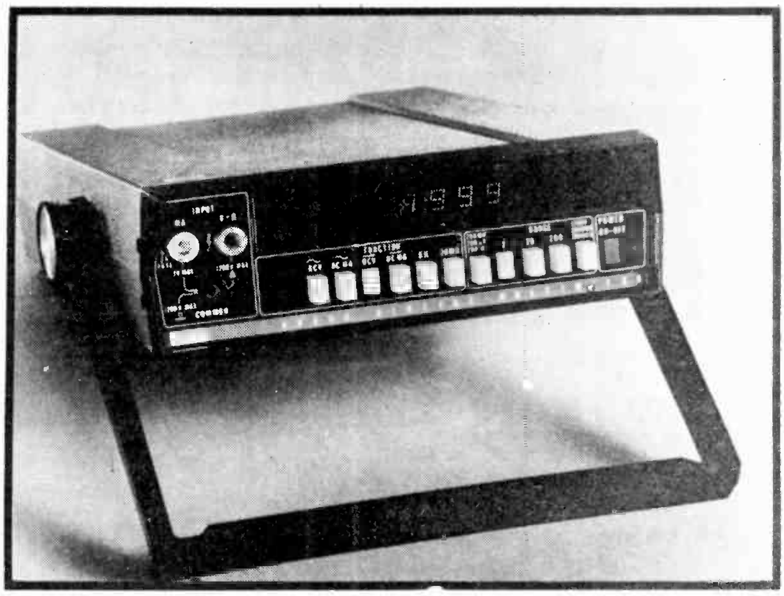
The dual-slope conversion provides the basic voltage measurement capability additional circuitry being added to measure resistance, dc current and ac voltage and current.



The Tech VOM is a 20kΩ/V multimeter. It costs £10.50 from RCA Components, Sunbury-on-Thames.



This electronic multimeter from AVO features 10 Meg impedance on dc and 316kΩ/V on ac. The 39 ranges of this instrument cover all the measurements you are likely to need.



The Fluke 8000A digital multimeter offers 0.1% accuracy with three and a half digits.

There is no ambiguity of reading. It is either 8:23 or 8:24 one cannot misread it.

This is one of the great advantages of digital readouts. There are no reading errors due to parallax or scale resolution, and in the case of electronic digital instruments no friction or hysteresis to cause mechanical errors.

Hence even the cheapest of digital multimeters has better than 1% accuracy, (actually accuracy should be stated the other way — a meter is 99% accurate, not 1%). whereas an analogue meter with a mechanical movement of 1% accuracy is quite expensive and still subject to further reading errors caused by parallax and scale resolution.

Until recently digital multimeters were priced beyond the reach of the amateur experimenter the cheapest being well over £100. However now there is a choice, albeit restricted at less than £100.

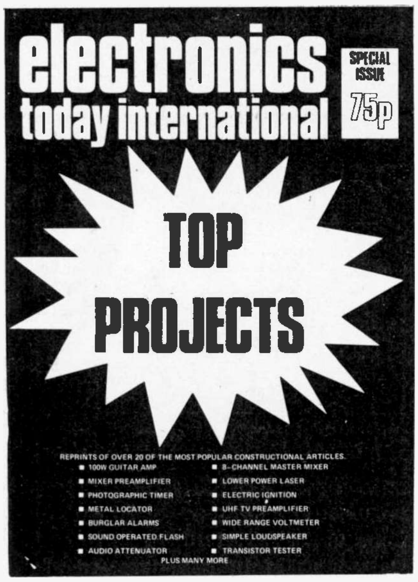
Such prices make the digital instrument competitive in price with the best of analogue transistorized multimeters and — they have better accuracy.

All digital multimeters have input impedances of one megohm or better and hence loading is seldom a problem with such instruments.

Digital instruments are sensitive to noise and a dc voltage with superimposed hum and noise may give incorrect and/or jittery readings on some instruments. Analogue instruments on the other hand tend to reject and average out superimposed noise.

It is doubtful that digital meters will ever completely replace analogue meters. But they will almost certainly replace those at the higher priced end of the analogue range. ●

TWO GREAT SPECIALS FROM ETI



No. 1, now available only from ETI, (100 pages)

ETI Top Projects Books contain reprints of some of the most popular projects from past issues.

No. 1, with 21 projects, was originally published in October 1974 and No. 2, with 26 projects, in July 1975.

IF BOTH COUPONS ARE SENT TOGETHER, IGNORE POSTAGE! SEND ONLY £1.50.

No. 2, from newsagents and ETI, (124 pages)

TO: TOP PROJECTS NO 1
Electronics Today International,
36 Ebury Street,
London SW1W 0LW.

Please send me a copy of TOP PROJECTS NO 1.
I enclose a cheque/P.O. for 85p, payable to Electronics Today International, which includes 10p postage.

Name ______________________

Address ______________________

____

____

December 75

TO: TOP PROJECTS NO 2
Electronics Today International,
36 Ebury Street,
London SW1W 0LW.

Please send me a copy of TOP PROJECTS NO 2.
I enclose a cheque/P.O. for 90p, payable to Electronics Today International, which includes 15p postage.

Name ______________________

Address ______________________

____

____

December 75

MHI KIT SYSTEM

MHI (Monolithic Horometric Integration) is a complete module system to enable the building of digital timing circuitry. Two basic modules are required for each system: one clock or counter kit plus one display kit. Each of the six display kits is compatable with any of the clock kits and thus you can decide which display size or how many digits you require quite independently from your choice of clock kit.

Most of the PCBs for the clock kits are 2in × 4in with the exceptions being only slightly larger, the PCB contains spaces for all of the basic components excluding switches, transformer and display. Each clock kit includes main LSI chip plus socket, segment driver chip, PCB and may also include any other unusual components. The kits exclude resistors, capacitors, transistors and switches which are all easily obtainable types and values. All clock kits will interface to any MHI display kits or to any other common-anode LED displays.

MHI-5039 (UNIVERSAL COUNTER)

Uses a new counter chip from MOSTEK (MK50395) and will count up or down at speeds of up to 1MHz with a total system speed of 400kHz. Count and compare registers can be loaded from logic ICs or BCD switches, features count inhibit, display latch, display decode. Outputs: 6 digit drives, BCD and 7-segment, count = compare, count = zero, etc. Applications include: very fast stopwatch, sequence timers, 'auto-cue' for tele-cine, batch counters, repeatable "pill" counters, etc.

Interfaces with any six digit MHI display kit
£24.00 + VAT

MHI-5024 (DIGITAL STOPWATCH KIT)

Based on the MOSTEK MK50204 chip the MHI5024 is a modified calculator chip which will still function as an 8-digit four-function calculator but has the additional facilities of conversion of hours, minutes and seconds to seconds or vice-versa. The Chip will also count in Hours, Minutes, Seconds and tenths with start/stop/reset facilities. The timing source for the counting is an RC network set to run at 140 KHz.
The Kit includes: MK50204, 28-pin skt., CA3081 segment driver and P.C.B. £14.00 + VAT.
(For H.MM.SS.s use MHI-D7x7/6, for M.SS.s use a four-digit MHI display).

MHI-5378 (DIGITAL CAR CLOCK KIT)

Uses the new National MM5378 Auto-Clock chip. The Chip has full car/boat clock facilities with a voltage range of 9-20v with no-loss-of-time down to 5v. Timing source is a 2.097152 MHz Quartz Crystal which is driven and divided by the chip. Facilities include: (i) display on/off switching with ignition leaving the clock running at all times (draws about 5mA). (ii) display brightness control. MM5738 kit skt CA3081, 2MHz Xtal and Trimmers, P.C.B. £15.10 + VAT. (Interfaces with MHI four-digit displays kits).

MHI-5314 (BASIC CLOCK)

Uses National MM5314 chip to give a four or six digit clock with 12/24 hour readout from 50/60Hz supply. This kit and chip are so simple that no previous electronics experience is really necessary to have an electronic clock working within a couple of hours. £6.60 + VAT.

MHI-5025 (ALARM CLOCK)

For a digital bedroom clock with accurate alarm time, snooze facility and display brightness control. Six digit output in 50Hz, 24-hour format. Alarm tone oscillator is on-chip and will drive small loudspeaker with single transistor interface. Very simple to assemble. £9.35 + VAT.

MHI-5023 as MHI-5025 but with 12/24 hour option. £9.35 + VAT.

MHI-7001 (ALARM/DATE/TIMER)

A six digit clock with optional display of date. Has switched alarm output and a switched timer (clock/radio, "sleep") output. Apart from being a very unusual clock this kit can be used for remote switching of tape recorders, etc. We advise the use of a six digit readout with this kit. £10.00 + VAT.

The DL707 display is a standard 0.3in LED display readable from distances of 10 feet or so. Four or six digits plus a PCB.
MHI-D707/4 £6.60 + VAT
MHI-D707/6 £9.50 + VAT

NEW MHI-D727 0.5" DIGITAL DISPLAY KITS

The DL727 is a new double-digit display from Litronix presented in an 18-pin pack. Four or six digits are provided with P.C.B. The MHI display kits connect directly to the outputs of any of the MHI clock kits.

Four digits — MHI-D727/4 £8.50 + VAT
Six digits — MHI-D727/6 £12.00 + VAT

The DL747 "JUMBO" display is the largest single package LED display available with a digit height of 0.6in. Can be read from distances over 25 feet. Four or six digits plus PCB.
MHI-D747/4 £9.80 + VAT
MHI-D747/6 £14.70 + VAT

DISPLAYS

*DL701, DL704, DL707	£1.48
DL721, DL727 (per pair)	£3.75
DL749, DL750, DL747	£2.45
5-LT-01, 5-LT-03*	£5.80
Minitron 3016, 3017	£2.00
Itoka 2½in.	£8.00
Itoka 5in.	£21.80
L-C Watch Display	£10.00

CHIPS:

MM5309, MM5311	£5.18
MM5314	£4.44
MM5316	£9.25
MM5378	£7.43
MK50250, MK50253	£5.60
MK50204, MK50206	£15.11
CT7001, CT7002*, CT7003	£7.30
CT6002*	£15.00
HEEC2*	£8.50
CA3081 7 segment Interface chip	£1.47

ALSO: Some other displays, calculator and clock chips available in small quantities to callers only.
LSI sockets for 24, 28, 40 pin: £1.00
PCBs for MHI and other kits

DATA available on most chips, send SAE.

* Subject to availability

Terms: C.W.O., Access, Barclaycard (Simply quote your number and sign). Credit facilities to Accredited Account Holders.

All prices on this advert exclude VAT at 8%

BYWOOD

BYWOOD ELECTRONICS
68 Ebberns Road
Hemel Hempstead
Herts HP3 9QRC
Tel. 0442 62757

New Course in Digital Design

Understand the latest developments in calculators, computers, watches, telephones,

television, automotive instrumentation....

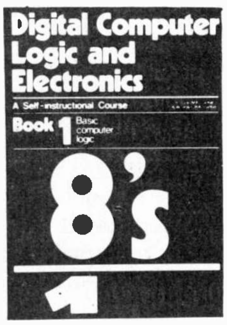
Each of the 6 volumes of this self-instruction course measures 11¾" x 8¼" and contains 60 pages packed with information, diagrams and questions designed to lead you step-by-step through number systems and Boolean algebra, to memories, counters and simple arithmetic circuits, and on to a complete understanding of the design and operation of calculators and computers.

After completing this course you will have broadened your career prospects and considerably increased your fundamental understanding of the changing technological world around you.

Design of Digital Systems

A Self-Instruction Course in 6 Volumes

1. Computer Arithmetic
2. Boolean Logic
3. Arithmetic Circuits
4. Memories & Counters
5. Calculator Design
6. Computer Architecture



Also available — a more elementary course assuming no prior knowledge except simple arithmetic.

In 4 volumes:

1. Basic Computer Logic
2. Logical Circuit Elements
3. Designing Circuits to Carry Out Logical Functions
4. Flip flops and Registers

£3.95 plus 50p p&p

Offer. Order this together with Design of Digital Systems for the bargain price of £9.25, plus 50p p&p.

Design of Digital Systems contains over twice as much information in each volume as the simpler course, Digital Computer Logic and Electronics. All the information in the simpler course is covered as part of the first volumes of Design of Digital Systems which, as you can see from its contents, also covers many more advanced topics.

£5.95

plus 50p packing and surface post anywhere in the world (VAT zero rated). Payments may be made in foreign currencies. Quantity discounts are available on request.

Designer
Manager
Enthusiast
Scientist
Engineer
Student

These courses were written so that you could teach yourself the theory and application of digital logic. Learning by self-instruction has the advantages of being quicker and more thorough than classroom learning. You work at your own speed and must respond by answering questions on each new piece of information before proceeding to the next.

