ELECTRONICS TODAY

electronics today international

FEBRUARY 1976
30p
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CANADA $1

This photo was taken using this

EXPOSURE METER

ELECTRONICS IN GEOPHYSICAL SURVEYS

PROJECTS:
CMOS TESTER
TONE BURST GENERATOR
DYNAMIC NOISE FILTER

NEW SERIES
CMOS
INTRO TO THIS VERSATILE TECHNOLOGY

NEWS . . . CONSTRUCTION . . . DEVELOPMENTS . . . AUDI

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C-MOS

mix prices

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Dual in line

8 pin 13p.	24 pin 26p.	105
14 pin 15p	28 pin 30p.	8 pin 31p.
16 pin 15p	36 pin 39 p.	10 pin 35p.

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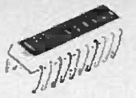
PHOTO-DARLINGTON

Vceo 25v 2N5777
Vcbo 25v
Vebo 8v
Il 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.

74 TTL

mix prices

	1-24	25-99	100
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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 *
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7448	75p*	67p*	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 *
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7490	49p*	40p*	32p *
7491	65p*	55p*	45p *
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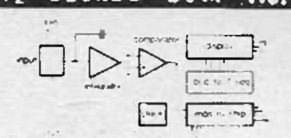
7493	45p*	40p*	32p *
7495	67p*	55p*	45p *
74100	£1.08 *	89p*	72p *
74107	35p*	28p*	22p *
74121	34p*	29p*	23p *
74122	47p*	39p*	31p *
74141	78p*	63p*	53p *
74145	80p*	58p*	48p *
74154	£1.62 *	£1.48 *	86p *
74174	£1.00 *	83p*	67p *
74180	£1.06 *	88p*	71p *
74181	£3.70 *	£2.50 *	£1.90 *
74192	£1.35 *	£1.14 *	90p *
74193	£1.35 *	£1.14 *	90p *
74196	£1.64 *	£1.34 *	99p *

3½ DECADE DVM I.C.



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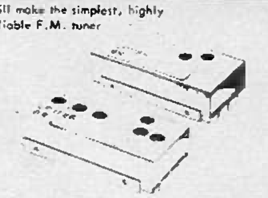

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711 (14 pin dip)	44p
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Common Cathode as Common Anode (Red only)

NOTE MAN 4000 Series pin outs are 14 pin dil the same as MAN 50; 70 and 80 series.

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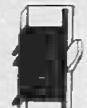

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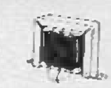

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FEBRUARY 1976 VOL 5. No. 2.

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News & Information

Cover: It's a nice exposure meter we know, but we thought you'd rather see a picture of a pretty girl. Well, we asked Lia to St James's Park and did some photos. This cover shot was taken using 1/125 at F8 measured on our simple meter.

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7401	0.12	0.09	7450	0.12	0.10	74123	0.58	0.50
7402	0.10	0.09	7451	0.12	0.10	74141	0.62	0.60
7403	0.12	0.09	7453	0.12	0.10	74145	0.70	0.65
7404	0.10	0.09	7454	0.12	0.10	74150	1.30	1.25
7405	0.10	0.09	7460	0.12	0.10	74151	0.65	0.60
7406	0.28	0.25	7470	0.26	0.24	74153	0.65	0.60
7407	0.28	0.25	7472	0.22	0.20	74154	1.30	1.25
7408	0.14	0.10	7473	0.26	0.22	74155	0.65	0.60
7409	0.14	0.10	7474	0.27	0.23	74156	0.65	0.60
7410	0.08	0.07	7475	0.44	0.40	74157	0.90	0.80
7411	0.20	0.18	7476	0.28	0.25	74160	0.95	0.85
7412	0.20	0.18	7480	0.40	0.35	74161	0.95	0.85
7413	0.26	0.25	7481	0.95	0.90	74162	0.95	0.85
7416	0.28	0.25	7482	0.72	0.62	74163	0.95	0.85
7417	0.27	0.24	7483	0.80	0.68	74164	1.20	1.10
7420	0.10	0.09	7484	0.85	0.80	74165	1.20	1.10
7422	0.25	0.23	7485	1.20	0.95	74166	1.20	1.10
7423	0.26	0.24	7486	0.30	0.25	74174	1.00	0.90
7425	0.26	0.24	7489	2.70	2.50	74175	0.95	0.85
7426	0.26	0.24	7490	0.38	0.32	74176	1.00	0.95
7427	0.26	0.24	7491	0.60	0.50	74177	1.00	0.95
7428	0.36	0.34	7492	0.43	0.35	74180	1.00	0.95
7430	0.12	0.10	7493	0.38	0.35	74181	2.00	1.80
7432	0.25	0.22	7494	0.45	0.40	74182	1.00	0.90
7433	0.35	0.32	7495	0.58	0.50	74184	1.50	1.40
7437	0.25	0.22	7496	0.68	0.63	74190	1.40	1.30
7438	0.25	0.22	74100	1.00	0.90	74191	1.40	1.30
7440	0.12	0.10	74101	0.30	0.25	74192	1.10	1.00
7441	0.64	0.58	74105	0.30	0.25	74193	1.10	1.00
7442	0.60	0.52	74107	0.30	0.25	74194	1.00	0.95
7443	0.95	0.90	74110	0.50	0.45	74195	0.75	0.70
7444	0.95	0.90	74111	0.80	0.75	74196	1.00	0.95
7445	0.75	0.55	74118	0.90	0.82	74197	1.00	0.95
7446	0.95	0.85	74119	1.30	1.20	74198	1.90	1.80
7447	0.68	0.65	74121	0.26	0.25	74199	1.80	1.70

Devices may be mixed to qualify for quantity price. (TTL 74 series only) data is available for the above series of I.C.'s in booklet form. Price 35p.

SOCKETS

BPS8 9p BPS14 10p BPS16 11p

LINEAR IC

741P 8PIN 20p

TIMERS

NE555 42p DUAL NE556 85p

TRANSISTORS

TYPE	PRICE
AC128	10p
AC153K	18p
AC176K	20p
AC153/176K MP	38p
AC187K	20p
AC188K	18p
AC187K/188K MP	38p
OC71	9p
BC107	6p
BC108	6p
BC109	6p
BC118	8p
BC154	20p
BC147	8p
BC148	8p
BC149	10p
BC157	12p
BC158	10p
BC159	10p
BC169C	7p
BC170	5p
BC171	5p
BC172	5p
BC182 L&K	10p
BC183	10p
BC184	12p
BC212 L&K	10p
BC213	10p
BC214	12p
BC251	6p
BC327	12p
BC328	12p
BC337	11p
BC338	11p
BF115	10p
BF167	10p
BF173	10p
BF198	12p
BF199	12p
BF194	9p
BF195	9p
BF196	11p
BF197	11p
BF257	22p
BF258	26p
BF259	30p
BFX29	18p
BFX84	15p
BFX85	20p
BFX86	16p
BFY50	15p
BFY51	15p
BFY52	15p
BFY53	14p
2N696	10p
2N697	11p
2N706	6p
2N706A	6p
2N708	7p
2N1613	15p
2N1711	15p
2N1893	18p

TYPE	PRICE
2N2217	15p
2N2218	14c
2N2218A	15p
2N2219	14p
2N2219A	15p
2N2221	14p
2N2221A	15p
2N2222	14p
2N2222A	15p
2N2369	12p
2N2369A	12p
2N2904	12p
2N2904A	13p
2N2905	13p
2N2905A	13p
2N2906	10p
2N2906A	12p
2N2907	11p
2N2907A	13p
2N2926G	9p
2N2926Y	8p
2N3053	15p
2N3055	40p
2N3702	8p
2N3703	8p
2N3704	9p
2N3705	8p
2N3706	8p
2N3707	7p
2N3708	7p
2N3709	7p
2N3710	7p
2N3711	7p

F.E.T.

2N3819	12p
2N3903	8p
2N3904	8p
2N3905	9p
2N3906	9p
2N4058	8p
2N4059	8p
2N4060	9p
2N4061	9p
2N4062	9p
2N5172	9p

UNIJUNCTION

UT46 = T1543	20p
ZTX300	5p
ZTX5D0	8p
ZTX107	5p
ZTX108	5p
ZTX109	5p

DIODES

TYPE	PRICE
OA10	15p
OA47	5p
OA85-OA81	5p
OA91	5p
OA200/BAX13	5p
IN914	4p
IN4148	4p
IN4001	3p
IN4002	4p
IN4003	4p
IN4004	5p
IN4005	5p
IN4006	6p
IN4007	7p

S.C.R.'s

1A/50V TO5	15p
1A/400V TO5	25p
5A/50V TO66	25p
5A/400V TO66	40p

VOLTAGE REGS.

L129 (UA7805)	85p
L130 (UA7812)	85p
L131 (UA7815)	85p

L.E.D.

TIL209/FLV117 RED 5 for 50p

PCB MARKER PENS 65p

BI-PAK

High quality modules for stereo, mono and other audio equipment.

NEW

PUSH-BUTTON STEREO FM TUNER

Fitted with Phase Lock-loop

OUR PRICE ONLY

£19.95

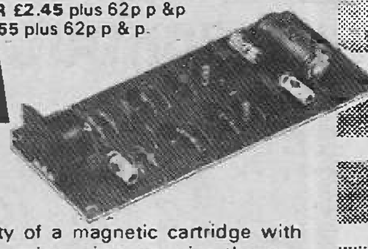
The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.
Used with your existing audio equipment or with the BI-KITS **STEREO 30** or the **MK60** Kit etc. Alternatively the **PS12** can be used if no suitable supply is available, together with the Transformer **T461**.
The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

- FET Input Stage
- VARI-CAP diode tuning
- Switched AFC
- Multi turn pre-sets
- LED Stereo Indicator

Typical Specification:
Sensibility 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

TRANSFORMER £2.45 plus 62p p &p
TEAK CASE £3.65 plus 62p p & p.

MPA 30



Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.
It is provided with a standard DIN input socket for ease of connection. Full instructions supplied.

£2.65

STEREO PRE-AMPLIFIER PA 100

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

Frequency Response + 1dB 20Hz - 20KHz. Sensitivity of inputs
1. Tape Input 100mV into 100K ohms
2. Radio Tuner 100mV into 100K ohms
3. Magnetic P.U. 3mV into 50K ohms

P.U. Input equalises to R1AA curve with 1dB from 20Hz to 20KHz
Supply — 20-35V at 20mA.
Dimensions — 299mm x 89mm x 35mm.

MK. 60 AUDIO KIT: Comprising 2 x SPM80. 1 x BTM80. 1 x PA100. 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet.

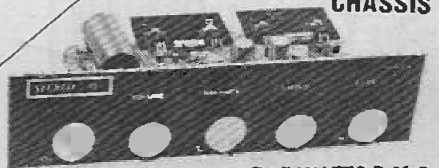
COMPLETE PRICE £27.55 plus 62p postage.

TEAK 60 AUDIO KIT: Comprising Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE £9.20** plus 62p postage.

OUR PRICE £13.50

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 pick-up, 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 and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

£15.75
P & P 45p

VAT ADD 25%

POSTAGE & PACKING
Postage & Packing add 25p unless otherwise shown. Add extra for airmail. Min. £1.00

AL10-20-30

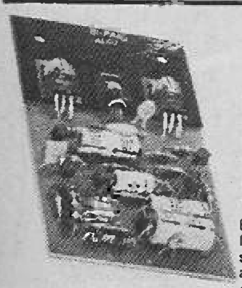
AUDIO AMPLIFIER MODULES

Ideal for record players, recorders, stereo amplifiers, etc.

Harmonic Distortion Po=3 watts f=1KHz 02.5%
Load Impedance 8-16ohm
Frequency response ±3dB Po=2 watts 50Hz-25KHz
Sensitivity for Rated O/P — Vs=25v. RL=8ohm f=1KHz 75mV. RMS
Size: 75mm x 63mm x 25mm

AL10 3w R.M.S.	**£2.30**
AL20 5w R.M.S.	**£2.65**
AL30 10w R.M.S.	**£2.95**

AL 60 25 Watts (RMS)



★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design Improvements ★ Load — 3,4,5, or 16 ohms ★ Signal to noise ratio 80db ★ Overall size 63mm. 105mm. 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.

£3.95

NEW

PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL10/20/30 Amplifier Modules. Features include on/off volume, Balance, Bass and Treble controls. Complete with tape output.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V .5mA. Size 152mm x 84mm x 33mm.

£6.50

PS12

Power supply for **AL10/20/30, PA12, SA450** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.

OUR PRICE

Transformer T538 £2.30

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80**, the unit will provide outputs of up to 1.5A at 35V. Size: 63mm. 105mm. 30mm. Incorporating short circuit protection.
Transformer BMT80
£2.60 + 62p postage

£3.00

BI-PAK

P.O. BOX 6, WARE, HERTS

news digest

An Ampex BCC-2 portable colour camera was recently carried to the summit of the Dufourspitze, Switzerland's higest peak. The cameraman is also wearing the back-pack, through which this new hand-held camera generates full broadcast-quality pictures. Behind him is the dish of the temporary microwave link, and the Ampex VR-3000B portable videotape recorder is in the foreground with a monitor.

'SILVER' CALCULATOR FROM SINCLAIR

This new Sinclair 'Cambridge Memory' pocket calculator, which is finished in 'silver' and matt-black is supplied with a comprehensive instruction booklet and a rigid plastic carrying case, all packaged in an attractive 'silver' gift presentation box.

Featuring the four basic functions + – ÷ x, the unit also incorporates a percentage key and an accumulating memory, which makes it ideal for all non-scientific applications. It is expected to appeal to a wide cross-section of people ranging from housewives to business men.

Typical selling price is £14.95 including VAT.

£1 OFF SINCLAIR CALCULATORS

These giant size Daz packs, which feature '£1 refund on any Sinclair Calculator' vouchers are currently being sold into 100,000 retailers nationwide. Millions of 'money-off' packs of Daz will carry this joint Proctor and Gamble and Sinclair Radionics promotion, which is valid until 1st November, 1976. The offer is valid for any Sinclair calculator, regardless of the price paid to the retailer.

Customers must supply the following proof of purchase to Sinclair, who will send a £1 refund by return

— the front of the calculator pack.
— £1 voucher from the Daz pack.
— the connecting strip from the top of any bottle of Fairy liquid, and, either, — the end flap from any carton of Fairy household soap
— any Head and Shoulders shampoo carton top.

NOVUS BONUS

This is just one of many letters we've received:

Dear Sir,

I have just received my Novus 3500 calculator and am delighted with its performance.Those of your readers who have also purchased one of these machines will be pleased to know that it is capable of lower case functions in addition to those of the inverse trig. functions. Prompted by the similarity between the 3500 and the more expensive 4510 I have found that the ARC key can be used in the same way as the F key on the 4510. With x in the display and after touching ARC, the functions shown in the right hand column are performed on touching the corresponding key in the left hand column:

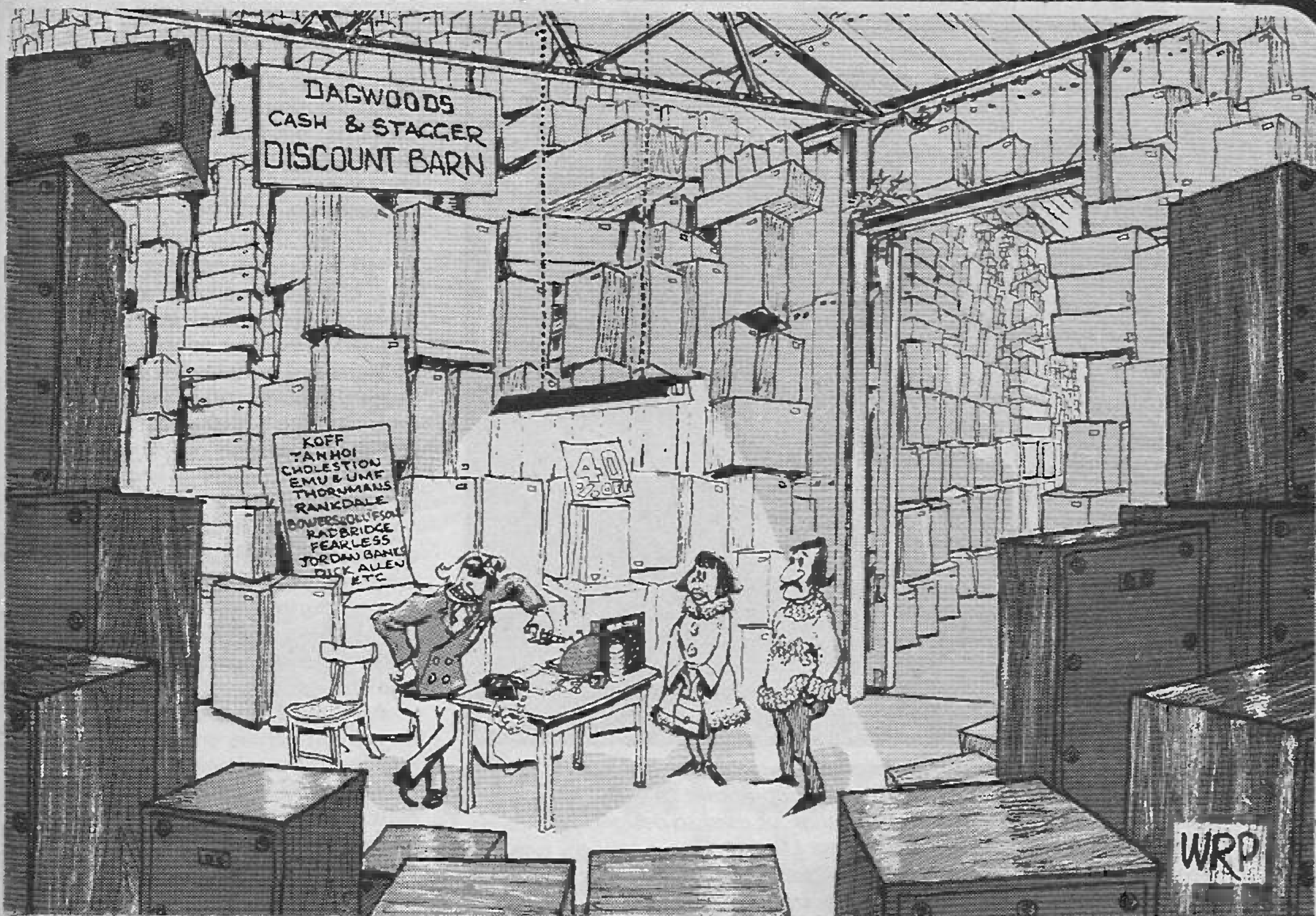
√	x^2
MS	$M+x^2$
÷	degrees→rads
x	rads→degrees
–	M–
+	M+

The two machines are therefore identical in performance. In correspondence with Novus prior to receiving my 3500 they had explained that the difference between the two was the lack of lower case functions on the 3500 excepting the inverse functions. This bonus greatly enhances the value of an already exceptional offer.

Yours faithfully,
G.O.Hayward,
Dyfed.

WHAT'S THIS?

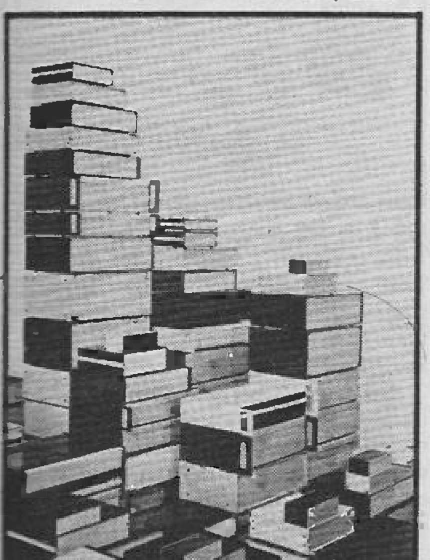
Is it a flying saucer, or a contemporary flying pan? A new hovercraft perhaps? In fact, this is the new 3M Scotch 948 "Winchester" magnetic disc data module. The one illustrated has a capacity of 70 million bytes of information.



"SORRY, LADY, WE DAREN'T RISK DEMONSTRATIONS — — WE'RE NOT INSURED AGAINST AVALANCHE!"

TRANSISTEK MODULAR CASES FOR ELECTRONIC INSTRUMENTS

Following their recent launch of the Transistek range of modular electronic instrument cases, Lektrokit Ltd now have available ex-stock a number of models in the WS3 Series. Ideal for housing logic circuitry, remote control units, power supplies, telecommunications equipment and the like, these



low-cost extruded and laminated aluminium cases are suitable for both production units and prototype or development work.

Four sizes of the functional WS3 instrument case are offered (from 70mm high x 220mm deep x 286mm wide to 128.5 x 260 x 442mm) and each enables most types of electronic or electrical components to be fitted. Several sizes of perforated support trays and extruded aluminium cross sections are available for mounting such components, and the cases can also be supplied with ventilation holes in their lids.

There are eight styles of instrument case in the complete Transistek range, all of which are offered in various colours for production quantities; items from stock are blue and unventilated. Further models will be announced as soon as they are available. Lektrokit Ltd, 3 Trafford Road, Reading RG1 8JR.

HANDBOOK OF DATA COMMUNICATIONS

This 400-page volume has been published by the National Computing Centre for the Post Office, and is aimed at computer people who need to acquire a knowledge of telecommunications. The Post Office holds a range of training causes in data communications for computing staff and have now utilised their expertise in the production of a volume which serves both as an introduction to, and reference on data communications. The text, although easily readable, is also concise and quick to use for reference. Starting with the basics of communications and telephone systems the book progresses through transmission and modulation systems, terminals, error correction, concentrators and multiplexers, to distributed intelligence, message and packing systems and a summary of data transmission services in the UK and abroad. Priced at £8.50, the book can be obtained from technical bookshops or direct from the Post Office at: Data Communications Division (TMk4.3.1), Freepost, London EC2B 2TX.

ELECTROVALUE CATALOGUE

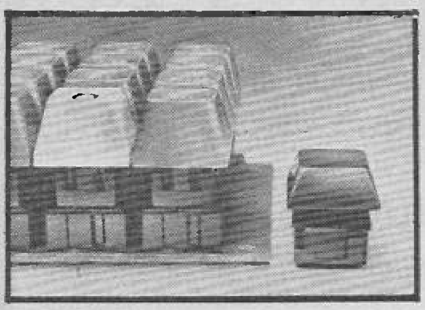
Now available is the latest edition (No.8) of the Electrovalue catalogue. This runs to 144 pages and gives plenty of useful information on transistors and IC's. Virtually all the components and hardware one could want are listed. Included is a 40p voucher refundable on purchases of £5 or over. The catalogue is available for 40p post paid, from Electrovalue Ltd., 28 St. Judes Road, Englefield Green, Egham, Surrey TW20 OHB.

news digest

LASER GUN -- A lightweight laser gun, weighing only 13 pounds, can be aimed by infantrymen to pinpoint targets for laser-homing missiles and projectiles, or used to designate targets for airborne laser spot trackers. It is built by the Hughes Aircraft Company, which has delivered 12 development units to the US Army Electronics Command. Starting March 1, the US Army will begin a six-month programme to field test the equipment under actual operating conditions against a variety of laser seekers and laser spot trackers.

LOW-PROFILE KEY SWITCHES

The new DC-60 Series switches from Invader Components offers the same desireable features as expensive reed or solid state switches at less cost than menchanical types. Profile of the new switch is a mere 19.558mm (0.7770in) including cap.



High reliability is achieved with a trifurcated gold contact design giving a minimum 10,000,000 operations. Mounting alternatives include snap-in clips, high strength solder terminal mounting and heat stable. bottom locating pins.

Switch housing is in mineral filled nylon for high stability throughout the life of the device.

CMOS PRESETTABLE COUNTERS

Two new presettable up/down counters have been added to the comprehensive CD4000 Series of COS/MOS digital integarted circuits produced by RCA Solid State—Europe. The RCA-CD4510BE is a presettable binary-coded-decimal up/down counter and the CD4516BE is a presettable binary up/down counter; each device consists of four synchronously clocked gated D-type flip-flops connected as counters. Applications include up/down difference counting, multistage synchronous counting, multistage ripple counting, and synchronous frequency division.

The devices are designed for medium-speed operation (typically 7MHz), and incorporate facilities for resetting and presetting. The counters are cleared by a high level on the 'reset' line, and can be preset to any binary number by a high level on the 'preset' line. The counters can be cascaded in ripple mode by connecting the 'carry-out' to the clock of the next stage. Both devices are supplied in 16-lead dual-in-line plastic packages. RCA Ltd, Sunbury-on-Thames, Middx.

5-FUNCTION LCD WATCH CIRCUIT

AMI Microsystems have announced the development and production of the first 5-function, 4-digit LCD (liquid crystal display) watch with a voltage tripler.

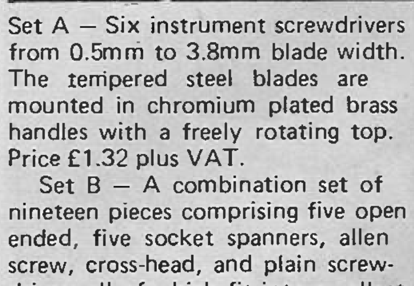
Designated S1424A, it is designed to interface directly with the standard 4-digit LCD and requires only two push buttons for all display and setting functions. In normal operation the S1424A provides a continuous display of hours and minutes. By pressing one button, hours and minutes are replaced with a display of the month and date; a second operation of the same button causes a display of seconds.

Also contained in the circuit is a calendar which automatically compensates for the 28-, 30- and 31-day months during the course of the year, so that the watch needs only to be reset when the batteries have been changed.

An integral voltage doubling or tripling circuit derives either 3V or 4.5V display drive voltage from a single battery at 1.5V, without the need for coils or transformers. This allows the manufacturer a wider choice of liquid crystal displays which, additionally, will present a greater contrast and viewing angle when driven from a 4.5V source.

The S1424A is available in a variety of packages, including a 40-pin DIP (S1427A) for evaluation purposes or clock applications. AMI Microsystems Ltd, 108A Commercial Road, Swindon, Wilts.

METRIC TOOL SETS



Set A — Six instrument screwdrivers from 0.5mm to 3.8mm blade width. The tempered steel blades are mounted in chromium plated brass handles with a freely rotating top. Price £1.32 plus VAT.

Set B — A combination set of nineteen pieces comprising five open ended, five socket spanners, allen screw, cross-head, and plain screwdrivers all of which fit into a collect driving handle. Price £3.28 plus VAT.

All the tool sets are supplied in a rigid plastic case with clear lid. Light soldering Developments Ltd., 97-99 Gloucester Rd, Croydon, Surrey.

[CMOS]

THE FIRST PART OF A NEW SERIES BY T. BAILEY

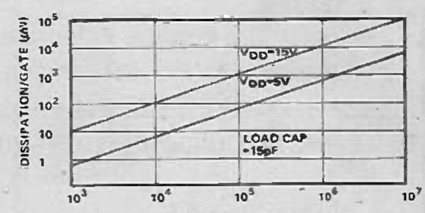
THE AVAILABILITY OF THE CD4000 series of chips brings CMOS to the forefront of logic technology to rival TTL in many applications. CMOS is far less critical as regards power supplies and possesses high noise immunity as well as capabilities which are not offered by other logic families. In this article we shall give various circuits which illustrate the use of CMOS. We suggest that these circuits can be 'breadboarded' on ETI Utilboard (Nov 75 issue) using DIL sockets, there is nothing like trying it to see. Some of the circuitry, of course, is capable of realisation in a number of different logic families, so that, in these cases, we will merely be introducing equivalents of familiar devices. However, some of the applications we give show the refolutionary possibilities of CMOS.

HANDLING AND USE

Firstly we shall deal with the disadvantages of CMOS and get these behind us before we look more closely at some of the virtues. The first point is that these devices are very susceptible to surges of over-voltage from static electricity and unearthed test equipment. When you come to buy any of the ICs we will discuss you should find them with their leads buried in foam. This foam is conductive and protects the device so do not remove it until the IC is to be put in circuit. If you run out of foam for storing devices then stick them into a piece of soft balsa wood. Whatever else you do, you must not keep them in plastic containers or use ordinary plastic foam which may develop a great deal of static. It is in fact a good rule to keep the devices away from all plastics as much as possible including any nylon clothing. It is sensible to use IC sockets for the more expensive devices and also for any chip you may wish to re-use, but if you do solder them solder the V_{DD} pin first, then V_{SS} and then all the others. The reason for this is that the common ranges of CMOS have internal protection devices which operate fully only when the supply lines are connected. While we are on the subject of soldering, check that your iron and any other instruments you may use (meters, oscilloscopes, etc.) are all properly earthed.

The only other real disadvantages of CMOS compared with TTL are that it is slower (typical gate rise time 25nS) and that a few operating precautions are necessary. Firstly, all unused inputs must go somewhere. The alternatives are tying unused inputs to used inputs, either supply line as appropriate, or to a supply line via a resistor (220kΩ is usually about right). The last solution is particularly helpful for inputs to which off-board connections are to be made. This avoids leaving the input "floating" until it is wired in. The other point is to ensure that the chips do not have signals at their inputs when the power supply is not on.

Now we shall consider a few of the advantages of CMOS. Most of these will come out more clearly later and so we shall just mention them briefly here. The principal virtue is the ease of choice of power supply which may be anywhere between three and fifteen volts at low current. The actual power required depends on operating frequency (see fig. 1) being comparable with TTL at ten megahertz but in the region of a few microwatts at sub-kilohertz speeds. Voltage regulation is not required but operating speed and current consumption rise with increasing supply voltage. For most practical purposes CMOS will run off a nine volt battery or the simplest of mains power supplies. Other advantages include high noise immunity and analogue possibilities. Before we proceed with some circuitry a table of operating conditions (table 1) has been given and these should be adhered to rigidly.



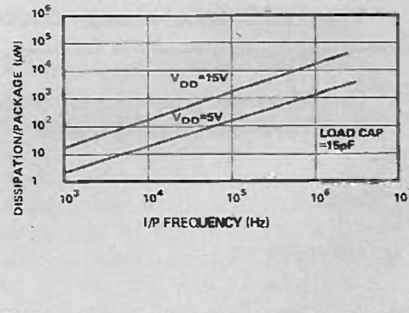
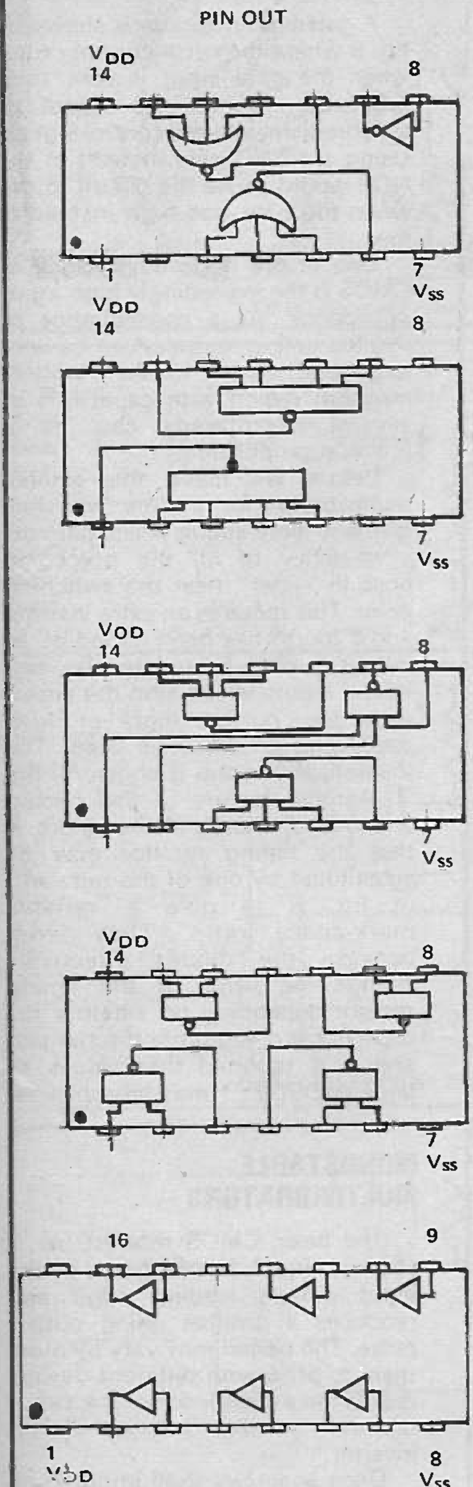


Fig.1. Power dissipation in CMOS as a function of frequency for a) a simple gate and b) an MSJ package.

TABLE 1 CMOS OPERATING LIMITS..........CD4000A SERIES

STORAGE TEMPERATURE	–65 to +150°C
OPERATING TEMPERATURE	–40 to + 85°C
SUPPLY VOLTAGE LIMITS (V_{DD}–V_{SS})	–0.5 to +15V
PACKAGE DISSIPATION	200mW max.
INPUT VOLTAGE	$V_{SS} \leq V_{in} \leq V_{DD}$
RECOMMENDED SUPPLY VOLTAGE (V_{DD}–V_{SS})	+3V to +15V

Unused inputs should be tied to a supply line. No input should be present when the supply lines are off.



TYPE NUMBER	FUNCTION
4000A	Dual 3 i/p NOR + inverter
4002A	Dual 4 i/p NOR
4012A	Dual 4 i/p NAND
4025A	Triple 3 i/p NOR
4023A	Triple 3 i/p NAND
4001A	Quad 2 i/p NOR
4011A	Quad 2 i/p NAND
4030A	Quad Exclusive OR
4049A	Hex inverting buffer
4050A	Hex non-inverting buffer

Fig.2. Some simple CMOS gate packages.

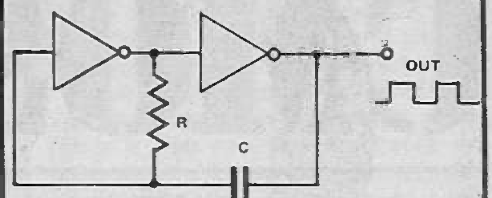


Fig.3. Basic CMOS astable.

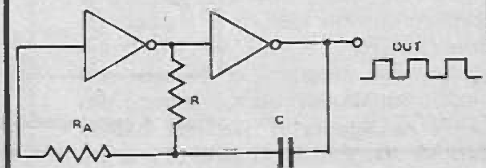


Fig.4. Improved astable multivibrator.

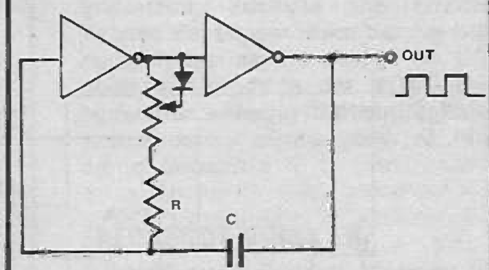


Fig.5. Duty cycle adjustment.

SIMPLE GATES

It is an unpleasant fact that it seems one must always start considering any subject at its least interesting parts and it is hardly surprising that the least interesting logic ICs are the simple gates.

We shall assume that the reader is familiar with the truth tables and terminology of the subject and consequently our discussion will mainly be on the subject of monostable and astable multivibrators. For ease of future reference a list of basic CMOS gates and their pin-outs is given in fig. 2. It is worth remembering that inverters may be realised by trying together all the inputs of a NAND or NOR gate, thus allowing a circuit requiring two NOR gates and two inverters to be constructed for a single type 4001A package.

ASTABLE MULTIVIBRATORS

The basic CMOS astable is shown in fig. 3. This could of course be built using any of the packages in fig. 2 with the exceptions of the 4030A and 4050A, indeed, the 4049A could produce three of these circuits simultaneously. The period is approximately 1.4RC (R in ohms, C in farads) and the waveform may have a non-unity mark-space ratio due to the voltage at which the inverters switch (called the transfer voltage—V_{tr}) not being exactly half way between V_{DD} and V_{SS}. The frequency is also dependent on the supply voltage. In keeping with normal practice, connections of the device to the supply voltage have not been shown.

The next few circuits will rectify some of the aberrations of the simple version. The addition in fig. 4 of R_A, which should be at least twice as large as R, makes the frequency almost independent of the supply voltage over a wide range. The frequency of any of the circuits may be made variable by making R a variable resistor.

Duty cycle adjustment may be achieved using the circuit in fig. 5. Altering the duty cycle will affect the frequency and the diode may have to be reversed to achieve the desired result.

CMOS

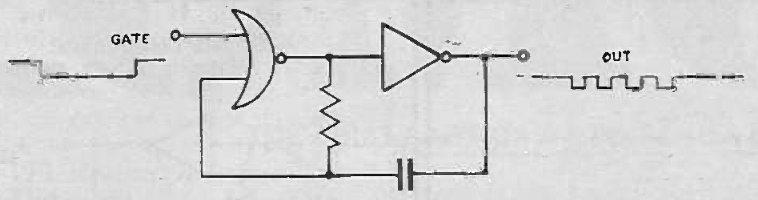


Fig.6. A gated astable multivibrator.

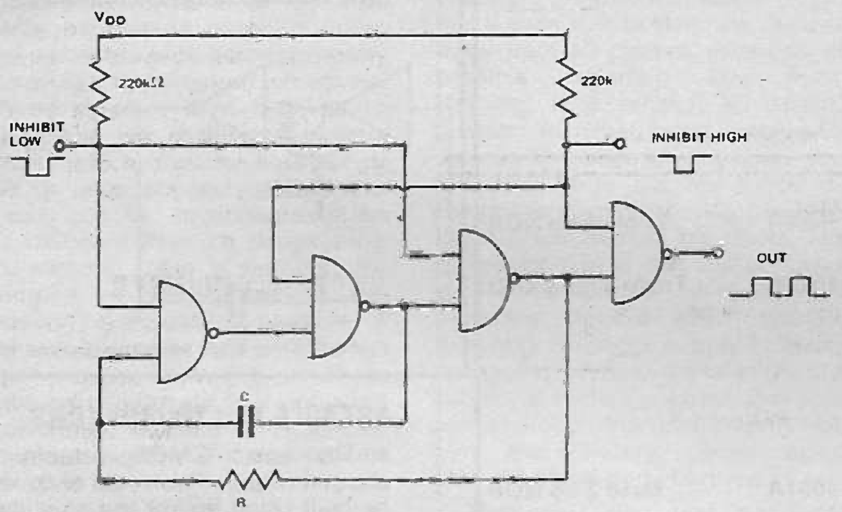


Fig.7. Jitter-free multivibrator with inhibits which may be made from a 4011A.

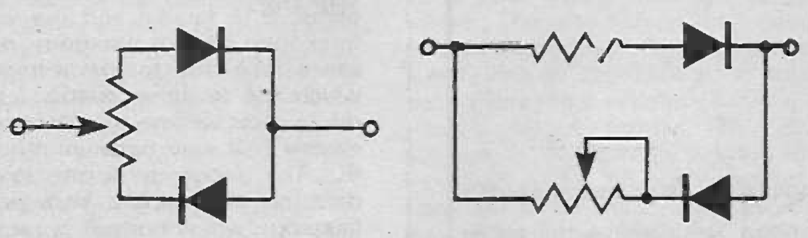


Fig.8. Two networks which will provide variable mark-space ratio for multivibrators.

