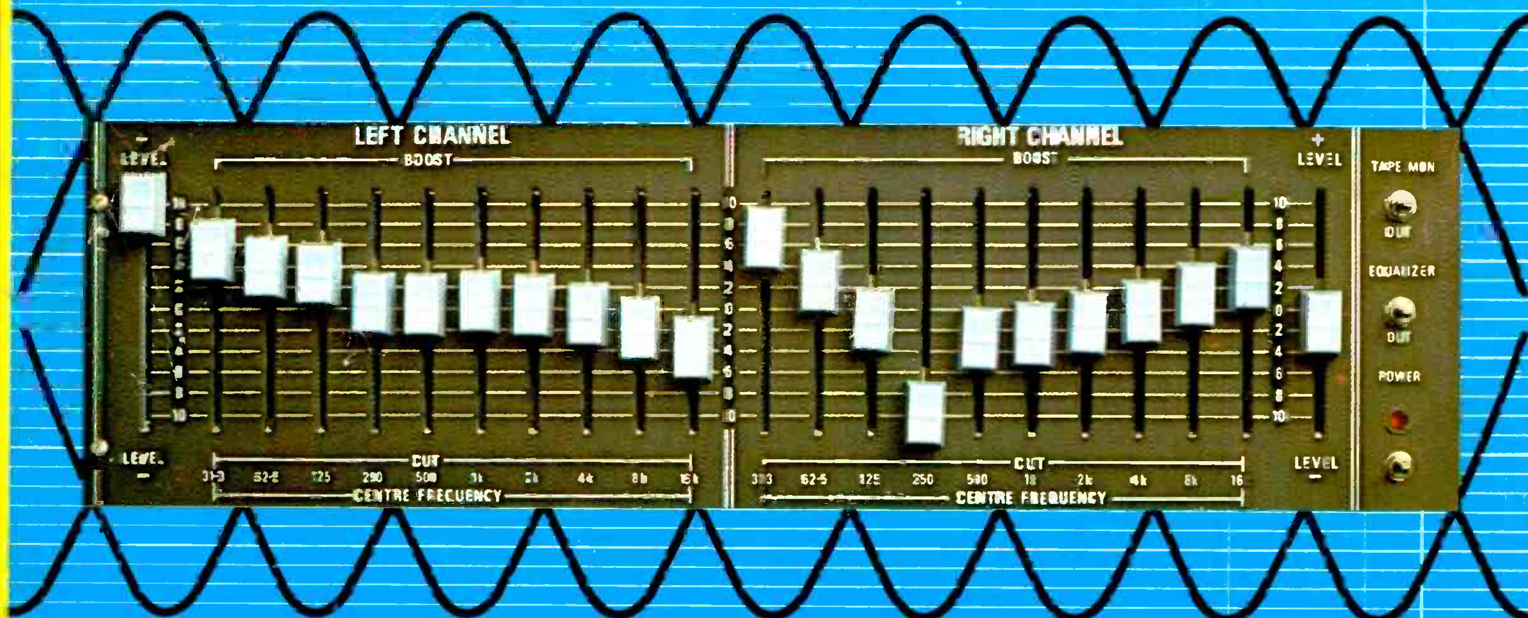
electronics today international

SEPTEMBER 1977

40p

GYRATOR BASED DESIGN: NO COILS TO WIND!

GRAPHIC EQUALISER



ETI SUMMER SALE—BARGAINS GALORE!

ALSO:

LOUDHAILER

CCD EXPLAINED

STEREO SIMULATOR

SYSTEM 68 CPU BOARD

CHOOSING & USING TRANSFORMERS

NEWS . . . CONSTRUCTION . . . DEVELOPMENTS . . . AUDIO

NEW MM5204 PROM PRICES
National Semiconductors have reduced the price of the MM5204Q UV erasable PROM to only £10.95 for a 512 byte PROM. We can supply these PROMs blank at this price or for only a little extra we can supply them programmed wilh one of our software routines. Examples are:

VOUBUG SC/MP control for System 68. 512 bytes. program charge £15.00
KITBUG SC/MP control for Introkit. 512 bytes. program charge £11.00
NIBL SC/MP BASIC language. 4K bytes, program charge ... £60.00

We can also arrange programming to your specification from paper lape. hex listing or even flowchart – send details for quote.