Guarantee – no risk to you

If you are not entirely satisfied with Design of Digital Systems or Digital Computer Logic and Electronics, you may return them to us and your money will be refunded in full, no questions asked.

To: Cambridge Learning Enterprises,
FREEPOST, St. Ives, Huntingdon, Cambs PE17 4BR

*Please send me ..... set(s) of Design of Digital Systems at £6.45 each, p&p included

*or ..... set(s) of Digital Computer Logic and Electronics at £4.45 each, p&p included

*or ..... combined set(s) at £9.75 each, p&p included

Name..

Address..

....

....

*delete as applicable. ETI 12

No need to use a stamp—just print FREEPOST on the envelope.

ELECTRONICS -it's easy! PART 22

More about filters

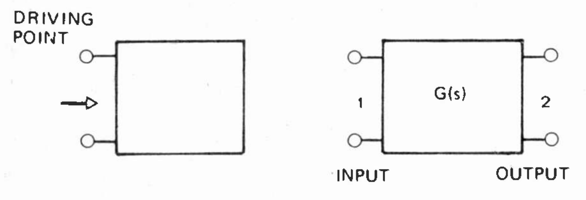


Fig. 1. Basic filter system block diagram.

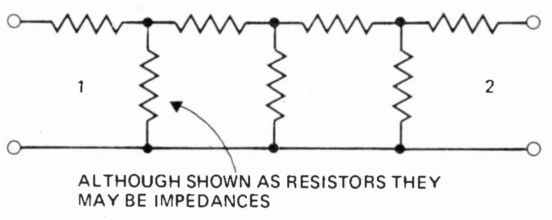


Fig.2. Ladder network.

AS WE saw in the previous section resistor-capacitor filters can only provide roll-offs of 6 dB/octave (20 dB/decade. On the other hand combinations of inductors and capacitors can provide much steeper rolls-offs and a response at the turn-over point which can be tailored to a desired shape.

The variety of LC component combinations that can be employed is great indeed and, to the uninitiated, the design of such filters can seem to be very confusing. However, circuit analysts have established design procedures which enable a filter having any practical characteristic to be designed in a logical, formalized manner. The method is based on the use of cascaded basic sections.

TWO-TERMINAL PAIR NETWORK CONCEPTS

As we have seen at various times in the course so far, filters can be circuits having just two terminals – a resonant circuit for example, or they can have two input and two output terminals – the so-called two-terminal pair networks. (The RC filter is of the two-terminal pair kind). The two different types are illustrated as system blocks in Fig. 1. Note that it is conventional to show input on the left and output on the right.

As said before many possible circuit configurations exist for filters, and the designer has to make a compromise between using a simple arrangement of many components that can be easily handled mathematically, or, a few components in a more complex network that cannot be treated by general formulae. Here we will examine the approach based on grouping numbers of simple and similar networks, to obtain the desired response, by the methods originally proposed by Zobel in 1923.

The simplest type of network is the LADDER, as illustrated in Fig. 2, the defining feature being that it has a common line. When the lower line also includes impedances (resistor elements are used to represent what are usually reactances) the network is called a LATTICE; these are much harder to design and are less commonly used. Let us examine how a ladder network is broken down into even more basic structures.

By convention the series elements of a ladder are labelled Z_1, and the shunt elements as Z_2. These elements will be either capacitors or inductors and, it is assumed that the filter is driven from, and drives into, pure resistances.

Within the ladder arrangement, shown in Fig. 2, can be seen three basic building structures – called the L section (inverted L to be absolutely correct), the T section and the π section. The three are shown separated in Fig. 3.

In Fig. 4 we see how standard T or π sections can be connected to provide the same effective ladder network. Conversely a ladder network may be subdivided into standard T or π networks by breaking the values up as shown.

The interesting and quite vital point is that the T or π stages have the same input and output impedance. That is they are *symmetrical*. The L section, however, is *unsymmetrical* in that input and output terminal pairs are not interchangeable. Two L sections in series will produce a T or a π section.

When two identical T or π sections are cascaded they are matched into the same impedance – maximum energy is transmitted and no reflections occur. Each terminal sees an image of itself, this property giving the name *image – parameter* design to this filter design method.

CONSTANT-K FILTERS

Even though a quite simple configuration has been used there can still be a wide range of combinations each with complicated mathematical solutions.

By introducing another assumption we can make some headway toward realising a wide range of characteristics with a reasonable degree of mathematical simplicity. This assumption is that $Z_1 \cdot Z_2 = R_0^2$ where R_0 is a true resistance called the characteristic resistance. (This may seem strange but the multiplication of capacitive reactance with inductive reactance yields just that). Hence Z_1 and Z_2 must be a combination of capacitor and inductor giving us

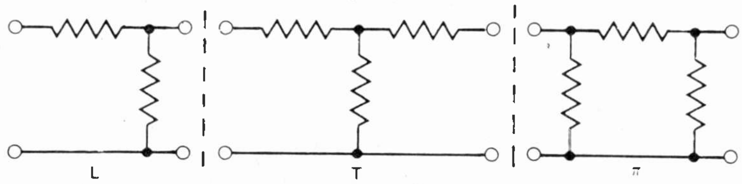


Fig. 3. The basic filter section.

ELECTRONICS -it's easy!

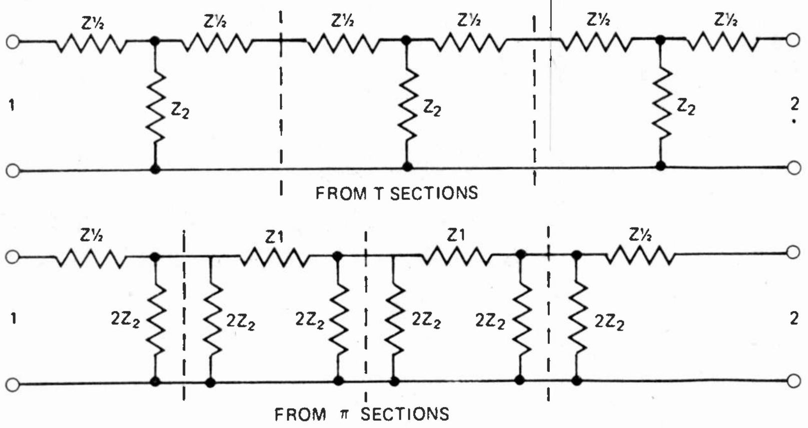


Fig.4. Building up the ladder network from basic sections.

equivalent stages with L and C proportions as shown in Fig. 5. The rule holds true for an L section provided we treat full shunt or series reactance as 2L or 2C.

The name constant-K arose from the original terminology where Zobel, in 1923, used K instead of our now accepted R_0. Filters designed to this rule are hence called *constant-K* filters.

Regardless of whether the stage is designed to be high pass or low pass — the cut off frequency will be the same, that is, at the resonance point of the LC values of the standard equivalent L section.

That is cut-off frequency $f_c = \frac{1}{2\pi\sqrt{LC}}$

For example in the T section of Fig. 6 the equivalent L section networks have L of 1 mH and a C of 0.5 microfard.

That is cut-off frequency

$$f_c = \frac{1}{2\pi\sqrt{10^{-3} \times 0.5 \times 10^{-6}}}$$

$$= 7.1 \text{ kHz}$$

Also from $Z_1 \cdot Z_2 = R_0^2$

characteristic resistance $R_o = \sqrt{Z_1 Z_2}$

However the capacitive reactance must be written as a reciprocal and in Fig. 6 this is Z_2. Hence:—

$$R_o = \sqrt{\frac{Z_1}{Z_2}}$$

$$= \sqrt{\frac{10^{-3}}{0.5 \times 10^{-6}}} = 45 \text{ ohms}$$

Thus we see that the source and load impedances used with this network must be 45 ohms, if maximum power is to be transferred, and the network is a low-pass stage having a cut-off frequency of 7.1 kHz.

If L and C were reversed the filter would have identical R_0 and f_c but it would now be a high-pass stage.

An important feature of image-parameter design is that image-matched stages can be cascaded without altering the cut-off frequencies or the characteristic resistances. Each additional stage improves the roll-off, thereby giving a powerfully reliable way to obtain the desired rapidity of attenuation without having to re-design the whole system as extra stages are added.

It can be shown that the attenuation, a, in the stop band, expressed in decibels, is a dB = 9.7 n α where n is the number of standard —T (or standard — π) sections cascaded, and α is 2 Cosh^{-1} f/f_c. Cosh^{-1} means the cosh function (a hyperbolic trigonometric expression) whose ratio is f/f_c. For those readers who are not familiar with this function Fig. 7 gives the relationship between values of α and frequency ratios, normally encountered. Note that either f/f_c or fc/f is used depending on whichever gives a value greater than one.

The following example shows how a constant-K filter is designed to given response requirements.

The basic design formulae are:

$$L = \frac{R_o}{2\pi f_c} \quad C = \frac{1}{2\pi f_c R_o} \quad n = \frac{a \text{ dB}}{8.7\alpha}$$

The values given at the start will be R_0, f_c, α and a dB. We need to establish, in the synthesis situation, the values of L, C and n. The necessary configuration is established by logical deduction of the appropriate placement of components in the sections.

Example: Design an high-pass filter having a cut-off frequency of 10 MHz and a signal attenuation of 100 dB at 5 MHz. The characteristic resistance is to be 50 ohms in order to match the existing system into which the filter is to be fitted.

$$L = \frac{R_o}{2\pi f_c} = \frac{50}{2\pi\, 10\, 10^6} = 0.769\,\mu H$$

$$C = \frac{1}{2\pi f_c R_o} = \frac{1}{2\pi\, 10\, 10^6 \cdot 50} = 318\text{pF}$$

To determine α

$$\frac{f_c}{f} = \frac{10.10^6}{5.10^6} = 2$$

From the chart $\alpha = 2.64$.

Number of stages required, $n = \frac{a \text{ dB}}{8.7\alpha}$

$$= \frac{100}{8.7 \times 2.64} = 4.35$$

We cannot however have 0.35 of a stage and therefore must use five stages to obtain at least 100 dB attenuation at 5 MHz.

The formulae for L, C are for the basic section so we have half values accordingly, giving us the circuit of Fig. 8. We could just as correctly divide the system into a π rather than a T configuration. Design of a low pass stage proceeds in just the same way.

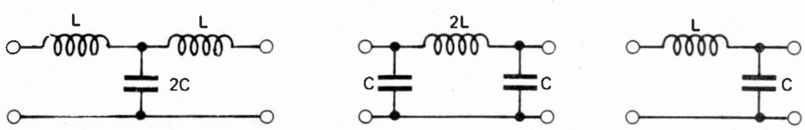


Fig.5. Convention used in this explanation of LC filter design.

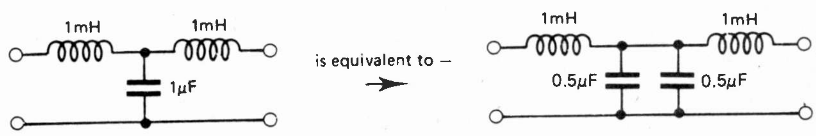


Fig. 6. A T-section filter and its equivalent L-sections.

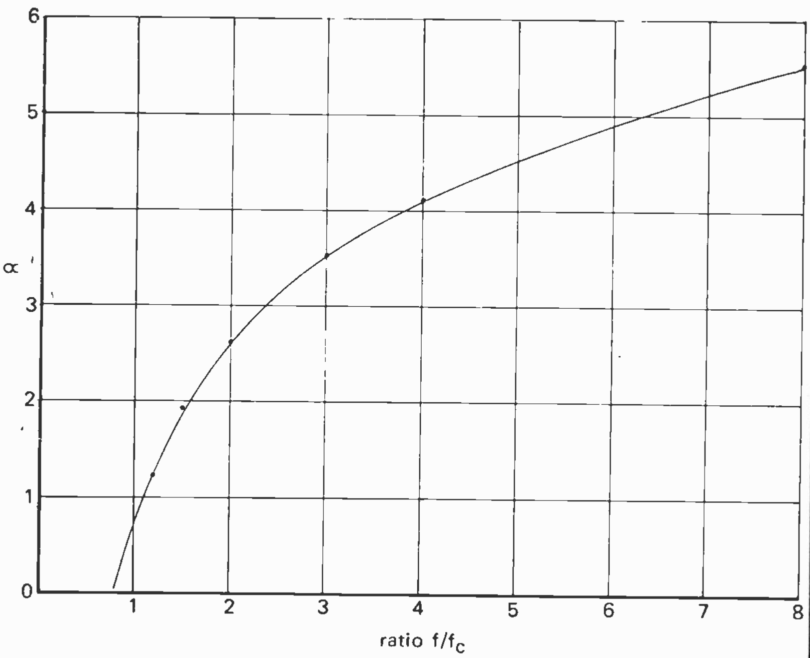


Fig.7. Chart relating value of α and frequency ratio.