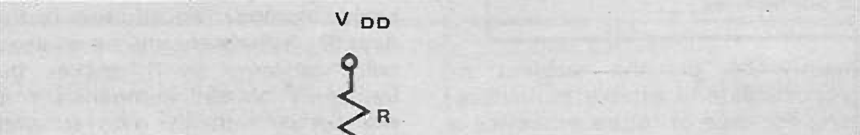


Fig.9. Basic Monostable Multivibrator.

GATING

A gated multivibrator is shown in fig. 6 where the oscillator only runs when the gate input is low, thus producing "bursts" of output in synchronism with the control signal. Using a NAND gate instead of the NOR would cause the circuit to run when the gate was high instead of low.

One of the huge advantages of CMOS is the exceedingly high input impedence. As a consequence of this the timing resistors can be very large and values in the hundred megohm region with capacitors of several microfarads can be a practical proposition.

Before we leave the astable multivibrator for a time we shall give one more circuit which corrects a tendency of all the preceding ones to "jitter" near the switching point. This requires an extra inverter and a fourth has been added as an output buffer. There are also two inhibit inputs which stop the circuit with the output high or low, depending on which is used. The theoretical diagram is shown in fig. 7. Another feature of this circuit, and indeed virtually all the others, is that the timing resistor may be substituted by one of the networks in fig. 8 to give a variable mark-space ratio. They work because the diodes effectively change the value of the timing resistor depending on whether the capacitor is charging or discharging and it is reported that values as large as 5000 : 1 may be achieved.

MONOSTABLE MULTIVIBRATORS

The basic CMOS monostable is shown in fig. 9. It is triggered by the input pulse's leading edge and produces a positive going output pulse. The period may vary by more than ± 50% with different devices due to the dependence of the circuit on the transfer voltage of the inverter.

Once again we shall improve on the basic circuit and also give several alternative versions. The circuit in fig. 10 operates in an interesting way. The quiescent state is with the first and second inverter outputs at "0" and "1" respectively. The falling edge of the triggering pulse makes the first inverter go high, C2 charges through the diode up to V_{DD} and the second inverter goes low thus initiating the output pulse. C1 recharges through R1 and crosses the transfer voltage of the first inverter which consequently goes

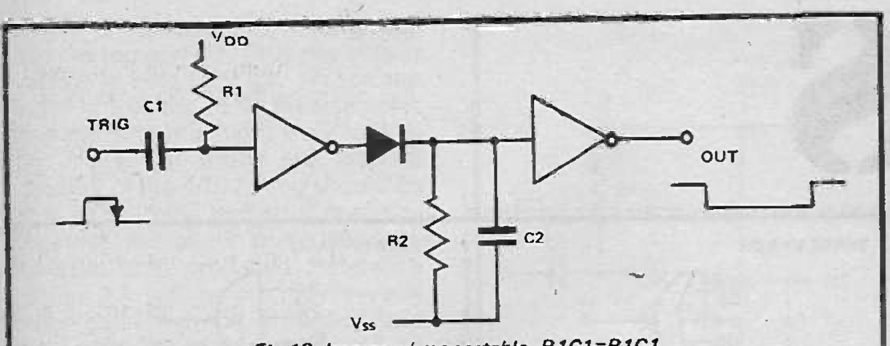


Fig. 10. Improved monostable, R1C1=R1C1.

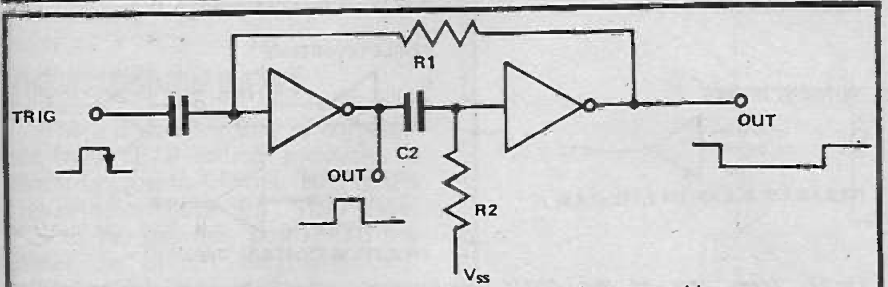


Fig. 11. A negative edge triggered monostable.

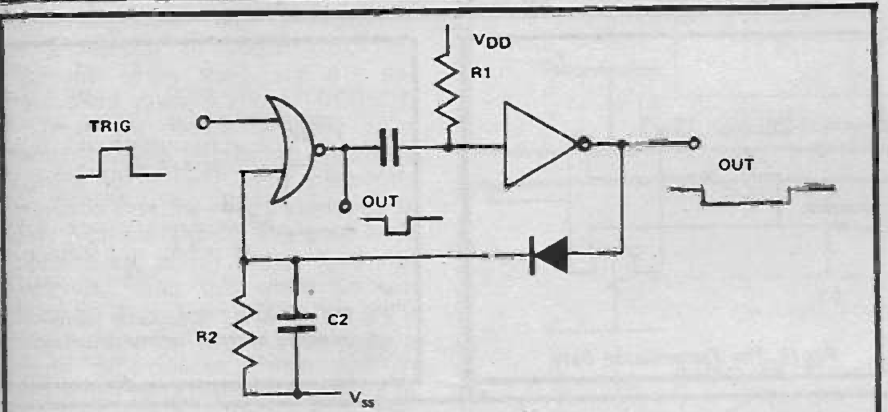


Fig. 12. Positive edge triggered monostable.

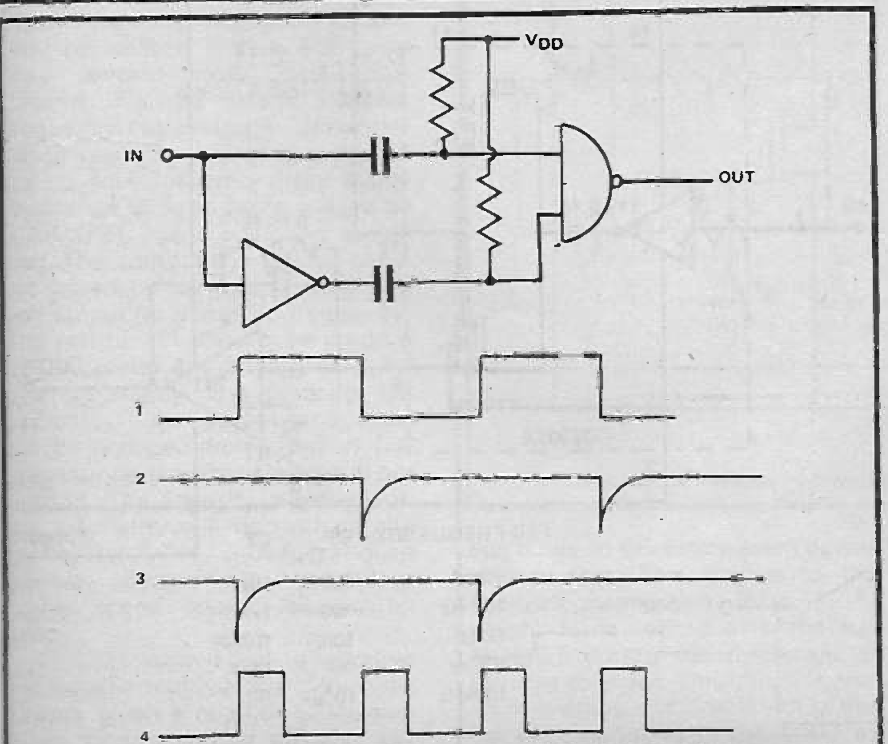


Fig. 13. A frequency doubler and its associated waveforms.

low and is isolated from C2 by the now reverse biased diode. C2 then discharges through R2 and causes the second inverter to revert to its initial state thus completing the output pulse. The advantage of all this is that inverters fabricated on the same chip have similar transfer voltages and if the two time constants (R1C1 and R2C2) are made identical, errors cancel out and the period becomes well defined. It is in fact approximately equal to 1.4R1C1 (=1.4R2C2) and this circuit is capable of being retriggered during the output pulse.

Our last two monostables (figs. 11 & 12) are non-retriggerable and the two time constants should be made the same, as in the previous circuit. Fig. 12 is particularly interesting because the circuit isolates the trigger input during the output pulse as the charge on C2 holds one input to the NOR gate high, thus keeping the output low independently of the state of the trigger unput.

FREQUENCY DOUBLER

The frequency doubler shown in fig. 13 works by differentiating the leading and trailing edges of the waveform and applying the resulting pulses to the two inputs of a NAND gate. This produces a complete output pulse at both the rise and fall of the input signal. The values of the discrete components will depend on the desired frequency of operation.

THE 4007

The next device we are going to consider has no equivalent in other logic systems. It is described as a "dual complementary pair plus inverter" and its type number is 4007. It can perform several different functions and while we are discussing it we shall present a number of useful circuits and have the added advantage of learning a little about the internal operation of CMOS.

In CMOS there are two different types of field effect transistors, namely n-channel and p-channel enhancement mode devices (see fig. 14). What all this means is that when biased in the conventional manner (drain positive in n-channel devices but negative in p-channel devices), the n-type turns on when the gate becomes sufficiently positive with respect to the source and the p-type when it is sufficiently negative. A "turned on" device may be considered to have a resistance of the order of 500-1k-

CMOS

between source and drain whereas the equivalent resistance when "off" is about $10^9\Omega$. The resistance at the gate is always very high ($>10^{12}\Omega$) regardless of the state of the device.

The working of the CMOS inverter (fig. 15) should now be fairly clear. When the input is

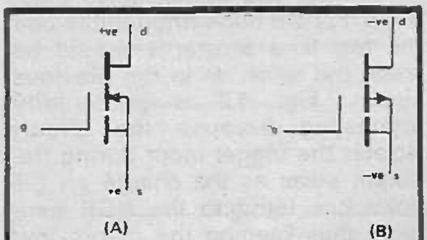


Fig.14. The 2 different MOSFETS used in CMOS, (a) n-channel, and (b) p-channel.

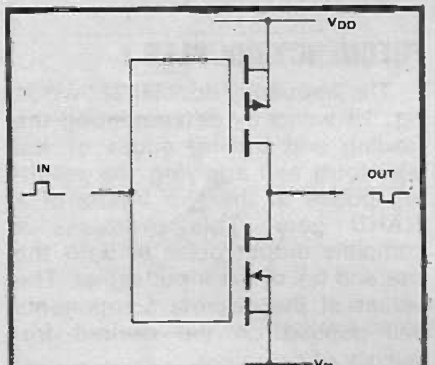


Fig.15. CMOS inverter, V_{SS}=0V. V_{DD}=+3–15V.

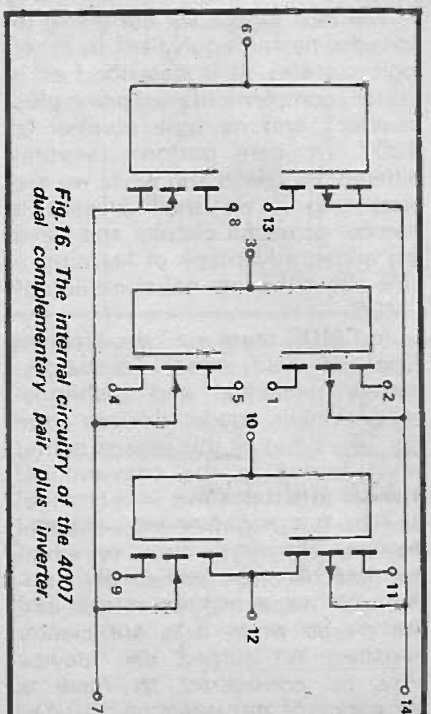


Fig.16. The internal circuitry of the 4007 dual complementary pair plus inverter.

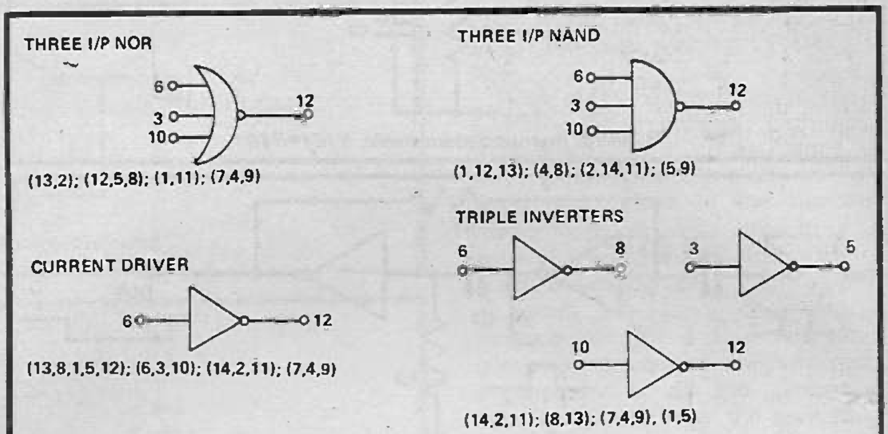


Fig.17. Some uses of the 4007; pins bracketed should be connected together. V_{DD}=pin 14, V_{SS}= pin 7.

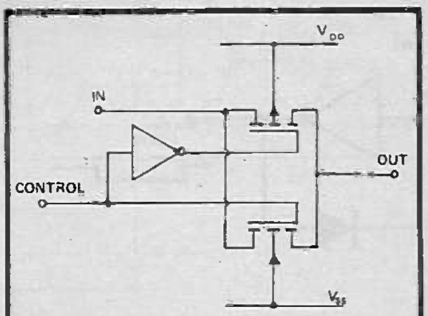


Fig.18. The Transmission Gate.

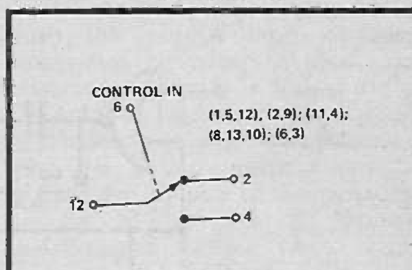
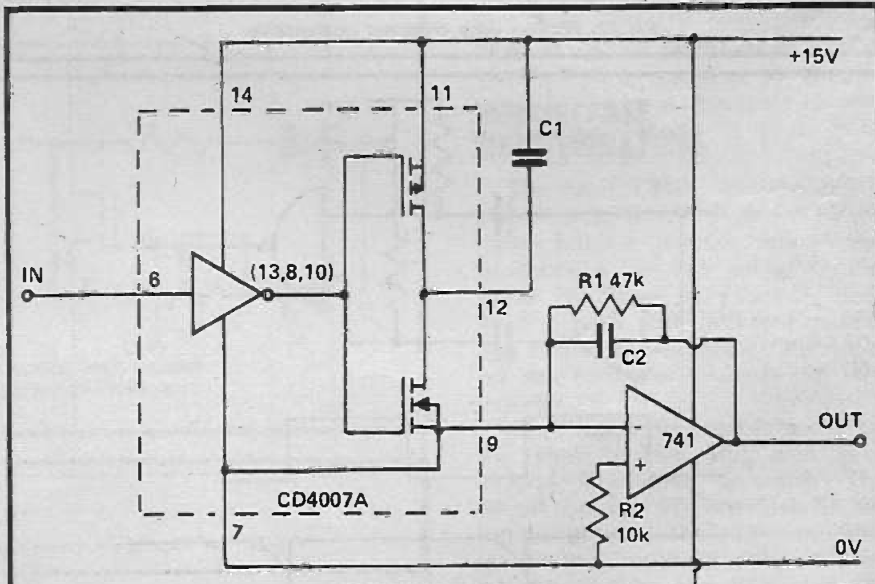


Fig.19. An SPDT Electronic switch which could be used for multiplexing.



FSD FREQUENCY	C1	C2
10Hz	1µF	10µF
100 Hz	100nF	1µF
1kHz	10nF	100nF
10kHz	1nF	10nF
100kHz	100pF	1nF

Fig.20. Linear frequency-to-voltage converter.

"high" the bottom FET is turned on and the top one off. Thus the output voltage is held very low. When the input is low the FETs reverse roles and the output is high. Now look at fig. 16 which shows the internal circuitry of the 4007. You should be able to see how joining a few pins together will allow three separate inverters to be produced. Reference to fig. 17 will reveal how several other gates may be produced and their mode of operation should be relatively easy to discern.

TRANSMISSION GATES

There is another way of connecting two FETS which produces a result unique to CMOS. This is the transmission gate (fig. 18). Here, due to the inverter, both FETS are either on or off simultaneously. When they are on, the path between input and output (they are interchangeable) may be regarded as a resistor of about 500-1kΩ whereas when they are off the equivalent value is about 1000MΩ.

Thus the device behaves as a switch capable of passing analogue signals with very little distortion provided that the load resistance is fairly high (≈100kΩ). We shall have more to say about these "bilateral switches" later but while we are dealing with the 4007 fig. 19 shows how to connect one as a single pole-double throw switch which will pass analogue signals in both directions.

Any of the three or less inverter circuits we have mentioned to date may be realised with a 4007, as may several more interesting designs. Fig. 22 shows a linear frequency to voltage converter which works by charging a capacitor up once for every input cycle, the charge to do so being passed by a MOSFET into a summing amplifier. The component values given are based on an approximate five volt output for the given frequency. The resistor R1 should be made a 100kΩ preset if it is required to set a range exactly. The capacitor C2 "smooths" the output and need not be changed from 10μF if fast response on the upper ranges is not needed. The linearity achieved on the top range will depend on the particular "741" used and if reliable operation is required a higher speed op-amp should be used.

Fig. 21 shows an alternative monostable multivibrator. We have already given a number of multivibrator circuits and so we shall say nothing more about this one except that it has an extremely small power consumption. This is due to the feedback connection (pins 12-6) which turns off the n-channel MOSFET during the discharge of the time constant. This circuit is also an interesting demonstration of the use of components in the 4007 as discrete transistors.

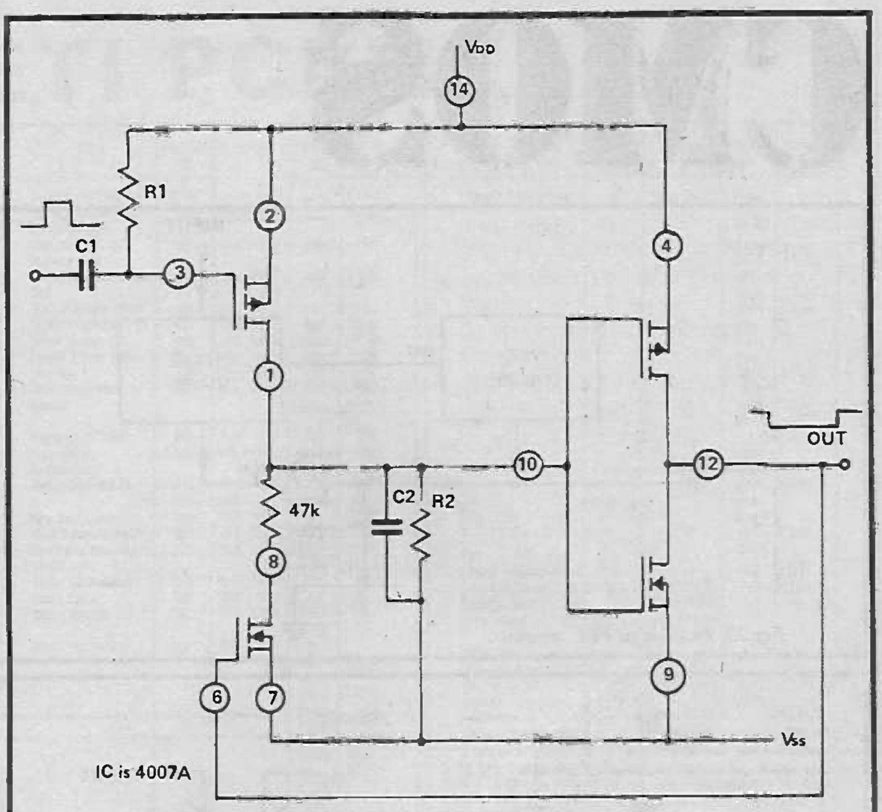


Fig.21. Low Power Monostable, for stability R2=3R1C1.

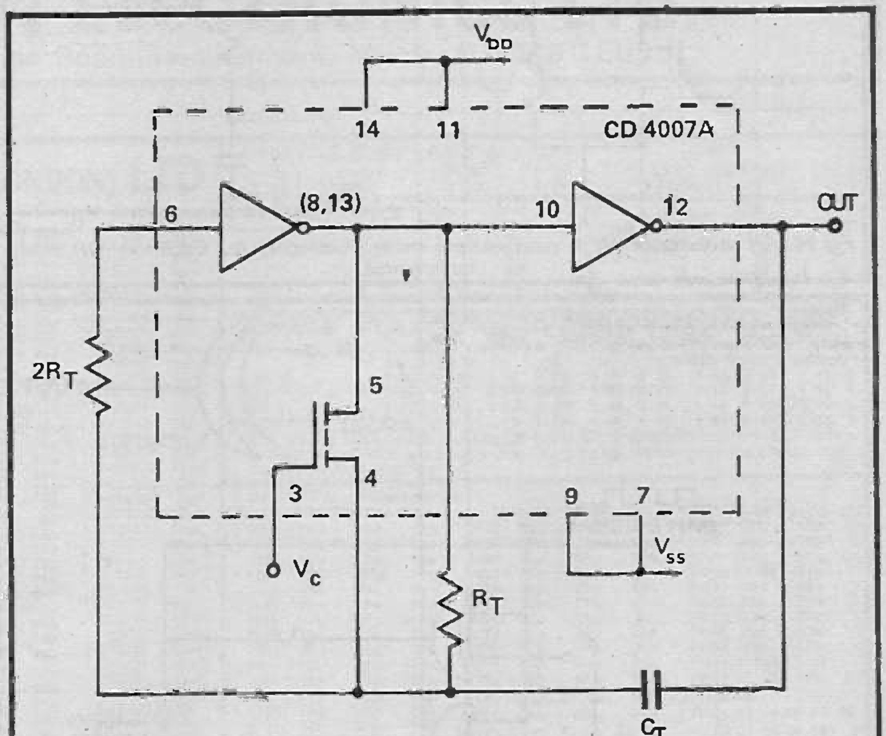


Fig.22. A voltage controlled oscillator using the 4007 IC.

A WIDE RANGE VCO

The voltage controlled oscillator depicted in fig. 24 uses two inverters as well as a separate transistor as a voltage controlled resistor. The inverters function as an astable multivibrator in the manner of Fig. 4 but the timing resistance is the parallel combination of R_T and

CMOS

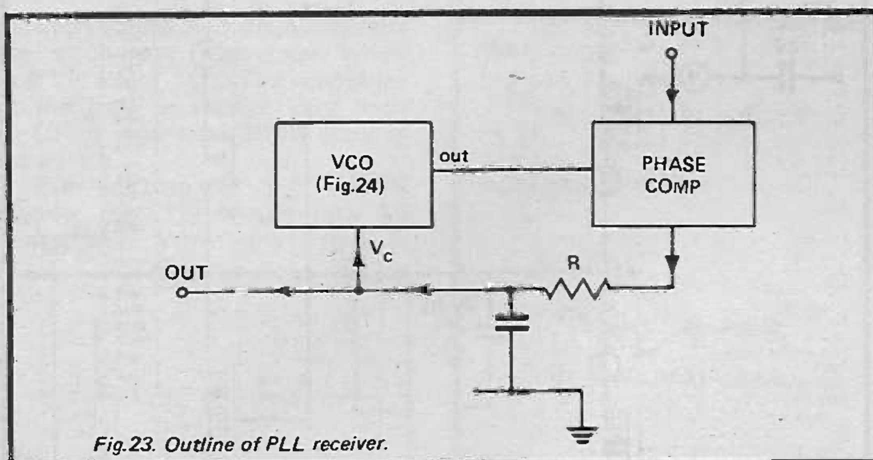


Fig.23. Outline of PLL receiver.

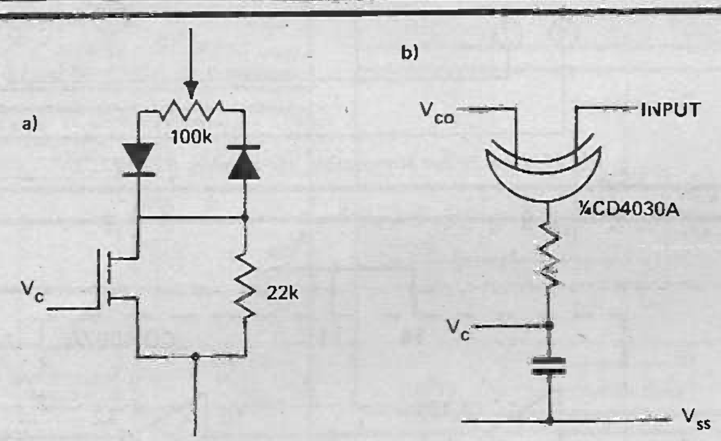
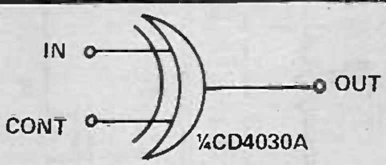


Fig.24. (a) Adjustable M–S ratio narrow range controller, (b) Exclusive–OR phase comparator.

Fig.25. Exclusive–OR gate used as a conditional inverter together with the device's truth table.

IN-1	*IN-2*	*OUT*
0	0	0
0	1	1
1	0	1
1	1	0



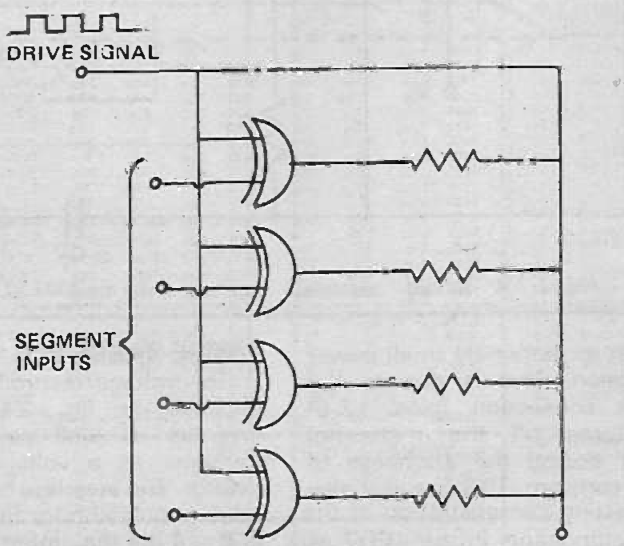


Fig.26. Exclusive–OR gates driving liquid crystal segments, represented by resistors.

the FET. As V_c varies between V_{DD} and V_{ss} so the resistance of the FET varies between about 1k and 1000MΩ. If the upper value is limited to 10MΩ by making R_T that value, then the circuit will sweep over a 10000 : 1 range in frequency. There would seem to be scope here for experimenting with a pulse frequency modulation communications system. One might produce an analogue system although distortion would probably be high due to mismatching. The transmitter could be the circuit in fig. 22 and the receiver a phase locked loop along similar lines (fig. 23) using some sort of phase comparator and a low-pass R-C filter.

EXCLUSIVE-OR GATES

Exclusive-or gates, for example the 4030 (see fig. 2) will function as phase comparators but they require a unity mark-space ratio to be effective. Perhaps a voltage controlled oscillator might be designed with a narrower range along the lines of fig. 24 for both transmitter and receiver, together with a phase comparator and low pass filter as shown in fig. 24. While we are on the subject of the exclusive-or function we shall consider two more uses of these devices. Fig. 25 shows the exclusive-or truth table and its use as a conditional inverter. This configuration causes the input signal to be inverted when the control input is high but not when it is low.

Liquid crystal displays are undoubtedly the readout devices of the future but they last longer in general if an a.c. drive is used. If then a square wave is applied to one end of a liquid crystal segment and also to the other connection via a conditional inverter (see fig. 26) then the control input will decide whether or not there is a net voltage across the segment.

CMOS and liquid crystal make an ideal combination for ultra-low power logic and display systems and so manufacturers have produced BCD to seven segment decoders and drivers specifically for this application. Their type numbers are 4054/5/6, the variations being due to the addition of latches and other refinements. These devices have too limited an appeal to justify a full description here and it is suggested that if it is intended to experiment with this technology, data sheets should be obtained from a manufacturer* or large distributor.

*e.g. RCA, Sunbury-on-Thames, Middlesex, for the "CD4054/5/6A" range. *Continued next month...*

ETI PCB's

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Int. Stereo Amp. 25 watts/chan.	Int. 25	Oct. 1975	Int. 25	£4.21
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Wide Range Voltmeter	107	Top Project No. 1	022	£1.09
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			117B	68p
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			414B	£1.52
			414C	£1.52
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			414E	£1.78
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International 420 Four Channel Amp	420	Apr. 1974	420A	76p
			420B	£1.11
			420C	£1.21
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TITLE	PROJECT NO.	ISSUE	BOARD NO.	TOTAL
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			533B	68
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AF117 20p
AF118 50p
AF139 33p
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BC108 13p
BC109 14p
BC109C 16p
BC117 19p*
BC125 18p*
BC126 20p*
BC141 28p
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BC182L 11p*

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BC184 11p*
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BC323 60p
BC327 18p*
BC328 16p*
BC337 17p*
BC338 17p*
BCY70 12p
BCY71 18p
BCY72 12p
BD115 55p
BD131 36p
BD132 40p
BD135 36p
BD136 39p
BD137 40p
BD138 48p
BD139 8p
BD181 86p
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BYX36-300 12p*
BYX36-600 15p*
BYX36-900 18p*
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C106D 50p
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CRS1-05 25p

CRS1-10 25p
CRS1-20 35p
CRS1-40 40p
CRS1-60 65p
CRS3-05 34p
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CRS3-20 50p
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SC40D 98p
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SC41D 85p
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IN4006 9p*
IN4007 10p*
2N696 14p

2N697 12p
2N706 10p
2N929 14p
2N930 14p
2N1131 15p
2N1132 16p
2N1304 20p
2N1305 20p
2N1711 18p
2N2102 44p
2N2369 14p
2N2369A 14p
2N2484 16p
2N2646 50p
2N2905 18p
2N2905A 22p
2N2926R 10p*
2N2926O 9p*
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100	25	25	40	47	48	54
200	27	35	45	58	60	68
400	30	40	50	87	88	98
600		65	70	1·09	1·19	1·26

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	4A (a)	4A (b)	6·5A (a)	6·5A (b)	8·5A (a)	8·5A (b)	10A (a)	10A (b)	15A (a)	15A (b)
100 V	0·60	0·60	0·70	0·70	0·78	0·78	0·83	0·83	1·01	1·01
200 V	0·64	0·64	0·75	0·75	0·87	0·87	0·87	0·87	1·17	1·17
400 V	0·77	0·78	0·80	0·83	0·97	1·01	1·13	1·19	1·70	1·74
600 V	0·96	0·99	0·87	1·01	1·21	1·26	1·42	1·50	2·11	2·17

N.B. Triacs without internal trigger diac are priced under column (a). Triacs with internal trigger diac are priced under column (b). When ordering please indicate clearly the type required.

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	1–24	25–99	100+		1–24	25–99	100+		1–24	25–99	100+
7400	14p	12p	10p	7445	85p	71p	57p	7492	57p	46p	36p
7401	14p	12p	10p	7447	81p	75p	65p	7493	45p	40p	32p
7402	14p	12p	10p	7448	75p	62p	50p	7495	67p	55p	45p
7403	15p	12½p	10p	7447A	95p	83p	67p	74100	£1·08	89p	72p
7404	16p	13p	11p	7470	30p	25p	20p	74107	35p	28p	22p
7405	16p	13p	11p	7472	25p	21p	17p	74121	34p	28p	23p
7409	16p	13p	11p	7473	30p	25p	20p	74122	47p	39p	31p
7410	16p	13p	11p	7474	32p	26p	21p	74141	78p	63p	53p
7413	29p	24p	20p	7475	47p	39p	31p	74145	68p	58p	48p
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7432	27p	22½p	18p	7489	£2·92	£2·80	£2·10	74192	£1·35	£1·14	90p
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SIMPLE CMOS TESTER

An inexpensive unit for the hobbyist.

eti project 123

NOW THAT the use of CMOS logic is becoming widespread there is an obvious need for a simple CMOS tester suitable for the hobbyist. In last month's issue we described a sophisticated tester for both CMOS and TTL. That particular instrument is very versatile but may be too expensive for many budding experimenters and we have therefore designed this simpler instrument to cater for their needs.

A simple CMOS tester, although being inexpensive, must be capable of performing the majority of tests required for CMOS logic without causing any damage to the ICs under test or being damaged itself. It must also use only those components which are readily available to the average home constructor. The ETI 123 Tester fulfills all these requirements.

The tester circuitry draws very little current except for that drawn by the LEDs. Even the LEDs only draw current whilst a device is actually under test. For this reason we thought that the expense of a mains power supply was unwarranted and chose to use batteries instead. For those who would rather operate the unit from a mains derived supply, one capable of supplying anywhere between 5 and 12 volts at up to 40 milliamps will be suitable. Another major expense, that of providing a large number of programming switches to set up the test conditions, has been alleviated by using flying leads fitted with alligator clips to connect to the IC under test.

Several steps have been taken to prevent damage to the IC by the tester and conversely, damage to the tester by the IC. Firstly each pin of the test socket is fitted with a static discharge resistor to earth. A current limiting resistor, R 37, is in series with the supply so that the tester is protected against damage due to possible excessive current into an internal short in the test IC. This limiting resistor also ensures that current through the input-protection diodes on the IC does not exceed the specified limit of 10 mA.

Only readily available components are used in the tester and, in fact the ICs used are available from at least four different manufacturers.

To test simple gate functions, eg NAND gates, NOR gates, we need at least four switches and a logic level detector but for the more complex functions, eg multipliers, we need at least six switches and six level detectors. A clock – pulse generator is required for the testing of flip flop and other clocked devices. This pulse generator must be free of the contact bounce that is typically encountered with mechanical switches. For this reason we used a pair of CMOS NAND gates wired as an astable multivibrator to generate a continuous train of pulses. This may be used to increment counters and to shift data in shift registers. As it is a CMOS circuit it is perfectly suited to driving other CMOS devices.

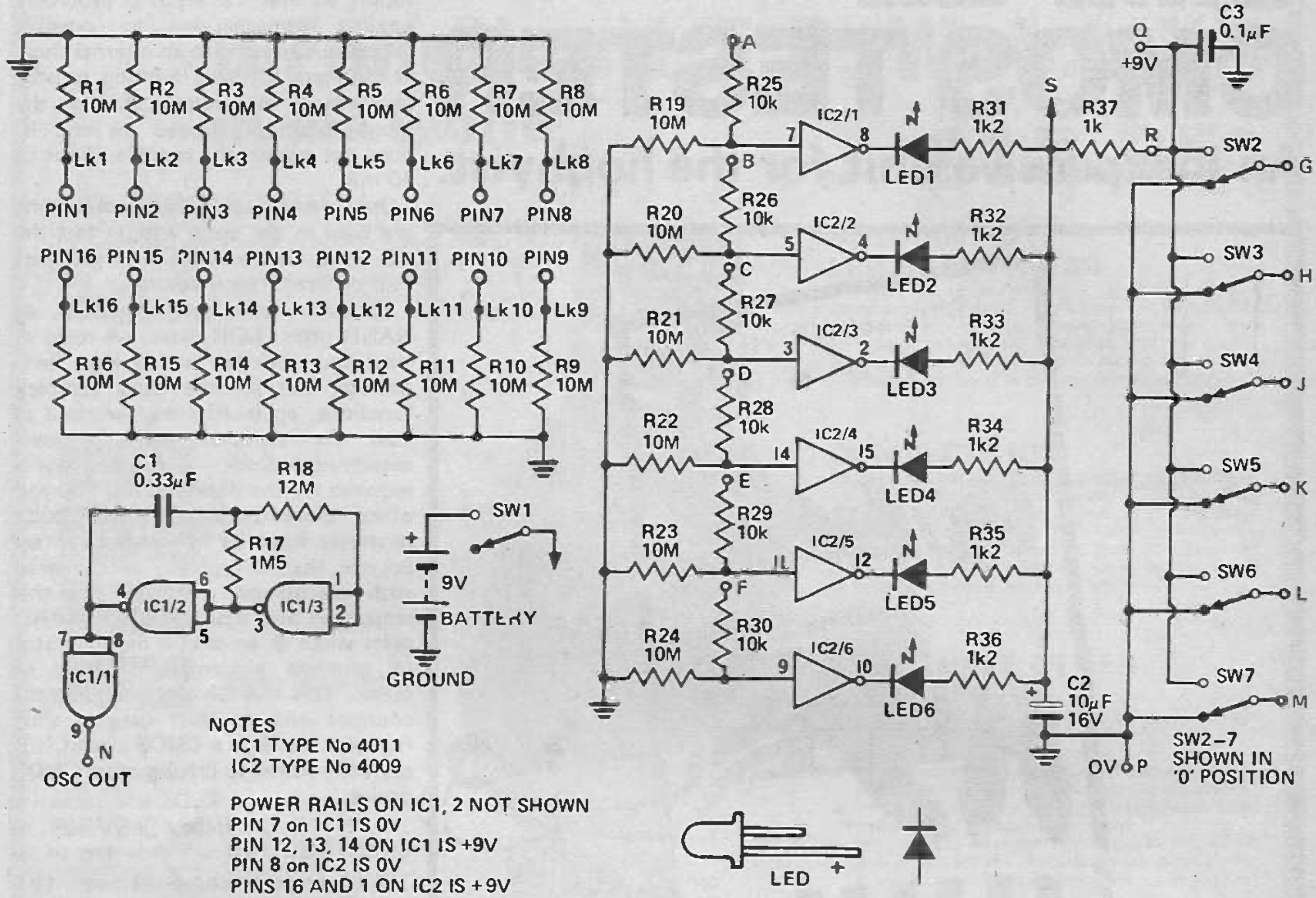
CONSTRUCTION

We recommend that the printed-circuit boards as specified be used as construction is thereby greatly simplified. The printed-circuit boards should be assembled as detailed in the component overlay diagrams. Switches SW1 to SW7 should be mounted by first glueing two strips of printed-circuit board to the front panel (copper side out). The switches may then be soldered to the copper side of the board. This procedure avoids the necessity of having 14 screw heads visible on the front panel.

The test socket is mounted on the non-copper side of board 123b. This board also carries links Lk1 to Lk16 which connect directly to the pins of the test socket. These links are also mounted on the non-copper side of the board and should be of reasonably heavy gauge tinned-copper wire, and should be installed such that sufficient room is under the link to enable test leads to be attached to them by means of aligator clips or Easy-Hooks Resistors R1 to R16 are mounted on the *copper* side of this board so that they are not visible when the board is bolted to the front panel. The top two screws, nearest to the LEDs, should be 18 to 25 mm long so that board 123a may also be mounted on them later.