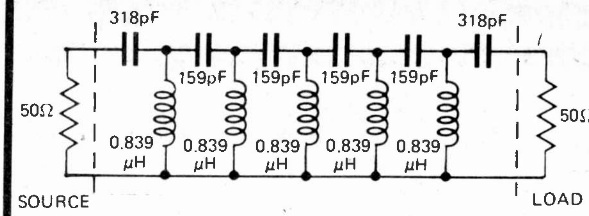


Fig.8. 5 section, constant -K, high-pass filter with cut-off of 10 MHz.

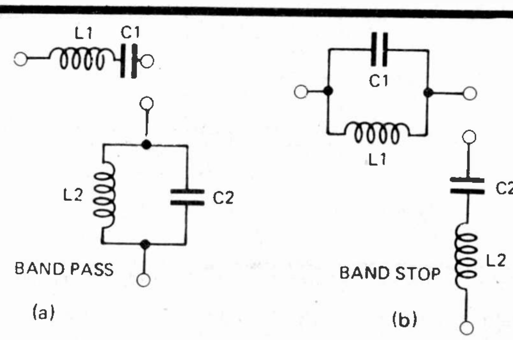


Fig.9. Basic elements of band-pass constant -K filters.

The design of band-pass and band-stop stages is more complicated going beyond the scope of this course. Suffice to say that the components in the arms now become series or parallel resonant combinations. The basic L-section for a constant-K band-pass is shown in Fig. 9a and the basic L-section for a band-stop in Fig. 9b. Readers who wish to pursue these can obtain guidance from the reading list.

M-DERIVED SECTIONS

As can be expected the simplifying assumptions made in the constant-K design, to obtain a reasonably straight forward mathematical procedure, also create practical disadvantages. The first defect is that the image impedance does not remain constant and varies in such a way that noticeable reflections occur near the cut-off points. The second defect is that the roll-off is slow just near the cut-off point: it is adequate further away from that point.

Zobel's concept to overcome this involved additional cascaded stages that, in effect, flatten out the passband response and sharpen up the cut-off point attenuation. These extra stages are called M-derived sections: one is usually added on each end of the ladder designed by the constant-K method.

We can only give an example circuit to illustrate this — Fig. 10. Although the formulae for arriving at the values are simple they must be applied with great care, the user having adequate experience in order to know the correct procedures. Again we must leave it to the reader to take this up in more specialized texts. The design of a full M-derived system requires extensive effort and training and is much more the task of a professional circuit designer than the reader for which this course is designed. The most extensive application of M-derived filters has been in communications engineering — telephones, telegraphy and multiplexed radio links. Voluminous books have been compiled that list tables giving values for chosen designs. Special computer programs have also been developed to provide automatic constant-K and M-derived section filter designs.

ACTIVE FILTERS

The basic active RC building blocks

Passive filter designs had reached their present sophistication as much as 50 years ago and in the absence of anything markedly better they continued to be the most used design until the mid 1950's. Amplification was added to make up for the attenuation that usually is experienced with passive designs.

With the introduction of reliable and less power-thirsty solid-state amplifiers in the late 1950's came the so-called active-RC filters. These combine an operational amplifier with passive RC components thereby producing filtering action more efficiently than the more obvious passive network followed by an active stage. One very valuable feature is that the effective value of, say, a capacitor can be multiplied up many times on its actual value thereby saving space and enabling designers to build circuits needing large effective values. It is also possible by active filter design to avoid the need for inductors in filter circuits. Inductors are best left out, if possible, for they are usually bulky, expensive and very lossy — they are nowhere as "ideal" as capacitors. They also are non-linear in operation and can be saturated by excessive current.

The basis of an active RC network is more often than not a reasonable quality operational amplifier set up to provide one of the following four basic circuit concepts.

1. The high gain (60 dB or more)

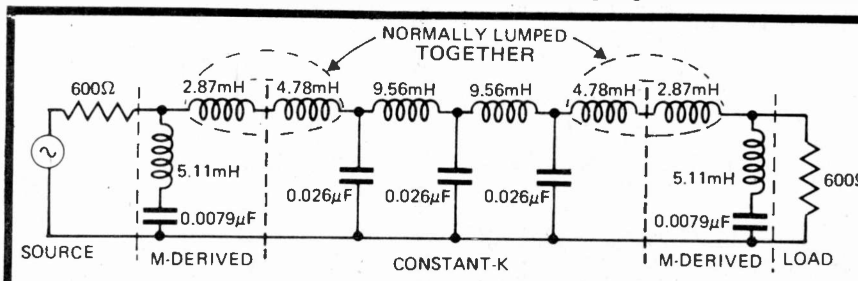


Fig.10. Example of constant -K filter with M-derived end sections.

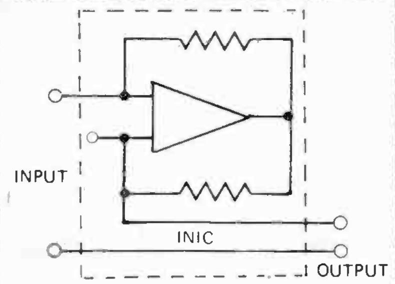


Fig. 11. Realising an INIC with an op-amp.

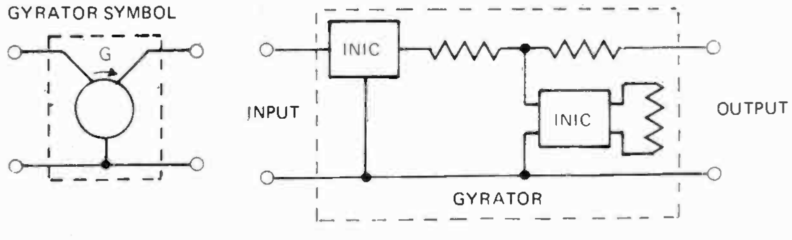


Fig. 12. The gyrator.

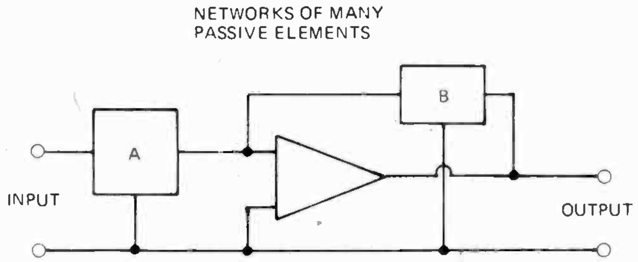


Fig. 13. Single-loop feedback active filter schematic.

voltage amplifier with close to infinite input impedance and almost zero output impedance – in short, the normal mode of an op-amp as we have discussed previously.

2. The low gain (20 dB or less) voltage amplifier, also referred to as a voltage-controlled voltage source or just VCVS.

3. The negative-emittance or negative impedance converter NIC. This is a most interesting system block for it enables positive value capacitance or resistance (that obtained with normal capacitors and resistors) connected at its input to appear as negative value capacitance or resistance at its output. It enables circuit designers to physically build circuits requiring non-physical negative capacitors and resistors. (INIC indicates an ideal current-inversion NIC, and VNIC indicates an ideal voltage – inversion NIC). A typical realisation is shown in Fig. 11.

4. The Gyrator. This is another intriguing unit for the output appears as the reciprocal of any impedance connected to its input. Thus a capacitor at its input appears as an inductor at the output. The gyrator, therefore, eliminates the need to use physical inductors and what is more, can provide more "ideal" inductors than real units. It can be realised using op-amps as shown in Fig. 12.

With these four basic possibilities available the circuit designer is rarely restricted by having synthesised a circuit needing non-physical components.

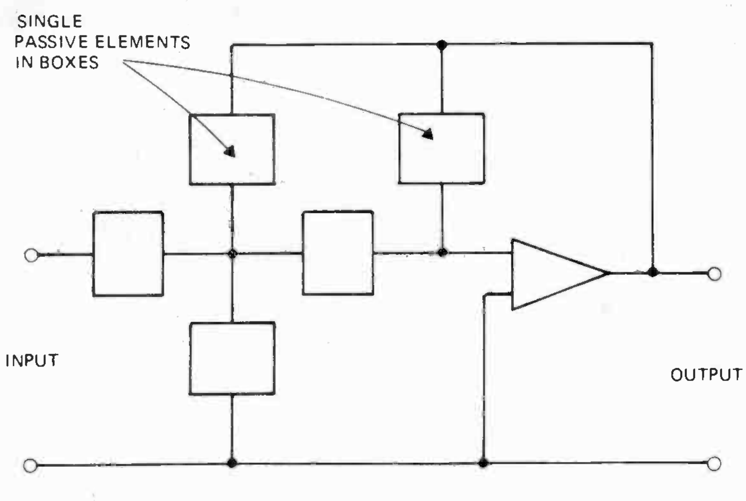


Fig. 14. The multiple-feedback-path active filter.

CHOOSING AN ACTIVE FILTER DESIGN

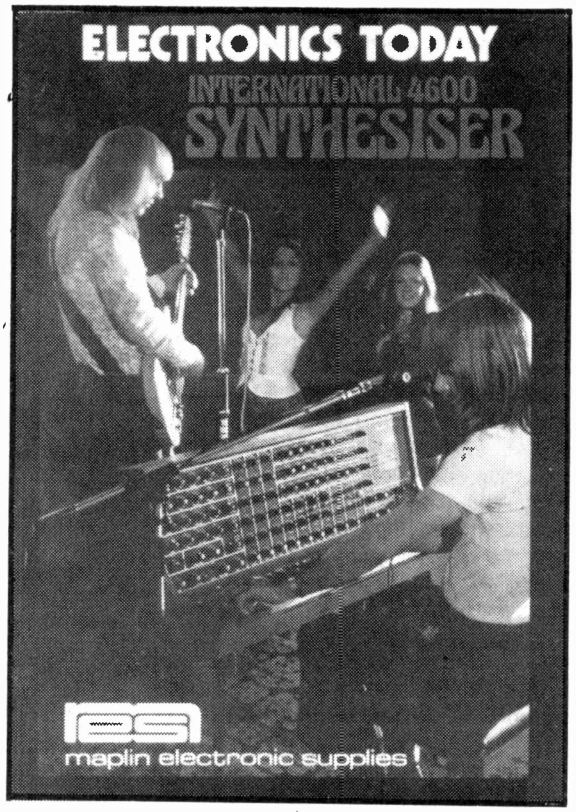
Given the above four system blocks it is possible to produce an incredible variety of active filters. As with advanced passive designs, few people have enough training to be expert active-filter designers. Here we can only give a guide that provides the necessary awareness of what to look for, along with words of caution as to what it is reasonable to expect from an actual active-filter design.

The voltage amplifier can be used in its simplest conceptual way with a *single-loop feed-back path* (SFP) as shown in Fig. 13 – remember how we have already seen that an op-amp integrator acts as a low-pass filter and how a notch-rejection filter, introduced into the feedback path, produces a notch-acceptance response instead.

Alternatively, we can make use of *multiple feedback paths* (MFD) as depicted in a general sense in Fig. 14, the design using minimum component count. These, somewhat surprisingly, use fewer passive elements than single-loop circuits. For this reason this form of active filter is the configuration most often used.

Our discussion about active filters will be continued next month....

TWO SPECIALS



Cut

ELECTRONICS IT'S EASY!

The first thirteen parts of our popular introductory series 'Electronics—It's Easy' will be published in mid November. If you want a copy when it is available send us this coupon with £1.35 (inc. 15p P & P) (send £1.40 from overseas) to **ETI Specials, 36 Ebury Street, London SW1W OLW.**

Name . . . .

Address. . . . .

. . . .

. . . .

. . . .

Cut

INTERNATIONAL 4600 SYNTHESISER

Maplin Electronic Supplies, who supply the parts for this project, have published a book including reprints of the INTERNATIONAL 4600 Synthesiser. This is available from ETI for £1.50 + 15p postage (send £1.70 from Overseas). Send this coupon to **ETI Specials, 36 Ebury Street, London SW1W OLW.**

Name . . . .

Address. . . . .

. . . .

. . . .

. . . .

Electronics Tomorrow

by John Miller-Kirkpatrick

ONE CHIP OR TWO?

Microprocessor chips that is. Is it better to build a microprocessor with only one chip or do you really need two? is what semiconductor manufacturers seem to be saying at present. Rockwell International have recently announced a two chip MP system designed for equipment manufacturers requiring a complete microcomputer capability for a total component cost of about £17 in quantities of 1000. The first chip in the high speed PPs-4/2 system has a clock, CPU and 12 I/O lines; the second chip contains a 2K by 8 bit ROM, a 128 by 4 bit RAM and 16 I/O lines. The prices of the chip pair in low volume quantities is only about £40 but before you rush out to order one you should know that the ROM masking charge is about £600, with a MP system with a separate ROM you can use a PROM and mask it for yourself at a lot less. A typical layout of the two chips and the additional chips required to make them do anything is shown in the photograph. As you can see the system can easily interface with a 64 key keyboard, a 16 character alphanumeric display, a printer, cassette, modem and TTL sub-systems.

For those of you want to build a microprocessor now (I would advise waiting for a few more months) there are some new kits available from Cramer. The kits are available with Intel 8080 chips, Texas chips and others. We hope to carry more information about these kits in the near future when we can find a good cheap printing Teletype to interface with the kits — any ideas?

THE CASE FOR A BETTER BOX

Having built your microprocessor or clock or power supply or whatever your latest project is do you put it in an old tobacco tin or something similar or do you attempt to make it look good both inside and outside? Vero have just published a small booklet that may help if you are as fumble fingered as I am. It is entitled 'Vero products for the home constructor' and costs 10p. It introduces you to Veroboard and the tools and accessories that go with it including a rather nice range of cases. How many of you still cut your copper strips with a knife or a drill bit — have you never heard of a face cutter or pin insertion tool? Did you know that Vero make bread-boards for use with DIL ICs, cable clips, PCB standoffs, plastic cases, metal cases and 19in rack modular cases. All this information and more is yours for only 10p and a 7in x 9in SAE from Vero. I have used most of the Vero cases at one time or another and I can well recommend them as being well designed with screw mounting holes, PCB slots, etc all well placed. There have already been several projects (Frequency counter, stopwatch) using the new plastic cases with aluminium front and back panels, and these projects would not have looked quite so professional in any other case.

Vero's other latest case for the home constructor is intended for very large and complex projects either for home or lab use or for the small volume special equipment builder. The 19in card frame/case is basically a standard European 19in rack frame with the optional extra of a surrounding case. The cased frame will take any of a range of plug-in boards or mobile carriers. The finished product allows for easy access to any module simply by releasing a catch and pulling the module out,' a simple plug and socket system on each module allows for accurate alignment when the module is slid back into the case. As with most Vero products the 19in case system is expensive, but if you are spending a lot of time and money on a special project then the additional expense of such a case might well seem insignificant.

ARE YOU BEING *LED* ASTRAY?

Digital watches are here with a vengeance this Christmas with about 20 different types available with virtually any number of brand names on them. There are several points to be wary of before rushing out to buy a digital watch and I hope that I might be able to help you to get value for money.

First decide whether you want LED or LCD display. With LED the display can only be seen after pressing a button whereas with LCD the display can be read in any good ambient lighting conditions. Some of the very latest LCD watches have a button that you press to backlight the LCD for viewing in darkness and with LCD technology now giving a much longer lifetime for the display I would join the experts in forecasting the demise of the LED watch within a couple of years. So for my first tip buy a back-lit LCD watch in preference to LED. It might cost you £10 more but it is more convenient than either LED or analogue watches.

Secondly decide what functions you require on the watch. Most advertisers are using this rather stupid "Fantastic Two Function Watch" approach — what are the two (or three or four or five or six) functions?

TWO FUNCTIONS — Hours and Minutes (1 button push).

THREE FUNCTIONS — Hours and Minutes (1), seconds (2).

FOUR FUNCTIONS — Hours and Minutes (1), Seconds (2), Day number (3).

FIVE FUNCTIONS (a) — Hours and Minutes (1), Seconds (2), Day and Month number (3).
or (b) — Hours and Minutes (1), Seconds (2), Alpha Day (MO, TU, WE) and Day number (3).

SIX FUNCTIONS (a) — Five (a) plus Alternative Time Zone,
or (b) — Five (b) plus Month and Year number.

A lot of date watches now have 28/30/31 day calendars automatically but only if they also have month number as a feature. This is not an extra function but should always be available with the 5(a) type of watch. Watches with no month number feature usually have a 31 day calendar for each month, but this can be set back to the 1st without affecting the setting of the Hours, Minutes and Seconds counters.

Back-lit LCD watches may be

available with an alarm feature sometime in the middle of next year. The alarm will vibrate on the back of your wrist rather than emitting a loud noise. No further details yet but 'watch this space.'

Prices appear to reflect the number of functions and the case style. For a stainless steel case work on the basis of £10 plus £5 for each function. Thus a two function watch should cost about £20 and a five function about £35 (plus VAT at 8%). For plastic cases subtract about £2, and for gold (plated) add £1 per micron of gold (£5-£10).

Do not buy a watch with a gold thickness of 10 microns or more because this then becomes an item of jewellery and attracts 25% VAT. Beware of watch kits. Most of them are not designed for the amateur and require very fine instruments for construction and good equipment for adjusting the crystal accuracy. The rumour is that Uncle Clive has overcome most of his problems with his ITT watch chip and will be announcing his plastic watch within the very near future. On the basis of past products it will probably be available as a kit as well as a finished watch. Clive's kits are very good and are designed for the amateur but it might lead to a bulky watch — if it does come out as a kit I shall attempt to get hold of one for review in Electronics Tomorrow.

A final warning on watches — 18 months ago a simple LCD two function watch was selling for over £200, 12 months ago it was about £100, six months ago about £50, now it would be about £25. Watch prices may halve again in the next year or so but they will not go much further. You may be able to buy a two function LED watch for Christmas 1976 for less than £10 but don't rely on it.

REFERENCES

1 *Rockwell International, D-6374 Steinbach/Taunus, Industriestrasse 8, Germany.*
2 *Vero Electronics Ltd, Chandlers Ford, Eastleigh, Hants SO5 3ZR.*
3 *Cramer Electronics, 16 Uxbridge Road, Ealing, W5 2BP.*

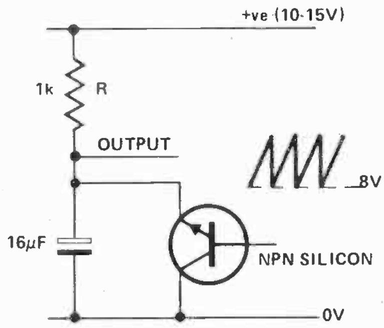
ANY GOOD AT CEEFAX?

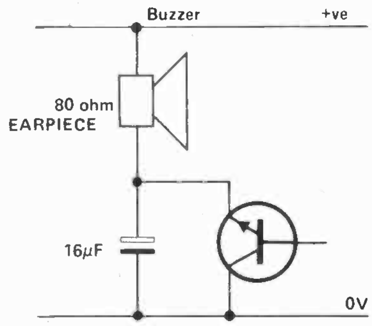
If you have already built a Ceefax decoder then ETI would like to hear from you. We are in an advanced state with a CEEFAX receiver and would like to compare notes with other constructors. We don't think it would be right to start a Ceefax series until we have got all the problems sorted out. Contact ETI on 730 8282.

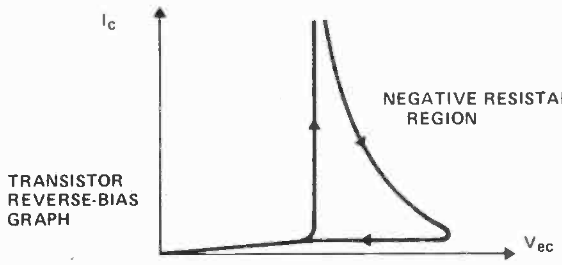
tech-tips

SIMPLE OSCILLATOR

The negative resistance region of a reverse-biased silicon transistor can be used in a relaxation oscillator circuit. Its advantage is that a surplus transistor is used instead of a UJT (which is more expensive) and it does provide a minimum of components. The frequency is governed by the time constant RC, the power supply voltage and the size of the negative-resistance region. The latter also governs the signal amplitude, so various transistors (from a surplus batch) should be tried for best results. The output is a sawtooth waveform with a mean dc level around 8V. Replacing the resistor with an 80 ohm earpiece makes an effective buzzer.







UNIVERSAL WIPER DELAY

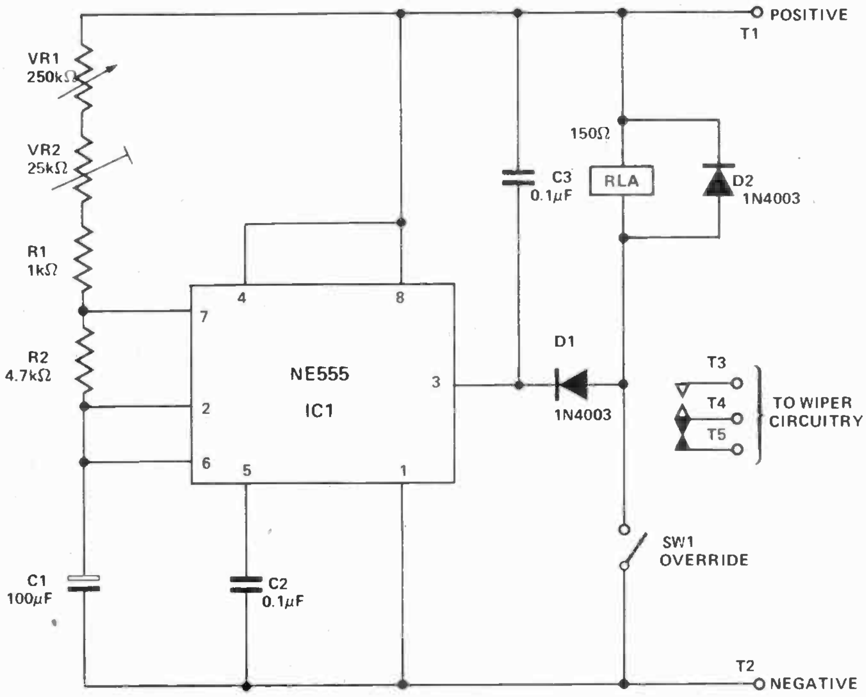


Fig. 1. Wiper Display Unit

Having recently experienced some difficulty in trying to fit a thyristor type wiper delay unit to the car, the trouble was eventually found to be a result of the design of the car's wiper circuit and also by noise spikes which spuriously trigger the thyristor. The following circuit should overcome these problems in both negative and positive earth vehicles.

IC1 is connected in the astable mode, driving RLA. C3, D1 and D2 prevent spikes from the relay coil and the wiper motor from triggering IC1. VR2 is adjusted to give the minimum delay time required. VR1 is the main delay control and provides a range of from about 1 second to 20 seconds. SW1 is an override switch to hold RLA

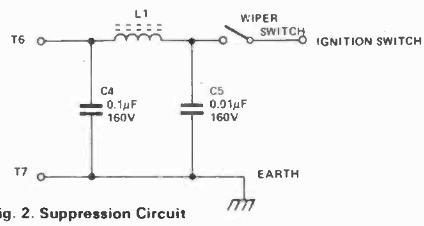


Fig. 2. Suppression Circuit

For Negative Earth Vehicle connect T6 to T1 and T7 to T2
For Positive Earth Vehicle connect T6 to T2 and T7 to T1

permanently on (for normal wiper operation).

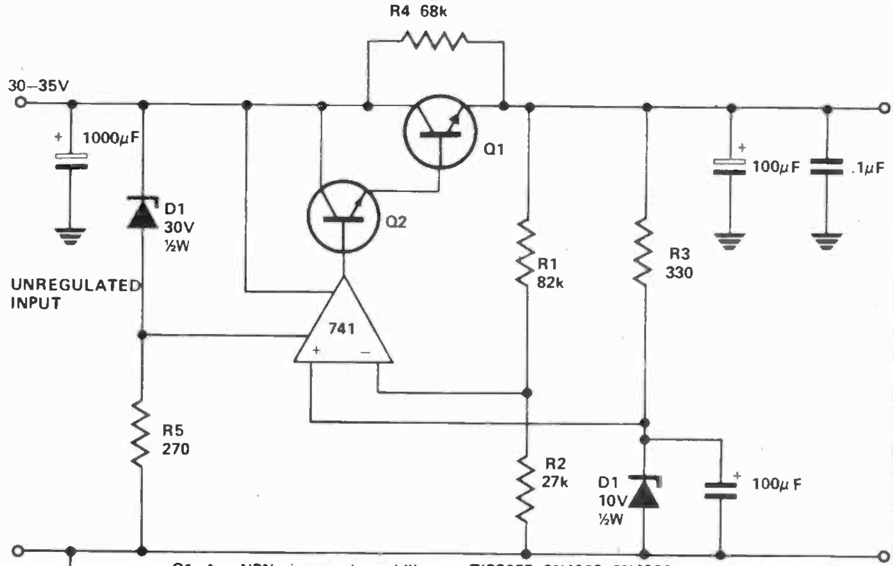
The relay should have a resistance of at least 150Ω and have heavy duty contacts. A set of change-over contacts, as shown in Fig 1, are necessary if the circuit is to be used on a car whose wipers are wired as on the Anglia or Cortina (inspection of the car's wiring diagram will confirm this).