On board 123a, mount and solder in position on the component side of the

SIMPLE CMOS TESTER



NOTES
IC1 TYPE No 4011
IC2 TYPE No 4009

POWER RAILS ON IC1, 2 NOT SHOWN
PIN 7 on IC1 IS 0V
PIN 12, 13, 14 ON IC1 IS +9V
PIN 8 on IC2 IS 0V
PINS 16 AND 1 ON IC2 IS +9V

POINTS A–Q GO TO ALIGATOR CLIPS

POINT Q IS +9V FOR IC UNDERTEST
POINT P IS 0V FOR IC UNDERTEST

Fig. 1. Circuit diagram of the CMOS tester.

HOW IT WORKS – ETI 123

The ETI 123 CMOS tester can be described in three separate sections. Firstly there is the test socket for the device under test. The test socket is mounted on a printed circuit board which also holds a 10 megohm static-discharge resistor to protect each pin of the IC. Each IC pin is also connected to a surface mounted link by which connections can be made to the IC.

The next major section of the tester contains detectors which monitor the voltage at each pin of the IC. Each detector consists of a CMOS inverter which drives an LED indicator. When the voltage at the input of the inverter is greater than half the supply voltage the LED will be alight. Conversely the LED will be off when the voltage at the input to the inverter is below half supply voltage. Resistors R19 to R30 protect IC2 against static charges and from the condition where a detector has no input. Resistors R31 to R36 set the operating currents for the LEDS.

The final section contains switches SW2 to SW7 and a clock oscillator. The output of the switches can be either 0 volts or +9 volts that is, a logic '0' or a logic '1'. These outputs are made available at test leads which may be connected to the IC under test as required. To protect the tester against internal shorts on the IC under test, and incorrect connections, R37 has been inserted in series with the supply rail to limit the current that may be drawn to a level which cannot cause any damage.

IC 1/2 and IC 2/3 are wired as an astable multivibrator where the frequency of oscillation is determined by the time constant of C1 and R17, whilst R18 is used to protect the input of IC 1/3 from any voltage excursions past the supply rails. IC 1/1 is used as an inverting buffer and the output of the circuit is made available at the front panel by means of a lead and alligator clip.

PARTS LIST — ETI 123

R37	Resistor	1k	¼ Watt 5%
R31-36	"	1.2k	" "
R25-30	"	10k	" "
R17	"	1.5M	" "
R1-16	"	10M	" "
R19-24	"	10M	" "
R18	"	12M	" "

C3 Capacitor 0.1μF polyester
C1 " 0.33μF "
C2 " 10μF 16 electrolytic
IC1 Integrated Circuit 4011 (CMOS)
IC2 " " 4009 (CMOS)
LED 1-6 Light Emitting Diode RL 4484 or similar
SW1-7 Miniature slider switch 2 pole 2 position.
IC Socket 16 pin DIL (preferably with IC removing slide)
Case 160 x 90 x 50 mm plastic box with aluminium front panel UBI
Alligator clips (15)
Battery 9V (6 penlight cells).

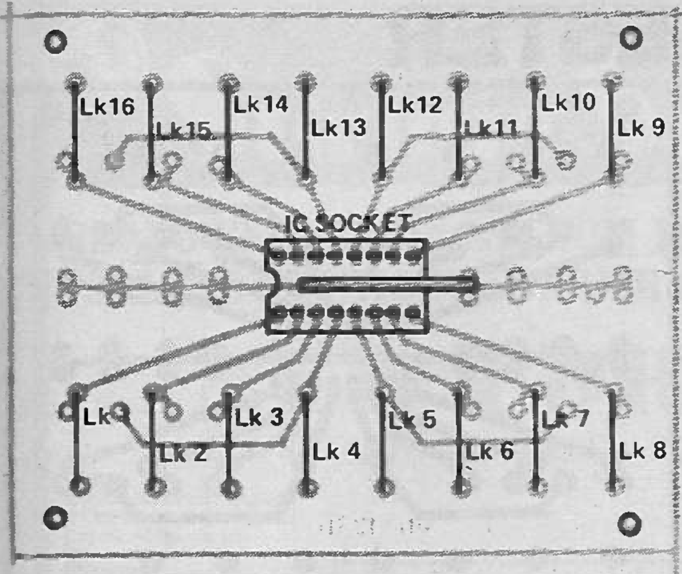


Fig. 2. Component overlay for the test-socket board ETI-123b, non-copper side.

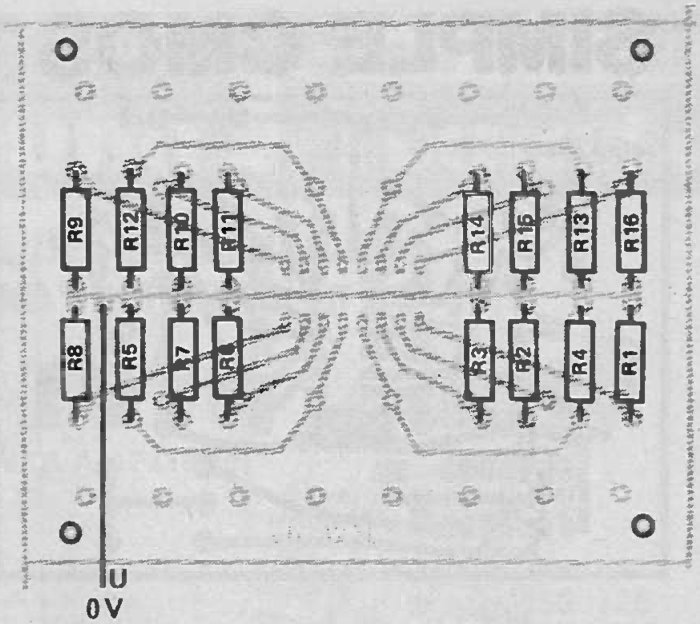


Fig. 3. Component overlay for the copper side of board ETI-123b.

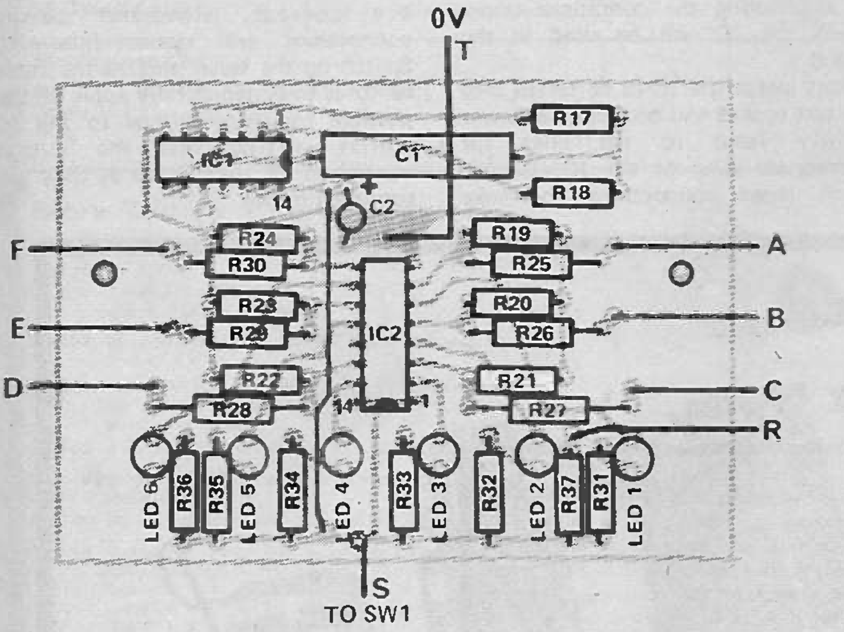


Fig. 4. Component overlay for board ETI-123a. Note that C1 may need to be mounted on reverse side, and that the LEDs should be mounted as detailed in the text.

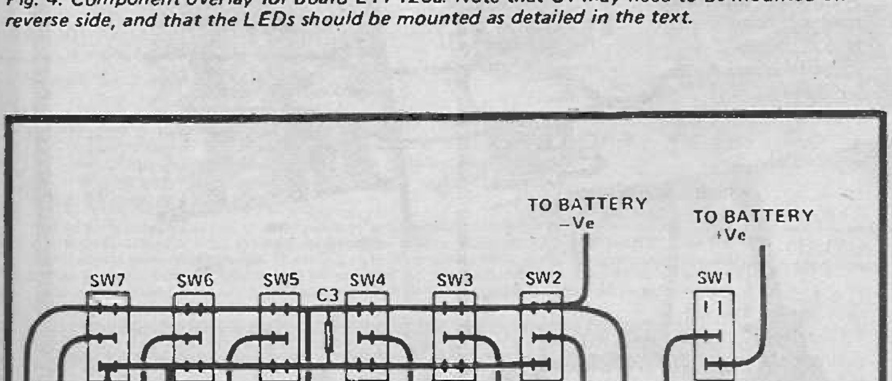


Fig. 5. Switch interconnection diagram. Note that C3 is mounted across one of the switches.

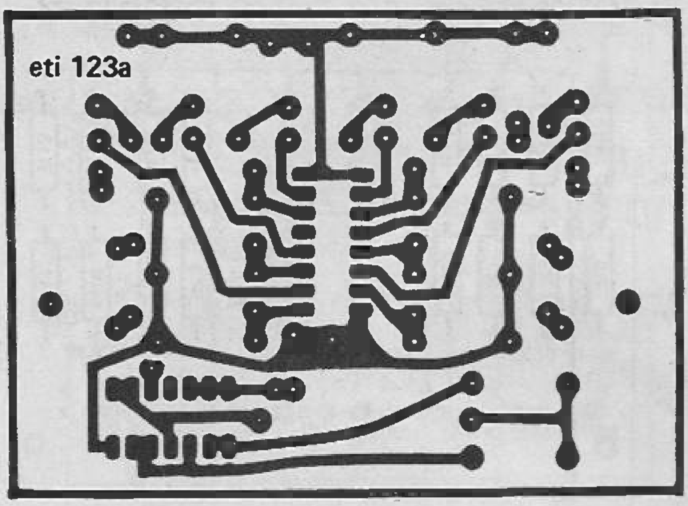
text continued from p 20

board, all components with the exception of the LEDs and capacitor C1. As C1 needs to be a polyester type it may be physically too big to be mounted on the component side without fouling the front panel and should therefore be mounted on the copper side. The LEDs should be inserted in their positions but not yet soldered. Temporarily mount the board in position such that the LEDs protrude through their correct holes in the front panel. Keeping the front panel face down, solder the LEDs into the board. Remove the board and solder 150 mm lengths of hookup wire to the points marked A to F on the overlay and pass these leads through the corresponding holes in the front panel. Do the same for the leads G, H. J. K L M P and Q from switches SW2 to SW7 using a different coloured wire to that used previously. These wires should also be passed through the appropriate holes in the front panel.

Finally solder alligator clips or Easy Hooks to the ends of all these leads and connect supply and earth leads to the 123b board. Check both boards for wiring errors or errors in component insertion before bolting board 123a in position. The battery may then be connected and the unit is ready for use.

Note that if the type UB1 box is used as in our protype the top corners of the 123a board may have to have the corners trimmed off at 45 degrees so that the board will fit in the box

SIMPLE CMOS TESTER



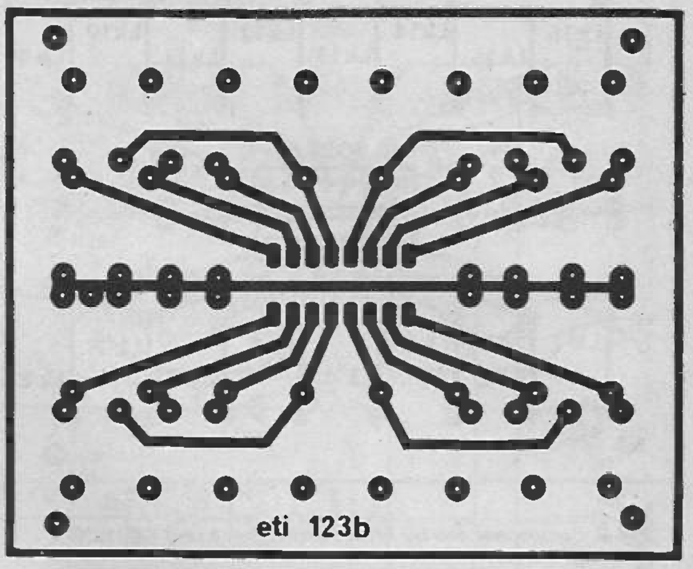


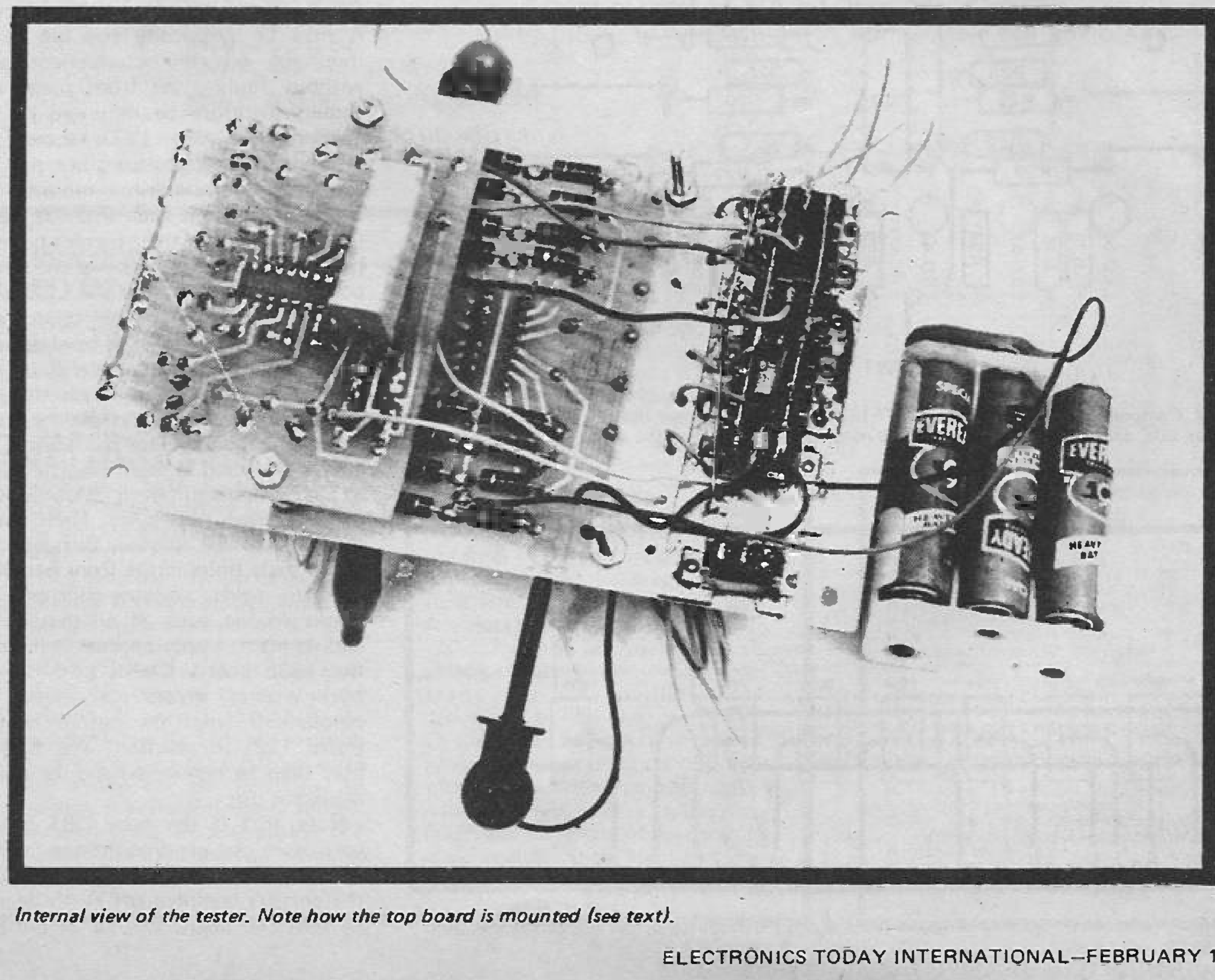
Fig. 6. Printed-circuit board layout – ETI 123a. Full size 88 x 63 mm. *Fig. 7. Printed-circuit board layout – ETI 123b. Full size 88 x 71 mm.*

without fouling the mounting pillars for the front panel.

OPERATION

Before testing or inserting any IC make sure that the power is switched off. Set up the operating conditions for the IC to be tested either by consulting the manufacturers data or by duplicating the conditions under which the IC will be used in the circuit.

Next insert the IC to be tested into the test socket and connect the power supply leads to the links for appropriate pins of the IC. Double check these connections to make absolutely sure that these connections are correct. Reversed power connections will destroy the IC. Switch on the tester and use the input switches to systematically apply all the possible input conditions to the IC whilst noting that the output conditions of the IC are as they are supposed to be. ●



Internal view of the tester. Note how the top board is mounted (see text).

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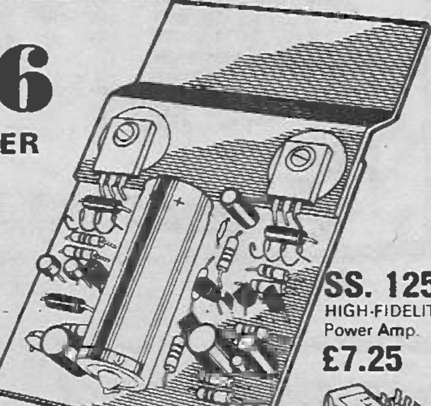

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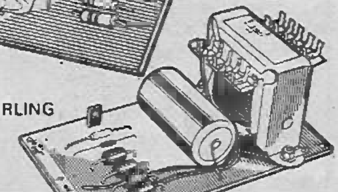

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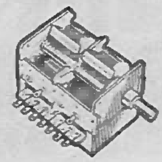

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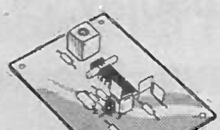

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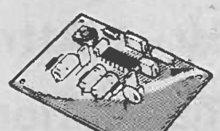

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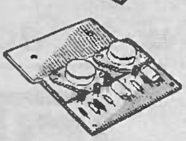

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TONE BURST testing is a technique which is rapidly gaining acceptance in a wide variety of applications. Typical applications are in testing of hydrophones, signal-to-noise in telephone channels, reverberation chamber testing and in the determination of peak distortion in loudspeakers. With loudspeakers, tone burst testing has the further advantage that the speakers may be tested with their maximum peak power level whilst keeping the average sound output level low enough to not annoy the neighbours – a considerable advantage indeed.

Some time ago our audio consultants, Louis Challis and Associates, asked us to build them a tone-burst generator and the resulting instrument has been used by them ever since with much success.

DESIGN FEATURES

A tone burst must always be an integral number of cycles. If the burst is switched on or off part way through a cycle then undesirable transients will be produced that will mask the test results. Thus the burst must start and end exactly at the zero-crossing point of the sine wave in the burst.

In the original unit, designed for Louis Challis, preset times can be independently selected for the on and off periods of the burst with the exception that the burst time is automatically modified to give an integral number of cycles. The preselected on/off ratio, however, is independant of the burst frequency. To give the required control range, six switched ranges as well as a variable control are provided for both the on and off periods. Other features of the original unit are the ability to start at any point in the cycle as well as the zero crossing point, a phase-inverting switch to select either the positive or the negative half cycle first and an OFF LEVEL control to set a base tone level which is modified when the tone burst occurs. In addition the dc level of the output can be set and a switch is provided to select burst, pure tone or off as required.

When it came to redesigning the unit as a project we decided that many of the features offered by the original design were unnecessary for the user concerned only with testing speakers. Hence the unit has been redesigned in a greatly simplified form.

Instead of using monostables to generate variable on/off times we now divide the input with a counter to obtain times that remain in the same ratio regardless of input frequency. We settled for the ability to select 2, 4, 8 and 16 cycles for the duration of either period, as this compromise

eti project 124

TONE BURST GENERATOR

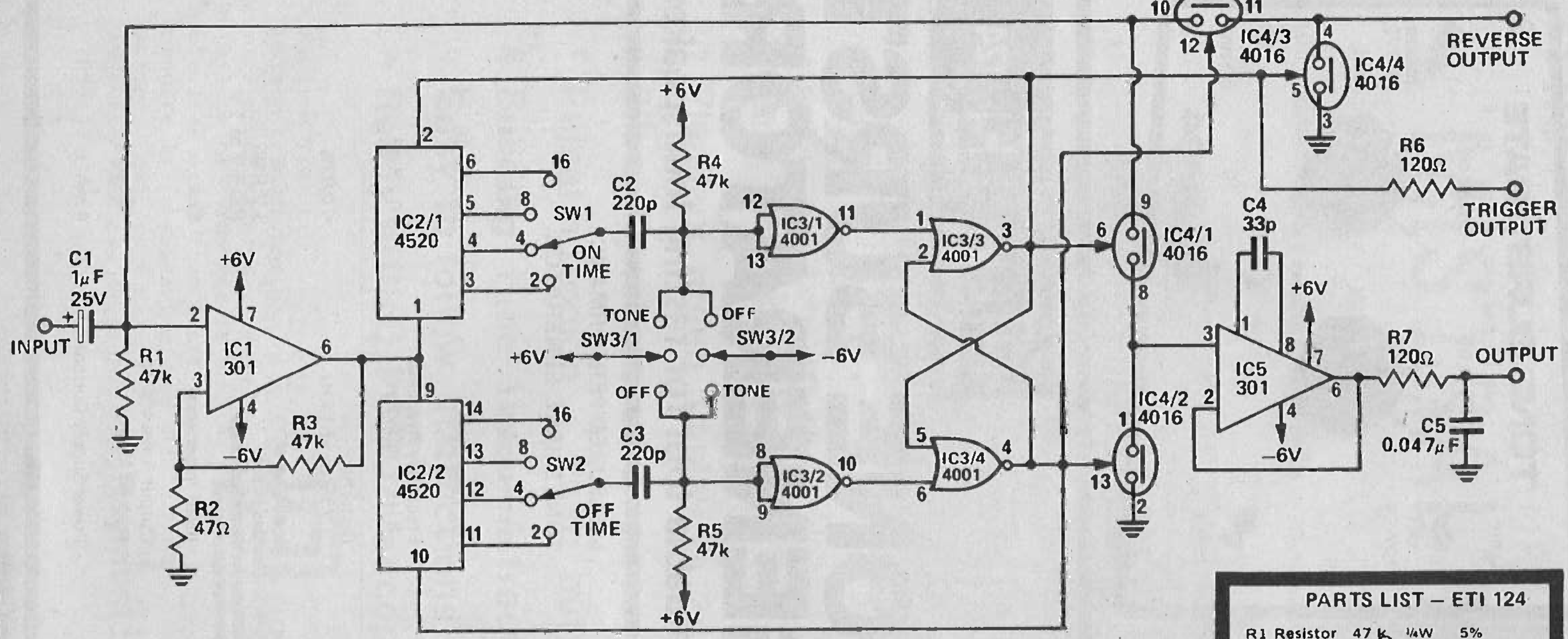
A valuable tool for testing loudspeakers.

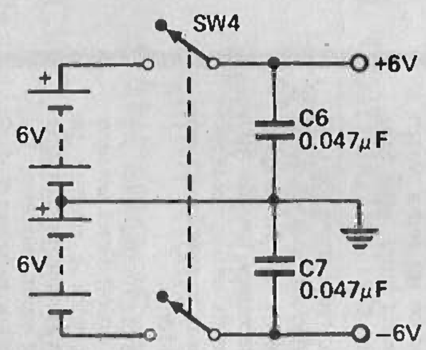
MEASURED PERFORMANCE

TONE BURST GENERATOR.

On Time Cycles.	2,4,8 or 16
Off Time Cycles	2,4,8 or 16
Frequency Response 3 Hz – 300 kHz	+0 –3 dB
Distortion 3 V input at 1 kHz	<0.02%
Input Level Maximum	3 V RMS
Nominal range	100 mV to 1 V
Input Impedance	47 k
Output Noise Voltage with no input	<25 μV
Power Supply Current	4 mA

TONE BURST GENERATOR





POWER RAILS OF IC2, IC3, AND IC4 NOT SHOWN
PIN 16 OF IC2 IS +6V
PIN 8 OF IC2 IS −6V
PIN 14 OF IC3 AND 4 IS +6V
PIN 7 OF IC3 AND 4 IS −6V
PIN 7 AND 15 OF IC2 ARE RESET PINS AND −6V

Fig. 1. Circuit diagram.

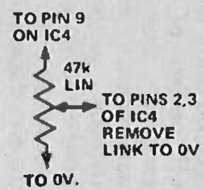


Fig. 4. How to add a potentiometer to the generator for burst-on-tone operation. That is the generator gives a continuous tone level with tone bursts of higher amplitude at intervals.

WHERE TO GET THE COMPONENTS

No problems should be experienced in obtaining the components assuming that you try a CMOS stockist for IC2,3,4. The 4520 is not widely advertised but is available from Sintel under the coding MC14520CP. The PCB will be available from either Ramar or Crofton.

PARTS LIST — ETI 124

R1	Resistor	47 k	¼W	5%
R2	"	47 Ω	¼W	5%
R3	"	47 k	¼W	5%
R4	"	47 k	¼W	5%
R5	"	47 k	¼W	5%
R6	"	120	¼W	5%
R7	"	120	¼W	5%
C1	Capacitor	1 μF 25V electrolytic		
C2	"	220 pF ceramic		
C3	"	220 pF ceramic		
C4	"	33 pF ceramic		
C5	"	0.047 μF polyester		
C6	"	0.047 μF polyester		
C7	"	0.047 μF polyester		
IC1	Integrated Circuit	LM 301A		
IC2	"	4520 (CMOS)		
IC3	"	4001 (CMOS)		
IC4	"	4016 (CMOS)		
IC5	"	LM301A		

SW1 Switch 1 pole 4 position rotary
SW2 Switch 1 pole 4 position rotary
SW3 Switch DPDT Toggle with centre off
SW4 Switch DPDT Toggle

PC Board ETI 124
8 1.5V 'AA' pencell batteries
2 4-way battery holders and clips
Plastic case
Escutcheon
3 single phono sockets
2 knobs

HOW IT WORKS – ETI 124

The input signal is squared by comparator IC1 such that the output of the comparator will be high if the input is above +6 mV, and low if the input signal is below –6 mV. Resistors R2 and R3 provide the necessary positive feedback to cause the IC to act as a comparator. The output of the comparator is connected to both clock lines of IC2. If the enable line is high these counters (IC2) will toggle at the input frequency.

IC3/3 and IC3/4 form an RS flip flop where the output must be in either a high or a low state, that is the flip flop has only two stable states. If the output of IC3/3 is high IC2/1 is allowed to clock and, after the number of input pulses selected by SW1 have been counted, the output from SW1 goes low. This low is coupled to the flip flop by C2 toggling the flip flop, disabling IC2/1 and enabling IC3/2. After the number of cycles, as selected by SW2, have been counted the flip flop is again toggled. IC3/1 and IC3/2 are used to square up the pulses generated by C2 and C3 respectively.

The input signal is also coupled to the output buffer, IC5, by the analogue switch IC4/1. When this switch is closed (control signal high) the output of the buffer will be the same as the input. When switch IC4/1 is open IC4/2 will be closed and the output will be held at zero. Since these switches are controlled by the flip flop the output will be the required tone burst.

A trigger output is taken from the flip flop to synchronize an oscilloscope if required. A second output is also available from pins 4/11 of IC4 which is the reverse of the main output.

Switch SW3 forces the flip flop into either of its two possible states thus allowing continuous tone or no output to be selected as required. In the centre position the normal tone burst is obtained.

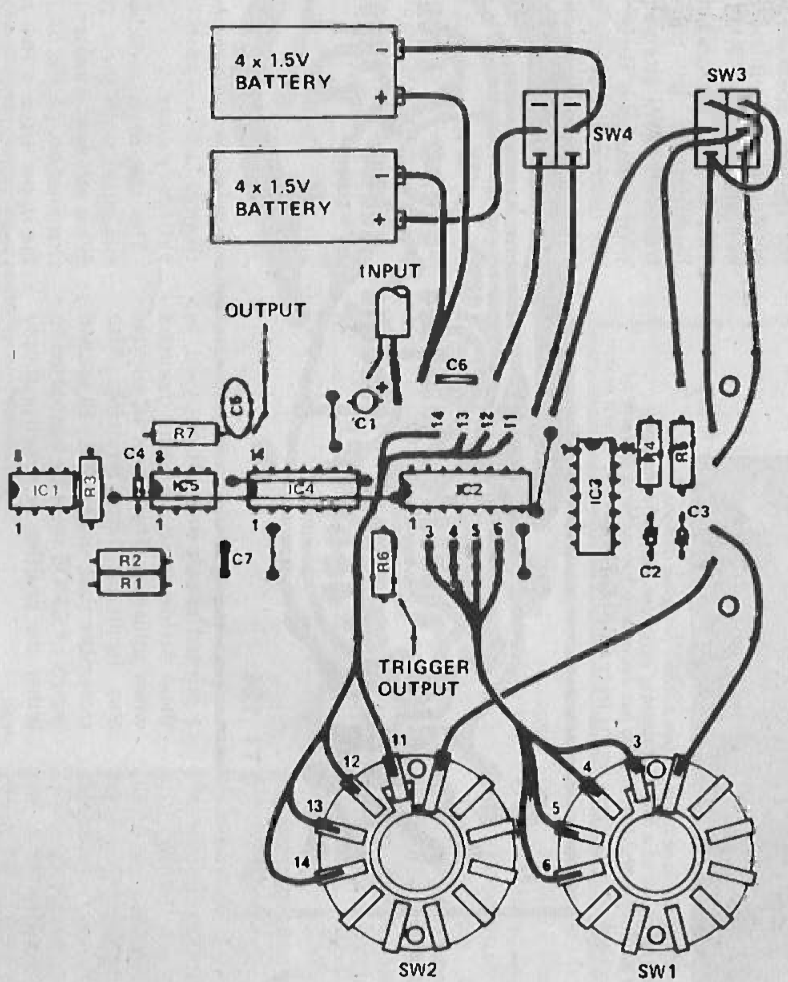
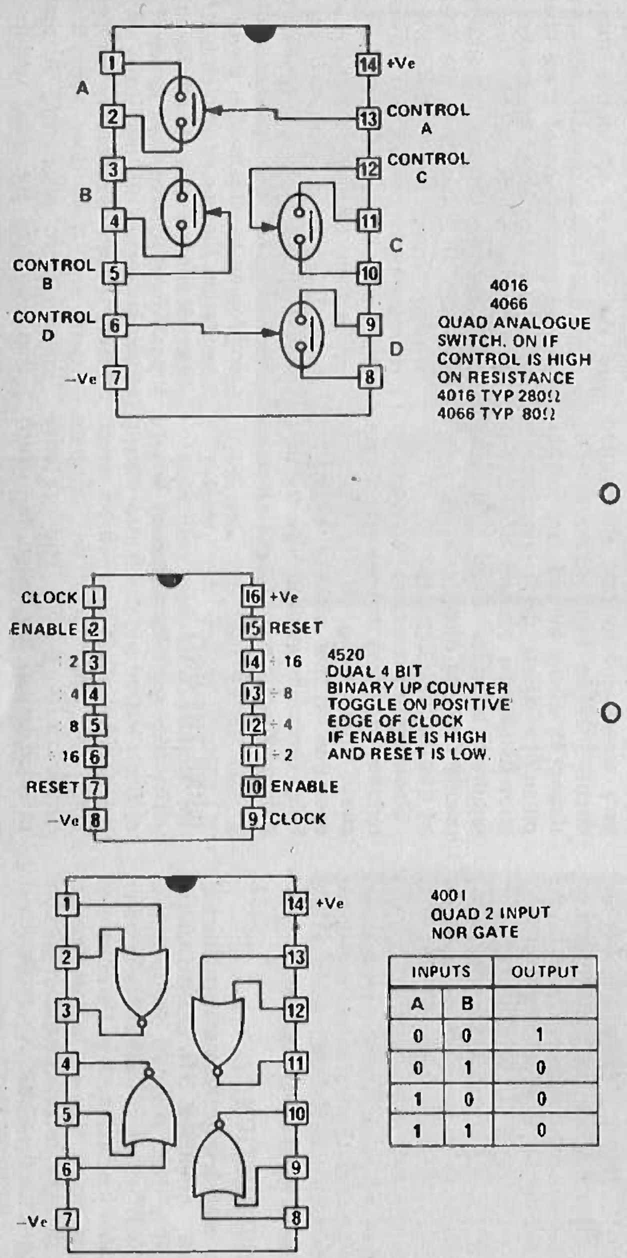


Fig. 2. Component overlay and interconnection diagram. Note that there are six links on the board, including two under IC4, which should be installed first.



INPUTS		OUTPUT
A	B	
0	0	1
0	1	0
1	0	0
1	1	0

Fig. 3. Pin connections of the ICs used in the generator.

TONE BURST GENERATOR

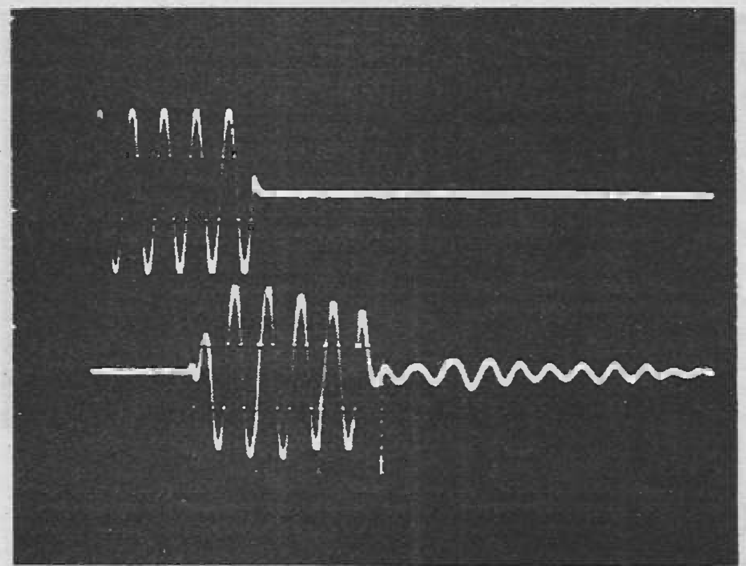


Fig.5 (a) Top trace — the input tone burst of five cycles. (original design).
(b) Bottom trace — the response of a low-cost speaker at 1 kHz. Note the reduced amplitude of the first half cycle and that ringing has added another cycle at the end of the burst. The room reflection can be seen on the trace after the burst.

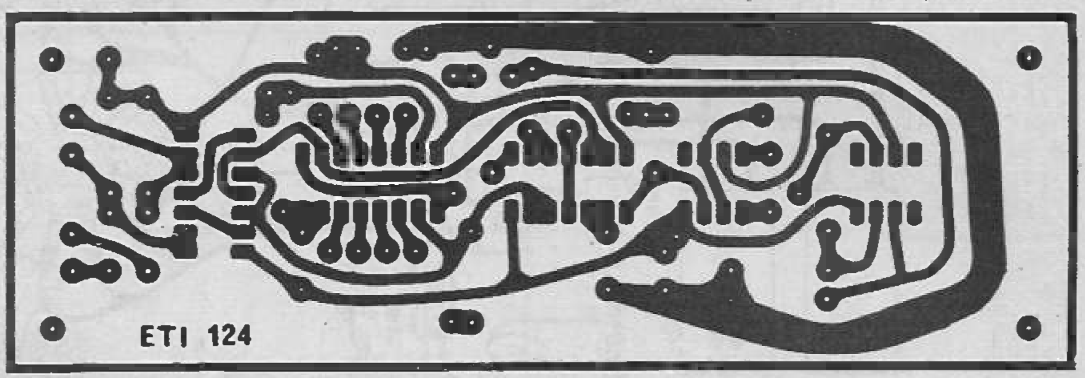


Fig.6. Printed circuit board for the Tone Burst Generator Full size. 142 x 47mm.

greatly simplifies the circuitry. We still have the switch to select tone, tone burst or off, but the OFF LEVEL control has been deleted. The latter control may quite easily be added, however, as shown in Fig. 4. . The output dc level control and the starting-point phase change have also been deleted.

Since we only need half of a CMOS 4016 IC, to give the required output, the other half may be used to give an inverse output if required, that is, the reverse output is on when the other is off and vice versa. This output is not buffered or brought out to the front panel. If it is intended to load this output with less than 47 k it is recommended that a 4066 IC be used instead which will handle loads down to 10 k. For loads of lower impedance than this, a buffer such as is on the normal output should be used.

CONSTRUCTION

As with any project construction is greatly simplified if a printed circuit board is used. However the layout of the unit is not critical and any other suitable method, such as Veroboard or Matrix board may be used if desired. We strongly recommend that sockets be used for the CMOS ICs, especially if a printed circuit board is not used, as these devices are quite easily damaged when soldering. The use of IC sockets also facilitates later servicing. Also remember that, unlike TTL, all unused inputs of CMOS must be connected to either the positive or negative supply rail.

The plastic box that we used measured 160 x 95 x 50 mm and is very convenient in that the printed circuit may be held in position by sliding it down behind two of the pillars to which the front panel is screwed. As the amount of lettering required is quite small, this may readily be done directly on the panel by hand or with Letraset.

Shielding of the internal wiring is not required providing that the unit is kept away from strong 50 Hz fields. If operation in the vicinity of strong fields cannot be avoided then the unit should be mounted in a diecast box.

USING THE UNIT

The testing of loudspeakers is very difficult indeed and much effort is still being spent to find test methods which will not only give an accurate understanding of the relative effectiveness of the design, but which will be easy to reproduce.

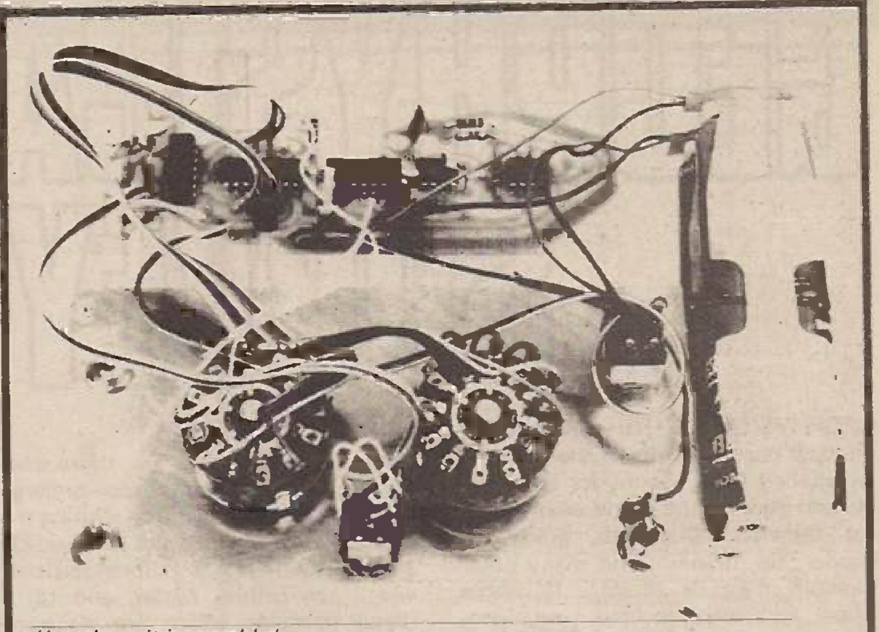
One of the main problems with speaker testing is that the speaker cannot easily be isolated from its environment. For example, reflections from the walls of a room modify the response, seen by a microphone, no matter where the microphone is placed in the room. If one could eliminate reflections then the situation would be improved considerably, and hence the use of anechoic (echo free) chambers for testing speakers. But such chambers are very expensive to build and consequently not readily accessible to the amateur.

A further problem is in assessing the transient power handling capability of the speaker. Speakers will handle far greater peak transient power than is indicated by their RMS power rating. This is a very important attribute of loudspeakers in handling musical transients. Any attempt to assess this with a sinewave signal may result in the destruction of the speaker due to thermal failure — apart from also being extremely noisy.

The use of a tone-burst generator minimizes both these problems. How this is achieved is better understood by examination of Fig.5. This shows on the upper trace a five cycle 1000 Hz burst that is fed to a loudspeaker. The second trace shows the same burst as picked up by a microphone in front of the speaker. We notice that the burst has been changed by the speaker and an examination of these changes can tell us a lot about the speaker. For example we notice that the first half cycle has not reached full amplitude and this indicates that the speaker would have some difficulty in reproducing high frequency transients. Next we notice that instead of five cycles there are now at least five and a half. This could mean one of two things. Either there is a speaker/room resonance or, the speaker itself is continuing to vibrate after the original excitation has ceased. Which is it? We can determine this by changing the position of the speaker to see if any change occurs in the shape of the burst, if not it is caused by the speaker itself, and if it does then it is a speaker/room resonance. A speaker that lengthens the burst unduly will sound muddy in that region. Of course the speaker must be examined over its whole range to gain a thorough assessment of performance.

It is of course possible to eliminate room reflections simply by performing the tests outside. However unless one lives in a very quiet area, background noise will introduce problems – and your neighbours are unlikely to appreciate the noise that you will generate.

By varying the off period we can also select a ratio where the room reflection, the oscillation seen after the cessation of the burst, does not interfere with the first few cycles of the burst and the response versus frequency of the speaker may then be assessed from the amplitude of the first half cycles that are stable in amplitude. Thus it is possible to gain an appreciation of the frequency response, transient performance and quality in terms of ringing of a speaker by careful use of the tone-burst technique.



How the unit is assembled.

The transient power handling capability of a speaker may be assessed by selecting a fairly long off to on ratio for the burst and by feeding the burst to the speaker via a high-power amplifier. If for example an off to on ratio of 8:1 is used then the peak power will be eight times the average power. Thus the speaker may safely be driven to a peak level where a predetermined amount of distortion occurs. Take care that the amplifier is capable of providing the peak power required.

Of course a tone-burst generator may be used for a wide range of testing. We have mainly concentrated in this article on its application to the testing of loudspeakers.

The circuitry of the tone-burst generator may easily be modified for use as a 'silent switch' for A/B speaker testing. The method of doing this will be described next month. ●

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.

ELECTRONICS IN GEOPHYSICAL SURVEYS

by Martin Blanchard

GEOPHYSICS IS THE study of the physcial characteristics of the earth. In its applied form geophysics is an important tool in the world-wide search for minerals. Diamonds, gold, oil, copper, tin, uranium and many other minerals may be directly or, more often, indirectly located using geophysical methods.

The advantage of airborne geophysics over other prospecting methods is the ability to cover large areas of the earth's surface in a relatively short time. Interpretation of the survey results, combined with prior knowledge of the area's geology and follow-up field investigations, provides a short list of sites which merit intensive investigation. Areas of hundreds of square miles may be surveyed in a period of months rather than the years which would be required using more traditional methods.

The three characteristics studied in modern airborne geophysical surveys are (a) Magnetic (b) Radioactive (c) Thermal.

MAGNETIC EFFECTS

The earth's rocks have become magnetised by two methods; by induction due to their alignment in the earth's magnetic field or by a permanent (remanent) magnetisation which occcured when the rocks were formed. Often remanent magnetisation is completely disorientated with respect to the earth's field due to the fact that the rocks have been twisted and turned since they were cooled. These rocks modify the earth's magnetic field in the area and this attracts the interest of the prospector. A device used to measure magnetic flux density is called a magnetometer. There are two types: (a) the static type, which measures the field directly, and (b) the dynamic type, which measures the modification of a signal transmitted into the ground.

In geophysics the field is usually measured in gammas: 10^5gammas = 1 Gauss = 10^{-4} weber/m.

The magnetic flux density at the surface of the earth is normally between 25,000 and 60,000 gammas.

RADIATION EFFECTS

Radioactive elements are those containing atoms whose nuclei undergo spontaneous disintegration. During the disintegration two types of particle are emitted: (1) α (alpha)particles, which are helium nuclei, and (2) β (beta) particles, which are electrons or positrons.

After the emission of particles a nucleus is in an excited energy state and in order to return to its ground state a γ (gamma) quantum is emitted (Not to be confused with a gamma, the unit of magnetic flux density). In the atmosphere alpha and beta particles are quickly attenuated but gamma rays have a much greater range.

The Gamma rays are pure electromagnetic radiation. They do not alter the nuclear charge of the emitter but they are composed of discrete packages of energy (quanta) (the difference between finite energy levels in the atom). Each radioactive substance has a characteristic spectrum of gamma ray emission energies. Gamma ray energy is usually measured in electron Volts (eV), where 1 eV = 1.602 10^{-19} joules. The range of energies of interest to the prospector is about 0.1 to 3.0 Mega-electron Volts (MeV). The following elements occur naturally and are important in geophysical work. They have these useful energy peaks in their spectra:

(a) Uranium 1.12, 1.38, and 1.76 MeV.
(b) Thorium 1.61 and 2.62MeV
(c) Potassium 1.46MeV

Gamma rays are attenuated by surface soil or sand and are usually detected with a Geiger counter or a scintillation counter.

THERMAL EFFECTS

Temperature changes on the surface of the earth are due either to the effects of the sun and atmosphere or to volcanic action. Various types of rock have differing thermal conductivities so that temperature measurements made over a period of time enable differentiation between the types of rock. Sub-surface volcanic heat is also detectable (providing that faults or cracks in the rock, or water rising to the surface, can transfer the heat).

In airborne geophysics temperature measurements are made with an Infrared line scanner. Originally IR radiation comes from the sun or is emitted by the ground — it can be a combination of both. IR is electromagnetic radiation with a wave length range of about 0.000075 to 0.04cm.

Temperature measuring, although useful for additional information, is not as important as radiometric (radiation measuring) or magnetic techniques. IR line scan surveys are very useful, however, for such tasks as checking power station and industrial plant pollution in rivers or the sea.

MAGNETOMETERS

This month we will discuss the instruments used in Magnetic Surveys. Three types of magnetometer will be considered: (a) the proton precession magnetometer, (b) the flux gate magnetometer, and (c) the electro-magnetic (em) magnetometer. Types (a) and (b) are static magnetometers, (c) is a dynamic type.

PROTON PRECESSION MAGNETOMETER

This device uses the principle of nuclear magnetic resonance (NMR) to measure the earth's magnetic field. The NMR principle shows that in a suitable liquid the proton spins are aligned in the earths field.

The detector head of a proton magnetometer consists of a container filled with a proton rich fluid (water or paraffin usually) and a coil either wrapped round the container or immersed in the fluid. The container and coil are often towed behind the survey aircraft in an airfoil known as a 'bird' so that the detector is not affected by the magnetic field of the aircraft.

The essence of the operation of this magnetometer is shown in Fig. 1. A current pulse of several amps is switched from the unit power supplies

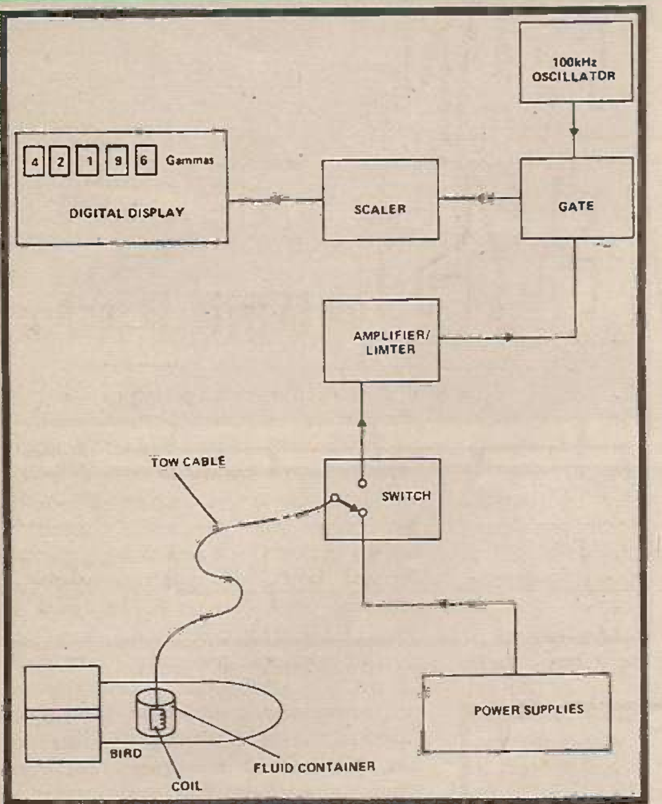


Fig. 1 Basic Proton Precession Magnetometer.

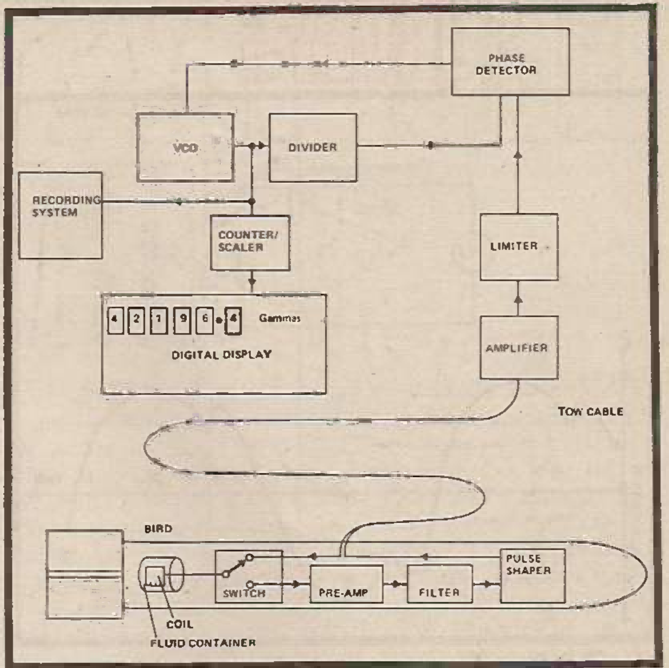


Fig. 2 Complete Proton Precession Magnetometer.

Photo 1. Proton magnetometer 'bird'.

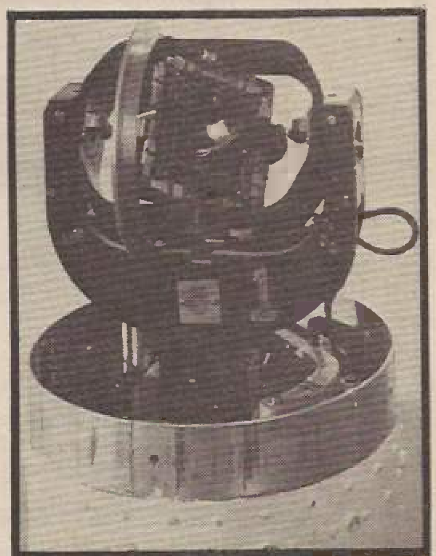


Photo 2. Fluxgate magnetometer detector head showing detector coil within the two sets of gimbals.

down the tow cable and through the detector coil to create the strong magnetic field necessary to disturb the proton spins. As soon as the current pulse ends the protons begin to precess and the precession signal is picked up by the detector coil and passed through the tow cable to a sensitive amplifier in the main unit.

The next stage is to measure the frequency of the precession signal. A resolution of ±1 gamma in a field of 50,000 gammas requires that the precession frequency be measured within 0.04Hz in about 2kHz. The counter output is scaled so that a digital display may be read directly in gammas.

Fig. 2 shows the more sophisticated system normally used. The bird now contains not only the detector head but also an electronic package consisting of a preamplifier, a filter and a pulse shaper. These circuits improve the signal to noise ratio of the precession signal when it is passed through the tow cable.

Outputs from the counter are taken to the recording systems which are described later. The measurement accuracy of the system is within ±0.5 gammas and is a total field value. The main disadvantage of the proton precession magnetometer is the necessity to switch between energising and detecting from the coil as this means that the fastest sampling rate is about one reading per second which may mean that anomalies are missed. These factors of speed and resolution are important considerations in airborne geophysics as the survey aircraft travels about 200 feet in one second.

FLUXGATE MAGNETOMETER

The fluxgate is the detector in this type of magnetometer The permeability of a ferro-magnetic material depends on its intensity of magnetisation. If a coil with a ferro-magnetic core is driven cyclically through saturation by ac, the inductance of the coil is proportional to the slope of its hysteresis curve. A distortion occurs in the voltage output across the coil. (see Fig. 3). If now two coils are connected in series, as shown in Fig. 4, with an external magnetic field in the direction shown the 'kink' in the coil output voltage waveform is shifted in phase and the summed output voltage V_O varies with the external field as shown in Fig. 4.

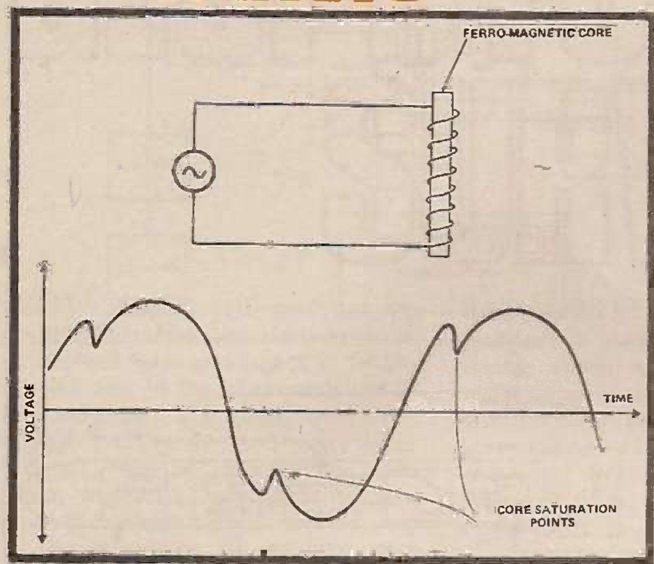


Fig. 3. Coil Output Voltage Waveform—see Fluxgate Magnetometer.

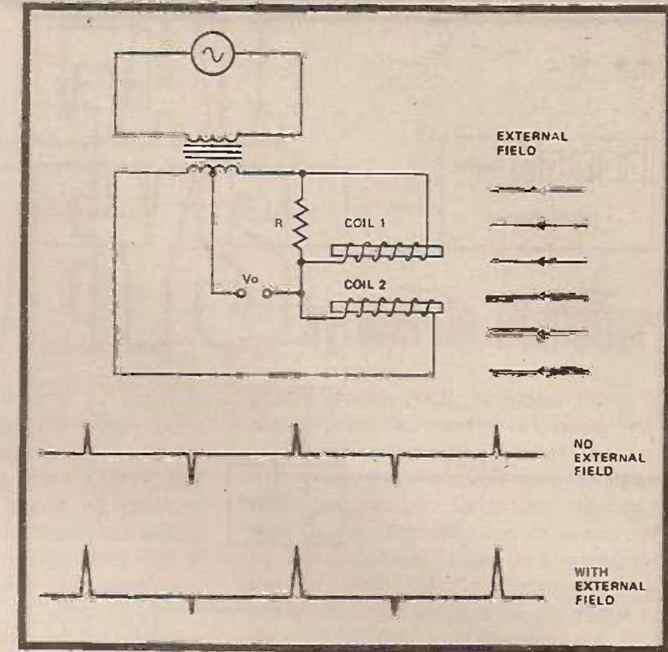


Fig. 4. Basic Fluxgate and Output Waveforms.

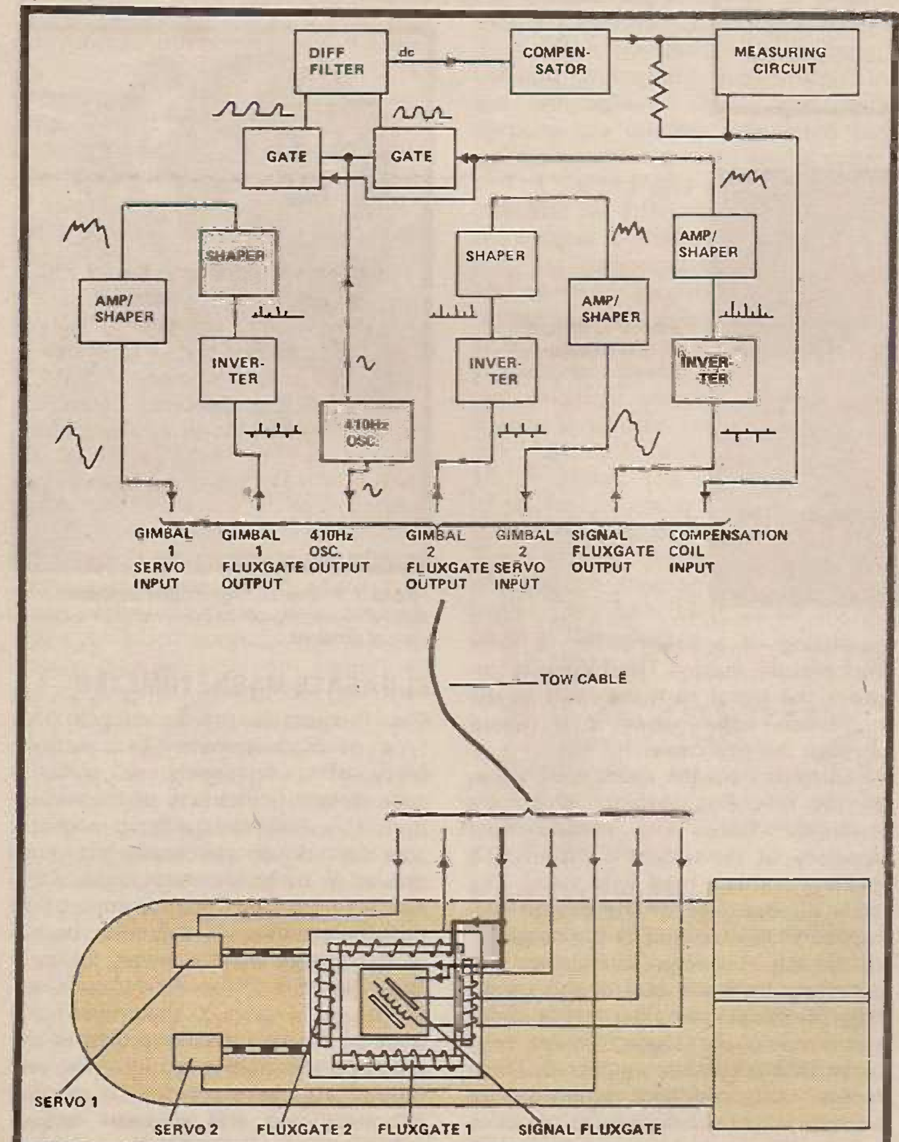


Fig. 5. Fluxgate Magnetometer.

If now an artificial field is produced so that the fluxgate output pulses are always kept at the same amplitude then the artificial field is proportional to the external field. The external field is measured by the amount of current required through the compensation coil to cancel out the field.

In Fig. 4 it can be seen that the fluxgate is highly sensitive to an external field in the direction shown but that a field at right angles to that shown would have little or no effect. This means that the detector element must be orientated so that its sensitive axis is aligned with the total field vector of the earth.

PRACTICAL FLUXGATE MAGNETOMETER

A complete fluxgate magnetometer detector element consists of three fluxgates. Two of these provide orientation signals and the other provides the field measurement and has a compensation coil. Each fluxgate is energised at 410Hz as this avoids any harmonic interference from other supply frequencies used in aircraft. The operation can be seen in Fig. 5.

The current through the compensator coil is directly proportional to the external field and so measurement of the current will be an analogue of the field value. The usual problem of resolution arises as the current must be measured with an acuracy of 1 part in 50,000 (1 gamma in a total field of about 50,000 gammas).

The fluxgate detector is often towed behind a survey aircraft in a bird. Another method is to mount the detector in a 'stinger' which is an

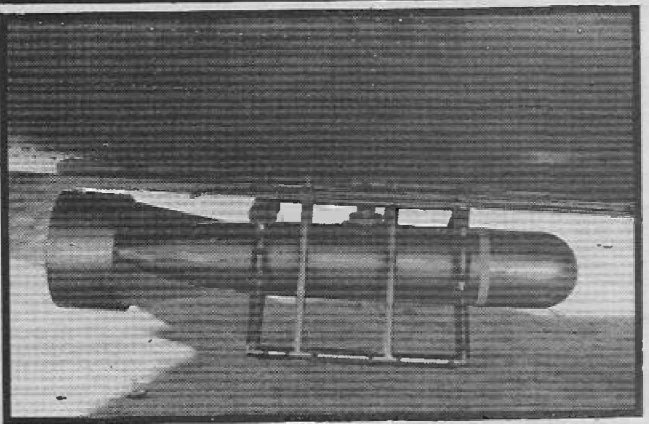


Photo 3. Fluxgate magnetometer 'bird'.

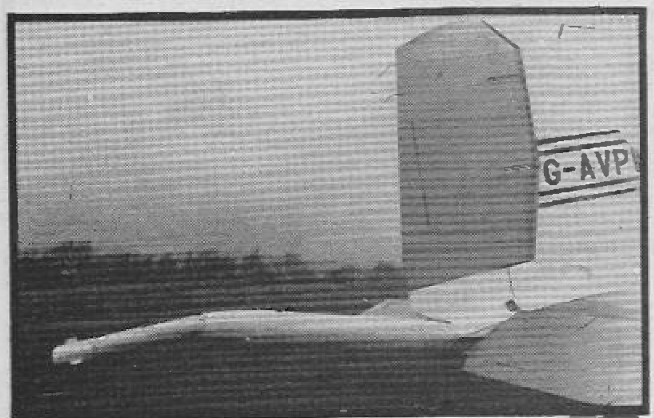


Photo 4. DC-3 aircraft fitted with a 'stinger' suitable for a fluxgate magnetometer detector head.

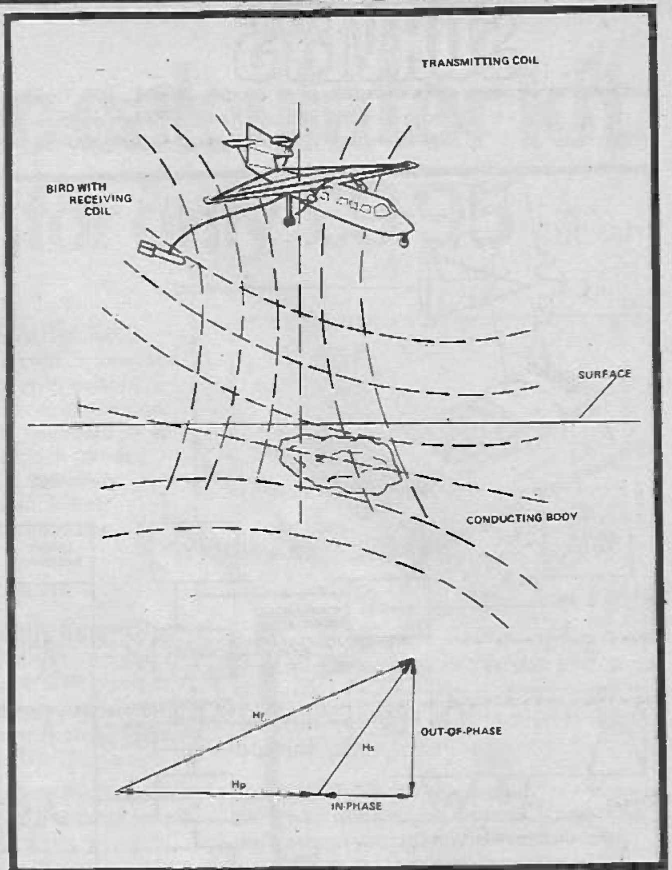


Fig. 6. Basic EM Magnetometer Operation.

extended portion of the tail of the aircraft. Using a stinger means that the detector is influenced by the magnetic field of the aircraft and in order to overcome this problem compensation coils are built in. A fluxgate magnetometer bird fitted to a DC-3 aircraft is illustrated in photo 4.

Generally the fluxgate magnetometer has an accuracy of ±1 gamma but values are relative rather than absolute and some instrument drift takes place. The fluxgate magnetometer does, however, provide a continous record.

ELECTRO-MAGNETIC MAGNETOMETER

Electro-magnetic (em) magnetometers differ from those already described in the important respect that they do not measure the earth's magnetic field but rather the conductivity of the ground over which they are flown. There are many types of em magnetometer and they vary in performance, construction and operation. The general principle is illustrated in Fig. 6. Here a signal transmitted from the survey aircraft causes a current to be induced into any conducting body within the transmitted field. This induced current then sets up a secondary field which is detected along with the transmitted (primary) field by a receiving coil.

The vector diagram shows that the resultant, Hr, of the received primary (Hp) and secondary (Hs) fields may be resolved into an in-phase and out-of-phase component of the primary field.

Two important characteristics of em systems are that the separation between the transmit and receive aerials is roughly proportional to the depth penetration capability and that the out-of-phase component is largely independent of the aerial spacing and alignment.

EM systems can be broadly split into two groups, rigid boom systems and towed bird systems. Rigid boom systems measure both in and out-of-phase components usually at a single frequency and with the aerials at fixed positions relative to each other. This is achieved by using a long boom towed by a helicopter or by mounting an aerial on each wing-tip of an aircraft. Towed bird systems measure out-of-phase components usually at two frequencies which give more detailed information about bodies of only moderate conductivity. The transmitting aerial is usually mounted in the survey aircraft while the receiving aerial is towed in a bird.

A serious problem in em magnetometers is the fact that the amplitude of the received primary field component is very much greater than the secondary field component which leads to some difficulties in measurement. A system known as INPUT (INduced PULse Transient) overcomes this problem by using a pulsed transmission and by only receiving the secondary field after the transmitted pulse is over.

INPUT EM MAGNETOMETER

In this system (Fig. 7) the transmitting aerial is a large loop strung between the aircraft wing-tips, nose and tail. The timing of the system is derived from the divided output of a crystal clock. The transmitted pulse has an output power of 2kW and a duration of 1mS at a repetition frequency of about 3kHz. The receiver is gated open when the transmit pulse is over and received signals from the aerial in the towed bird. The received signal is sampled at increasing intervals, usually six times between the transmitted pulses from 150 microseconds after to about 2 milliseconds after. Each sample is displayed as a channel on a chart recorder. A rapidly decaying signal. which indicates a porrly conducting body, only shows a response in early channels while a slowly decaying signal, which indicates a good conductor, has a response in all chan-

ELECTRONICS IN

GEOPHYSICAL SURVEYS

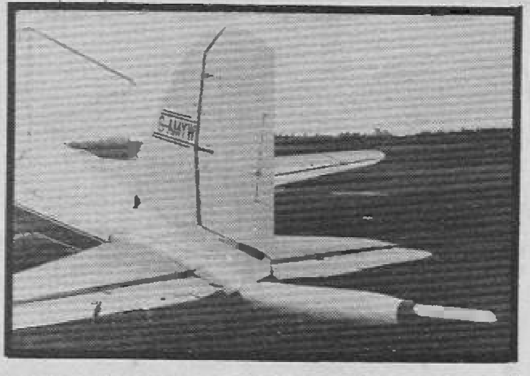


Photo 6. DC-3 aircraft fitted with em magnetometer transmitting loops (on top of fusalage) and detector coils in the 'stinger'.

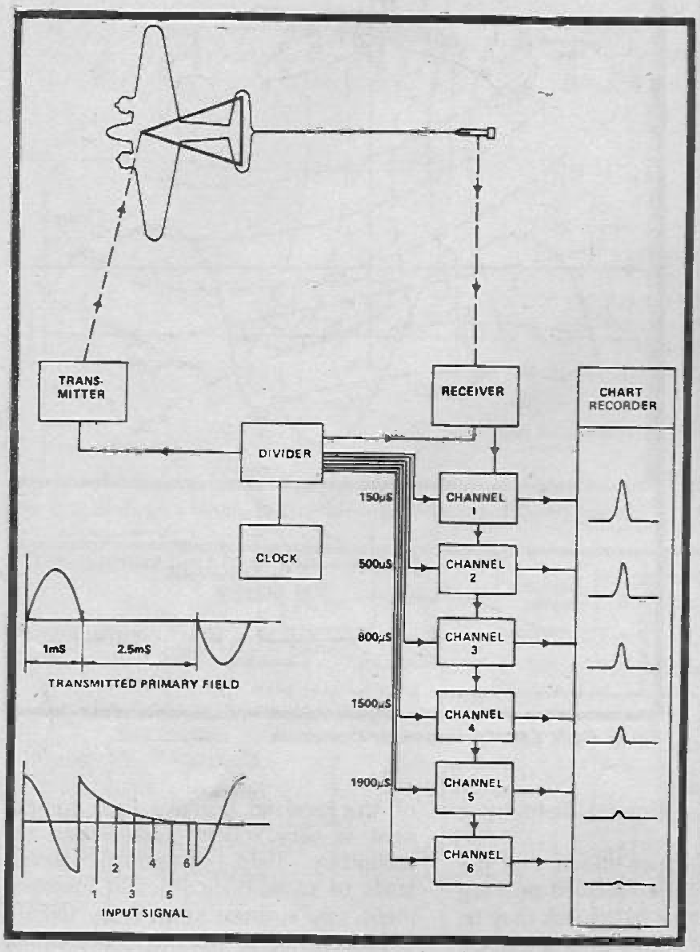


Fig. 7. INPUT EM Magnetometer System.

Photo 5. Catalina aircraft with em magnetometer system fitted.

nels. As measurements are made when there is no primary field in the input system it is independant of aerial orientation.

OPERATIONAL TECHNIQUES WITH MAGNETOMETERS

As with the use of most airborne geophysical equipment the two main operational parameters to be decided before the start of the survey are the altitude at which the aircraft is to fly and the line spacing. Line spacing refers to the manner in which survey areas are covered. Obviously the area must be flown in a methodical manner and this is done by covering the area with a series of parallel lines. The spacing of the lines and the altitude chosen are linked, in that the higher the magnetometer is flown, the greater is the area covered and therefore the wider apart the flight lines can be. Usually the line spacing and altitude are chosen to give the best results for the type of survey. Small ore bodies are best detected flying at fairly low altitude (say 150 meters) with a narrow line spacing (about 400 meters) while general geological surveys are more usually carried out at about 600 meters altitude with a line spacing of 1500 meters. These figures apply to proton and fluxgate magnetometrs only — as em magnetometers will only function at low altitude. In practice the operational height is more limited by the terrain in the survey area and the performance of the aircraft being used.

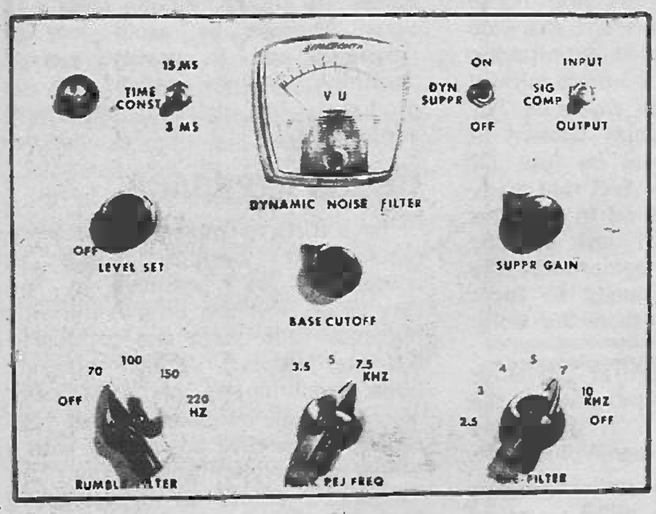
Generally em magnetometers operated from conventional aircraft cannot be used below 100 meters because of safety considerations. Operation of em magnetometers from helicopters enables the survey height to be reduced to about 50 meters.

The magnetic field at any point on the surface of the earth is not constant but undergoes daily variations and during magnetic 'storms' (often caused by sun-spot activity) the field value will change radically over a very short period. Compensation for these effects is usually achieved by keeping another magnetometer at a ground base in the survey area. This ground magnetometer (often called a storm monitor) is run continuously and gives a record of daily magnetic variations which may be used to modify the results obtained from the airborne magnetometer and thus provide more accurate results. If the ground magnetometer indicates the presence of a magnetic storm magnetometer, flying is usually stopped as compensation for the large rapidly changing field values is not possible.

Often surveys are carried out with the aircraft carrying more than one type of detection system and the operational parameters must then be a compromise that best suits the characteristics of the various systems.

Next month we will look at the other two techniques used by the geophysicist: Radioactive Surveys and Thermal Surveys.

Flexible low-cost noise filter virtually eliminates record surface noise . . .



DYNAMIC NOISE FILTER

PART ONE

by M.G. Strange

This two-part article gives you the theory you need to design your own unit . . . plus advice on construction.

DESPITE denials from many record manufacturers, many present day recordings have excessively loud surface noise – and this cannot be reduced using conventional tone controls without also losing a substantial amount of the programme content.

Serious collectors of older recordings have an even more serious problem. Most of these records are quite noisy – even by today's standards. For example, 78 rpm commercial discs, even though in mint condition, will have a typical signal-to-noise ratio of only 30 to 35 dB due to the abrasive nature of the record material.

Many collectors dub their best records onto tape. This way they may be played as often as desired – and conveniently shared with other collectors – while the often irreplaceable originals are safely preserved. Also, the sound can often be improved considerably during the copying process through equalization and filtering.

This article describes a flexible, low-cost noise filter designed for taping records with a maximum "fidelity-to-noise" ratio. It can be duplicated by the serious electronics hobbyist for about £40, or slightly less if certain features or ranges won't be needed. Although not recommended as a beginner's project, the experimenter with some circuit experience should have no difficulty. Minimum equipment requirements are an oscilloscope, sine wave generator, and multimeter.

The heart of this circuit is a dynamic noise suppressor with frequency characteristics and convenience features which are optimized for its intended use. The concept of dynamic noise suppression has existed for many years. Workable circuits were designed by H.H. Scott in 1946, and their performance was improved by Scott and others in 1947 and 1948. Then with the advent of the vinyl microgroove record and the rapidly increasing use of tape, both of which offered a considerable noise improvement over the 78 rpm system, the dynamic noise suppressor was almost forgotten. Recently, R. Burwen has revived this principle and applied it primarily to tape playback. Taking full advantage of modern integrated circuits, Burwen has designed highly sophisticated and flexible systems with impressive specifications. These, however, are too expensive for many hobbyists and do not have frequency characteristics optimized specifically for old, intrinsically band-limited material.

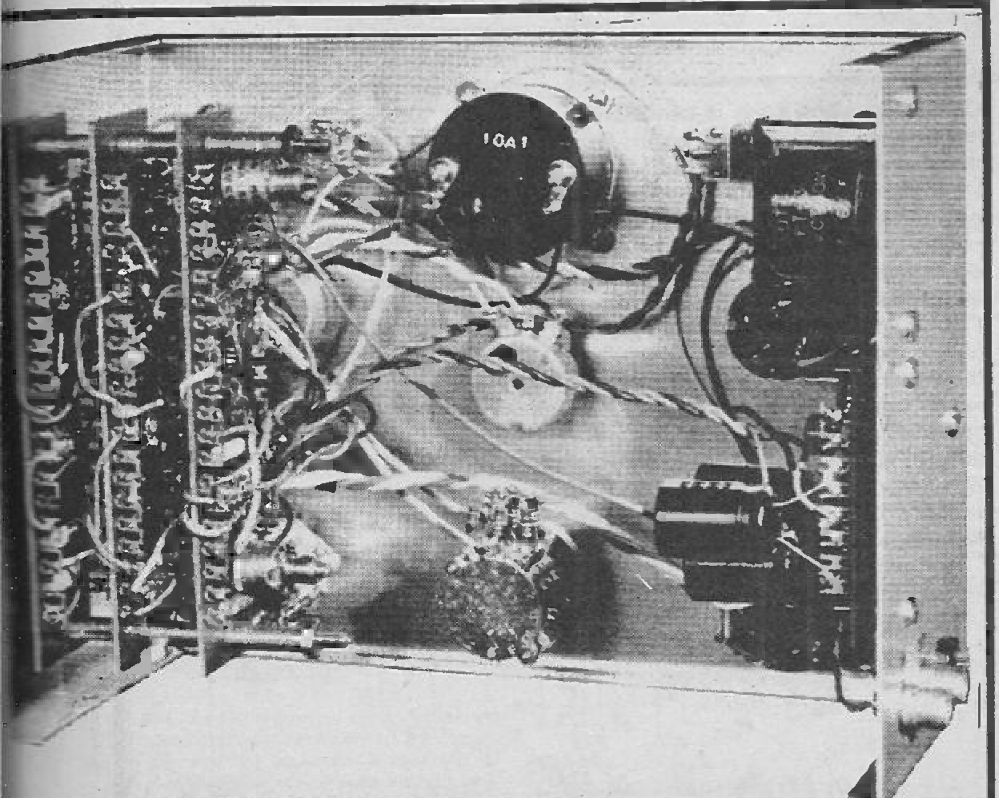


Fig.1. Interior of prototype unit.

THEORY

Dynamic noise suppression is simple in concept. Record surface noise varies in spectral content, but the higher frequencies (above 1 or 2 kHz) predominate. Low-pass filtering is commonly used to limit noise. But unless used sparingly, this type of filtering band-limits the programme material, making it sound muffled and lifeless. The dynamic filter, however, provides a method by which a signal can be effectively extracted from the noise (at least subjectively) *when signal and noise occupy overlapping frequency ranges.*

DYNAMIC NOISE FILTER

Operation of the dynamic noise suppressor depends upon a characteristic of the human auditory apparatus. If two signals occupying well-separated frequency ranges are present simultaneously, they are clearly perceived as individual entities. (This effect is often used to advantage in public address systems for noisy environments. If considerable high-frequency boost is used, voice announcements will seem to cut through ambient noise of predominately lower frequency without having to be excessively loud.) This is the case, at least for a large portion of the time, for a typical recorded signal with attendant surface noise; hence, the annoyance of the noise. However, if two simultaneous signals occupy substantially the *same* frequency ranges, the ear will tend to hear only the louder signal and ignore the weaker one. A level difference of only a few dB is sufficient for one signal to effectively override, or mask, the other. Operation of the dynamic noise suppressor depends upon this masking effect.