The suppression circuit shown in Fig 2 was found to be necessary for the protection of IC1.

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.

ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to the Editor, Electronics Today International, 36 Ebury Street, London SW1W 0LW.

STABILISED POWER SUPPLY



Q1: Any NPN power series stabiliser eg: TIP3055, 2N4923, 2N4921
Q2: Any NPN transistor capable of driving the above eg: BC182L

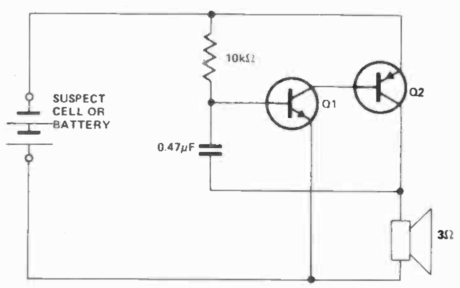
The operation of the circuit is quite simple and straightforward, as regulated power supplies can be considered merely as special kinds of feedback amplifier. Here, the output signal is sampled by R1 and R2, and compared with a reference voltage supplied by D2. The resultant correction signal is fed back via the 741 to the series pass element Q1. Note that the stability of the circuit is improved by supplying the reference source R3-D2 from the stabilised output as opposed to from the unstabilised input as is usual. In order that the circuit operates when turned on, a leakage resistance R4 is put in parallel with the series pass element. This ensures that the feedback loop starts to operate. No regulation is lost as a consequence of R4, because it is the overall output that is sampled by R1-R2, and so the effect of the ripple current flowing through R4 is corrected by the feedback.

The output may be made variable by replacing R1-R2 with a potentiometer, but in its present form, the circuit cannot be made to regulate below the zener voltage of D2. If continuous variation is required, the reference source R3-D2 must be supplied from the unregulated input, with consequent slight loss of stability.

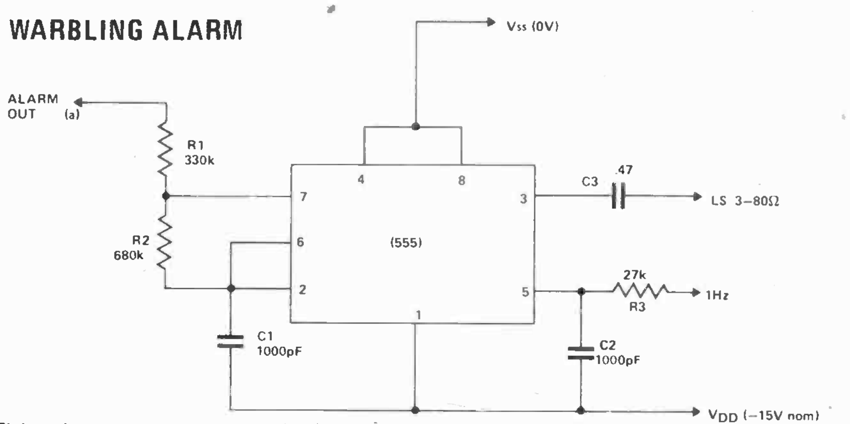
The amount of power the circuit can deliver is limited chiefly by the current rating of Q1 and the rated output of the unregulated supply.

BATTERY TESTER

This device tests the condition of dry cells. The circuit consists of a simple oscillator whose output frequency is relatively independent of supply voltage, but varies greatly with changes in supply impedance. Thus, with the component values shown, a fresh battery or cell will give a note of about 500Hz, whereas an exhausted cell will give a note above 1kHz. The device has been tested with battery voltages between 1.5V and 14V, using a 2N2923 as Q1, and an OC81D as Q2. The unit is undamaged by reversed supply potentials.



WARBLING ALARM

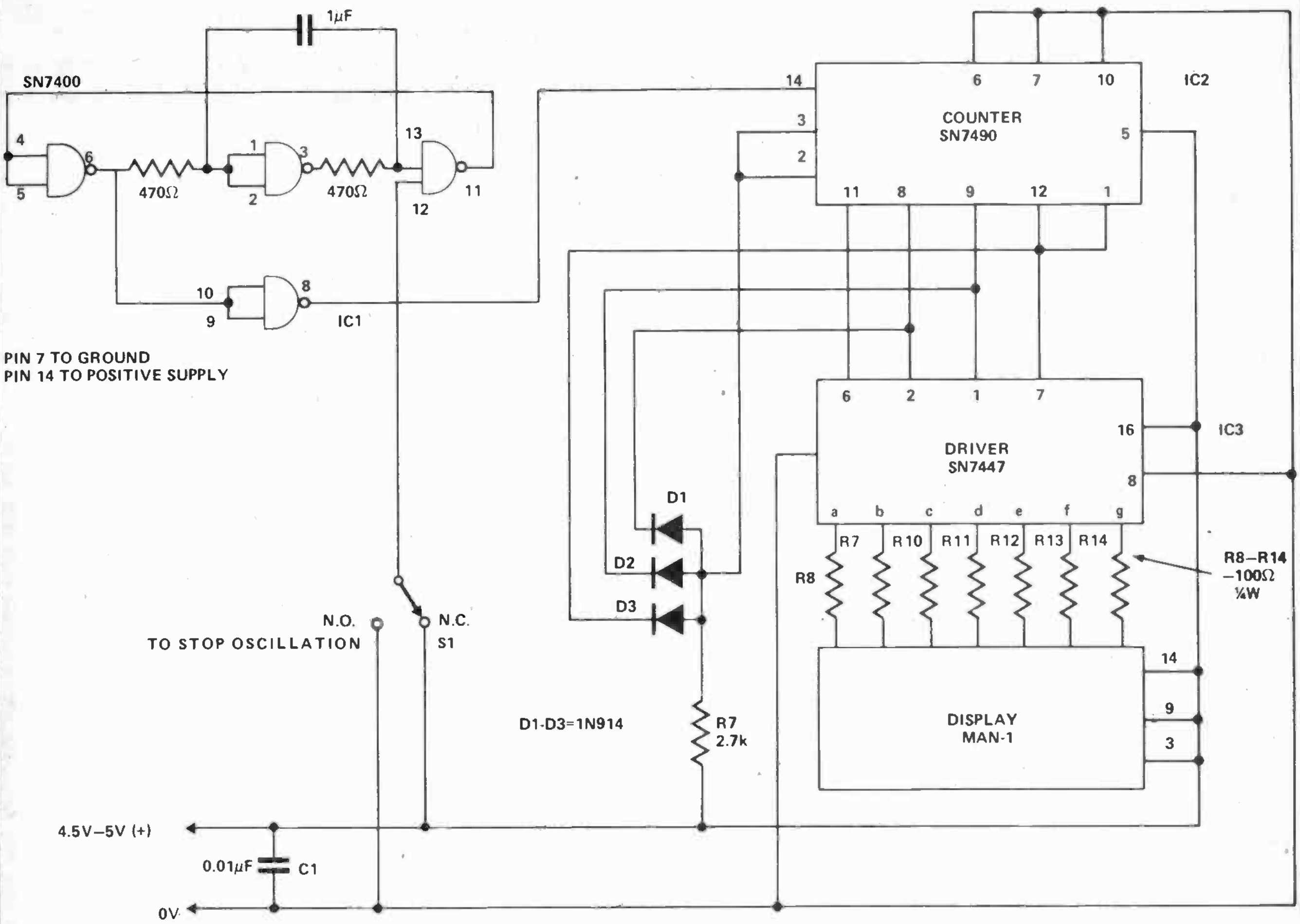


This device gives a two-tone alarm from a digital clock. It may be used with any CMOS alarm clock chip having an active high alarm output and 1Hz (optional) output. It was built to work with a CT7001 chip and requires no interface components.

The 555 operates in normal astable mode when the alarm goes high (ie point (a) approaches VSS). Pin 5 is the normal control voltage input and swings from almost VSS to VDD via the 27K resistor at a 1Hz rate. This causes the audio output to switch between high and low tones, above and below the frequency determined by R1, R2 and C1. To vary the frequency difference, R3 may be altered within wide limits, but it is inadvisable to keep it below 15K. The basic frequency is best varied by changing C1. Audio output may be varied by changing C3 (depending on LS impedance). In the original, a 35Ω speaker was used with -12V VDD and was sufficient to rouse an expert heavy sleeper.

tech-tips

DIGITAL DIE

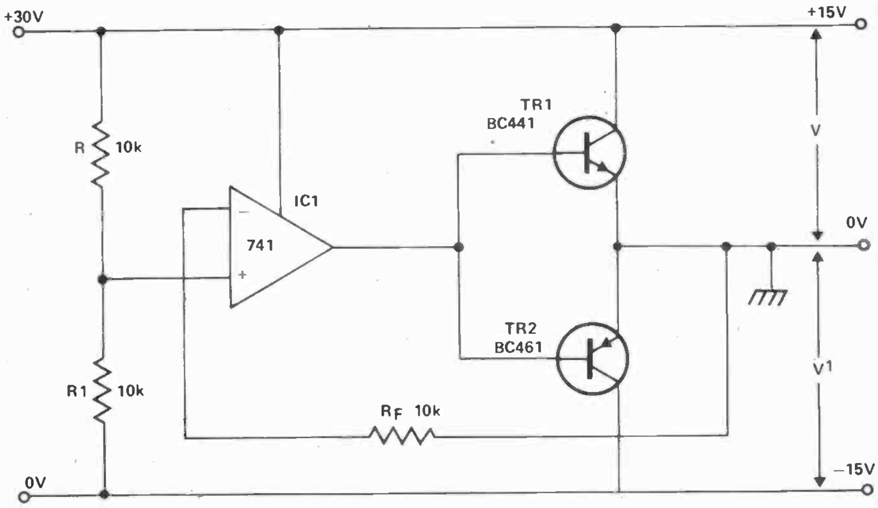


This device is based on a multivibrator (ICI) which has a frequency of about 1kHz. Oscillation continues as long as the input to pin 12 is high; as soon as the input is taken low or connected to earth it stops the cycle. This is used as a stop switch which causes the LED to indicate the random digit.

A diode AND gate, made up of D1 D2, D3 and R7 is used to reset the counter (IC2) to zero so that only 0-6 are counted. To stop the 0, pin 5 of IC3 is connected to the negative supply. A 4.5v or 5v supply may be used; capacitor C1 reduces the noise on VCC line when TTL outputs switch logic states.

PRECISION VOLTAGE DIVIDER

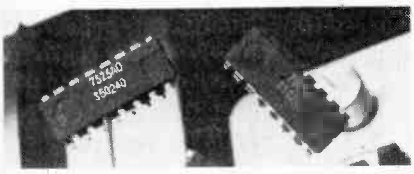
This circuit has the advantage over the simple 'two resistor' voltage divider in that the voltage ratio V:V' does not depend on the current taken from it. The ratio of resistances R:R' sets the voltage ratio. The OP AMP detects any change in this ratio via R_f and provides correction. The actual voltages used will be limited by the upper and lower operating voltages of the OP AMP. The circuit shown was designed to provide 15V for operational amplifiers from a single supply.



 Continued from page 8

OCTAVE SYNTHESIZERS.

AMI Microsystems have announced a new family of PMOS top octave synthesizers, which generate the top 13 musical frequencies in electronic organs and other electronic musical instruments.



Models S50240 and S50242 have output duty cycles of 50%; the S50241 has 30% duty cycles on all 13 outputs, to provide waveforms with odd and even harmonics. They come in 16-pin DIL packages. AMI, 108 Commercial Road, Swindon.

PULSAR CLOCKS

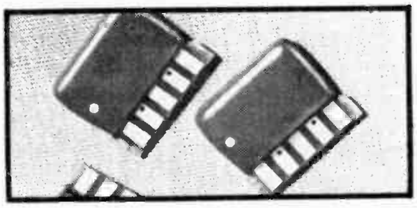
We would like to apologise to those readers who have had to wait for the delivery of their Pulsar clocks.

This offer was so enormously popular that stocks were exhausted very quickly. For the first two months, we were able to get new supplies very fast but new deliveries stopped for several weeks.

We hope that by the time that this issue appears that the back-log will largely have been cleared, but we are entirely in the hands of our suppliers.

BALANCED MIXER

This single-balanced mixer has low distortion and conversion loss and is designed for applications requiring large quantities, such as television tuners, CATV converters, FM stereo, mobile radio and instrumentation. Its 2nd order

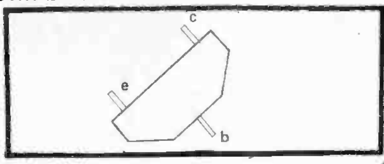


distortion intercept is +32dBm; its 3rd order intercept is +8dBm. Conversion loss is 6.5dB and isolation (LO to RF/IF) is 45dB at 200MHz; 25dB at 900 MHz.

The Hewlett-Packard 5082-9200 printed circuit balanced mixer covers the range dc to 1200MHz (RF/IF) and 100 to 1200MHz (LO). It uses a monolithic Schottky diode pair and a printed circuit transformer. Celdis Ltd., 37/39 Loverock Road, Reading Berkshire.

ERRATA

International 25, October, p28. R51 and R52 should be 330 ohms. International 25, November, p55 & 56 In Fig.2, the emitter and collector lables of the BD266 are reversed. The correct way to mount the BCX35 and BCX31 (Q5,Q6,Q11,Q12) is shown below.



ETI HELPING HAND COMPETITION

The Silver Trophy specially designed for the winners of Helping Hand

THE PROBLEMS

1 A sick person is being looked after by a deaf person. The deaf person has no useful hearing and requires to know whether the sick person is all right and above all needs to know if the sick person is in a state of distress anywhere in the sick room.

2 A hard of hearing person is attending a College of Further Education and has considerable difficulty in understanding what the lecturer says due to his distance from the lecturer and to the background noise in the room. A device is required to enable him to make the best possible use of his hearing.

3 Many deaf people have great difficulty in using the telephone and in fact many of them cannot use the telephone at all. The development of a writing tablet which would allow them to write a message on a small pad and for this to be communicated over the telephone line to a pad at the other end would have many great advantages. In addition the communication should be two way so that the person can receive a message or an indication that the message has been received.

This is our open competition to find solutions for problems facing the deaf.

This closing date is March 31st 1976. ETI and the Royal National Institute for the Deaf (RNID) are co-operating fully in the organisation of this competition.

Three problems are shown above. We invite individual readers, clubs, schools, universities, companies, in fact anybody, to develop a practical solution. The rules are as basic as possible and impose virtually no restriction apart from insisting that any Patent Royalties are waived if the idea is produced.

The prizes, three in all, will each be a silver trophy specially designed for ETI. At the close of the competition the magazine will hand over £250 to the RNID to help with development costs. There is a £1.00 entry fee (payable to RNID) and this will be added to the £250.

Background information has been prepared to help readers and say what is alreayd known. This is available from ETI on receipt of a large self-addressed envelope. Enquiries should be sent to:

Helping Hand,
ETI Magazine,
36 Ebury Street,
London, SW1W 0LW.

MINI-ADS

FOR DETAILS ON ADVERTISING IN MINIADS, OR ELSEWHERE IN ETI, CONTACT BOB EVANS, 01-730 8282

PRECISION POLYCARBONATE CAPACITORS

440V AC RANGE:

VALUE (μF)	DIMENSIONS (mm) L	D	PRICE EACH:
0.1μF	27	12.7	51p
0.15μF	27	12.7	59p
0.22μF	33	16	64p
0.25μF	33	16	67p
0.33μF	33	16	75p
0.47μF	33	19	80p
0.5μF	33	19	87p
0.68μF	50.8	19	93p
1.0μF	50.8	19	£1.03
1.5μF	50.8	25.4	£1.21
2.0μF	50.8	25.4	£1.44

Axial or Radial leads available
63V DC Range:

Value (F)	±1%	±2%	±5%
0.01μF	66p	49p	42p
0.1μF	66p	49p	42p
0.22μF	67p	50p	43p
0.33μF	67p	50p	43p
0.47μF	67p	50p	43p
0.68μF	74p	53p	46p
1.0μF	82p	62p	52p
1.5μF	89p	71p	58p
2.2μF	96p	75p	61p
3.3μF	£1.15	82p	68p
4.7μF	£1.62	£1.13	94p
6.8μF	£1.96	£1.38	£1.13
10μF	£2.40	£1.95	£1.64
15μF	£3.22	£2.79	£2.24
22μF	£4.28	£3.68	£3.08

*TANTALUM BEAD CAPACITORS — Values available: 0.1, 0.22, 0.47, 1.0, 2.2, 4.8, 6.μF at 15V/25V or 35V; 10μF at 16V/20V or 25V; 22.0μF at 6V or 16V; 33.0μF at 6V or 10V; 47.0μF at 3V or 6V; 100.0uF at 3V. ALL at 10p each, 10 for 95p, 50 for £4.

TRANSISTOR

BC107/8/9	9p	*BC212/212L	14p	BFY50	20p
*BC147/8/9	10p	*BC547/558A	12p	BFY51	20p
BC157/8	12p	BC558A	12p	BFY52	20p
*BC182/182L	11p	*BF194/BF195	12p	OC71	12p
*BC183/183L	11p	BF197	13p	2N3055	50p
*BC184/184L	12p	AF178	30p	*2N3702/4	11p

POPULAR DIODES: All brand new and marked: 1N914 6p; 8 for 45p; 18 for 90p; 1N916 8p; 6 for 45p; 14 for 90p. 1S44 5p; 11 for 50p; 24 for £1.00. 1N4148 5p; 6 for 27p; 12 for 48p. LOW PRICE ZENER DIODES 400mW; Tol. ±5% at 5mA. Values available: 3V; 3.6V; 4.7V; 5.1V; 6.2V; 6.8V; 7.5V; 8.2V; 9.1V; 10V; 11V; 12V; 13V; 13.5V; 15V; 16V; 18V; 20V; 22V; 24V; 27V; 30V. All at 7p each; 6 for 39p; 14 for 84p. Special Offer: 100 Zeners for £5.50. RESISTORS: High stability, low noise carbon film 5%; ½W at 40°C; 1/3W at 70°C. E12 series only, from 2.2Ω to 2.2MΩ. All at 1p each; 8p for 10 of any one value; 70p for 100 of any one value. Special Pack: 10 of each value 2.2Ω to 2.2MΩ (730 resistors) £5.00 SILICON PLASTIC RECTIFIERS, 1.5A. Brand new wire ended DO27: 100 P.I.V.—7P (4/26p). 400 P.I.V.—8P (4/30p). BRIDGE RECTIFIERS: 2½A 200V—40p. 350V—45p. 600V—55p. SUB-MINIATURE VERTICAL PRESETS: 0.1W only; All at 5p each. 50Ω, 100Ω, 220Ω, 470Ω, 680Ωm 1k, 2.2k, 4.7k, 6.8k, 10k, 15k, 22k, 47k, 68k, 100k, 250k, 680k, 1M, 2.5M, 5M.

Please add 15p post and packing on all orders below £5. All export orders add cost of sea/air mail. Please add 8/ VAT to all items except those marked with * which are 25%. Send S.A.E. for lists of additional ex-stock items. Wholesale price lists available to bona fide companies.

MARCO TRADING
Dept. T12, The Old School, Edstaston, Near WEM, Salop. Tel. WIXHALL 464/465 STD (094872)
(Props: Minicost Trading Ltd.)

INDEX TO ADVERTISERS

IMPORTANT ! PUBLISHERS' ANNOUNCEMENT

The Electronic Calculator prices appearing on Henry's Radio advertisement page 83 are incorrect and should read as follows:

SINCLAIR

Cambridge built	£10.65
Cambridge Kit	£9.90
Scientific Kit	£13.50
Scientific built	£14.45
Cambridge Memory	£14.45

Cost and packing 30p includes V.A.T.

ALUMINIUM PROJECT BOXES

lids and screws included

Box No.	Length in.	Width in.	Height in.	Price
7	5¼	2¾	1½	47p
8	4	4	1½	48p
9	4	2¾	1½	46p
10	5¼	4	1½	49p
11	4	2½	2	46p
12	3	2	1	38p
13	6	4	2	58p
14	7	5	2½	75p
15	8	6	3	93p
16	10	7	3	£1.14

Prices invlude VAT (at 8%) but 18p should be added to the total order value for postage & packing.

8 WATT 12 VOLT FLUORESCENT LIGHT KIT
Complete Kit including all components, heatsink, channel, tube, etc.
ONLY **£3.49** inc. VAT p&p
Ready Built £4.10 inc. VAT p&p
Diffuser 59p extra inc. VAT p&p
Send cheque or PO's with your order direct to:
ELECTRONICS DESIGN ASSOCIATES Dept. ET1 9, 82 Bath Street, Walsall WS1 3DE. Phone Walsall 33652

PCB's

Printed Circuit Boards for all ETI projects. Boards also available for other published designs or individual requirements, one-offs or small runs.

HARDWARE

Screws, nuts, washers, etc. Sheet aluminium cut to size or in standard packs, plain or punched/drilled to spec. Fascia panels, dials, name plates, etc., in etched aluminium.

Send 10p stamps for Catalogue

RAMAR CONSTRUCTOR SERVICES
MASON'S ROAD
STRATFORD-ON-AVON
WARWICKSHIRE
Tel: Stratford-on-Avon (0789) 4879

magswitch

introduce their brilliant and comprehensive range of

DIGITAL CLOCKS

The MAGSWITCH philosophy is to offer a range of clocks, kits and modules that are imaginative in concept — exciting to construct — styled to add prestige to any home or office setting.

BASIC KITS

Designed and engineered for successful assembly. Versatile and extendable for advanced functions — calendar — alarm — radio timer.

MODULES

Build into your hi-fi, embed it into a wall or anywhere.

COMPLETE CLOCKS

Assembled and tested or in kit form. A stunning choice of styles, cases and colours. From the simple to the prestigeous.

Square clocks — cylindrical clocks — trendy cool clocks — hot rainbow clocks — ultra-modern chrome clocks

Priced from £15.45-£29.95 + 8% VAT

Let MAGSWITCH convince you with a set of information sheets and full colour photograph of the range. Send 15p (gladly refunded against order) to:

MAGSWITCH
36 CELL BARNES LANE
ST. ALBANS, HERTS. AL1 5QY

MCLEOD SPECIALS?

McLeod International Ltd., Special Products Division offer design, source, manufacture and consultancy on all types of digital electronic equipment such as Public Display clocks, data recording instruments, stop clocks, etc.

Give us your specification and let us quote you.

McLeod International Limited,
(Special Products Division)
Sovereign House, Lion Green Road, Coulsdon, Surrey.
Tel: 01-668-8286, Telex: 945832.

PLEASE MENTION ETI WHEN REPLYING TO ADVERTISERS

TELETYPE 28 — NEW SPECIAL PRICE

TELETYPE 28 without keyboard. Good condition (can be used as receive only) **£32.50**

TELETYPE 28 with housing, keyboard and Power supply **£45** ea.

Limited quantities — information in process of being obtained — this may not be available when orders are dispatched but we guarantee to forward comprehensive information at the earliest possible time.

Ex BEA

Control Units by Univac.

Consisting of 2 -50way plug/socket; 3 multiway switch assembly; a 2 & 4 decade push button assembly electrical reset; etc. Very good value. **£12.50 each.**

FHACHI VCO MODULE FX11—10—100KHZ

Size 2 x 1⅛ x ⅝"H. Input 12V to 24V DC (not centre tapped) 18V input giving 10V constant amplitude output. Requires only 1 meg ohm potentiometer to tune entire range — or can be swept with a saw tooth input.

Price £5.75. P&P 20p.

MARCONI OSCILLOSCOPES

DC — 15 MHZ

TF1330 — Single Beam . . . . **£65 ea.**

TF 1331 — Double Beam . . . . **£85 ea.**

FHACHI RAMP MODULE FX21. 24 Volt DC input for 18 volt saw tooth output. Requires only external capacitor and 100K ohm potentiometer to control frequency range up to 100KHZ (eg 50 mfd electrolytic gives sweep of approx 1 cm per second). In or out sync capability. Price **£5.75.** P.&P. 20p.

EX-MINISTRY CT436 Double Beam Oscilloscope DC-6 megs. Max Sensitivity 10mv/cm. Small compact. Size 10 x 10 x 16 in. Suitable for Colour TV servicing. Price **£85** each including copy of manual.

12" CRT Magnetic Deflection. Blue Trace Yellow Afterglow (P7). Information and recommended circuits with all purchases. Brand new boxed. **£4** each. Carriage £2.

LOW FREQUENCY ANALYSER

50Hz—50kHz

ASSEMBLY AND INSTRUCTION INFORMATION S.A.E.

PRICE **£27.** P. & P. 75p

Board, modules and all components (excluding P.U.).

GRATICULES. 12 cm. by 14 cm. in High Quality plastic. **15p** each. P. & P. 8p.

★**PANEL** mounting lamp holders. Red or green. **9p** ea.

BECKMAN MULTITURN DIAL
Model RB. Brand new
£1.90. P. & P. 15p

FIBRE GLASS PRINTED CIRCUIT BOARD. Brand new. Single or Double sided. Any size **1½p** per sq. in. Postage **20p** per order.

★**LIGHT EMITTING DIODES** (Red) from Hewlett-Packard. Brand New. **38p** ea. Information **5p.** Holders **1p.**

METERS by SIFAM type M 42. 25—0—25 micro amp. Scaled 25—0—25 green: 250—0—250 red; linear. As new. **£2·95** ea. P. & P. 37p.