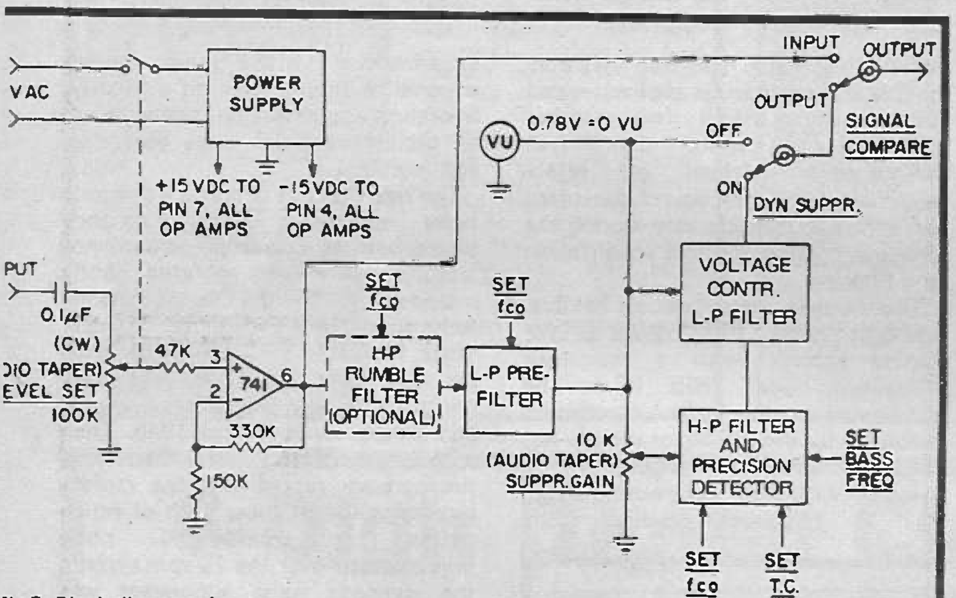


Fig.2. Block diagram of system.

CHARACTERISTICS

The dynamic filter has a fairly steep low-pass characteristic which, in the absence of signal, starts cutting off at about 1 kHz. This very effectively rejects the noise spectrum. When a signal having high-frequency components at sufficient amplitude comes along, the filter is made to "open up"; that is, its cutoff frequency is quickly raised. As the high-frequency programme content drops in frequency and/or amplitude, bandwidth contracts. The idea is that when high-frequency signal components are present, they will tend to mask the accompanying noise. When highs are not present, the wide bandwidth is not needed. Admittedly, the recovered signal is not as faithful as a noise-free original would be. For example, high-frequency content in low-level passages may be lost. Of some help here is the fact that many musical instruments tend to have less harmonic content at low acoustic levels. In spite of this compromise, the processed signal is usually far more pleasing to the ear than the noisy input signal.

The bandwidth control signal is derived by separating the high-frequency programme components from the signal-plus-noise. Unless the signal level is consistently higher than the noise to begin with, this becomes impossible. Thus, there is a minimum signal-to-noise requirement below which no improvement is possible. As the original S/N improves, the dynamic suppressor's performance improves also.

Ideally, the signal frequency range to which bandwidth is most sensitive should correspond to the frequency range of maximum noise. The optimum filter characteristic for separating the bandwidth-control signal from the noisy input thus varies widely with the characteristics of the noise with which we are dealing. Bandwidth control sensitivity (or gain) must be set properly for the incoming signal level and noise properties. Bandwidth should respond rapidly to signal changes to avoid loss of transients and to prevent audible "swishing" sounds which can be produced by delayed bandwidth contraction.

DESIGN APPROACH

I have tried to implement the basic requirements outlined above as completely as possible in an easy-to-use, low-cost unit. A dynamic high-pass filter stage was considered but later dropped, as high-frequency noise predominates on most older records. Low-frequency noise can usually be handled adequately with a simple manually-set rumble filter.

Figure 2 shows an overall block diagram of the noise filter. Operational amplifier A1 is connected as a non-inverting amplifier with a voltage gain of 3.2 (10 dB), enabling the system to be driven to 0 VU with an input level of 0.25 volt. This amplifier also serves as a buffer, providing an input impedance of 100 kilohms for compatibility with virtually any signal source.

Amplifier A1 drives the *rumble filter*, which could be omitted if one is available in the associated external equipment. Following this is the *pre-filter*, which is simply a low-pass filter with a manually set cutoff. This filter is important for several reasons. First, it removes noise which is above the frequency range of the recorded signal. Many recordings have no signal content above 4 or 5 kHz (even lower for acoustic records), and no programme content is lost by cutting off the upper range. Thus, the total noise voltage is lowered, often appreciably, permitting the use of higher suppression gain settings as will be seen later. Another reason for this filter is that the dynamic filter can do nothing to reduce the annoyance of high-frequency distortion. Furthermore, since a limited-bandwidth signal cannot effectively mask higher-frequency noise, removal of the latter helps to eliminate audible evidence of the continually changing bandwidth.

From the pre-filter output the signal passes to the *voltage-controlled*

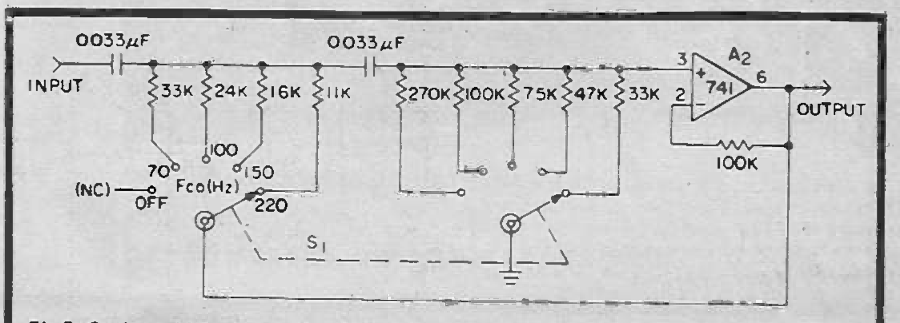


Fig.3. Optional high-pass rumble filter schematic.

low-pass filter and, via the *suppression gain* control, to the *high-pass filter/precision detector* whose function is to derive the bandwidth control signal. This point additionally goes to a switch which permits the dynamic filter to be by-passed at will so that its effect with various control settings may be easily judged. Another switch permits the output to be compared with the "raw" input signal.

All of the filters used in this system, including the voltage-controlled filter, are of the 2-pole active type, giving a 12 dB/octave rolloff slope. The damping factor is chosen (with one exception) for a Butterworth response, which produces the steepest possible slope beyond cutoff with no peaking in the passband. (High-pass filters with 3 dB peaking were tried, but these produced a slightly rough, "grainy" sound compared to the flat-passband version.) The design approaches are widely published and need no further discussion here. The rumble filter (Fig. 3) and the pre-filter (Fig.4) are of this type; their response curves are shown in Fig.5. The rumble filter is not essential to proper suppressor operation, but is convenient in case an effective low-cut filter is not included with the associated preamplifier in the copying setup. The design shown here has rather high settings intended primarily for acoustic records.

BANDWIDTH

The bandwidth control signal is derived with the circuit of Fig. 6, which consists of a high-pass filter followed by a precision detector. The filter damping factor is made low in order to produce a pronounced peak and more rapid low-frequency rolloff (Fig. 7). Three selectable cutoffs produce peaks at 3.5, 5, and 7.5 kHz; these were empirically determined to best accommodate a wide range of noise characteristics and recorded bandwidths.

The knowledgeable enthusiast could readily modify the cut-off points to suit his own particular application.

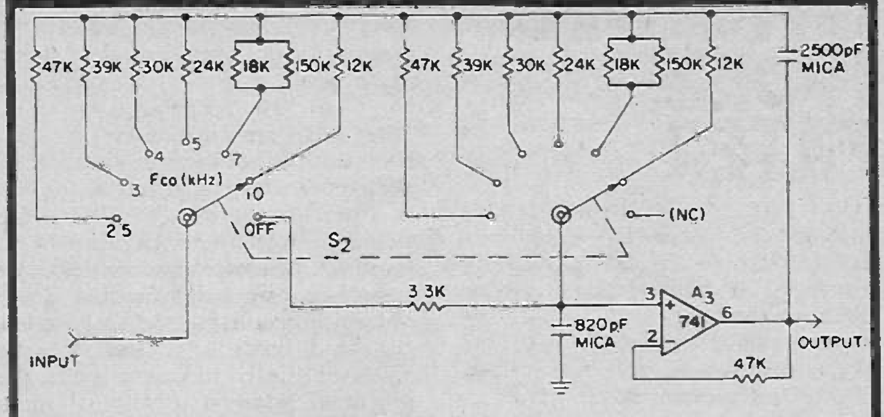


Fig.4. Schematic of the low-pass pre-filter.

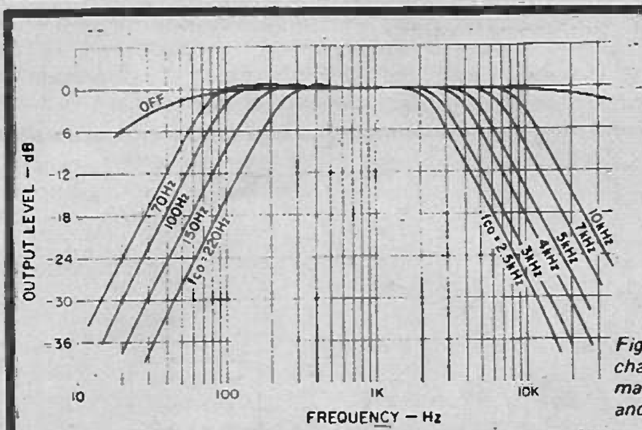


Fig.5. Frequency characteristics of the manually-set rumble filter and pre-filter.

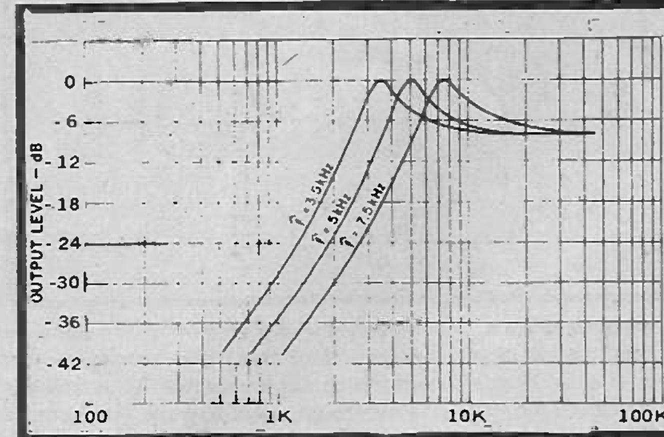


Fig.7. Frequency characteristics of the filter used to derive the bandwidth control signal.

The filter output is coupled to a detector and an integrator. The operation of these circuits and discussion of the variable-cutoff filter and construction follows next month in the final part to the article.

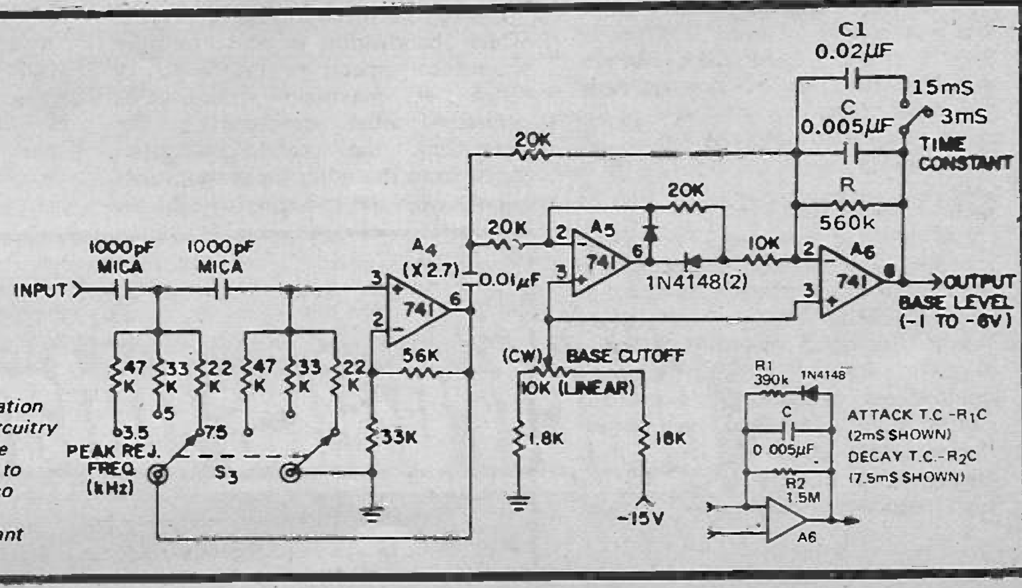


Fig.6. Bandwidth control signal separation filter and precision rectifier. IC A6 circuitry may be modified, as shown in separate detail, for shorter attack with respect to decay time — note that R1 and R2 also affect rectifier gain so time constant changes are not completely independant of 'suppression' gain.

We're usually pretty brash about the way we announce what is planned for the next issue. The March issue is something special so we decided to tell you about it in a different way: quietly.

First we've got a rather special competition which we are running in conjunction with Henry's Radio. It is a sort of 'Sale of the Century' for the winners —something like a 99% discount (up to a certain limit) for goods in the Henry's catalogue.....and quite a lot is being given away at that. It won't be an easy competition to enter, we get excellent responses to our competitions mainly because they are challenging and don't insult the readers intelligence.

Second, there is a pretty good reader offer. Now, we can't tell you too much about it at this stage, when you see it you will understand why. We are not being mysterious to hide a mediocre offer. We can say that it is for a highly popular product, especially of interest to the technically minded and at a price which is about 40% cheaper than the current cheapest price for any product in this field. As someone put it to us the other day, ETI brings you today's products at tomorrow's prices. In our field that could be taken as a compliment.

Next we have a Data Sheet Special: on Op-Amps. This will cover various types and should be something you will want to keep for future reference. It also forms a nice wrap-up to our series which finishes in this issue.

We've also got an Index for you, covering every issue of ETI to date - that's four year's next month. In the March issue we are dealing with all subjects except Tech Tips and Data Sheet; these will be done in April.

Then there is an excellent article by Gordon King on Distortion. Did you know that in certain cases distortion can actually help the sound quality? This is an article which we feel will be of interest to everyone.

There are plenty of projects of course.
A 5V Switching Regulator Power Supply. An unusual design operating on very different principles to the regular stabilised PSU. Next is an Audio Level Meter using a 'bar' of LEDs instead of a moving coil meter. Even if you have no interest in this subject, the technique may be of interest. There is also an article describing how to modify the Tone-Burst Generator for silent A-B switching. Cannibals and Missionaries - sounds ridiculous, but it's a great party game.
Another simple project is a headphone adaptor with adjustable stereo separation — it also restores natural damping, giving a better quality sound.

Well, if you have read this we hope your appetite has been whetted. We have to add the rider that circumstances can affect the final contents but everything we mentioned is at an advanced state of preparation. The March issue will be published on Friday, February 6th.

electronics today *international*

ETI DATA SHEET

AY-1-0212 & AY-1-5051 ORGAN DIVIDER IC's

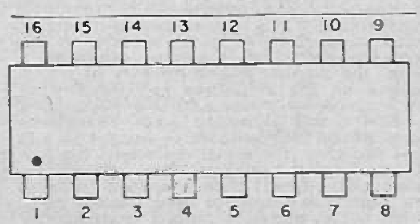
GIM

The General Instruments Master Tone Generator is a digital tone generator which produces from a single input frequency, a full octave of twelve frequencies on twelve separate output terminals.

The MTG consists of twelve divider circuits which divide the input by an exact integer to produce a chromatic scale of twelve notes. When used in conjunction with an oscillator and frequency dividers, a system may be configured which generates all the frequencies required by an electronic music synthesiser. The AY-1-0212 operates at input frequencies up to 1.5MHz. Typical advertised price is £7.

P/N	FUNCTION	P N	FUNCTION
1	V_{SS}	9	V_{GG}
2	INPUT I_0	10	V_{DD}
3	÷451	11	÷268
4	÷379	12	÷284
5	÷319	13	÷338
6	÷301	14	÷358
7	÷253	15	÷402
8	÷239	16	÷426

TOP VIEW



ELECTRICAL CHARACTERISTICS

VGG Power consumption	16mA
VDD Power consumption	20mA
Input frequency	0.25–1.5MHz
VGG	–26V approx.
VDD	14V approx.

The AY-1-5051 is a 4 stage divide-by-two frequency divider which will operate up to 1MHz on either sine or square wave input. The outputs change state on the negative going edge of the clock.

Other divider configurations are available:

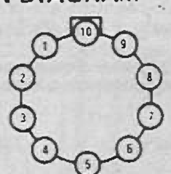
AY-1-6721/5	5 stage divider	10 lead CAN
AY-1-6721/6	6 stage divider	12 lead CAN
AY-1-5050	7 stage divider	14 pin DIL
AY-1-6722	8 stage divider	16 pin DIL.

The typical advertised price of the AY-1-5051 is £1.50.

ELECTRICAL CHARACTERISTICS

Input Logic Levels	
"0" Level	–2V max.
"1" Level	–10V min.
Output Logic Levels	
"0" Level	–1V max.
"1" Level	–11V max.

PIN DIAGRAM

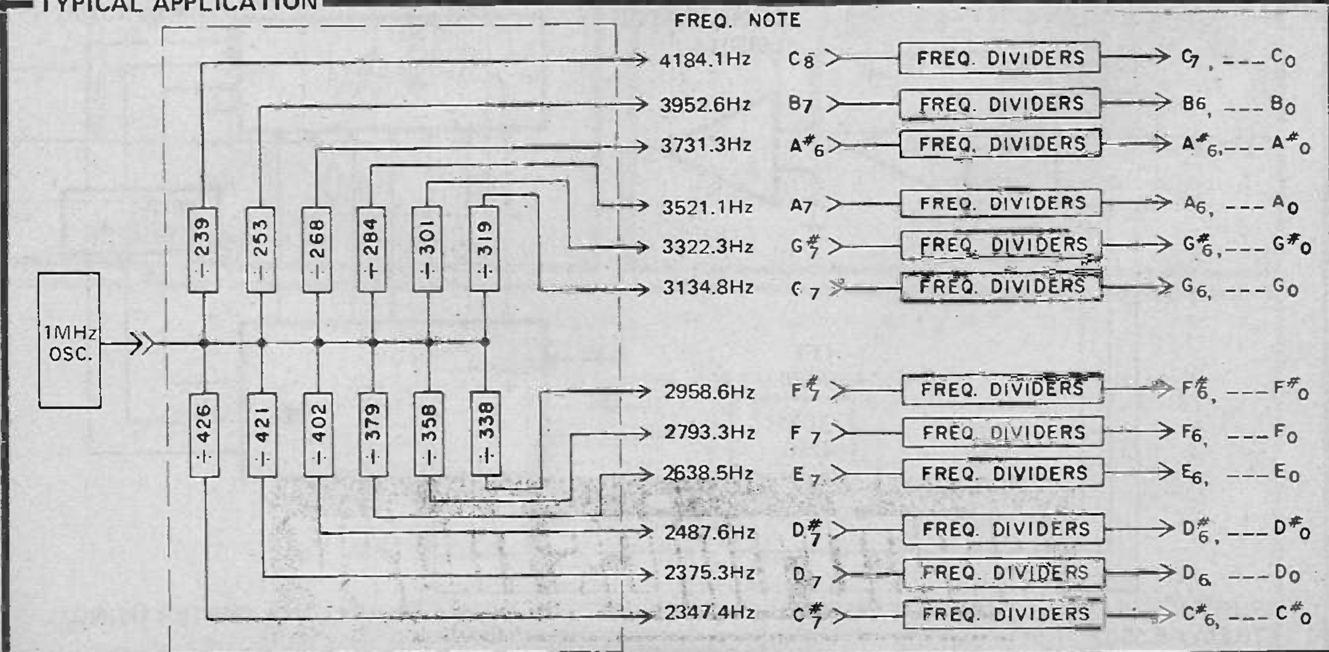


TOP VIEW

4 STAGE AY-1-5051

PIN	FUNCTION
1	OUT A_1
2	OUT A_2
3	IN B
4	OUT B
5	GND
6	IN C
7	OUT C
8	V_{GG}
9	V_{DD}
10	IN A

TYPICAL APPLICATION



AY-5-3507 3½ DECADE DVM

The AY-5-3507 is a MOS LSI chip containing all the logic necessary for a 3½ Decade Digital Voltmeter utilising Dual Ramp integration. Automatic polarity detection is incorporated, as is automatic overrange indication. The outputs are multiplexed onto a 7 segment highway allowing easy interface to LED and similar displays whilst keeping the pin count to 18. Typical advertised priced is £6.50.

OPERATION

The operation of the circuit is as follows: Intially the signal and reference outputs are in the logic '0' state. The counter continuously and at the 1999 to 0000 transistion a ÷ 2 is toggled driving the signal switch output to logic '1' turning on the signal switch. The integrator generates a ramp. the amplitude and polarity of which depend on the amplitude and polarity of the input signal. After a further 2000 clock pulses the ÷ 2 is toggled again. This stores the state of the comparator output in a D type flip flop (the signal represents the sign of the input signal). The appropriate reference switch is then energised to cause the integrator output to ramp back to zero. When the comparator output subsequently changes state the reference is switched off and the number in the counter is transferred to the store together with polarity information.

Should the input signal be so large that zero is not reached during one counter cycle, an overrange flip flop will be set and will remain set until the next 1999 to 0000 transition of the counter. During overrange the main display will be set to 0000 and the overrange indicator will flash.

To minimise pin requirements a time shared output is used. The display store output (including ±, 0/1 and overrange) is gated sequentially a decade at a time onto a common 7 line output highway.

PACKAGE INFORMATION

18 lead Dual-in-Line

PIN	FUNCTION	PIN	FUNCTION
1.	Segment F	10.	Vss
2.	Segment G	11.	Segment C
3.	Segment E	12.	Segment D
4.	Signal Switch	13.	V_{GG}
5.	Comparator Input	14.	Clock
6.	Negative Ref. Switch	15.	Mux 1
7.	Positive Ref. Switch	16.	Mux 2
8.	Segment A	17.	Mux 3
9.	Segment B	18.	Mux 4

18 17 16 15 14 13 12 11 10

1 2 3 4 5 6 7 8 9

ELECTRICAL CHARACTERISTICS

CLOCK & COMPARATOR INPUTS

Logic '0' level	between –6V & –18V
Logic '1' level	between +0.3V & –1V
Clock frequency	between DC and 20kHz

DISPLAY MULTIPLEX OUTPUTS

Logic '1' sink current	2mA typical
Logic '0' leakage current	less than 10μA

SWITCH OUTPUTS

Logic '1' sink current	0.8mA typical
Logic '0' leakage current	less than 10μA

SEGMENT OUTPUTS

Logic '1' sink current	7mA typical
Lohic '0' leakage current	less than 10μA

SUPPLIES

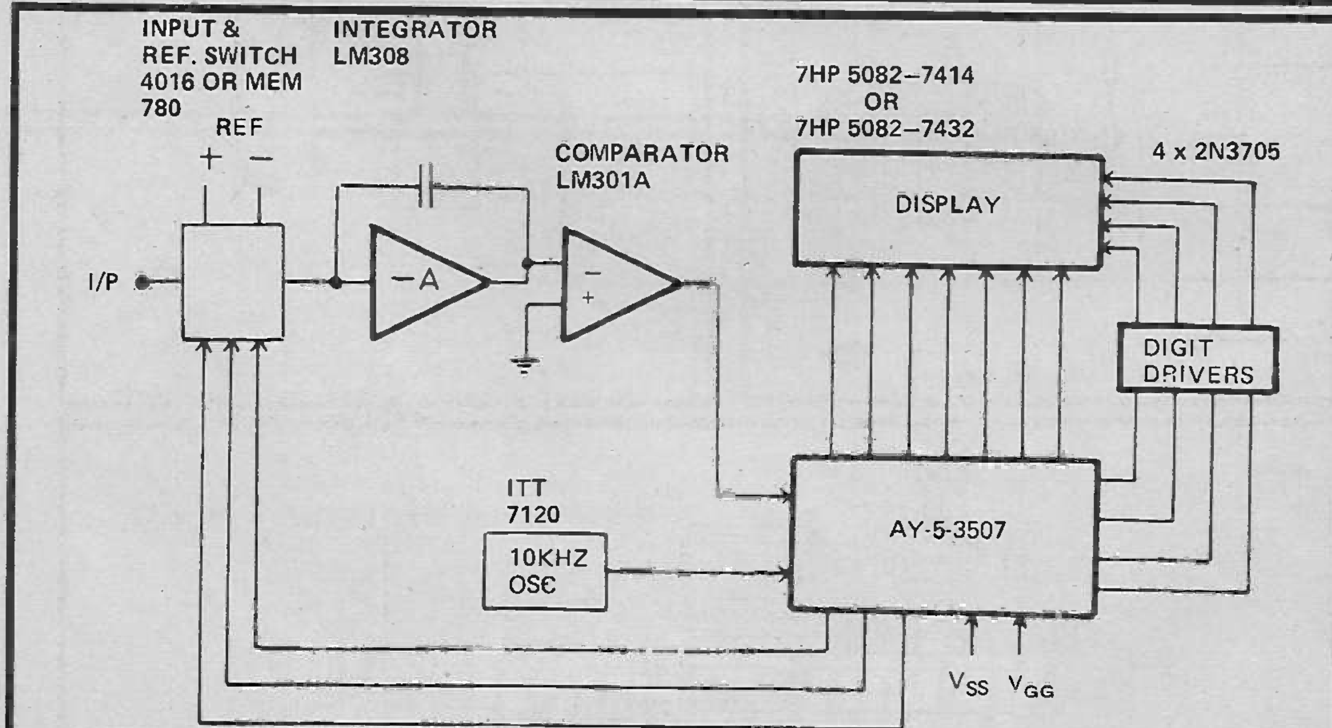
V_{SS}	0V
V_{GG}	–12V to –18V

At VGG = –12V, Supply current is 1.5mA typical

At VGG = –18V, Supply current is 3.6mA typical

INPUT AND OUTPUT SIGNALS

COMPARATOR INPUT	A logic '0' level corresponds to a negative input signal. A logic '1' level corresponds to a positive input signal.
CLOCK INPUT	This signal should be supplied from an external oscillator giving a square wave signal.
REFERENCE SWITCH OUTPUTS	These outputs drive analogue switches which connect the Reference Voltages to the Integrator. A logic '0' at the Comparator Input will be followed by a logic '1' at the Positive Reference Switch Output. A logic '1' at the Comparator Input will be followed by a logic '1' at the Negative Reference Switch Output.
SIGNAL SWITCH OUTPUT	This output will be at 'logic' during the time that the signal is connected to the Integrator.
DISPLAY MULTIPLEX OUTPUTS	These outputs will be at logic '1' to display. The outputs selected will be as follows:- MX1 0/1, ±, Over-range; MX2 Decade 3 (102); MX3 Decade 2 (10¹); MX4 Decade 1 (10⁰)
SEGMENT OUTPUTS	The outputs of the 3 decade counters are presented sequentially on the outputs A, B, C, D, E, F, G. In the first multiplex position 1 is indicated by segments B and C, – is indicated by segment G, overrange by the flashing of segments A and D. 0, + and underrange are not indicated.



FURTHER INFORMATION ON G.I.M. APPLICATION NOTE 'BUILDING A DIGITAL VOLTMETER USING THE AY-5-3507

EXTERNAL CIRCUITRY TO BUILD A DVM

We give here circuitry required to build a 3½ digit Dual Ramp Integrating DVM which will run from a 6V battery and has an FSD of ± 2V. The circuits described here are an integrator, a comparator, a voltage reference, a clock oscillator and a display.

ANALOGUE CIRCUITRY (Fig. 1)

This consists of an LM308 Integrator followed by an LM301A comparator. The input and reference signals are switched onto the integrator by an MEM 780 quad n-channel MOS FET switch.

Zero setting is achieved by injecting a small current into the input, sufficient to balance out the bias current of the LM380 and the leakage current of the MEM 780. Full scale setting is achieved by adjusting the Positive and Negative references.

The LM301A negative supply is decoupled with 220 Ohms and 150µF, this is only when the ITT 7120 power supply is used.

VOLTAGE REFERENCE (Fig. 2)

A BZV10 temperature compensated Zener diode is used to provide a basic 6.5V reference. An LM301A operational amplifier is used to generate a +3.25V and a −3.25V reference from the Zener voltage. Four outputs are provided, the Positive and Negative references (± 2 Volt nominal) a −3.25V substrate bias for the MEM 780 analogue switch and a zero set control for the integrator.

DISPLAY INTERFACE (Fig.3)

The high output current capability of the AY 5-3507 allows direct driving of LED segments. With a 6V supply, the output drive to the digit select transistors be 5mA and the peak segment current will be typically 16mA, giving an average segment current of 3.2mA.

The segment output is high enough to give outdoor visibility on 0.11" displays such as the 7HP 5082-7414 and 7232. Larger displays can be driven if indoor use is intended.

POWER SUPPLY AND CLOCK OSCILLATOR (Fig. 4)

The circuit is designed to be run from a 6V battery, an ITT 7120 calculator power supply is used to generate a −14V supply. This results in supplies of +6V for the DVM. The 7120 also contains a clock oscillator, this runs at 10kHz giving a reading rate of 2.5 per second.

Typical power consumption for the circuit, excluding the display, is 50mA at 6V. The display as shown takes on average a further 50mA.

Alternative power supplies may be used, the restriction being that each supply must lie within the range 4.5 to 10.5V and the sum of the supply voltages must be in the range 12 to 18V. If it is desired with a positive supply greater than +6.5V, limiting resistors will be required in the segment and multiplex outputs.

OVERALL PERFORMANCE

Full scale range	± 1.999V
Accuracy	± 0.1% reading ± 1 digit
Input Resistance	220k
Operating Temperature	0°C to +70°C
Zero stability	1 digit change 0°C to 70°C supply 5 to 7V
FSD stability	0.004% per °C 0.16% per volt supply
Reading rate	2.5 per second
Power supply	4.5 to 6.5V, 6V nominal at 100mA

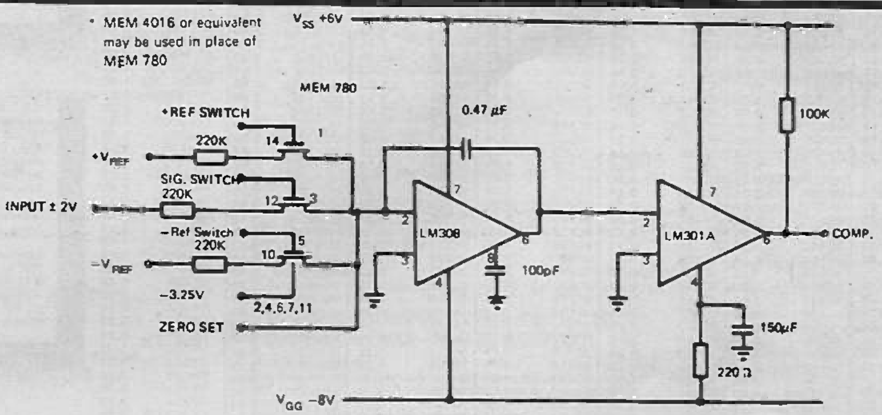


FIG. 1. ANALOGUE CIRCUIT

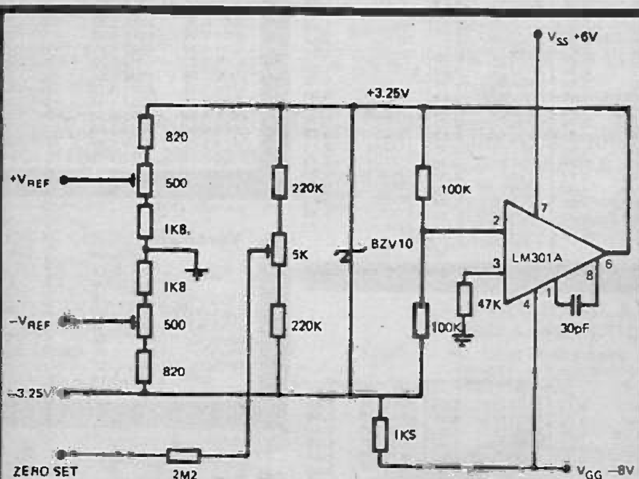


FIG. 2. AY-5-3507 VOLTAGE REFERENCE

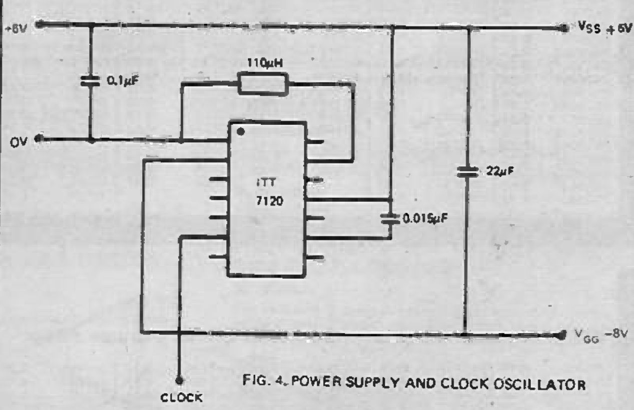


FIG. 4. POWER SUPPLY AND CLOCK OSCILLATOR

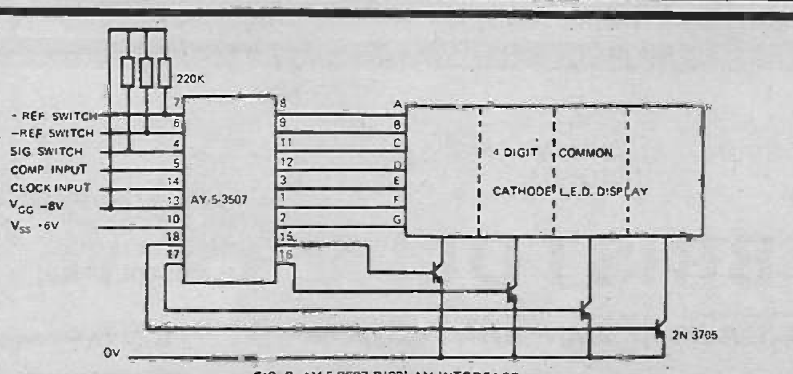


FIG. 3. AY-5-3507 DISPLAY INTERFACE

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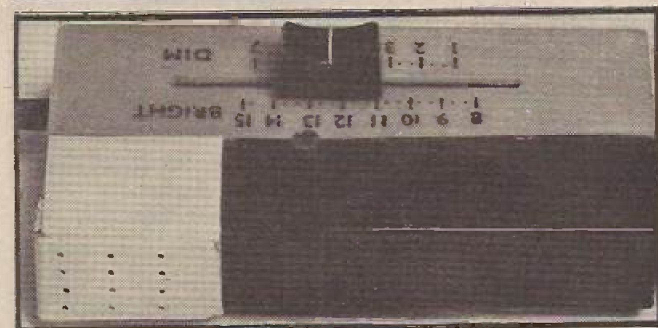
EXPOSURE METER

eti project

By Dave Adams



The prototype unit as seen on the front cover. The case is a Kodak 20-exposures transparency case.

The Mark II meter is built into a Vero box.

IT IS COMMON for amateur photographers to find three or four useless prints in the wallet picked up from the chemists, and usually there are a couple of shots lost because the exposure was so way-out that there is no image on the negs. For a few quid, however, you can build this simple instrument and ensure that all your shots are correctly exposed.

The exposure meter uses an LDR (Light Dependent Resistor) to measure the amount of light falling on a translucent window. The position of the potentiometer control when the meter is set is directly related to this quantity. Setting up simply involves adjustment of the knob until the two LEDs glow with equal brightness.

The prototype is built in a 20-exposures transparency case and uses a slider control. The control is calibrated in units which are 1 stop (representing a doubling in quantity of light) apart; we call these LV (Light Value) units. Having found the LV number, the camera setting can be found using the circular calculator on the underside of the meter.

After building the first prototype we found that we needed to build a second one (there were two of us at ETI who wanted the meter, so to save arguments we built another). The mark II shows some of the possible alternative methods of construction — we used a small Vero box and a conventional pot. Now the rotation of the control automatically sets the calculator without the need for LV numbers. The circuit was the same in each case.

As it stands the meter is ideal for measuring light levels normally found indoors — but it cannot cope with highly illuminated sets or outdoor work. To give an additional range to the meter we use an optical attenuator, a mechanical filter placed in front of the LDR window. Now the instrument can cope with all the lighting conditions met by the amateur photographer.

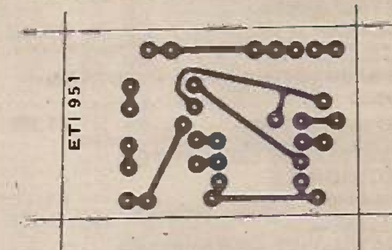


Fig. 2. The pcb design.

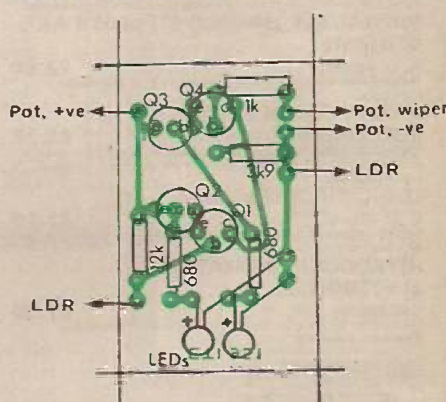


Fig. 3. The component overlay.

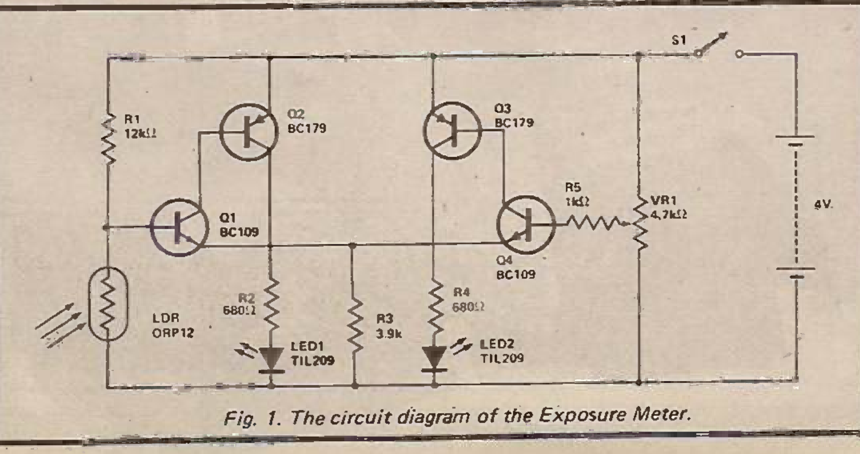


Fig. 1. The circuit diagram of the Exposure Meter.