BLOCK PAPER CAPACITORS AVAILABLE. S.A.E. with requirements.

★**PHOTOCELL** equivalent OCP 71. **13p** ea.

★**STANDARD** 2 meg. log pots. Currant type. **15p** ea.

INSTRUMENT 3in. Colvern 5 ohm **35p** ea.; 50K and 100K **50p** ea.

BOURNS TRIMPOT POTENTIOMETERS. 20; 50; 100; 200; 500 ohms; 1; 2; 2·5; 5; 10; 25K at **35p** ea. ALL BRAND NEW.

★TELEPHONES

MODERN STYLE 706 BLACK OR TWO-TONE GREY **£3.75** each. P.&P. 45p. STYLE 7006 TWO-TONE GREEN and GREY **£3.75** each. P.&P. 45p. HANDSETS—complete with 2 insets and lead **75p** each. P.&P. 37p. **DIALS ONLY 75p** each. P.&P. 25p.

MODERN STANDARD TELEPHONES IN GREY OR GREEN WITH A PLACE TO PUT YOUR FINGERS LIKE THE 746. **£3.00** each. P.&P. 45p.

RELIANCE P.C.B. mounting 270; 470; 500 ohms; 10K at **35p** ea. ALL BRAND NEW.

VENNER Hour Meters—5 digit wall mount —sealed case. Standard mains. **£3·75** ea. P. & P. 55p.

TRANSFORMERS. All standard inputs. Gard/Parm/Part. 450-400-0-400-450. 180 MA. 2 x 6.3v. **£3** ea.

FANTASTIC VALUE
Miniature Transformer. Standard 240V input. 3Volt 1 amp output. Brand New. **65p** each P. & P. 20p. Discount for quantity.

★**CAPACITOR PACK** 50 Brand new components only **50p.** P.&P. 27p.

★**P.C. MOUNT SKELETON PRE-SETS.** Screwdriver adjust 10, 5 and 2.5M @ **2p** ea. 1M, 500, 250 and 25K @ **4p** ea. Finger adjust 10, 5 and 2.5M @ **3p** ea. 1M, 500, 250 and 25K @ **5p** ea. Min P. & P. 15p.

★**1000pf FEED THRU CAPACITORS.** Only sold in packs of 10—**30p** P. & P. 15p.

RECTANGULAR INSTRUMENT FANS. American Ex-equ. Size 4¾ x 4¾ x 1½". 115 Volt. Very quiet **£3** ea. P.&P. 47p.

DELIVERED TO YOUR DOOR 1 cwt. of Electronic Scrap chassis, boards, etc. No Rubbish. FOR ONLY **£4.** N. Ireland £2 extra.

P.C.B. PACK S & D. Quantity 2 sq. ft.—no tiny pieces. **50p** plus P. & P. 20p.

★**TRIMMER PACK,** 2 Twin 50/200 pf ceramic; 2 Twin 10/60 pf ceramic; 2 min strips with 4 preset 5/20 pf on each; 3 air spaced preset 30/100 pf on ceramic base. All BRAND NEW **25p** the LOT. P.&P. 15p.

ALMA precision resistors 200K; 400K; 497K; 998K; 0·1% **27p** ea.; 3·25K, 5·6K, 13K—0·1% **20p** ea.

RELAYS

Varley VP4 plastic covers 4 pole c/o 15K—**33p**; 5·8K—**40p** ea.

★**HIGH-VALUE—PRINTED BOARD PACK.** Hundreds of components, transistors, etc.—no two boards the same—no short-leaded transistor computer boards. **£1.75** post paid.

Large quantity LT, HT, EHT transformers and chokes.

★Vast quantity of good quality components —NO PASSING TRADE—so we offer
3 LB. of ELECTRONIC GOODIES for £1.70 post paid

★**CRYSTALS.** Colour 4.43MHz. Brand New. **£1.25** ea. P.&P. 15p.

★**Beehive Trimmer 3/30 pf**
Brand new. Qty 1—9 **13p** ea. P. & P. 15p; 10—99 **10p** ea. P. & P. 25p; 100—999 **7p** ea. P. & P. free.

HF Crystal Drive Unit. 19in. rack mount. Standard 240V input with superb crystal oven by Labgear (no crystals) **£5** ea. Carr. £2·00.

★**A.B. POTENTIOMETERS LIN.** 100K + 100K DUAL GANG. **25p** each. Discount for quantities. P. & P. extra.

★**METER PACKS**—3 different meters for **£2.** P.&P. 55p.

RESETTABLE COUNTERS—4 digit by Stonebridge/Sodeco. 1000ohm coil. **£2** ea. P.&P. 35p.

DON'T FORGET YOUR MANUALS S.A.E. WITH REQUIREMENTS

LOW FREQUENCY WOBBULATOR

For alignment of Receivers, Filters etc. 250KHz to 5 MHz, effective to 30 MHz on harmonics. Three controls—RF level sweep, width and frequency. Order LX63. Price **£8·50** P. & P. 35p.

As above but can have extended cover range down to 20KHz by addition of external capacitors. Order LX63E. Price **£11.50** P. & P. 35p.

Both models can be used with any general purpose oscilloscope. Requires 6·3V AC input. Supplied connected for automatic 50Hz sweeping. An external sweep voltage can be used instead. These units are encapsulated for additional reliability, with the exception of the controls (not cased, not calibrated).

20HZ to 200KHZ SINE AND SQUARE WAVE GENERATOR

In four ranges. Wien bridge oscillator thermistor stabilised. Separate independent sine and square wave amplitude controls. 3V max sine, 6V max square outputs. Completely assembled P.C. Board, ready to use. 9 to 12V supply required. **£8·85** each. P. & P. 25p. Sine Wave only **£6·85** each. P. & P. 25p.

WIDE RANGE WOBBULATOR

5 MHZ to 150 MHZ (Useful harmonics up to 1·5 GHZ) up to 15 MHZ sweep width. Only 3 controls, preset RF level, sweep width and frequency. Ideal for 10·7 or TV IF alignment, filters, receivers. Can be used with any general purpose scope. Full instructions supplied. Connect 6·3V AC and use within minutes of receiving.

All this for only **£6·75.** P. & P. 25p. (Not cased, not calibrated.)

TRANSISTOR INVERTORS

TYPE A	TYPE B	TYPE C	TYPE D
Input: 12V DC	Input: 12V DC	Input 12V to 24V DC	Input 12V to 24V DC
Output: 1.3kV AC 1.5MA	Output: 1.3kV DC 1.5MA	Output 1.5kV to 4kV AC 0.5MA	Output 14kV DC 100 micro amps at 24V. Progressively reducing for lower input voltages
Price **£3.45**	Price **£4.70**	Price **£6.35**	Price **£11**

Postage & Packing 36p

MAKE YOUR SINGLE BEAM SCOPE INTO A DOUBLE WITH OUR NEW LOW PRICED SOLID STATE SWITCH.
2 HZ to 8 MHZ. Hook up a 9 volt battery and connect your scope and have two traces for ONLY **£6.25.** P. & P. 25p.
STILL AVAILABLE our 20 MHZ version at **£9·75.** P. & P. 25p.

Unless stated – please add £2.00 carriage to all units.

VALUE ADDED TAX not included in prices—Goods marked with ★ 25% VAT, otherwise 8%

Official Orders Welcomed, Gov./Educational Depts., Authorities, etc., otherwise Cash with Order

Open 9am to 5.30pm Mon to Sat.

Buy it with Access

CHILTMEAD LTD

BARCLAYCARD

7/9 ARTHUR ROAD, READING, BERKS. (rear Tech. College, Kings Road) Tel.: Reading 582605/65916

CHROMASONIC electronics

Dept. 7. 56, Fortis Green Road, Muswell Hill, London, N10 3HN.
telephone: 01-883 3705

C-MOS

mix prices

	1-24	25-99	100up
CD4000AE	19p *	17p *	14p *
CD4001AE	19p *	17p *	14p *
CD4002AE	19p *	17p *	14p *
CD4006AE	£1.59 *	£1.33 *	£1.06 *
CD4007AE	23p *	19p *	15p *
CD4008AE	£1.75 *	£1.46 *	£1.17 *
CD4009AE	Use	CD4049*	
CD4010AE	Use	CD4050*	
CD4011AE	19p *	17p *	14p *
CD4012AE	19p *	17p *	14p *
CD4013AE	59p *	50p *	46p *
CD4014AE	£1.75 *	£1.46 *	£1.17 *
CD4015AE	£1.75 *	£1.46 *	£1.17 *
CD4016AE	55p *	48p *	44p *
CD4017AE	£1.29 *	£1.07 *	93p *
CD4018AE	£1.89 *	£1.56 *	£1.25 *
CD4019AE	80p *	66p *	53p *
CD4020AE	£1.97 *	£1.64 *	£1.31 *
CD4021AE	£1.75 *	£1.46 *	£1.17p *
CD4023AE	19p *	17p *	14p *
CD4022AE	£1.83 *	£1.53 *	£1.27 *
CD4024AE	£1.26 *	£1.05 *	84p *
CD4025AE	19p *	17p *	14p *
CD4026AE	£2.79 *	£2.33 *	£1.86 *
CD4027AE	98p *	82p *	65p *
CD4028AE	£1.53 *	£1.28 *	£1.02 *
CD4029AE	£1.89 *	£1.56 *	£1.15 *
CD4030AE	71p *	59p *	47p *
CD4035AE	£1.75 *	£1.46 *	£1.17 *
CD4040AE	£2.01 *	£1.69 *	£1.34 *
CD4042AE	£1.49 *	£1.24 *	99p *
CD4046AE	£2.15 *	£1.79 *	£1.44 *
CD4049AE	69p *	58p *	46p *
CD4050AE	69p *	58p *	46p *
CD4051AE	£2.78 *	£2.32 *	£1.85 *
CD4052AE	£2.78 *	£2.32 *	£1.85 *
CD4056AE	£2.12 *	£1.76 *	£1.41 *
CD4060AE	£2.39 *	£1.99 *	£1.55 *
CD4066AE	£1.13 *	94p *	75p *
CD4068AE	28p *	24p *	19p *
CD4069AE	28p *	24p *	19p *
CD4070AE	28p *	24p *	19p *
CD4071AE	28p *	24p *	19p *
CD4077AE	71p *	59p *	47p *
CD4081AE	28p *	24p *	19p *
CD4082AE	28p *	24p *	19p *
CD4085AE	£1.28 *	£1.06 *	85p *
CD4086AE	£1.28 *	£1.06 *	85p *
CD4093AE	£1.56 *	£1.20 *	£1.04 *
CD4099AE	£2.95 *	£2.46 *	£1.96 *
CD4511AE	£2.36 *	£1.79 *	£1.44 *
CD4528AE	£1.30 *	£1.08 *	87p *

I.C. SOCKETS

Pin Sockets, pins in strips of 100. Just snip off what you need. ~~55p~~ per strip *

Dual in line

8 pin 13p — 24 pin 26p — TO5
14 pin 15p — 28 pin 30p — 8 pin 31p
16 pin 15p — 36 pin 39p — 10pin 35p

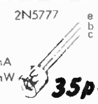
FREE CIRCUITS

Our 8 Page A4 Audio I.C. Booklet is supplied FREE with purchases of Linear I.C.'s worth £1. or more (35p. if sold alone) Contains circuits and pin connections

- 15 Amplifiers 250 mW to 20 watts
- 5 Audio Pre-Amplifiers
- 1 Tape Pre-Amplifier
- 1 Power Driver
- 1 Instrument Amplifier (Bifet)
- 1 General Purpose Mini Amplifier
- 1 D.C. Controlled Gain Control
- 1 Micro-mini radio (2 I.C's)

PHOTO-DARLINGTON

Vceo 25v — 2N5777
Vcbo 25v
Vebo 8v
I 250 mA
Pd 200 mW
Hfe 2500

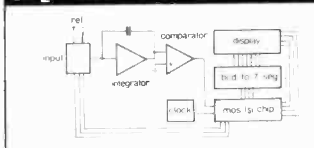


35p.

LINE-O-LIGHT

NEW LED Linear Cursors each device contains 10 light emitting diodes in a 20 pin dual-in-line package. Ideal for solid state analogue meters or dials Type 101 RED £2.26.* Complete with leaflet.

3½ DECADE DVM I.C.



This state-of-the-art MOS LSI chip contains all the logic necessary for a 3½ decade, dual slope integrating, automatic polarity detecting DVM. Supplied with free data and circuit booklet. AY-5-3507

OUR PRICE ONLY £6.59.*

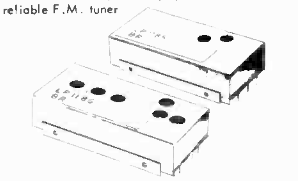
(Data and Circuit Booklets alone 20p.)

The AY-5-1224 tick-tock

Another marvel from G.I. A 16 pin 12-24 hr. Clock I.C. with 25 pin capability and low external parts count. Supplied with manufacturers detailed leaflet £3.95p*(inc. VAT) (Leaflet alone 20p.) Full Kit (excluding case) available towards end of 1975. Phone Clive for details.

MULLARD MODULES

Still make the simplest, highly reliable F.M. tuner



LP1186 Varactor front end £5.38
LP1185 I.F. Strip £6.22
LP1400 Multiplex decoder £5.62

74 TTL

mix prices

	1-24	25-99	100+
7400	14p*	12p *	10p *
7401	14p*	12p *	10p *
7402	14p*	12p *	10p *
7403	15p*	12½p*	10p *
7404	16p*	13p *	11p *
7408	16p*	13p*	11p *
7409	16p*	13p*	11p *
7410	16p*	13p*	11p *
7413	29p*	24p*	20p *
7417	27p*	22½p*	20p *
7420	16p*	13p*	11p *
7427	27p*	22½p*	18p *
7430	16p*	13p *	11p *
7432	27p*	22½p*	18p *
7437	27p*	22½p*	18p *
7441	75p*	62p*	50p *
7442	65p*	55p*	43p *
7445	85p*	71p*	57p *
7447	81p*	75p*	65p *
7448	75p*	62p*	50p *
7447A	95p*	83p*	67p *
7470	30p*	25p*	20p *
7472	25p*	21p*	17p *
7473	30p*	25p*	20p *
7474	32p*	26p*	21p *
7475	47p*	39p*	31p *
7476	32p*	26p*	21p *
7482	75p*	62p*	50p *
7485	£1.30 *	£1.09 *	87p *
7486	32p*	26p*	21p *
7489	£2.92 *	£2.80 *	£2.10 *
7490	49p*	40p*	32p *
7491	65p*	55p*	45p *
7492	57p*	46p*	36p *
7493	45p*	40p*	32p *
7495	67p*	55p*	45p *
74100	£1.08 *	89p*	72p *
74107	35p*	28p*	22p *
74121	34p*	28p*	23p *
74122	47p*	39p*	31p *
74141	78p*	63p*	53p *
74145	68p*	58p*	48p *
74154	£1.62 *	£1.48 *	86p *
74174	£1.00 *	83p*	67p *
74180	£1.06 *	88p*	71p *
74181	£3.20 *	£2.50 *	£1.90 *
74192	£1.35 *	£1.14 *	90p *
74193	£1.35 *	£1.14 *	90p *
74196	£1.64 *	£1.34 *	99p *

LINEAR I.C.'s

555 (8 pin dip)V	55p *
555 (TO-99)T	81p *
556 (14 pin dip)	£1.29 *
703 (RF/IF Amp)	68p
709 (8 pin dip)	38p
709 (T0-99)	45p
709 (14 pin dip)	39p
710 (8 pin dip)	39p
710 (T0-99)	45p
710 (14 pin dip)	44p
711(T0-99)	51p
711 (14 pin dip)	44p
720 (A.M.Radio)	£1.76
723 (T0-99)	£1.09
723 (14 pin dip	74p
741 (8 pin dip	36p
741 (T0-99)	43p
741 (14 pin dip)	36p
747 (14 pin dip)	£1.04
748 (8 pin dip)	42p
748 (T0-99)	46p
748 (14 pin dip)	49p
753 (F.M. 1st.I.F)	£1.08
75491	88p *
75492	£1.10 *

Regulators 100 mA

78105WC (T0-92)	60p *
78L12WC (T0-92)	60p *
78L15WC (T0-92)	60p *

Regulators 100mA

78L05AWC (TBA625A)	90p *
78L12AWC (TBA625B)	90p *
78L15AWC (TBA625C)	90p *

Regulators 500mA

78M05HC	£1.35 *
78M12HC	£1.35 *
78M15HC	£1.35 *
78M18HC	£1.35 *
78M24HC	£1.35 *

Regulators 1A

7805KC (T0-3)	£2.09 *
7812KC (T0-3)	£2.09 *
7815KC (T0-3)	£2.09 *
7818KC (T0-3)	£2.09 *
7824KC (T0-3)	£2.09 *

Regulators 1A

7805UC (T0-220)	£1.72 *
7812UC (T0-220)	£1.72 *
7815UC (T0-220)	£1.72 *
7818UC (T0-220)	£1.72 *
7824UC (T0-220)	£1.72 *
ICL8030	£3.52 *

AY-1-0212	£6.93
AY-1-5051	£1.44
AY-5-1224	£3.95 *
AY-5-3500	£6.59 *
AY-5-3507	£6.59 *
AY-5-4007	£7.94 *
BHA0002	£3.01
CA2111	£1.19
CA3045	£1.69
CA3046	88p
CA3053	59p
CA3065	£1.60
CA3075	£1.64
CA3078	£1.26
CA3080	59p
CA3081	£1.86
CA3082	£1.86
CA3089E (TDA1200)	£2.43
CA3097E	£1.67 *
CA3123E	£1.76
CA3130	84p
CA3401E (LM3900)	68p
CA3600E	£1.44
CT7001	£5.34 *
L005T1 (T0.3)	£1.46 *
L036T1 (T0.3)	£1.46 *
L037T1 (T0-3)	£1.46 *
L129 (SOT-32)	85p *
L130 (SOT-32)	85p *
L131 (SOT-32)	85p *
LM301T (T0-99)	65p
LM301S (8 pin dip)	59p
LM301A T(T0-99)	67p
LM301A S(8 pin dip)	59p
LM307 T (T0-99)	59p
LM307 S (8 pin dip)	57p
LM308 T (T0-99)	£1.96
LM308 S (8 pin dip)	98p
LM308A T (T0-99)	£7.92
LM308A S (8 pin dip)	£6.90
LM309K	£2.34 *
LM339	£2.25
LM370N	£2.85
LM371	£2.08
LM372N	£1.99
LM373N	£2.99
LM377N	£2.71
LM380	£1.25
LM381	£1.85
LM382	£1.66
LM703	68p
LM1820	£1.03

LM2111	£1.12
LM3900	69p
LM3909	66p *
MC1303L	£1.84
MC1306P	80p
MC1310P	£2.39
MC1312	£2.42
MC1314	£4.13
MC1315	£4.62
MC1327	£1.12
MC1330P	83p
MC1339P	£1.52
MC1350	64p
MC1351	88p
MC1352	88p
MC1357	£1.57
MC1358(CA3065)	£1.16
MC1375	£1.48
MC1455 (555T)	62p *
MC1456CG	£1.68
MC1458CP1	84p
MC1468G	£2.18 *
MC1495L	£4.24
MC1496G	96p
MC3302P	£1.50
MC3401P	74p
MFC4000B	87p
MFC4060A	79p *
MFC6030A	79p *
MFC6040	96p
MFC6070	£1.66
MM5314	£4.80 *
MM5316	£9.99 *
MVRSV (T0-3)	£1.45 *
MVR12V (T0-3)	£1.45 *
MVR15V (T0-3)	£1.45 *
NE5401	£1.25
NE546A	£1.16
NE555V	73p *
NE556	£1.29 *
NE560B	£5.06
NE561B	£5.06
NE562B	£5.06
NE563	£2.96
NE565N	£2.63
NE566V	£1.87
NE567V	£2.63
SL414A	£2.09
SL415A	£2.75
SL437D	£7.50
SL440	£2.84 *
SN75491N	88p *
SN75492N	£1.10 *

ZN414 Leaflet free with devices (10p alone)

MC1310; 2, 4 & 5 Leaflet free with devices (10p alone)

SN76001N (TAA611)	£1.82 *
SN76003N	£3.30
SN76013N	£1.98
SN76023N	£1.98
SN76 227N(MC1327)	£1.89
SN76532N	£1.86
SN76544N	£1.81
SN76550-2(TAA550)	89p
SN76552-2	81p
SN76660N(TBA120)	75p
SN76666N (CA3065)	£1.12
TAA263	£1.50
TAA300	£2.16
TAA310A	£1.87
TAA320	£1.44
TAA350	£2.43
TAA370	£3.45
TAA550	75
TAA570	£2.75
TAA700	£5.03
TBA120S	£1.25
TBA231	£1.02
TBA281 (723)	£2.59
TBA500Q	£3.16
TBA520Q	£3.85
TBA530Q	£3.27
TBA540Q	£3.72
TBA550Q	£5.29
TBA560CQ	£5.29
TBA625A	£1.03 *
TBA625B	£1.03 *
TBA625C	£1.03 *
TBA651	£1.87
TBA720Q	£2.79
TBA750Q	£2.79
TBA800	£1.11
TBA810S	£1.24
TBA810AS	£1.24
TBA820	86p
TBA920Q	£4.71
TBA990Q	£4.71
TCA270Q	£5.24
TCA760	£2.16
TCA800Q	£7.24
TCA830S	£1.04
TCA940	£2.25
TDA1054	£1.50
TDA1200	£2.43
TDA1405	80p *
TDA1412	80p *
TDA1415	80p *
TDA2010	T.B.A.
TDA2020	T.B.A.
ULN2111A	£1.52
ZN414	£1.26

LED DISPLAYS

Litronix Double Digit Displays 0.5" Common Anode, 2 R/H Decimal Points
DL721 ± 1.9
DL727 0.0 to 9.9
Suitable for Clocks, Meters, Instruments, Channel Indicators
Our price £4.75 * each

NEW

Low cost Red GaAsP Motorola MLED 500 in a T092 package

15p.*

		C.Anode R/H Dec. pt.	C.Anode, L/H Dec.pt.	C.Anode ±1	C.Cathode R/H Dec.Pt.	
0.33"	Litronix DL 707 Series	✓	✓	✓	✓	all £1.82* each (Red only)
0.33"	Monsanto MAN 50/70/80/3600	✓	✓	✓	✓	all £1.82* Each (Red, green, yellow, Orange)
0.33"	Xciton XAN 70 Series	✓		✓	✓	all £1.49* Each (Red Green, yellow)
0.43"	Monsanto MAN 4000 Series	✓	✓	✓	✓	all £2.32* Each (Red, Green, Yellow, Orange)
0.63"	Litronix DL747 'Jumbo' Series		✓	✓		all £242* Each (Red only)

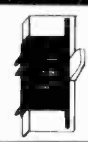
Common Cathode as Common Anode (Red only)

NOTE: MAN 4000 Series pin outs are 14 pin dil the same as MAN 50; 70 and 80 series.

DIGITAL SWITCH

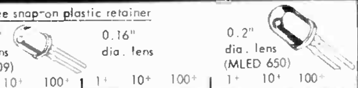
BCD encoded digital switch Reading 0 to 9. Suitable for digital clock alarm setting DVM input Scaling etc.

1 to 9. £1.49 each *



LIGHT EMITTING DIODES

Free snap-on plastic retainer



	0.125" dia. lens (TIL209) 1+	10+	100+	0.16" dia. lens 1+	10+	100+	0.2" dia. lens (MLED 650) 1+	10+	100+
Red	16p	15p	13p *	27p	24p	22p*	18p	16p	14p *
Green	27p	24p	22p*	33p	30p	27p*	30p	27p	25p *
Orange	27p	24p	22p*	33p	30p	27p*	30p	27p	25p *
Yellow	34p	31p	29p*	35p	32p	29p*	35p	33p	30p *

.......Cont'd

Our Bulk Buying Power enables a repeat of our Special Offer:
0.43" (LIT 707) 90p.*(inc. VAT)
0.63" (LIT 747) £1.99 .*(inc. VAT)

OPTO-ISOLATORS

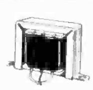
1LI 4N25 or TIL116
6 pin industry standard package
2.5KV isolation £1.00.*

MAINS TRANSFORMERS

Secondaries

6-0-6V	100 mA	97p. *
9-0-9V	100 mA	97p. *
12-0-12V	100 mA	97p *
20-0-20V	1 A	£4.55 *
24-0-24V	500 mA	£2.48 *
28-0-28V	1 A	£6.18 *

	½A	1A	2A	4A
0-9-17 V	-	£1.95 *	£2.27	£2.64 *
0-12-15-20-24-30 V	-	£2.48 *	£4.15.	- *
0-24-30-40-48-60 V	-	£5.18 *	£7.02	- *
0-19-25-33-40-50 V	£2.70 *	£3.40 *	£4.53	- *



p.p. on transformers 10% of price min. 20p

VAT INC

Items followed by a* inc. VAT at 8% all others include 25%

Overseas Customers deduct 2/27 from * items. 1/5 from others

postage & packing 20p. Orders for over £6. post free. Except transformers

Data Sheet and photocopy service available 10p. per page

Advert No. 1A of Series B

CALLERS WELCOMED