PARTS LIST

R1	Resistor	12k	1/8W	10%
R2	"	680Ω	"	"
R3	"	3k9	"	"
R4	"	680Ω	"	"
R5	"	1k	"	"
VR1	Potentiometer	4k7 lin	"	"
Q1,Q4	Transistors	BC108		
Q2,Q3	"	BC178		
LEDs		TIL209		
LDR		ORP12		
S1		Miniature slide switch or push-on switch		
Batteries		3x1.35V Mercury Cells		
PCB		ETI 951		
Box		Either Kodak (or similar) 20-exposures transparency case or Vero 75-1413-E.		

Also: 18swg aluminium for the filter; 3.1mm perspex (at least 50 x 35mm), red perspex 30 x 15mm; matt black paint, plastic card, impact adhesive, etc.

The reward! This is the kind of picture you can take with this meter (shown in action on the front cover).

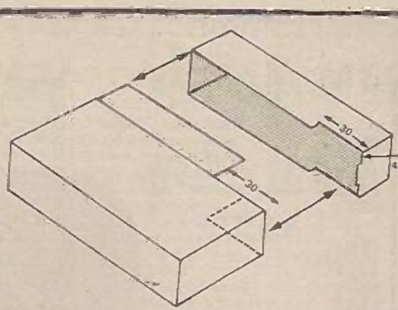


Fig. 4. The work required to modify the transparency case.

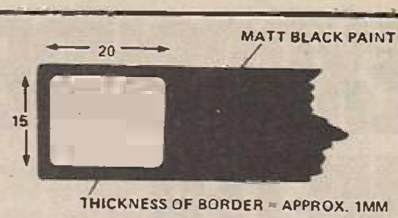


Fig. 5. The LDR Window. This is rubbed inside with wirewool and then the surrounding area is painted matt black.

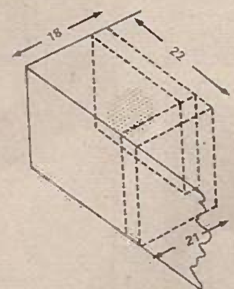


Fig. 6. How the LDR Holder is made using two pieces of perspex inside the lid.

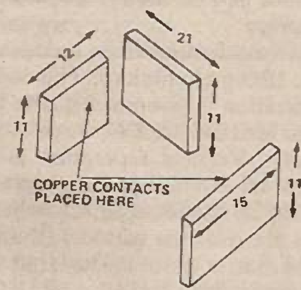


Fig. 7. Construction of the battery holder. The inside of the end faces of the holder should be lined with copper contacts.

CONSTRUCTION

The pcb holds all the electronics except the pot, the batteries, the switch and the LDR. The transistors must be mounted as low as possible on the board so that it can be fitted under the pot. The positioning of the LEDs can be finalised only when the board is mounted in its case.

We will give details of construction in the slide case. Fig. 4 shows how slots are cut to enable the mechanical filter to be fitted. The LDR window is marked out, according to Fig. 5, and made into a diffuser by rubbing with wirewool. Then the transparent top is painted (except for the window) with a couple of coats of matt black paint.

Fig. 6. shows the construction of the LDR holder. The dimensions here are important — they decide how much of the light falling into the window will be measured by the LDR. The holder must be a light-tight box — use matt-black paint and glue to achieve this.

The battery holder is located at the other end of the box top, and is made from perspex; see Fig. 7. A useful source of copper contacts is raw printed circuit board — glue pads at each end of the holder and solder leads to these.

The photographs show how the slider pot and on-off switch are mounted. Fig. 8 gives details of calibration for the pot. The pcb is mounted by one bolt through the centre — this bolt also acts as the centre of the calculator. The prototype calibrations, Fig. 9, will work if the meter is constructed exactly like the prototype. Check the meter against a known accurate instrument, then if adjustment is required this only needs to be done by moving the scale of LV numbers a little (the time and aperture scales ought to be ok).

The prototype was held together by

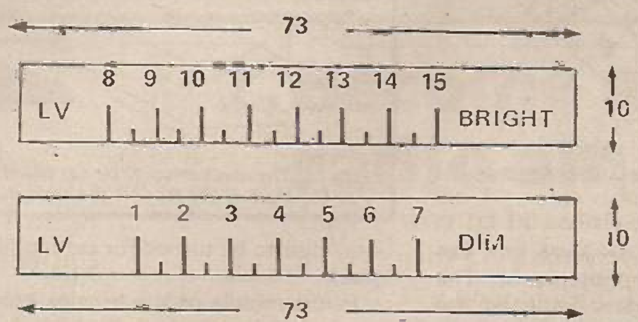


Fig. 8. The scales for calibrating the slider pot.

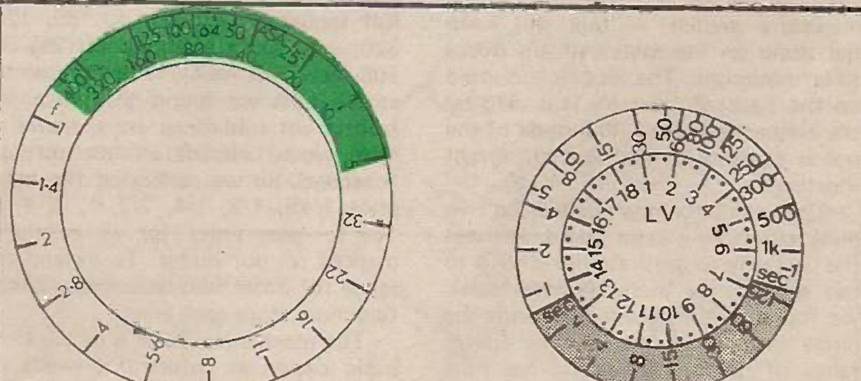
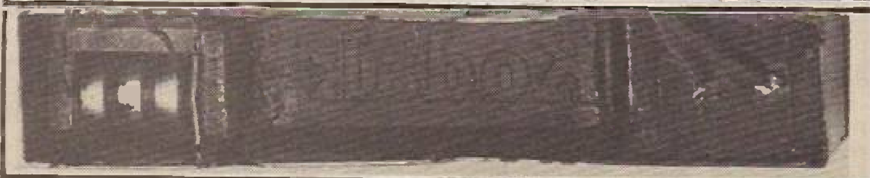


Fig. 9. The calculator.



The top of the transparency box is painted black inside. Then the Battery Holder (left) and LDR Holder (right) are built into opposite ends.

EXPOSURE METER

a 6BA bolt (Fig. 10), but less crude methods can be used if you can think of them.

The mechanical filter is constructed from 18swg aluminium. The necessary information is given in Fig. 11. Twelve holes are drilled, in three columns of four. Vertical separation is 4mm, horizontal 9mm. The size of the holes is 1.16mm diameter. Check that all the holes are over the window (the format of the matrix is not critical, but should be symmetrical).

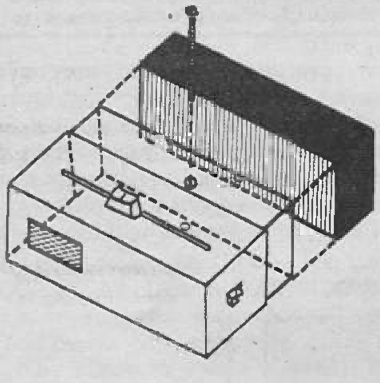


Fig. 10. How the meter is held together – a 6BA bolt.

Inside the Mark II. The pcb is mounted on the back of the pot.

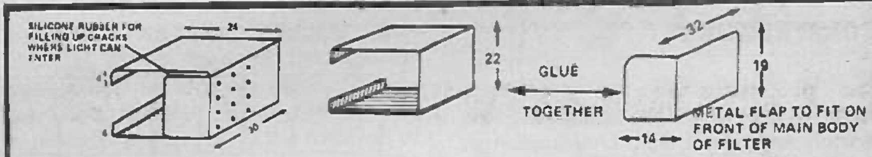


Fig. 11. The mechanical filter for the Mark I meter is constructed from 18swg aluminium. For the Mark II the front is the same but the supports need re-designing to fit the case.

Construction in the Vero box can be seen from the photographs. The LDR holder and battery holder are the same as before. We used a push-on miniature switch – this will keep the drain on the mercury cells down to a minimum. The pcb is mounted on the back of the pot. It is held by the connecting wires. The body of the pot is covered in pvc tape to prevent shorting.

The calculator was made from two discs cut from plastic board. Perhaps the best way to calibrate the MkII is to use an accurate meter (borrow one). We found that we needed to divide the circle into 13 segments. The useful range of the pot's rotation has nine stops (nine of these segments). The aperture settings found on your camera can be marked on the outer disc (in the sequence 1, 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, etc).

Beneath the outer disc we glued a pointer (a plastic arrowhead) which runs in a slot cut into the thick perspex block beside the calculator. This holds the outer disc firm while the inner is rotated and allows the outer disc to be turned for setting film speed.

In the middle of the perspex block we marked a speed of 80 ASA. (the full sequence was 20, 40, 80, 120, 320; with extra markings for 25, 50, 100, and 200 ASA). With the pointer at 80 ASA we found that with the control set mid-range an aperture of f5.6 would require an exposure of 1 second. So we calibrated the inner scale 1/15, 1/8, 1/4, 1/2, 1, 2, 4, 8, 16; to give times for all apertures marked on our meter. To extend the range for other film speeds we marked two more stops each way.

The mechanical filter is of the same basic design as before but needs re-modelling to fit around this box. The inner scale of the calculator is in fact cut into 26 sequents so that the second range (with the mechanical filter) could be incorporated. On this range we got an exposure of 1/250 sec at f5.6, ASA 100, with the pot mid-range.

All that remains now is to find some black leather, a 5" zip, and some obliging lady to make you a case! ●

HOW IT WORKS

The resistance of the LDR varies from 300Ω to 10MΩ, from bright sunlight to darkness. When the meter is set up the ratio of LDR resistance to R1 is the same as the ratio of resistances on the pot, so the position of the wiper contact varies with the light being measured.

In equilibrium Q1 and Q4 are both turned off (Q2 and Q3 sense this condition and the LEDs light up). Setting up equilibrium is made critical by the common emitter resistor, R3. When one transistor is conducting the potential on the emitter rises and helps turn off the other transistor.

WHERE TO GET THE COMPONENTS

The slider pot is available from Electrovalue (Type PG58) for 38p. (plus 15p small-order surcharge) inc VAT.

The batteries are type 675 from boots, but these aren't critical.

The PCB can be obtained from advertisers in this magazine (Ramar or Crofton).

The Vero boxes are available from Vero only in 10-off quantities. Your local components shop is likely to sell them for about 30p, plus VAT, each.

North America Radio Shack supply the following components for this project – Cadmium Sulphide photocell (LDR); General purpose NPN transistors=2N3904 etc; General purpose PNP transistors=2N3906 etc; Resistors, pot, switches, LEDs, all ok.

South Africa Hamrad can supply the components for this project. The MK7251 Cadmium Sulphide photocell will do for the LDR but the calibration might have to be done again.

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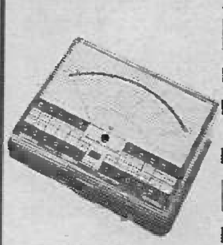

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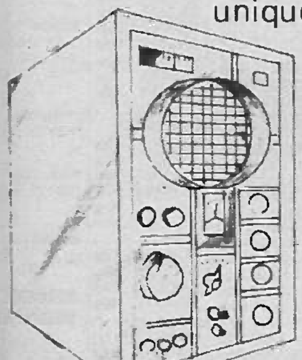

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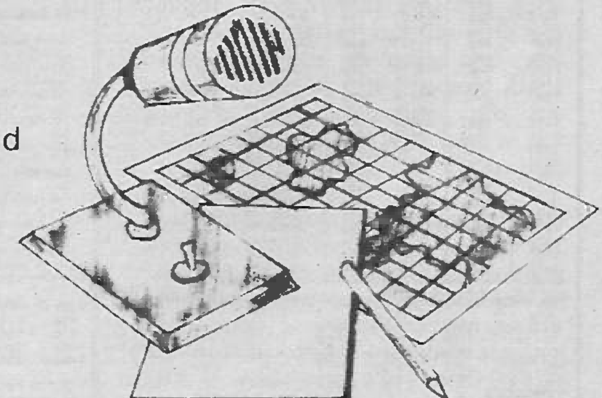

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7406	38p	7491	75p
7407	38p	7492	45p
7408	14p	7493	40p
7409	20p	7494	75p
7410	13p	7495	65p
7412	23p	7496	78p
7413	32p	74107	30p
7414	60p	74121	30p
7416	33p	74122	46p
7420	14p	74123	68p
7422	18p	74141	65p
7423	34p	74151	72p
7426	30p	74153	85p
7427	37p	74154	150p
7430	14p	74155	78p
7432	26p	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	65p
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	66p
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
'CA3090E	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 / 'MC1315	SQ Quad Dec	14 pin DIL	1100p
'MFC4000B	1/4W Audio Amp.	PCB	70p
MFC6040	Electronic Attenuator	PCB	90p
NE555	Timer	8 pin DIL	46p
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	150p
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	80p
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	120p	150p
6 Amp	88p	150p	180p
10 Amp	109p	180p	195p
15 Amp	145p	210p	250p

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 4A/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

AC126	12p
AC127	12p
AC128	11p
AC141	18p
AC142	18p
AC176	11p
AC187	13p
AC188	12p
AD149	43p
AD161	36p
AD162	36p
AF114	18p
AF115	18p
AF116	18p
AF117	18p
AF139	33p
AF239	38p
BC107	9p
BC108	9p
BC109	10p
BC109C	12p
'BC147	7p
'BC148	7p
'BC149C	8p
'BC157	11p
'BC158	10p
'BC159	11p
'BC169C	12p
BC177	18p
BC178	17p
BC179	18p
'BC182	10p
'BC183	10p
'BC184	11p
BC187	30p
'BC212	11p
'BC213	10p
'BC214	14p
BC478	30p
BCY70	18p
BCY71	22p
BD123	100p
BD124	65p
BD131	36p
BD132	40p
'BD135	43p
'BD139	63p
'BD140	70p
BF115	22p
BF167	23p
BF170	23p
BF173	25p
BF177	26p
BF178	28p
BF179	33p
BF180	33p
BF181	33p

TRANSISTORS

BF182	33p	ZTX502	18p
BF184	22p	2N697	13p
BF185	22p	2N698	30p
'BF194	10p	2N706	12p
'BF195	9p	2N708	18p
'BF196	14p	2N918	40p
'BF197	15p	2N928	20p
BF200	32p	2N930	18p
BF257	32p	2N1131	18p
'BFR39	30p	2N1132	18p
'BFR40	30p	2N1304	21p
'BFR79	30p	2N1305	21p
'BFR80	30p	2N1306	28p
'BFR88	30p	2N1307	28p
BFX30	30p	2N1308	28p
BFX84	26p	2N1309	28p
BFX85	25p	2N1613	20p
BFX86	25p	2N1711	20p
BFX87	20p	2N1893	30p
BFX88	24p	2N2218	21p
BFY50	16p	2N2219	20p
BFY51	15p	2N2220	19p
BFY52	16p	2N2221	20p
BRY39	34p	2N2222	20p
BSX19	16p	2N2369	14p
BSX20	18p	2N2484	30p
'BU105	140p	2N2904	20p
BU108	250p	2N2905	20p
'MJE340	45p	2N2906	20p
MJE2955	99p	'2N2926R	7p
MJE3055	65p	'2N2926B	7p
'MPSA06	30p	'2N2926O	8p
'MPSA12	50p	'2N2926Y	9p
'MPSA56	32p	'2N2926G	9p
'MPSU06	62p	2N3053	18p
'MPSU56	78p	2N3054	45p
OC28	65p	2N3055	50p
OC35	55p	2N3439	67p
OC36	60p	2N3442	140p
'OC41/2	15p	'2N3702	11p
'OC45	15p	'2N2703	11p
'OC71	20p	'2N3704	11p
'TIP29A	40p	'2N3705	11p
'TIP30A	48p	'2N3706	10p
TIP31A	52p	'2N3707	11p
TIP32A	58p	'2N3708	9p
TIP33A	90p	'2N3709	9p
TIP34A	115p	2N3773	220p
TIP35A	225p	2N3866	90p
TIP36A	270p	'2N3903	18p
TIP41A	65p	'2N3904	20p
TIP42A	70p	'2N3905	18p
TIP2955	70p	'2N3906	20p
'ZTX108	10p	'2N4058	15p
'ZTX300	13p	'2N4059	10p
'ZTX500	15p		

'2N4060	13p
'2N4289	20p
2N4347	130p
2N4348	160p
40360	40p
40361	38p
40362	40p
40364	120p
40409	55p
40410	55p
40411	225p
40594	75p
40595	85p

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

DIODES

SIGNAL

'OA47	7p
'OA70	9p
'OA81	8p
'OA85	10p
'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 100p

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

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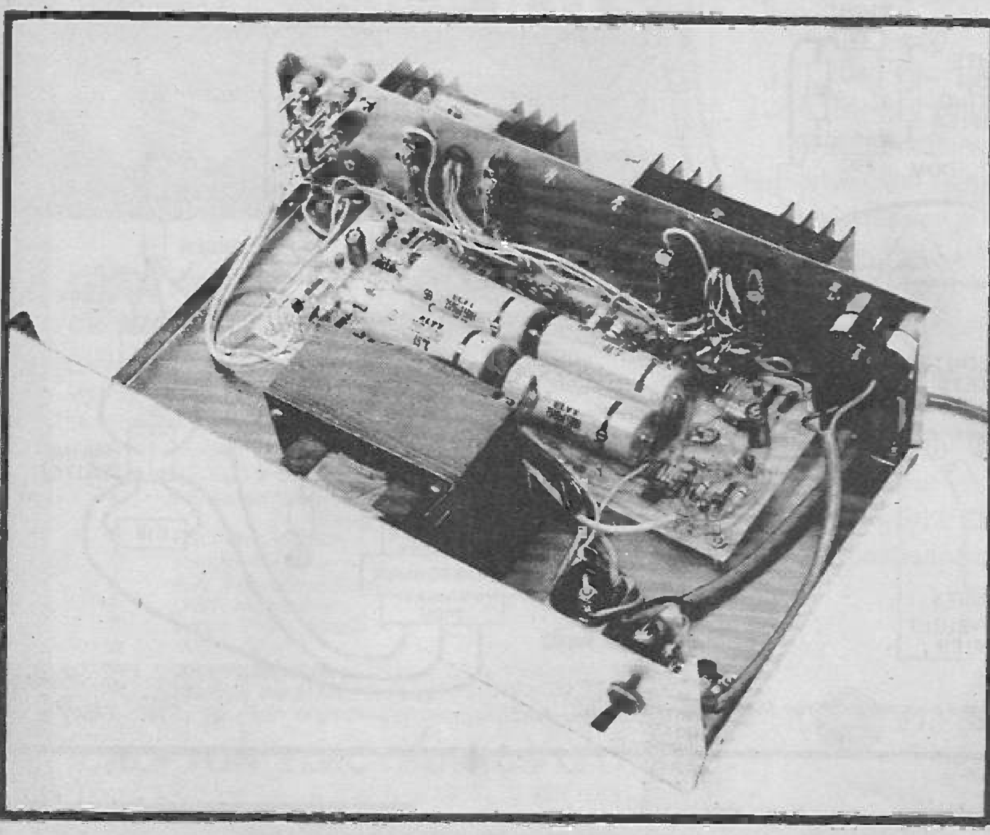
BOOSTER AMPLIFIER



The booster amplifier (cover removed).

ETI project

Increase the output from your existing amplifier to 50 watts per channel.

MEASURED PERFORMANCE OF THE PROTOTYPE

POWER OUTPUT			
Both channels driven into 8 ohm load	50 watts RMS		
FREQUENCY RESPONSE.			
20 Hz – 20 kHz	± 0.5 dB		
CHANNEL SEPARATION			
at rated output and 1 kHz	80 dB		
HUM AND NOISE			
With respect to rated output	–100 dB		
SENSITIVITY			
For 50 watts output	500 mV		
DISTORTION	100 Hz	1 kHz	6.3 kHz
1 watt	0.14%	0.11%	0.12%
5 watts	0.17%	0.13%	0.15%
10 watts	0.16%	0.11%	0.13%
50 watts	0.27%	0.38%	0.60%
DAMPING FACTOR	> 70		

AFTER many years of faithful service you have finally decided to update your old Hi-Fi system with a new pair of speakers. Upon evaluation however, you find that the modern speakers you have chosen are much less efficient than those you presently have. This means that not only do you have to get new speakers, but you also have to replace an otherwise perfectly good amplifier because its five-to-fifteen watts output is no longer anywhere near enough. A pity, because there may be nothing wrong with the preamplifier and you may have to pay out £60 or more just to get that additional power.

An obvious solution is to retain your existing amplifier, which has all the facilities that you require, and obtain the extra power required by means of a booster amplifier. Unfortunately commercial booster amplifiers are very rare, if available at all. The ETI 422B is designed to fulfill this need and thus save the person updating his system a considerable amount of money that need not be spent in replacing the preamplifier.

The ETI 422B is designed to be used as a main amplifier, driven from the existing preamplifier, or as a booster amplifier driven directly from the speaker output of the existing power

BOOSTER AMPLIFIER

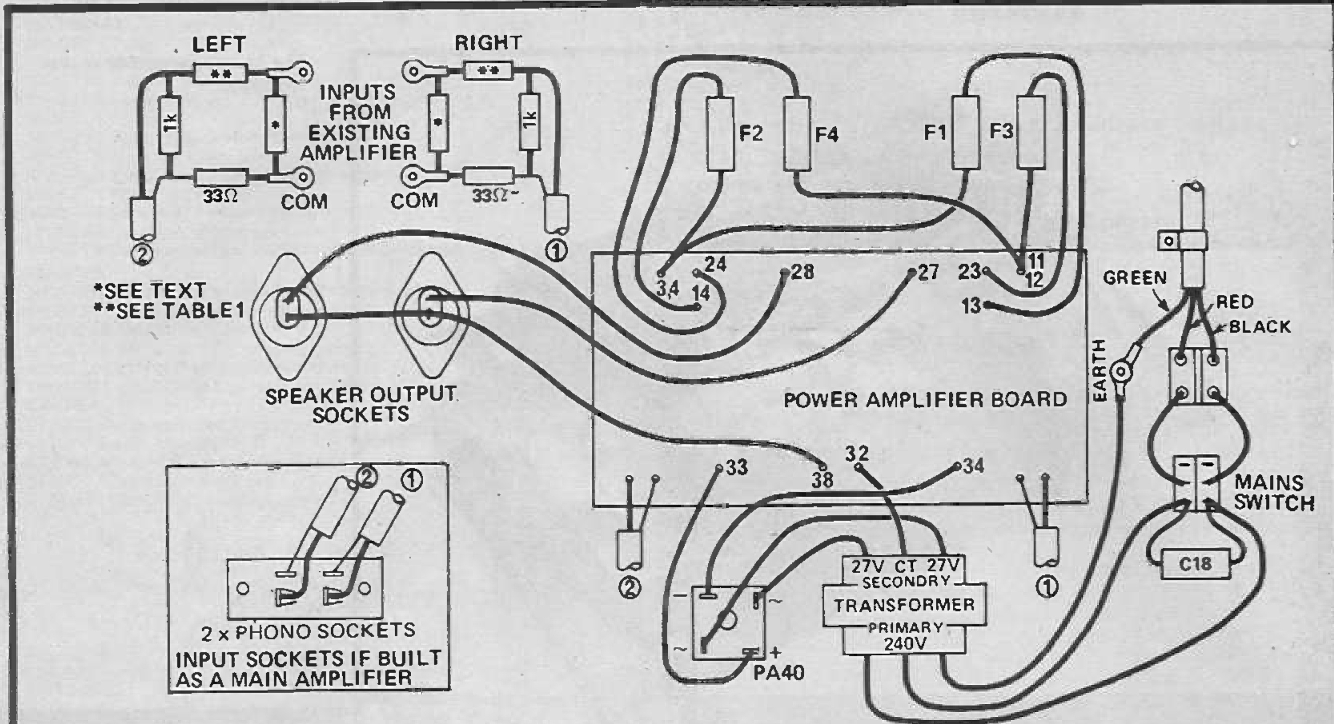


Fig. 1. Interconnections of the booster amplifier (heatsink not shown).

amplifier. It provides an output of up to 50 watts into 8 ohm speakers with a distortion that is typically around 0.2%.

It must be noted however that the distortion and noise cannot be less than that available from the existing amplifier and you must ensure that this amplifier is of good quality if this add-on technique is to be successful.

HOW IT WORKS

The amplifier is constructed around the power module from the ETI 422 first described in the August 1974 issue of ETI and subsequently reprinted in Project Book 2. The only additional circuitry required is that for the input attenuator or for a direct input depending on whether a booster or main amplifier approach is being used. We have used 33 ohm resistors in the earthy side of each input to prevent the damage which may occur to some amplifiers if the leads to the booster amplifier are inadvertantly connected the wrong way around.

CONSTRUCTION

Assemble the main amplifier printed-circuit board and the heatsink assemblies in accordance with the component overlays and drawings for the 422.

Any conveniently sized box would be suitable as a housing. To minimize hum pickup the transformer was mounted centrally to keep it as far away from the input circuits as possible. If a larger box is used put the transformers as far away as is possible from both inputs. Chassis mounting fuses were used as they are less expensive than the rear-panel mounting types, and only need to be changed on the very rare occasions when the speakers leads are accidently shorted.

A power outlet socket was fitted to the amplifier so that the existing amplifier may be powered from it if required. The individual constructor may include or omit this socket as required. The interwiring details (except for the heatsinks) are given in Fig. 1. For the values of resistors required in the divider networks reference should be made to Table 1 as these will vary depending on the power output of the existing amplifier. If required these may be made adjustable by substituting a potentiometer (10 k) for the series resistor.

Most modern amplifiers can work into a high impedance without trouble. However some older types, especially those with an output transformer need to be terminated into the correct load. The resistors shown across the inputs are for this purpose and should be made equal in value to the nominal output impedance of the existing amplifier. The rating of these resistors should be about two watts. ●

TABLE 1

AMPLIFIER POWER (8 ohms)	VALUE OF SERIES RESISTOR
2W	2.7 k
5W	4.7 k
10W	6.8 k
15W	8.2 k
20W	10 k

FOR NEW READERS

The circuit and full constuctional details of this extremely popular 50W audio module are still available in Project Book 2, copies of which may be obtained by sending 90p (inc. postage)
to: Top Projects No. 2.
ETI Magazine,
36 Ebury Street.
London SW1W 0LW.

FOR CANADIAN READERS

Copies of Top Projects No. 2 will be sent to Canada surface mail for $2.00 (2–3 weeks) or Air Mail $3.00.

Transistor equivalents to those shown: BC177 may be replaced by Radio Shack's RS 2022. BD139 and BD140 may be replaced by 2N4921 and 2N4918 (Archer-Pak #276–117). MJE2955 is complimentary of 2N3055.

PARTS LIST ETI 422B

All components as per 422 parts list
Chassis and cover as required.
4 Input terminals
2 speaker sockets
Power outlet socket (if required)
Power switch (2 pole)
Neon indicator (if required)
Nuts, bolts, spacers etc.

DESK-TOP GRAPHICS

AT THE END of November, Tektronix revealed for the first time in Europe a new development in the micro-computer field. Their new 4051 desk-top micro-computer offers a facility never seen before in the most sophisticated of progammable calculators — graphics ability.

It has long been obvious that the human half of the man-machine interface can become punch-drunk when confronted with too many columns of figures on a print-out; and since time immemorial information has been presented in the forms of graphs, charts and histograms on paper. How often has a scientist, statistician or businessman processed all his figures in a few moments and then spent a few hours plotting the results on graph paper, only at the end, to discover he'd made a mistake and had to repeat the process? Only the lucky few who had access to a graphics computer terminal which was coupled to a full-scale, expensive and probably underworked computer, could delegate the boring plotting to a machine, and gain the full benefits of working interactively with the machine.

Programmable calculators have been getting smaller in size (to pocket size now) and more powerful, to minicomputer standards virtually, until now we have the Tektronix 4051 which is a megalomaniac's dream. This microcomputer is programmable in BASIC, a very well-known, simple, yet powerful language, through a keyboard similar to that of a typewriter so that anyone who knows BASIC will be able to walk up to the 4051, switch on, and commence solving problems. The basic BASIC (?) language has been supplemented by some special instructions which are easy to learn — for instance, typing SET DEG will put the unit in degrees mode for trigometric calculations.

One important benefit of the graphics screen is that one can see up to 35 lines of program at once; when used with the editing keys, one can delete and alter lines at will, so that correcting programs is very simple. But the main benefit of the screen is the display of graphs, drawings and histograms.

ETI watched the 4051 plot sin x from 0° to 360° in a few seconds, then add the first harmonic to this curve. Adding up the first 10 odd harmonics we were able to see a fair approximation to a square wave — what would Fourier have done with a machine like the 4051?

WHAT MAKES IT TICK?

The electronics inside are based on the Motorola M6800 microprocessor with 8k of RAM supplied as standard — this is expandable to 32k.

Microprocessor enthusiasts will be interested to know that all the standard routines and the BASIC language interprets are squeezed into 32k of read-only memory. The RAM storage is backed up by a magnetic tape cartridge unit which offers another 256k characters of storage.

The Tektronix 4051 - computer on a desk-top

NO NEED TO PROGRAM

One very reassuring feature is that one needn't write programs to solve simple calculations. For example, we tried "2+2, carriage return" and the 4051 responded with "4". The extra calculator keyboard beside the main one is very useful when using this "immediate" mode.

By pushing the 'TUTOR' tape and pressing the 'AUTO LOAD' button, a completely inexperienced user can be taught to use the 4051, *by* the 4051. The program asks questions which are answered YES/NO, and the machine then proceeds to a new question, or explains fully the last point more fully if a mistake was made. Obviously, the principle can be expanded to enable the 4051 to 'teach' other subjects, such as statistics, electrical engineering, as well as solving problems in these fields. And at the price of about £4,500 it's probable that the 4051 will appear in schools and offices — it won't be long before you meet one.

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

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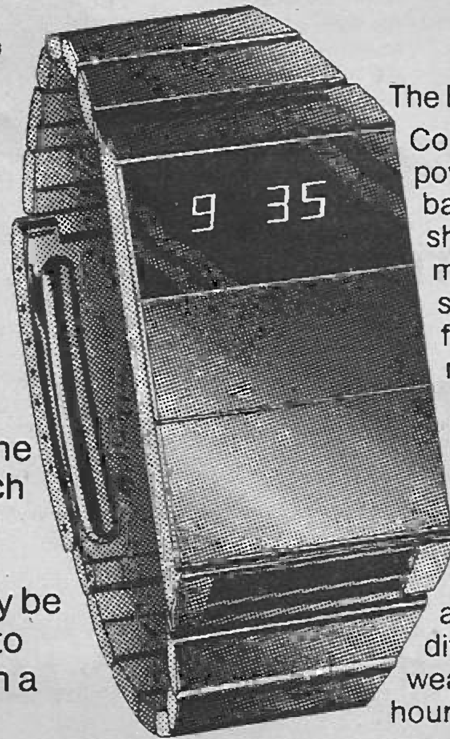


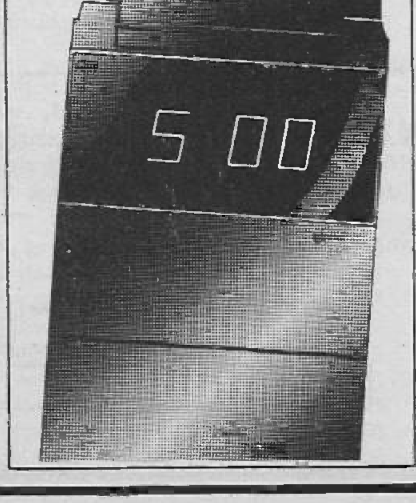
The Black Watch by Sinclair is unique. Controlled by a quartz crystal... powered by two hearing aid batteries...using bright red LEDs to show hours and minutes and minutes and seconds...it's also styled in the cool prestige Sinclair fashion: no knobs, no buttons, no flash.

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

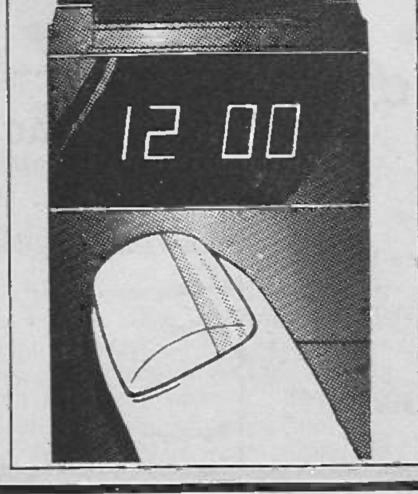
It's simple – anybody who can use a soldering iron can assemble a Black Watch without difficulty. From opening the kit to wearing the watch is a couple of hours' work.

The special features of The Black Watch

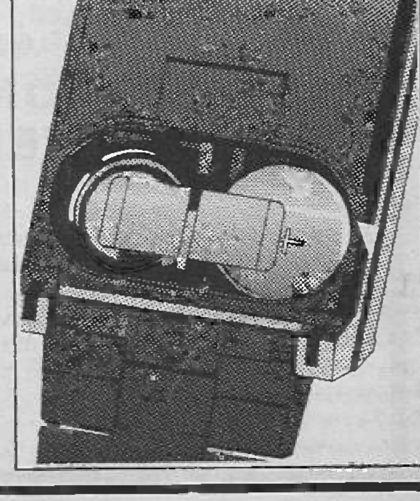
Smooth, chunky, matt-black case, with black strap. (Black stainless-steel bracelet available as extra – see order form.)



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.



PART 3

Op Amps

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

THE SINE WAVE oscillator described in the previous article was an example (albeit an extreme one) of how frequency selective feedback is used with operational amplifiers. We shall now go on to consider an amplifier employing non frequency-selective feedback and then amplifiers using feedback of such a nature as to produce two particular forms of frequency response. Then to conclude, there is a description of the use of an op. amp., as a dc amplifier, to increase the sensitivity of a moving coil meter — in this case the frequency is required to be limited to dc up to a few Hz only.

Figure 1 gives the circuit of a high input-impedance amplifier with a nominal voltage gain of 48 and a bandwidth of from 10 Hz to at least 50 kHz. In the prototype the measured value of input impedance was 10M Ω at 1 kHz. This value will vary slightly with frequency and with the particular layout employed, but in any case is likely to be as high as will normally be required for most applications.

As an ac connection, via a capacitor, is provided at the non-inverting input there would be no dc return for bias current, at that input, if R_3 were not present. The value of R_3 is 47 k however, bootstrapping is used to raise the apparent value of R_3 to the value of 10 megohm as quoted, in the following manner.

Due to the extremely high gain of the op. amp, and to the feedback between the output and the inverting input pin 2, there is very little difference in the signal levels at the +ve and —ve inputs, and, since C1 has a negligible reactance, there is similarly very little difference in signal voltage at either end of R_3. Accordingly, very little signal current can flow into R_3 from the signal input, thus R_3 appears, to the input signal, to be many times its actual value.

With the op. amp. arranged in the non-inverting configuration, the voltage gain is:

$$Av = \frac{R_1 + R_2}{R_1} = 48$$

This amplifier set-up is most likely to be used in the design of a pre-amplifier for an oscilloscope or millivoltmeter, where the high value of input impedance is necessary in order to load the circuit under test as little as possible.

In audio applications, a 'tailored' frequency response is often called for; for example, the output of a tape replay head should be fed to a stage with a gain rising at 6dB per octave below about 2.5 kHz, and a flat response above that frequency. (The actual value of the break frequency depends on the tape speed and the particular replay characteristic employed). Such a response is readily arrived at by replacing R_2 of Fig. 1 with the network shown in Fig. 2a.

At high frequencies C_5 has a reactance low compared to R_6 and hence it can be ignored. Thus the gain is determined by R_6 alone (although R_5 is in parallel its value is large enough to be disregarded). As the frequency is lowered, the reactance of C_5 rises and consequently the feedback is reduced, so giving the frequency response shown in Fig. 3a. Resistor R_5 provides a dc connection for the negative input of the op. amp. and limits the gain at very low frequencies.

The voltage gain of this circuit at high frequencies is about 16 times; this will make the tape head output comparable to that from a magnetic pick-up. If more gain is called for, this is best done by increasing the value of R_6 and reducing the value of C_5 in proportion.

What if a response suitable for pre-amplification of the output of magnetic pick-up is required? In this case the network of Fig. 2b is a suitable replacement for R_2 in the original circuit; the overall response of the stage is now as given in Fig. 3b.

Similar reasoning to that given for the tape head amplifier applies here also — the gain rises at lower frequencies as C_6 reactance becomes larger, falling at the higher frequencies as the reactance of C_6 and C_7 both fall. As before, R_7 sets the low-frequency gain.

These two latter configurations are good examples of the shaping of a frequency response to suit a particular need — as indeed was the audio oscillator of Part 2. Note that the response and the overall gain can be

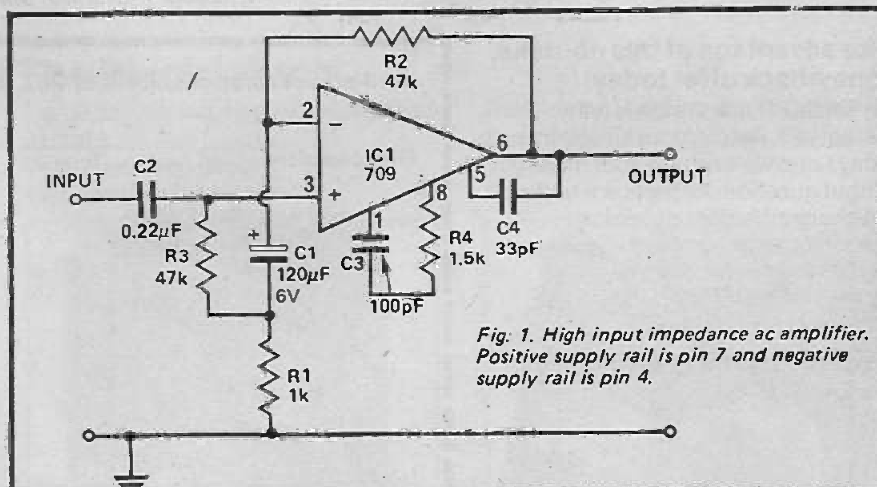


Fig. 1. High input impedance ac amplifier. Positive supply rail is pin 7 and negative supply rail is pin 4.

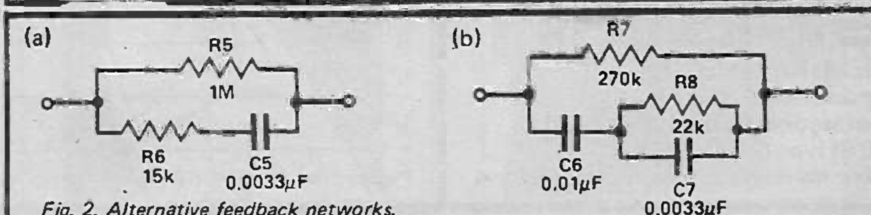


Fig. 2. Alternative feedback networks. (a) Tape head; (b) Magnetic pick-up.

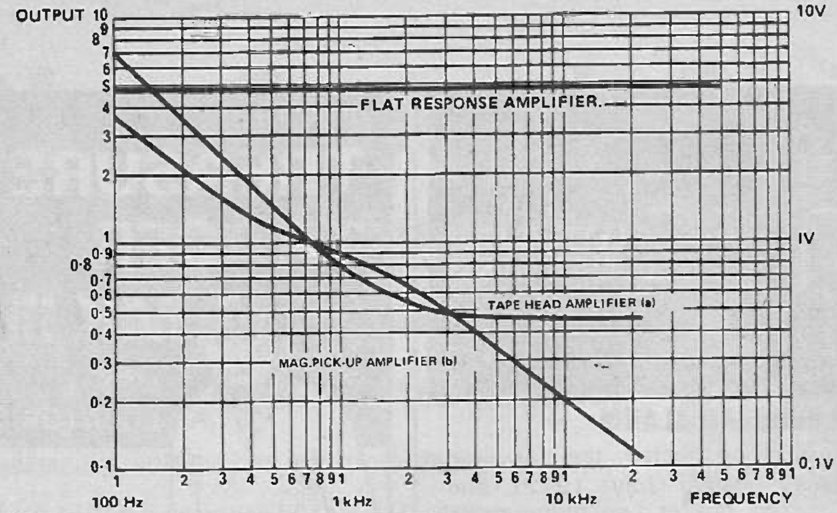


Fig. 3. Responses of the three different amplifiers.

PARTS LIST

Flat response amplifier
IC1 Integrated Circuit 709 8 pin DIL
R1 Resistor 1k ¼ watt 5%
R2 " 47k " 5%
R3 " 47k " 5%
R4 " 1.5k " 5%

C1 Capacitor 120 µF 6V electro.
C2 " 0.22 µF polyester
C3 " 100 pF ceramic
C4 " 33 pF ceramic

Tape head network plus all of Fig. 1
R5 Resistor 1MΩ ¼ watt 5%
R8 " 15k " 5%
C5 Capacitor 3,300 pF polyester

Pick-up network plus all of Fig. 1
R7 Resistor 270k ¼ watt 5%
R8 " 22k " 5%
C6 Capacitor 0.01 µF polyester
C7 " 3,300 pF polyester

Meter amplifier
IC1 Integrated Circuit 741 8 pin DIL
R1 Resistor 1k ¼ watt 5%
R2 " 6.8k ¼ watt 5%
R3 " 33 ¼ watt 5%
R4 " 1k ¼ watt 5%
R5 " 10k ¼ watt 5%
R6 " 10k ¼ watt 5%
R7 " 10k ¼ watt 5%
RV1 Potentiometer 22k linear
C1 Capacitor 0.1 µF polyester
M1 Meter 1 mA movement

Miscellaneous
IC holders, Veroboard, small aluminium boxes etc.

adjusted independently.

All the circuits given so far in Part 3 are intended to make use of type 709 op. amps., although a 741 or an LM301 could be used with the appropriate equalizing network changes as detailed last month.

The amplifier configuration described is an inherently stable one and almost any convenient layout can be employed. A small piece of Veroboard was used in the prototypes, with a dual-in-line IC holder soldered in place and the remaining components placed around it.

For convenience, it is best to build the whole amplifier in a small metal box, either mounting this in existing equipment or leaving it as a separate unit for greater flexibility. The box must be earthed to give a measure of screening to reduce hum pick-up. This is especially necessary if the feedback networks of Figs. 2a or 2b are employed as both of these provide considerable bass boost thus aggravating the hum problem.

METER AMPLIFIER

Now for the dc meter amplifier which uses a 741 type IC. The circuit is given in Fig. 4. The values shown give full scale deflection on a 1 mA meter with only 10µA flowing into the input.

Circuit function depends on there being negligible difference between the voltages at the two inputs of an op. amp. when arranged in a negative feedback configuration. Accordingly, whatever voltage is applied to the non-inverting terminal, that is, across R_1, will appear at the inverting terminal, that is, across R_3. However, R_3 is only 1/100th of the value of R_1, so that the current through R_3 must be 100 times larger than that through R_1. It is, of course, the current through R_3 that flows through the meter, and it is worth noting that the value of this current is not affected by resistor R_2 in series with the meter — provided of course that R_2 is not too large to allow the required meter current to flow. The value of R_2 is chosen here to limit meter current to about twice the FSD current, so providing a useful safety device should an unexpectedly high voltage be applied to the non-inverting terminal.

Thus we have a circuit incorporating a meter of 1 mA basic sensitivity but which appears to be a meter of 100 times that sensitivity.

Resistor R_4 is included to improve the performance with regard to drift, of the meter reading, as temperature changes cause changes in the op. amp. bias currents. It is best selected by experiment, although the value given was found to be satisfactory with three individual 741's.

The voltage at the slider of RV_1 is fed via R_7 to the inverting input to provide a means of setting the meter zero. It can, if desired, be used to give a centre zero, so producing a 5 µA–0–5 µA meter. The capacitor C_1 ensures that the gain falls at high frequencies.

With a basic sensitivity of 10 µA., this amplifier enables a dc voltmeter of 100 kohm per volt to be constructed, by connecting the appropriate resistor in series with the input. The value of the resistor is given by:

R = 100 V kilohms

where V is the input voltage required to give FSD

Note that the basic meter of 1mA is a type of movement that is much more robust, and yet cheaper, than others of greater sensitivity.

The actual method of construction can be adapted to suit individual requirements. If a 1 mA meter is bought for the job, almost any housing capable of containing it will have room for the 741 and the few other components required, whilst only three short lengths of wire are required for connection to the power supply. The test-meter used in the prototype had a 1 mA range, so a small aluminium box was used for the circuitry, with two output terminals for the test-meter connections, and, again, three leads for the power supply.

As with the audio amplifier, it is best to use a small piece of Veroboard to mount the IC holder and components, and to bolt the board to the box with insulated spacers if required.

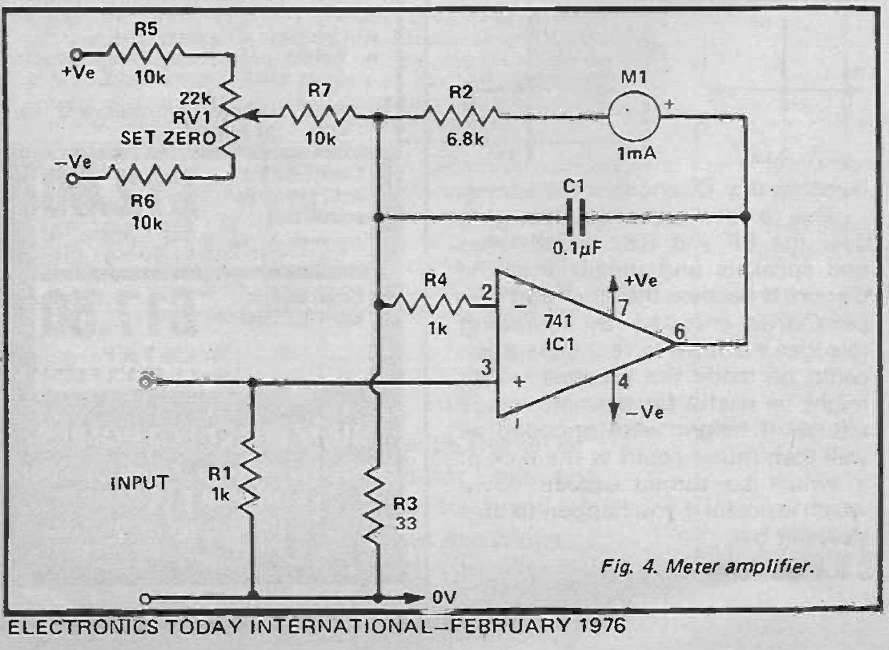


Fig. 4. Meter amplifier.

INPUT GATE

LETTERS FROM OUR READERS

STANDARD CANNON, STANDARD DIN

With reference to the article in your News Digest column (October issue) refering to the correct wirina standard for Cannon (or XLR) connectors, I am afraid you may have been misled as to the 'common' standard. As you may have noticed, DIN plug wiring is not always as standard as it should be (ie — right channel either 1 or 5 both — there are *two* "standard" ways of wiring a stereo DIN plug, both commonly appearing on domestic and foreign equipment and not interchangeable). As to saying that most manufacturers work to DIN standard, I can assure you that this is the exception. I know of two manufacturers of audio mixers that use male cannons on inputs and female cannons on outputs.

As to the correct wiring sequence, you were more correct in your original statement as Cannon plugs are wired in numerically ascending order ie: 1— Earth, 2— Low, 3— High (for balanced inputs) with 1 and 2 tied to Earth and 3— Hot (for unbalanced inputs). This system is easy to remember and suits the common name for these plugs in America, XLR, (earth, left, right); Cannons are mainly a US device. This system of wiring is common to all American radio and recording studios, and issued in all PA systems.

My band runs all of their equipment at 600 ohms: instruments, microphones, and amplifiers (customized by a US PA company). In the past 22 months we have never had to alter any wiring for feeds to any recording, radio. or T.V. studio nor PA company. This includes, recently, BBC radio, Capital radio, EMI Abbey Road studio, AIR London studio and The Music Centre, Wembley (DeLane Lea studio) as well as various radio and television studios in Europe and America. I believe this speaks for itself regarding 'standardization.'

Hoping I have been of assistance.

Wm. T. Penman, Equipment Manager "Renaissance"

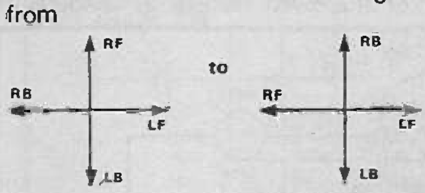
IR BURGLAR ALARM

Having constructed the infra-red burglar alarm (July 1972) and overcome one or two minor problems, I tried to obtain the sealed beam lamp recommended in the parts list without success. I contacted one of the largest importers of General Electric lamps, who said he did not have that model and that it was not worthwhile to import just one anyway. Other readers must have met the same problem and solved it, if so I should be grateful for information that would enable me to replace the bulb and reflector that I have at present with a sealed beam lamp giving a parallel beam.

A. P. N. Beaumont-White, Putney.

AMBISONIC SEPARATION

Using ambisonics the separation between the front pair of speakers is only 3dB whereas that between the diagonal pairs is (in theory) infinite. With most programme material the majority of the 'action' takes place in the front part of the sound stage. It would therefore seem better if the greater separation was between the front (and rear) pairs of speakers. Using the notion used in ETI Vol. 4 No. 7 and taking LF as the reference direction the 'A' channel could be changed from



(keeping the 'O' channel the same).

This is the same as changing over the RF and RB microphones and speakers and means that the diagonals become the front and rear pairs when encoded. By extending this idea the front to rear separation could be made the greatest which might be useful for dramatic stage effects. If height were encoded as well then music could at the flick of a switch be turned upside down which is useful if you happen to be a sleeping bat.

C. P. Isbell, Hants.

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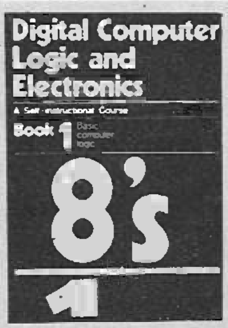

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ELECTRONICS —it's easy! PART 24

Introducing Digital Systems

WE BEGAN this course with a discussion of electronic systems in general; what they do, how they do it and how we can progressively break down a complex system into fundamental building blocks. The example chosen then, a TV system, uses, in the main, analogue signals. These we know from other parts of the series are those signals that contain information in the form of many continuously changing levels of an electrical voltage (or current).

Although we have already introduced the concept of the on-off, or digital kind of signal, the course so far has concentrated almost entirely on the linear, analogue circuits used in electronic systems. The time has now come to study an alternative philosophy and practice, by which tasks can be accomplished in another manner — the digital electronic approach.

DIGITAL OR ANALOGUE SIGNAL APPROACH?

By itself a purely electronic system has no real value until it is applied to the real world we exist in. At the input of a system physical variables are measured by sensors that convert the information, from the original form of energy, into an electrical signal. This electrical-input signal is then conveyed, through the system being modified, and converted in different ways as required. The output signal from the system is fed to actuators which convert this signal back to real-world variables at the output. It is the differences between two basic means of transmitting and converting information that we are concerned with now.

We have seen in the earlier part dealing with information that both analogue and digital signals can convey the same information between two points. It is a matter of how the information is coded on the signal. It is not possible to state categorically that one signal form is better than the other. Each has its advantages depending upon the application. Analogue systems can process the same information using far less components, than their digital counterparts, but they are unable to provide anywhere near the same ultimate accuracy, precision and long-term stability. In some uses, such as precise mathematical computation, digital techniques are a must. The same holds true for measuring equipment needing better than around 1 percent, or perhaps 0.1 percent, accuracy.

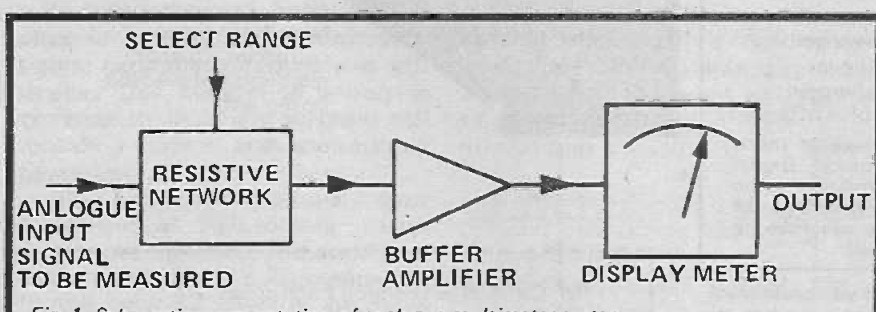


Fig. 1. Schematic representation of analogue multimeter system.

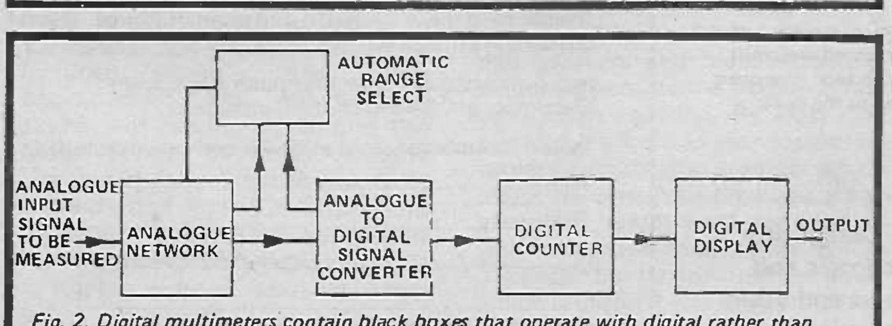
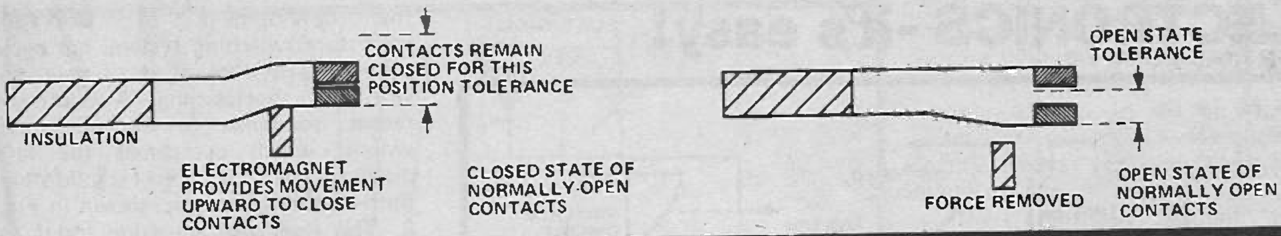


Fig. 2. Digital multimeters contain black boxes that operate with digital rather than analogue signals.

Other factors that decide the choice of signal form are the cost of components needed, the size of equipment and power supply demands. Today, the enormously large-volume production of digital circuits, especially when marketed as large-scale integrated systems, coupled with the tremendous effort that has been expended on digital techniques for computing markets, has now tipped the balance heavily in favour of using digital methods. This is now true even for what have traditionally been analogue applications. It may well now be cheaper to use a mass-produced digital assembly for a more unusual analogue requirement, even when analogue circuits could easily supply the need.

Take, for example, the choice confronted when purchasing a good quality multimeter. The traditional multimeter can be represented as a resistive network driving a display meter — see Fig. 1. The signal level can be ascertained by the degree of pointer deflection seen on the meter. High input impedance units incorporate a linear amplifier to buffer the signal source against a relatively low-impedance meter movement. Apart from the selector switch which has discrete settings, all components work with analogue signals and this means they must be linear in operation and adequately stable with time. Some components — the ballast and shunt resistors, for instance — must be made to tolerances that require expensive hand-made manufacture. We can summarize the situation as one where only a few components are needed but they are inherently expensive.

The alternative is to use a special circuit that we will discuss in detail in a later part. This is called an analogue-to-digital converter (or just A-to-D converter). As represented in the schematic of a digital multimeter given in Fig. 2, it converts the analogue input level into a digital signal form that is then used to drive a digital readout display. These units display the output value as a decimal number rather than as the position of a pointer as is used in totally analogue systems. We will see, as we delve more deeply into how such a system works, that the digital alternative uses literally dozens of active elements and many



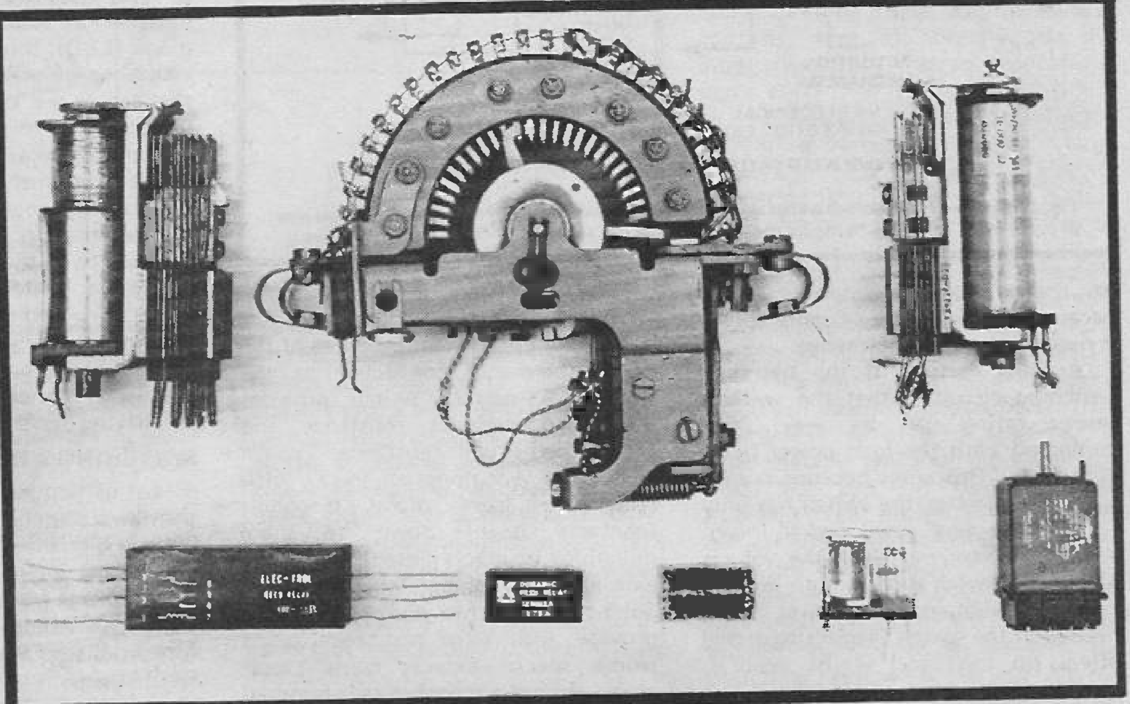


Fig. 3. Mechanical switches are designed to allow considerable lattitude in the open and closed contact positions, thus ensuring reliability. Electro-mechanical switches come in many shapes and sizes.

many more passive components than an analogue type of multimeter. Yet, today, there is little difference in the cost of either alternative for the same accuracy. The digital scheme, however, can be made considerably smaller, may be made more accurate, uses no more power and may even have circuitry that automatically selects the most appropriate range for itself.

Another example is found in computing. We have seen how operational amplifiers — those that perform linear arithmetic inherently — can be used to solve equations and do complicated arithmetical operations in what are called analogue computers. These can provide extremely powerful solutions of mathematical problems for quite small outlays. But only if the problem does not require high-accuracy — then digital computation is needed. Another instance where digital method is a must is when the problem involves logical type operations where yes-no decisions are needed. Digital computers can sort information into groups and decide which way to proceed at a decision junction. This will become clearer when we discuss the mathematics of logic which is quite unlike normal algebra.

As with the multimeter example, digital computers also involve many more components than the analogue units that would perform similar tasks. Yet, somewhat strangely, they can be far less expensive, much more accurate and more reliable. Undoubtedly the trend in electronic systems is toward more use of digital solutions — but this does not mean that analogue systems have no place in electronics.

One dominant reason why digital systems can be so reliable and positive to design is that the signal operations involve switching rather than continuous-mode action. We, therefore, begin our study of digital systems by looking at the design merits of various switching devices, starting with the mechanical kind.

MECHANICAL SWITCHES

The ON-OFF switch has only to define two states of circuit operation and hence the tolerances associated with each state can be very wide. Consider the basic mechanical switch having two contacts as shown in Fig. 3. When the contacts are disengaged it matters little how much further the designer separates them; the further they separate the less the chance of a spurious make-condition occurring. Conversely, when closed the spring action will ensure contact over a wide range of relative positions. The harder the two contacts are pressed together the better the reliability, but there will be negligible electrical change in the circuit-made state.

Continuing with the mechanical switch example we can also easily see that a switch with heavily over-travelled contact pressure or excessive opened distances will be slow

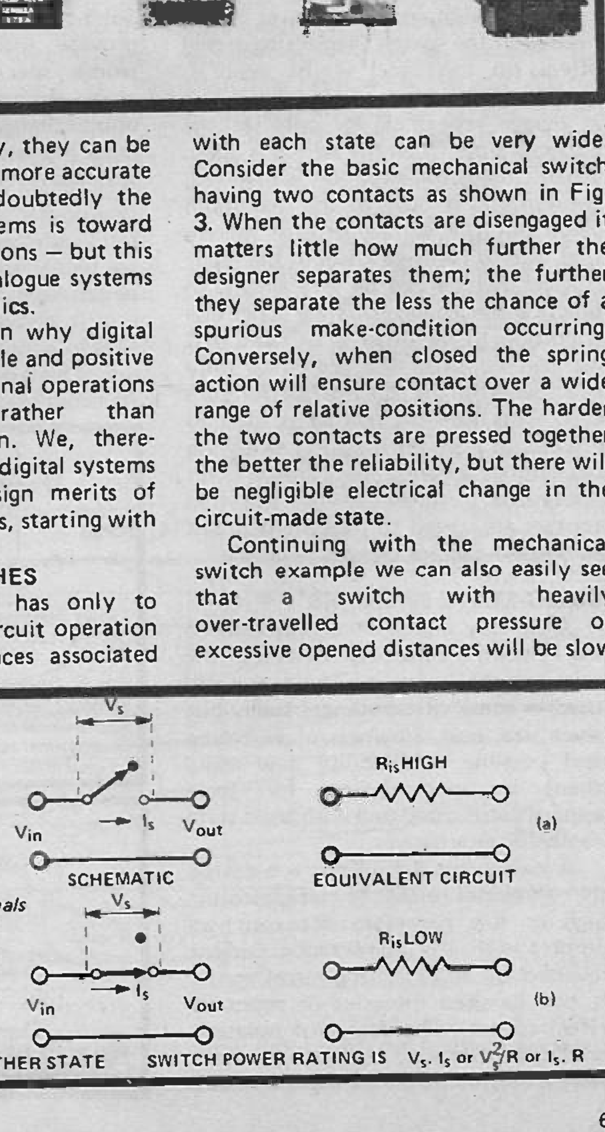


Fig. 4. Switches can handle large power signals with little loss (a) open (b) closed.

ELECTRONICS -it's easy!

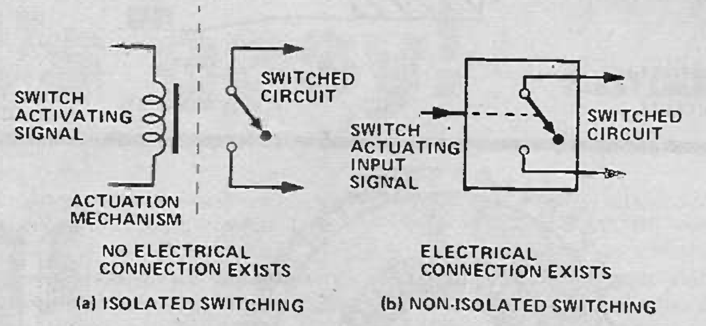


Fig. 5. Unlike electro-mechanical switches, most solid-state electronic switches do not provide ideal isolation between the actuating signal source and the controlled source.

to change to the opposite mode because greater force, or more travel, is needed to effect the change.

Another feature of the two-state switching circuit is that the switch's power rating can be very small compared with the load power being controlled. This arises because in each of the two states the switch has only to dissipate very small power losses. When open, see Fig. 4(a), the voltage across the switch is maximum but the current minimum. The power rating needed of the switch (neglecting arcing effects in this case) whilst open is, therefore, the product Vs.Is, and this is always very small, for only leakage currents flow when the switch is open. When closed, the situation is reversed; the current is now of the maximum value but the voltage drop is merely that due to resistive losses in the made contact (which can be very small). In practice the change of state from one condition to the other is so rapid that we can consider the switch as only ever being in the fully-off or fully-on case. This low-loss feature is used to effect in power-supply switching regulators where the "made" to "not-made" times of a vibrating contact are varied to pass the required amount of average power.

SOLID-STATE SWITCHES

Originally digital circuits did indeed use electro-mechanical switches; the relay as we know it. These are still used in some circumstances today but their size, cost, slowness of switching and possible unreliability now make them a poor choice, for logic applications, compared with solid-state switching alternatives.

A switch by definition, is a device that provides either a satisfactorily high or low resistance between two points, with the state being rapidly reversed by an external control input. It can be used in series or shunt to effect control. The degree of isolation provided is decided by the open-state resistance; the power rating is decided by the made-state switch resistance. What is high or low is purely relative, depending upon the impedances of the circuit elements connected to the switch. A perfect switch provides infinite open-circuit resistance and zero closed-circuit resistance. Typical resistances encountered in a small relay are from many megohms (contacts open) down to mere milliohms (contacts closed) thus giving excellent switching characteristics. Solid-state switches normally do not provide such large resistance ratios (some special devices come close) giving around a megohm to a hundred ohms change which is adequate for most logical tasks performed by digital systems.

Another disadvantage of most solid-state switches is that, as we will see below, the circuit connected to the switching part of the solid-state switch is not completely isolated from the circuit actuating the switch mechanism. This concept is shown in Fig. 5. At times this is most inconvenient and the development of workable solid-state switching systems has been influenced by the need to make-do with this shortcoming. A relatively recent newcomer to the solid-state switch, which overcomes the last disadvantage, is the solid-state opto-electronic isolator, shown in Fig. 6. This uses the actuating input to energise a solid-state light-emitting diode (LED); this, in turn, deduces the resistance of a light sensitive detector that acts as the 'contact'. This device is used in a minority of switching operations involved in digital circuitry where extremely high isolation is required between the switching and the switched circuits.

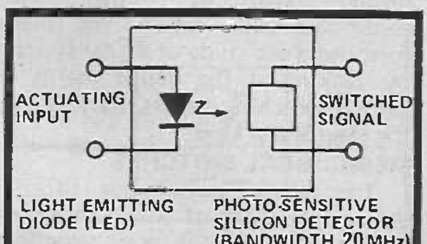


Fig. 6. Opto-electronic switches such as HP5082 series can provide a very close approximation to the low-power mechanical switch and are much faster in operation.

The two most commonly used solid-state switching techniques are those using two-terminal diode designs and three-terminal active element designs based on devices such as the transistor and other solid-state amplifying devices.

SWITCHING WITH DIODES

Let us first look at a diode wired to provide a switching function. In Fig. 7 a diode is connected to a bias supply V and to the input as shown. When the input voltage Vin is more negative that the bias voltage V the diode is forward-biased providing a quite low resistance path between the input and the output terminals. In this state Vout will be closely equal to Vin. If the bias voltage (or the input voltage) are changed to make Vin more positive than V the diode becomes reverse-biased placing a high-resistance between input and output. Thus, by changing V from positive to negative we have produced a switching action between input and output terminals.

A similar action is provided if the diode is wired in shunt across the line rather than in series as shown in Fig. 8. The state of V decides whether the diode shunts the line (when forward biased) or not (when reverse-biased).

In either design it is important that the diode resistances in the two states, the output impedance (R_S) of the preceding stage connected to the input, the load impedance (R_L) connected to the output and the

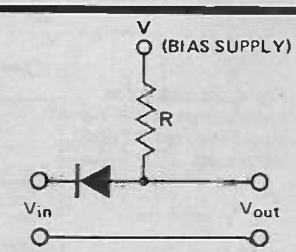


Fig. 7. Diode wired to provide switching action between input and output.

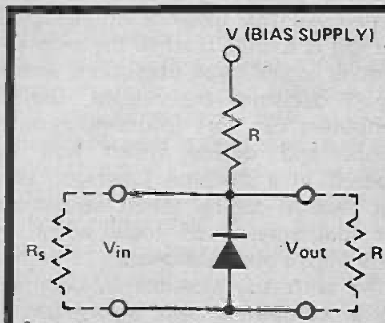


Fig. 8. Diode wired to provide shunt switching action.

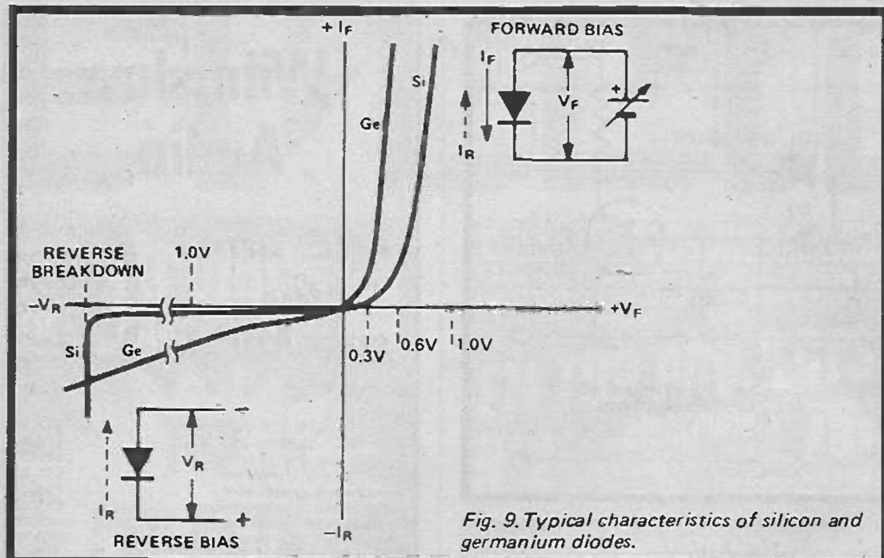


Fig. 9. Typical characteristics of silicon and germanium diodes.

bias-resistor value (R) are all chosen to have the right ratios in the two switching states. Adequate switching action will not result if the bias input is allowed to dominate the values being switched.

It is important that the bias voltage actually developed across the diode is sufficient to produce a diode forward-current greater than a value around the knee of the I_F against V_F characteristic — see Fig. 9. For a silicon diode this requires at least 700mV, a germanium diode at least 350mV: these values vary little with make or shape of particular device, being a parameter of the semiconductor material itself. Note how a quite large change in forward current hardly changes the dynamic resistance once the knee is passed. (Dynamic resistance is the slope of the characteristic which is reasonably constant beyond the knee). This reliable and constant loss switching (but not zero-loss) results over a very wide range of bias current conditions.

In its reverse-biased state the diode provides a larger resistance. Fig. 9 shows that germanium diodes do not provide as high an 'open' resistance as do silicon diodes — this is because the slope of the germanium characteristic is not as horizontal as that of silicon. Nevertheless both slopes represent higher resistance than in the forward-biased case, proving that resistance of the diode changes markedly. Again, we see that both reverse-biased curves are closely linear meaning constant resistance or, in other words, constant "open circuit" switch resistance.

When selecting the value of switching bias to apply it can be seen from Fig. 9 that too high a value for silicon devices will cause breakdown at the zener point, providing instead, a condition that could cause total failure of the device.

The speed at which diodes can switch is a function of circuit values and the characteristics of the diode. It is routine practice with diodes to switch at tens of megahertz rates or higher. Mechanical switches are limited to less than 1 kHz at the very best.

Later in the course we will see how these basic diode switches can be used to perform logical operations by connecting more than one diode to the same bias source. Such connections are called gates.

SWITCHING TRANSISTORS

Now to the use of three-terminal devices, transistors for instance, as switches rather than as linear amplifiers. This can be explained using the I_C versus E_C characteristics of a typical transistor, as is given in Fig. 10. The two switching states occur when I_b is either large or small. A chosen collector resistance value (in common emitter configuration) establishes the load-line on the characteristic. In a switching-mode the transistor operates around points A or B. At A, I_b is large; the transistor is, therefore, switched on with V_{CE} being very close to zero volts. At B I_B is small (practical circuits may apply a reverse polarity to ensure this); the transistor is switched off with V_{CE} being virtually at the supply voltage. In the on-stage the transistor provides a low-resistance path between its collector and emitter: when off, a high-resistance path.

The transistor switch, unlike non-amplifying diodes and mechanical contacts, does not directly pass the input signal but instead replicates a signal current in its base by providing an equivalent change in collector current or voltage. In reality a large proportion of digital circuits regenerate in this way with the output signal change closely following that of the input.

At either of the circuit operating points A or B the transistor is operated well within its allowable power dissipation. As we should expect, a given transistor used in a switching mode can handle a greater power than if operated as a linear amplifier. A little thought will also show that the load line can, in switching use, intercept the maximum dissipation curve, the reason being that the transistor does not dwell long enough in states other than A or B to produce deleterious heating. It is vital, however, in such designs to ensure that the switching action is rapid between states, and that the device never dwells on the way through. A ramp input signal may well destroy a stage designed to switch!

The above explanation is most basic — reality requires other criteria to be recognised to obtain more ideal switching. Like the over-travelled mechanical switch, a transistor switch with too much reverse-bias base current (off-state) or too much on state base current will be slower to operate than one not driven so hard. This is because the charge associated with the base current must be removed to alter the state and the more the charge there is to move, the slower will

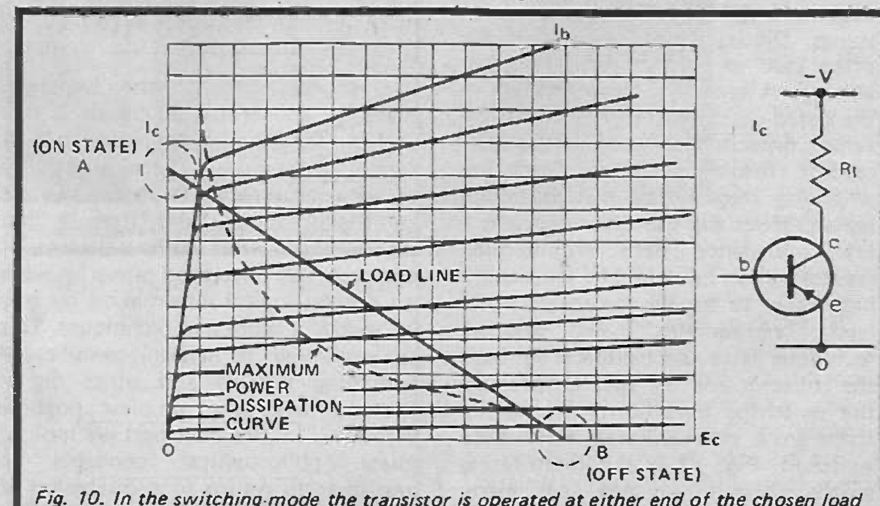


Fig. 10. In the switching-mode the transistor is operated at either end of the chosen load line.

ELECTRONICS -it's easy!

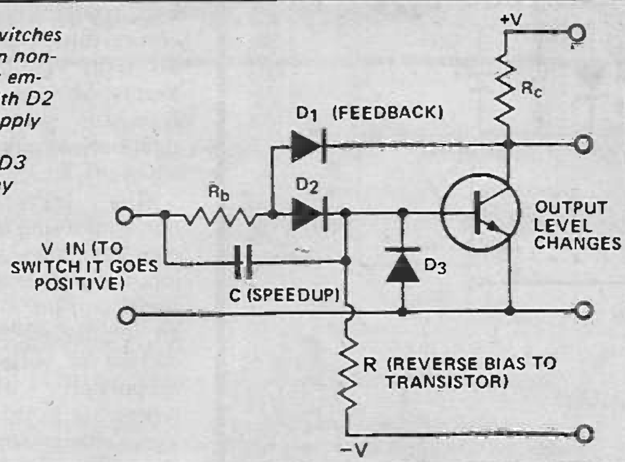


Fig. 11. High-speed switches are designed to remain non-saturated. This circuit employs feedback D1 with D2 providing a voltage supply needed. The speed-up capacitor is C. Diode D3 assists reduce the delay time.

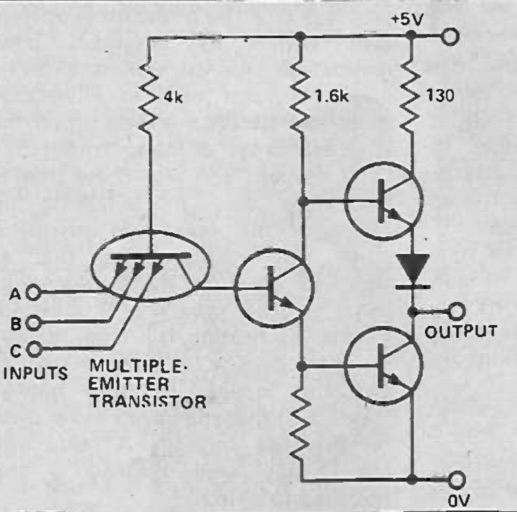


Fig. 12. Transistor-transistor logic, TTL is a commonly accepted integrated circuit manufacturing method. This gate combines up to three inputs switching with a delay of only 10 ns. The whole circuit is integrated on a common chip.

be the switching time. Solid-state switches operated very positively by use of large drive currents are said to be working in a saturated state.

Certain circuit devices can be added to the basic solid-state switch to speed up the response. The first is to supply a much larger input signal than would be needed to just turn it on. This speeds up the charge movement but would take the device into deep saturation unless clamps are added that hold the circuit nodes at given values. Diodes acting as switches are often used to hold a point at a given voltage. A second circuit addition is the speed-up capacitor. This is a small value capacitor placed across the resistor feeding the input of the switching stage. When fast switching signals occur the capacitor provides a low impedance path around the resistor which must be of a reasonably high value to supply correct dc signal level requirements. Yet another technique is to use feedback between the collector and the base to speed up the switching transition yet hold the stage in a non-saturated state once switched. Fig. 11 is a non-saturating switch circuit — one of many possibilities. It shows how the basic transistor needs the addition of more components to realise fast switching in discrete designs.

The integrated-circuit revolution has provided us with inexpensive, ready-made digital circuits of great sophistication. These are extremely basic yet super fast — see Fig. 12. Rarely does one now have to consider the in-depth design of switching circuits. The task is usually one of devising a system using a few basic, digital system building blocks which have been so developed as to facilitate their ease of connection into systems.

The reliability of the switching state of an electronic circuit is one reason for the widespread use of digital techniques. There is another equally important reason for the use of digital signals and that is that philosophers and mathematicians of the past have developed powerful ways to process logical information by way of special algebra and techniques. This is employed to design complicated switching circuits and other digital systems with the simplest possible circuitry. In the next part we look at these philosophical concepts in readiness to return to a discussion of the basic, digital-system building blocks. ●

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Electronics Tomorrow

by John Miller-Kirkpatrick

EARLIER THIS WEEK a small parcel insinuated itself through our letter-box; inside was a beautifully packaged Black Watch kit from Sinclair. As usual with Sinclair kits, all of the parts were laid out in a plastic tray and the whole kit is presented in a neat plastic case; first impressions — very good. Open up the case and find the instructions plus any of the usual addendas and read thoroughly to get a general idea of the construction sequence. The only addenda mentioned a plastic-backed copper shield which has to be bent eventually to surround the completed module in order to protect the module from large static build-up which the plastic case would not ground back to the skin.

First step — identify all of the components from the list and check that all of the components are there and that none are duplicated in any way. Most of the components listed are obvious but some could be identified better by drawings or by further description. For instance, the kit contains an ampule of grease and a small tube of varnish (these are mentioned as grease and varnish); if you open the grease in mistake for the varnish you could get into a very sticky mess. Now we will follow Sinclair's instructions through with any problems that I found or any comments that I feel are worth making.

ASSEMBLY

1. PREPARE PCB. "The component side of the board should be thinly coated with some of the varnish supplied. Do not get varnish on the rear of the board and do not varnish the lower row of contacts. Allow the varnish to set for 2-4 hours before proceeding." The varnish can be applied with a small piece of scrap paper but I suppose that a small paintbrush would be better — add this to your list of tools required. As you can see the kit is not to be completed within a couple of hours, in fact it will take you about 3-4 hours' construction time spaced over as many days.

2. PREPARE TRIMMER. "The arms of the trimmer should be carefully removed with side-cutters. Take care as the body of the trimmer is easily cracked. A small file will be useful to remove burr from the legs. The trimmer is now inserted in the board ensuring the base is flush with the board; it is then soldered in place. Do not use too much solder on the large lead . . . cut off the leads within ½mm of the rear of the board." The trimmer supplied has two legs, one fat, one thin; each has a small projection about halfway up which has to be removed in order to get the trimmer sitting correctly on the PCB. All of the components have to be as close to the PCB as possible and the leads and soldering on the back of the PCB have to be as short as possible in order for the completed module to fit into the case. The ruination of your kit could start here if this major rule is not adhered to.

3. CAPACITOR. "The capacitor should be soldered in place with the white dot facing toward the integrated circuit." Apart from the obvious and unfair comment that the integrated circuit is still in the box, the leads on this capacitor have to lie across tracks on the PCB. These tracks should have varnish on them and thus be insulated but ensure that the capacitor leads are not touching the tracks during soldering as I suspect that the heat could melt the varnish and cause a short.

4. QUARTZ CRYSTAL. No problem with this component, yet again Sinclair mention components being flush with the board.

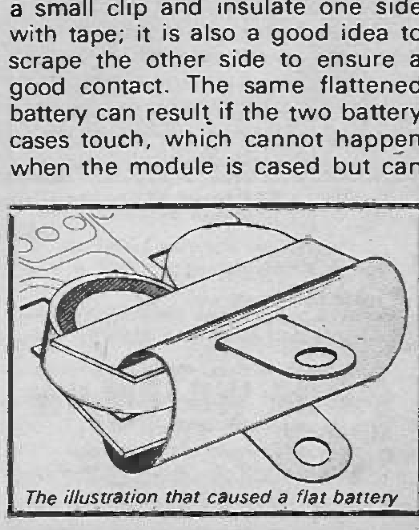
5. DISPLAY. Once you have identified pin 1 with the help of a drawing this major component should cause no problems.

6. INTEGRATED CIRCUIT. The instructions on handling the IC and soldering it into place are very clear and this component should cause no problems.

7. FLEXIBLE PCB. This PCB carries the switch contacts and the battery contacts; if you have one or two dummy runs at the instructions you will probably get it right. There is a drawing of the folding of the PCB but it is not quite clear enough at first. Be very careful with this PCB as it can be melted or torn quite easily; one of the problems with this type of PCB is that the track can break from continuous folding and this break can be very difficult to find and correct.

The basic module is now complete and we come to the crunch, the Sinclair testing procedure. If you follow the instructions correctly you stand a good chance of cracking the flexi or flattening one of two expensive batteries.

TESTING. "Place the batteries on the battery contacts in the correct positions and use the Bulldog clip to hold them in place as shown. The metal clip acts as a series connection between the batteries. When the contact pads are touched with a metal object the display should light up. If this does not happen check that you have assembled the board correctly and that the batteries are connected in the correct polarities. The clip must be making a good series contact. If a single bright digit appears, momentarily interrupt the battery supply. The watch should then appear blank until one of the contact pads on top of the IC is touched." I used a Bulldog clip as prescribed and immediately shorted one of the batteries; if the Bulldog clip is too large then the clip not only connects the negative of battery A to the positive of B but also can connect it to the positive of battery A — result no battery A. Use a small clip and insulate one side with tape; it is also a good idea to scrape the other side to ensure a good contact. The same flattened battery can result if the two battery cases touch, which cannot happen when the module is cased but can



The illustration that caused a flat battery easily happen at this point; use a small piece of tape or card to separate the two. Flat batteries can cause a lot of trouble and upset at this point so, if in doubt, check that the total voltage is 2.7 volts — on load as well as off load. Pin 18 of the IC is positive and pin 10 negative; if you can connect a meter to these points and then test the display you can check the condition of the batteries.

THE LONG HAUL STARTS

Now that your module works you have only to varnish the back of the PCBs, trim the timing with the trimmer and case the watch — this should take you three days. The instructions on varnishing and adjusting are very good and quite understandable but the final assembly into the case would be helped if an exploded diagram was given. It is reasonably obvious where everything goes but it might take you several tries to get everything in the right place, the right way round at the right time; a drawing could make it clearer. It is at this point that you find out how well you managed to get your components close to the board and how good your soldering and lead trimming was; if the back of the case does not fit don't try to force it, find out why it won't fit.

SUMMARY

The Sinclair Black Watch is a brilliant piece of design both inside and outside. If you want one I would suggest to most people that they should buy the completed watch from Sinclair at £24.95 plus VAT — they should be available from January 1st. If you really want to build one make sure that you have the right tools and the patience and the experience. Remember that this is probably the most intricate and the most compact kit that you have ever built. I would not recommend it for beginners or even for people with some experience; it is much more complicated and fiddly than a Cambridge or Scientific kit. On the other hand, a completed Black Watch kit will give a lot of pleasure and pride; not only do you own one of the first digital watches that looks like a digital watch, but you built it!

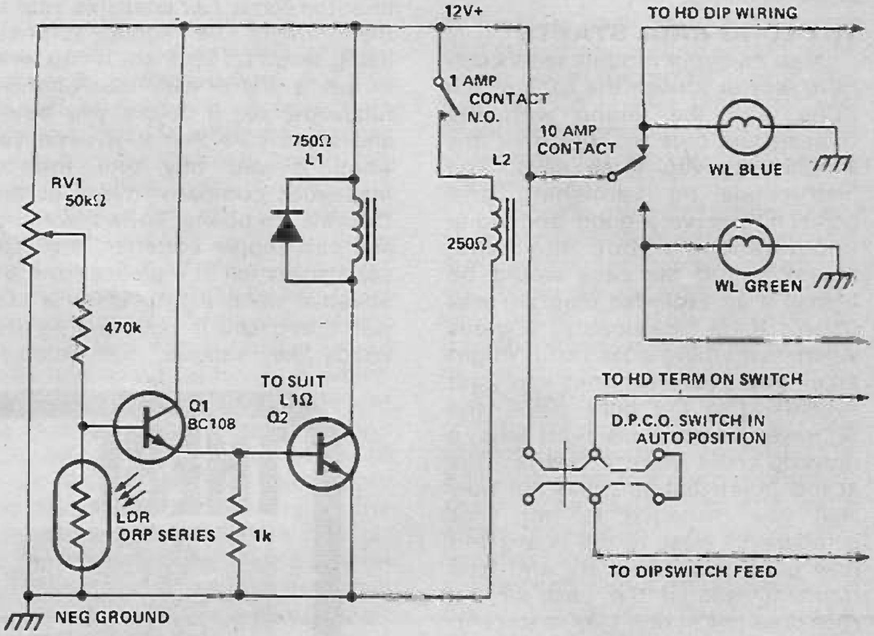
Editor's Note: We have not altered the author's comments on the Sinclair Watch but the Editor has also built one of these and considers some comments a trifle harsh. It is not a beginner's kit and we did have a few problems, largely due to our impatience to get it working. Nevertheless we consider these minor and do not detract, in the long run, from an excellent product. Our watch is incredibly accurate, gaining less than a second a week!

After my recent comments on digital watches I received a lot of letters asking for advice. I have not had time to answer these letters individually and my apologies to those people. I would not advise the purchase of a complex watch until after the *Basle Fair* later this year as there might be some surprises being saved up for then. If you want to buy a watch with four or more functions, see it before you buy it and make sure that it is what you want. If you buy one from a mail-order company make certain that the company knows watches and can supply batteries, etc. You can usually tell at a glance from the advertisement; if they show a LCD watch and call it LED, if they use words like "unique" too much, if they sell plastic toys in the same ad, especially if they say "scoop purchase," ie the original manufacturer has gone bust.

My personal recommendations are either of the Black Watches (from Sinclair or Metac), the TLC4 from Metac or the Novus range of multi-function watches. Tesco's watch is supposed to be very good and I haven't heard anything bad about it, but I haven't seen one to comment on. The two Black Watches offer similar functions at similar prices and the choice is really in the case style. I like the Sinclair but my wife hates it (check with yours before you buy). My favourite is the TLC4 which has hours, minutes and seconds plus a date readout; this is a LCD watch with the additional facility of a back-lit display for night viewing — surely this is much more logical than normal LCD or LED displays.

tech-tips

AN AUTOMATIC HEADLAMP DIPPER UNIT



The circuit follows an automatic parking light circuit in that when light from an external source falls upon the light dependent resistance LDR causing it to go low, the transistors in the circuit are not triggered, but when the external light fades, the resistance of the LDR goes high, allowing Q1 base to go positive and conducting so that Q1 emitter and Q2 base also go positive. Q2 collector current rises, energising the relay L1, this being 'normally open' contact arrangement, the contacts close and energise relay L12 which livens up the headlamp bright filaments. When approaching rays from street lamps or oncoming cars, the relay L1 drops out and disconnects L2 which drops out and energises the dipped filaments. RV1 controls the sensitivity.

The change over switch when switched to manual allows the dip switch to be used in a normal manner.

The unit can be placed under the forward edge of the dash. Then the headlamp wire is removed from the headlamp switch and taken to the unit and another is run back to the vacated terminal. The LDR should be mounted in a bicycle rear light housing (torpedo shape) and mounted at bumper height on the offside of the car.

HALF CHARGE RATE FOR CAR BATTERIES

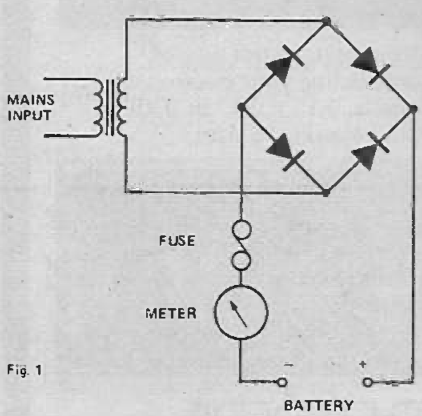


Fig. 1

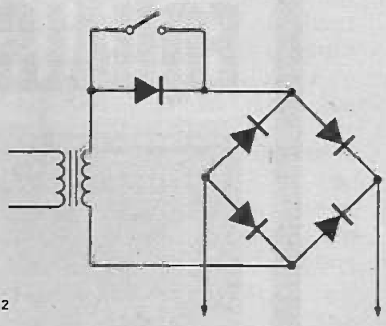


Fig. 2

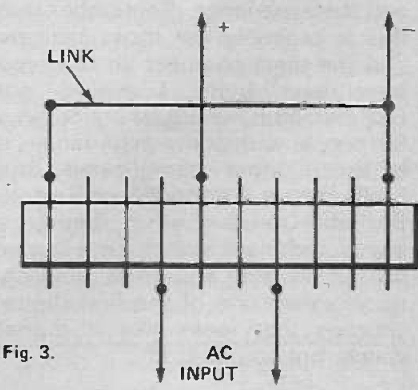


Fig. 3.

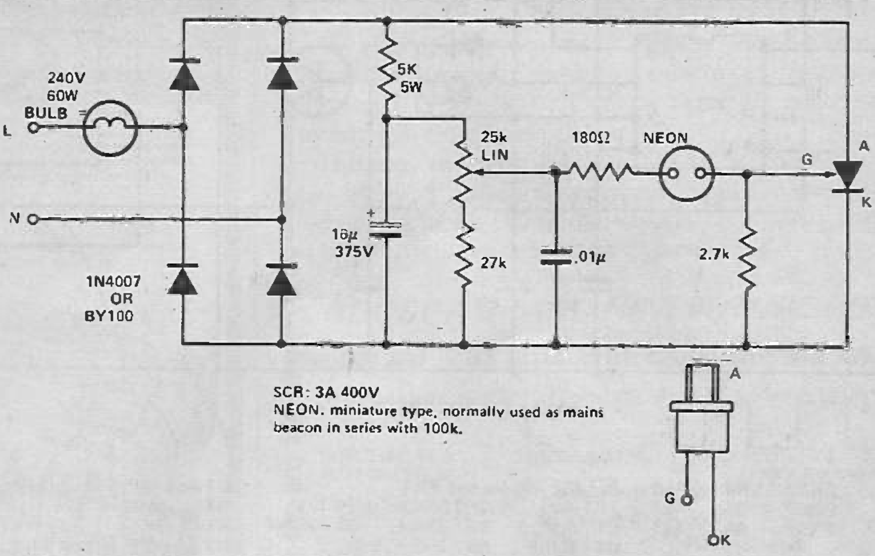
Many simple fixed rate battery chargers have a circuit as shown in Fig. 1. When the battery is very low, excessive current may be taken, but a half-charge rate switch would prevent this. A resistor switched into the positive lead would do, but this would need to have a very high wattage. An alternative is to switch in a single diode in the low voltage A.C. feed to the bridge as shown in Fig. 2. This turns the full wave charge into half wave, thus cutting down the current.

If a bridge is used, the addition of a switch in the link between the negative plates will cut out half of the bridge, and half charge is obtained without the additional diode, as shown in Fig.3.

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.

LOW FREQUENCY STROBE



The circuit will flash the bulb at a rate between 0 and 10 Hz. Points to note are:

(i) Because all components are connected directly to the mains, do not touch whilst the unit is on.

(ii) Use a television type 25k pot with insulated spindle.

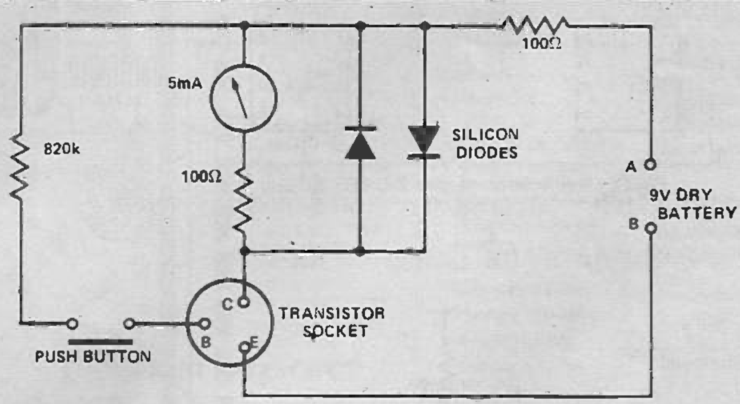
(iii) Mount in an insulated box with ventilation holes.

(iv) The 5k resistor gets hot, hence the wattage rating.

(v) The 27k may be altered to obtain as full range of control by the pot.

There is a risk of inducing convulsive seizures in people suffering from epilepsy if this unit is operated in their presence. Such people should avoid areas where strobe lights are used. A rate of nine flashes per second is considered the most dangerous and most people will find this unpleasant.

TEST TRANSISTOR CURRENT GAIN



A reasonable estimate of current gain can be obtained from the above circuit. Before the button is pressed, the meter should give negligible deflection. Closing the contacts gives approximately 10µA to the base of the transistor, so every mA indicated by the meter has to be multiplied by 100 to obtain the current gain. The resistors and diodes are to protect the meter in the event of a short circuit transistor being tested.

For NPN transistors, A & B should be + & − whilst for PNP, A & B should be − & +. The meter also needs to be reversed with the change of polarity.

The changeover for both meter and battery could be carried out with a two-way, four pole switch.

SIREN CIRCUITS FOR CHILDRENS TOYS

This circuit was originally designed to produce the sound of a police siren for my son's pedal car. It uses two 555 timers connected as oscillators (see Fig. a). The first oscillator IC1 is set for a period of 6 secs, 3 on and 3 off. Diode D1 is included to give equal mark-space ratio. This oscillator determines the rise and fall time of the siren.

The square wave output on pin 3 is turned into an exponential rise and fall by R3 and C3. This is reproduced at a low impedance by the emitter follower TR1 at pin 5 of IC2. The 555 timer has the facility for its timing period to be controlled externally by means of a control voltage applied to pin 5. IC2 is set for a nominal frequency of oscillators of about 1kHz, but this is pulled above and below the set frequency by the exponential waveform on pin 5. The output wave form starts at a low frequency, rises over 3 secs to a high frequency, falls over 3 secs to a low frequency and so on.

The loudspeaker used was a 75 ohm ex mobile radio handset speaker. This gave more than adequate volume off a 9V battery. Any loudspeaker can be used, provided a resistor is put in series with it to keep the total impedance above 45 ohms (for a 9V supply).

As originally designed the circuit gives an American-type police siren. It can easily be changed to give other types of siren: If R3, C3, TR1, R4 are omitted, and IC1 pin 3 is linked to IC2 pin 5 by R7 as shown in Fig. 1b, the "De-Dah" sound used by the British police is given.

If the values of R1, R2 are changed and D2 is added as shown in Fig. 1c we get the Star Trek "Red Alert". The values of R1 and R2 give a highly unsymetrical output from IC1. C3 now

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tech-tips

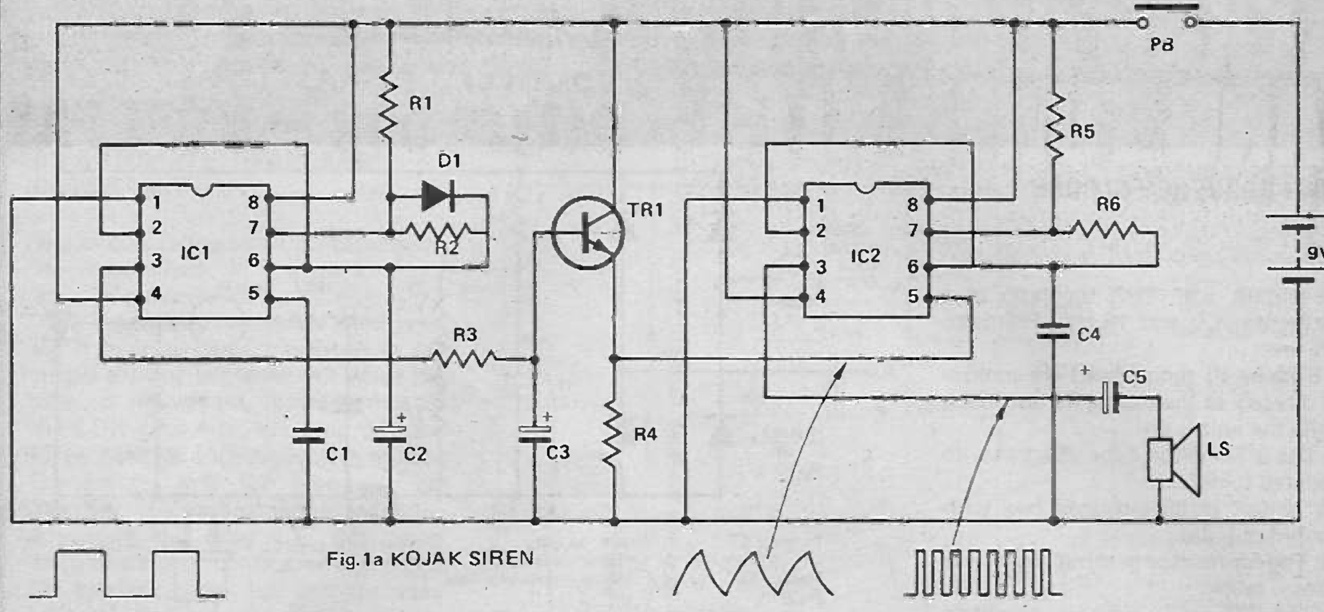


Fig.1a KOJAK SIREN

Component Values

R1	220k		R4	1k0
R2	220k		R5	4k7
R3	220k		R6	4k7

IC1,IC2 555 (or one 556)
TR1 Any G.P. NPN Silicon (eg BC107)
C1 0.01μF C2 250μF C3 250μF
C4 0.1μF C5 250μF 25V

D1 Any G.P. Silicon diode
R7 5k6 R2c 220k
R1c 1k
D2 Any G.P. Silicon diode

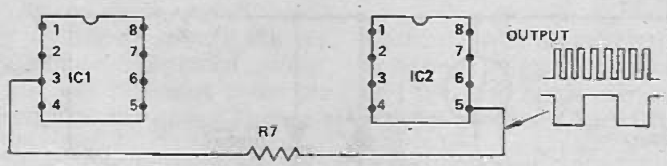


Fig.1b Modification to give Z-CARS SIREN

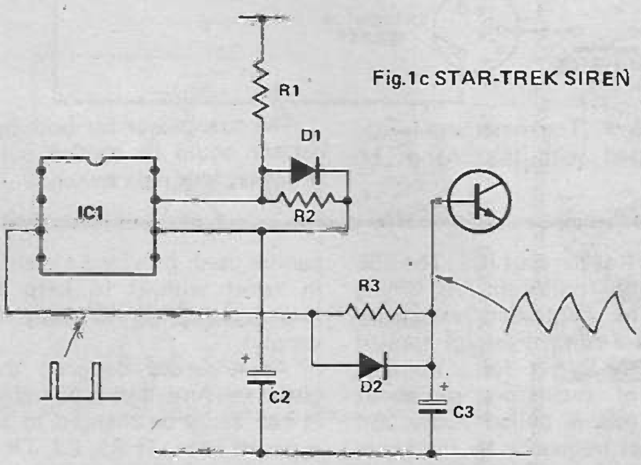


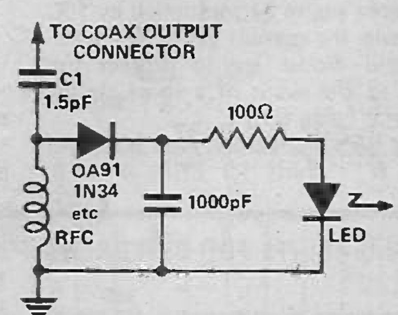
Fig.1c STAR-TREK SIREN

continued from previous page

gets a rapid charge via D2 during the short positive output from IC1, but discharges through R3 during the long low output time. The wave form at IC2 pin 5 thus approximates to a saw tooth, and the resulting output starts at a low frequency rises up to a high frequency over a period of 3 secs then falls abruptly to the low frequency again, and so on.

The circuits were originally built with 555 timers because I had a box full of them. A more elegant circuit can be made, however, by using the 556 dual timer. IC1 and IC2 can thus be obtained in one chip. The circuit works equally well with the 556, but the device has a slightly lower current rating than the 555. The loudspeaker impedance should be kept above 60 ohms by a series resistor as described above.

LED RF INDICATOR

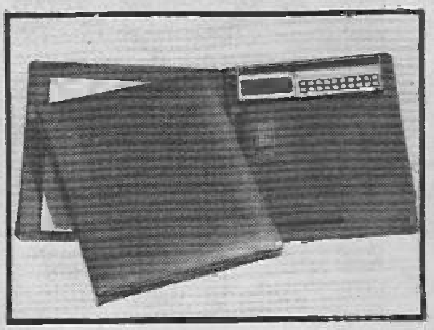


An RF output indicator using a LED is very useful for monitoring the output of a transmitter. This circuit will give indication from a 5 W transmitter. The capacitor C1 and the RFC are chosen for the appropriate frequency. The RFC could be replaced by a resistor for wideband use. The sensitivity depends on the value of C1 and the resistor used if the RFC is replaced. For high power transmitters, C1 could be a small 'gimmick" capacitor.

news digest

NEW CONSUMER PRODUCTS ANNOUNCED BY AMI

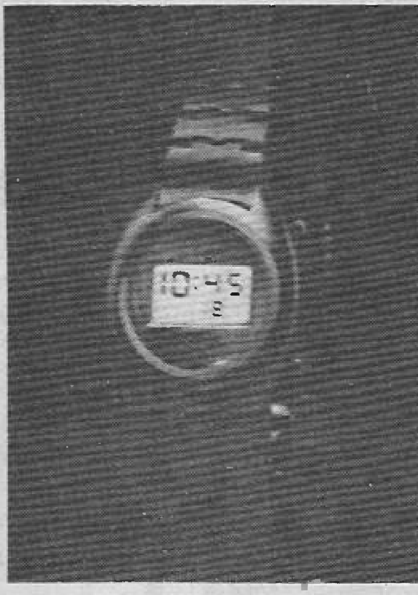
Under the name of OM:EX, AMI have introduced two new watches with back-lit liquid crystal displays, and a range of executive desk-top products. These include a calendar holder, notebook and 3-ring binder, each incorporating a 5-function calculator with an 8-digit electrofluorescent



display, floating decimal and automatic constant. Additional to this range is a memo pad holder with a built-in solid-state clock.

INSTRUMENT CASES

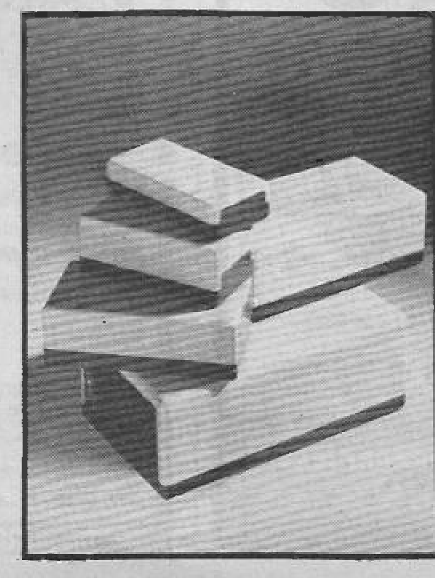
A new range of plastic instrument cases has been released by Mentor Electronics Ltd. of Northwood. The BOCON is a two-tone high-impact plastic case with interlocking tongue and groove seal. The smallest box (E410) is 25 x 50 x 100mm with the largest (E450) 60 x 110 x 188mm; this largest box will carry a Eurocard 160 x 100mm pcb. Brass inserts and screws are supplied and the screw head recesses are square for sealing compound. The lower section has inserts for mounting components or pcbs and there are key-hole lnock-outs for wall fixing. Prices start just over a pound for the E410. Mentor Electronics Ltd., Ryefield Crescent, Northwood, Middlesex HA6 1NN.



CMOS PRESETTABLE COUNTERS

Two new presettable up/down counters have been added to the comprehensive CD4000 Series of COS/MOS digital integarted circuits produced by RCA Solid State—Europe. The RCA-CD4510BE is a presettable binary-coded-decimal up/down counter and the CD4516BE is a presettable binary up/down counter; each device consists of four synchronously clocked gated D-type flip-flops connected as counters. Applications include up/down difference counting, multistage synchronous counting, multistage ripple counting, and synchronous frequency division.

The devices are designed for medium-speed operation (typically 7MHz), and incorporate facilities for resetting and presetting. The counters are cleared by a high level on the 'reset' line, and can be preset to any binary number by a high level on the 'preset' line. The counters can be



cascaded in ripple mode by connecting the 'carry-out' to the clock of the next stage. Both devices are supplied in 16-lead dual-in-line plastic packages. RCA Ltd, Sunbury-on-Thames, Middx.

TRANSISTOR SELECTION AND CROSS REFERENCE

Motorola Semiconductors have just published a free 24-page booklet entitled "Small-Signal Multiple Transistor Selection Guide and Cross Reference". This features full details of over 200 quad, dual and Darlington transistors. It also includes a most useful equivalents or replacement table for over 640 EIA devices.

A useful insight into transistors and transistor type numbers is given. This explains how the multitude of different types is derived from a smaller number of prime devices, each designed with specific parameters in mind.

Device selection is made easy by tables headed with major applications categories. In each table the first delineation is by NPN/PNP device types. Under these classifications are highlighted the prime devices, the basic (discrete) chip from which these are formed, the basic design parameters, and a list of derivatives.

WESTINGHOUSE POWER TRANSISTORS

Westinghouse have introduced two new NPN silicon power transistors designed for switching, amplication and regulation in industrial, commercial, and military applications. The new JEDEC types 2N6254 and 2N6262 transistors are particularly useful in power supplies, amplifiers, voltage regulators and ultrasonic cleaners.

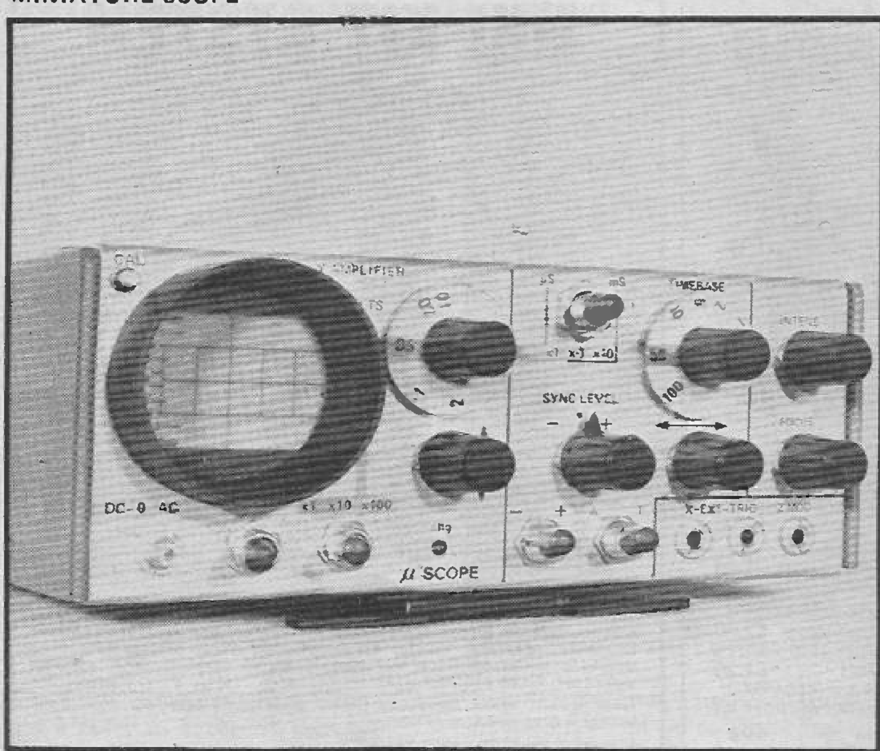
Rated at 15A and 150W, the new devices have large for forward and reverse safe operating areas for switching inductive loads. The 2N6254 transistor is rated at 8V and the 2N6262 device at 150V.

A 200°C temperature range permits reliable operation in high ambients, and a hermetically sealed case insures high reliability and long life. Both devices are 100% power tested at full rated load and carry the Westinghouse Lifetime Guarantee.

The extra gain of the 2N6254 transistor permits its use in circuits where the 2N3055 device is marginal. The extra voltage rating of the 2N6262 transistor allows replacement of the popular 2N3234 or 2N3442 devices to provide a greater margin of safety.

news digest

MINIATURE SCOPE



The B1010 miniature battery-mains oscilloscope is a development of the original A1010 announced in 1974 but with additional facilities with the same small dimensions.

It is the smallest 10MHz battery-mains oscilloscope available to meet the growing need for more sophisticated portable test equipment. The Y amplifier sensitivity ranges from 10mV/Div to 50V/Div with time base speeds from 1mS — 1 second/div. With the choice of free running or triggered time base and positive or negative slope selection the 'micro-Scope' is equally effective for display of complex waveforms as found in colour TV or for pulses with a large mark space ratio as found in radar systems. A decibel scale on the graticule gives direct reading of bandwidth response and modulation depths in communication applications. The rechargeable nickel badmium cells gives up to 3 hours operating time and it can also operate and recharge from 240V, 100 AC and 12V DC. The Z modulation display facility is retained and an internal Y amplifier calibrator has been added giving even greater overall facilities without increasing the small case size. Complete with the rigid carrying case the B1010 costs £198 Lawtronics Ltd, 139 High Street, Edenbridge, Kent TN8 5AX.

SILICONIX SHORT-FORM

The new Siliconix general short-form covers latchproof CMOS, A/D converters, multiplexers, driver-gates (NMOS, PMOS and CMOS), op amps, N and P-channel junction FET's, CR's and low leakage diodes. All major parameters are listed for device comparison, and circuit configuration are provided for the multiple-switch assemblies. Siliconix Limited,Morriston, Swansea SA6 6NE.

THE ENTERTAINING ELECTRON

The Faraday Lecture is now touring the country: presented by IBA engineers, and entitled 'The Entertaining Electron', it gives the inside story on modern TV techniques. Don't miss it if you can possibly go, Venues and dates are:

Birmingham Town Hall 26–27 January 1976 E MAE;
New London Theatre 3, 4, 5, 6 February 1976 E MAE ME MA;
The Great Hall, Exeter University 26 February 1976 AE;
St. George's Hall, Bradford 9 March 1976 AE;
The Albert Hall, Nottingham 11 March 1976 AE;
Liverpool Philharmonic Hall 19 March 1976 AE;
Manchester Free Trade Hall 22–23 March 1976 E AE;
The Kelvin Hall, Glasgow 21 April 1976 E;
The Usher Hall, Edinburgh 23 April 1976 AE;
The Newcastle City Hall 27 April 1976 AE;
Portsmouth Guildhall 4 May 1976 AE;

Tickets available from Local IEE offices M=Morning, A=Afternoon, E=Evening.

MARANTZ 112 AM/FM STEREO TUNER

Designed to match the newly-introduced 1040 and 1070 integrated stereo amplifiers, the Marantz 112 AM/FM stereo tuner is now available in this country through sole UK distributors of Marantz audio equipment, Pyser Limited. The 112 has an FM sensitivity (IHF) of 2.2μV with selectivity (IHF) of 65dB, and features Phase Lock Loop circuitry equipped with a separate automatic stereo/mono switching circuit.

In addition, this new model incorporates an FM muting circuit, to eliminate interstation noise and cut out the unit's side slope spurious response, a four-channel output jack, a Dolby FM switch and of course the now-famous Marantz gyro-touch combination fly-wheel and tuning control.

The Marantz 112 tuner will retail, under the new Marantz pricing policy, at between £150.00 and £181.25 (including VAT). The usual three year (parts and labour) guarantee will apply to the 112.

BRIEF SPECIFICATIONS

Capture Ratio	1.5dB
Total Harmonic Distortion	
Mono 0.30%	
Stereo 0.50%	
AM Suppression	50dB
Stereo Separation	
1kHz	40dB
10kHz	28dB
AM Sensitivity	20μV
Spurious Rejection	65dB
Signal-to-Noise Ratio	50dB
Freq. Response (-3dB)	50–3000Hz
Total Harmonic Distortion	0.7%

ERRATA

Review of Scientific Calculators, January 1976 issue page 26.

The CBM SR990 is now replaced by the CBM SR9120, which has the same features for the same price but calculates to 12 (not 9) digits. The machine is available only through Boots.

The Decimo machines are to be replaced by the Vatman Scientific — an 8, 8+2 calculator. The Decimo 2001E has a 10, 10+2 display, not the 8 digit one stated.

★ 6 Jumbo LEDs for £5.10! (incl.). See Jan. ET1 for details and coupon for this Special Offer which runs until 31st Jan. Unlimited supply available.

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Complete kit including attractive slim case with perspex panel for 6 digit alarm clock with bleep alarm, snooze and automatic intensity control, high brightness display driving; uses MK50253 IC and Jumbo 0.5in. LEDs. Kit also includes PCBs, active and passive components, IC skt., min. transformer, switches, flat cable, loudspeaker, mains cable and plug. Full instructions. Crystal control/battery back-up and touch switch snooze and alarm are optional add-ons **£27.31**

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(As featured in January Everyday Electronics). Ideal kit for the less experienced constructor; kit includes IC, pleasing ½" green display with colon, PCB, miniature transformer, slim white case with perspex front panel, and all other components including mains cable and plug. Full instructions **£16.20**

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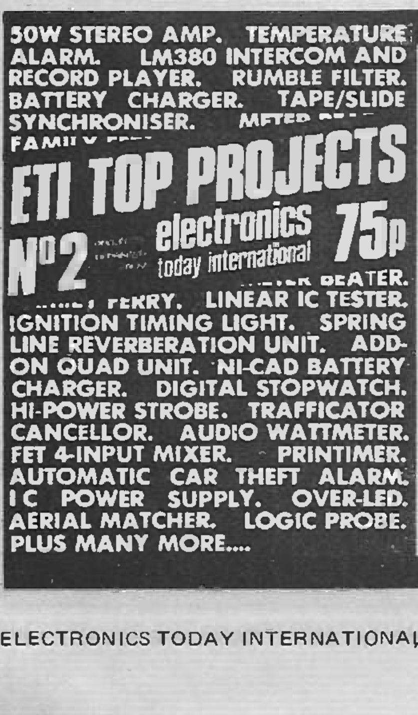

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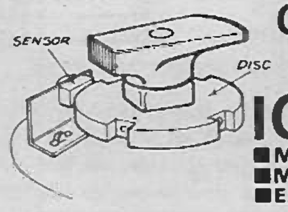

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