TEMPORARY STORAGE
This month we include in our stock list two new program storage media. The first is the ER3401 Electrically Alterable ROM which can be programmed like a RAM but can be removed from its power supply and still relain its data for up to 10 years. The second is a low power CMOS RAM the MM74C920 which has the high R/W speed of a RAM but can be run on standby batteries (or even a charged capacitor) for long periods without data loss. Both units come in a four bit wide configuration with the ER3401 having 1024x4 bits and the MM74C920 having 256x4 bits. Prices per chip are:
ER3401..........£28.85 MM74C920..........£11.83

LOW COST POWER SUPPLY
Our redesigned P297 power supply can supply 5v (±0.5v) variable supply at 2.25A plus a –12v and a –5v each at approx. 100mA. All electronic components are included with a specially wound transformer and PCB which can be mounted on the transformer. The supply is suitable for most MPUs and for other mixed voltage logic units.
P297 Power Supply .... £11.50 (kit form)

NEW SCRUMPI PRICE
You can now have a complete MPU kit for less than £60! Our new price on our SCRUMPI kit is only £55.56 for SC/MP, 256 bytes RAM, switches, LEDs, etc. For review see Practical Electronics Aug. 77.
Other kits we stock are:
INTROKIT SC/MP from NS. requires TTY or KBOKIT £66.33
KBOKIT adds to INTROKIT to give complete system £66.50
LCOS Nationals ready built development system £334.33

SYSTEM 68

MPU SUPPORT

74C00 Quad NAND	0.25
74C04 Hex Inverter	0.25
74C10 Triple NAND	0.25
74C42 BCD-Dec Decoder	0.95
74C157 Quad Selector	2.25
74C163 4 bit counter	1.15
74C164 PISO Shift reg	1.15
74C165 SIPO Shift reg	1.15
74C173 TriState Quad Latch	0.95
DM8095 TriState Hex Buffer	1.75
DM8096 Invert 8095	1.75
DM81LS95 TriState Buffer (8 True)	1.45
DM81LS96 TriState Buffer (8 Inv)	1.45
DM81LS97 TriState Buffer (4+4 True)	1.45
DM81LS98 TriState Buffer (4+4 Inv)	1.45
DS8833 TriState Transceiver (4 bit)	2.00
DM8678 CAB Char Gen 5x7	15.20
DM8678 BWF Char Gen 7x9	15.20
DM74LS139 Dual 2-4 line decoder	1.50

MPU KITS

SCRUMPI	55.56
INTROKIT	66.33
KBDKIT (for INTROKIT)	66.50
LCDS	349.30

SOFTWARE in 5204 PROMs

SC/MP VDUBUG
SC/MP NIBL (BASIC)
6800 HALBUG

MEMORIES

RAMS

MM2102-2 1Kx1 650nS RAM	2.11
MM2112-2 256x4 650nS RAM	3.08
MM74C920 256x4 CMOS RAM	11.83
2114 1Kx4 RAM	24.00

Erasable PROMs

MM1702Q 256x8	11.90
MM5204Q 512x8	10.95
MM2708Q 1024x8	31.15

N.B. Can be supplied programmed.

Elect. Alterable ROM

ER3401 1Kx4 EAROM 950nS	28.25

Communications

MM5307AA Baud Rate Generator	12.68
MM5303 (AY-5-1013) UART	6.34
Crystal for 5307	

MPU Chips

SC/MP PMOS	12.00
SCMP2 NMOS	10.00

System 68

VEROCASE KIT	39.92
VDU KIT	83.34
SC/MP Control Card with VDUBUG PROM	32.40
6800 Control Card with HALBUG PROM	
4K PROM Card (5204) with 2 blank PROMs	29.63

CLOCK CHIPS & KITS

TYPE	SPECIAL FEATURES	£CHIP	£KIT
MM5309	7 seg + BCD RESET ZERO	8.53	12.50
MM5311	7 seg + BCD	4.26	8.00
MM5312	7 seg + BCD 4 DIGIT ONLY	5.65	
MM5313	7 seg + BCD	6.50	
MM5314	7 seg + BASIC CLOCK	4.26	7.00
MM5315	7 seg + BCD RESET ZERO	6.50	
MM5316	Non-mpx ALARM	7.50	
MM5318	7 seg + BCD External digit select	4.93	8.00
MM5371	ALARM. 50 Hz	12.19	
MM5378	CAR Clock. Crystal control. LED	9.86	14.00
MM5379	CAR Clock. Crystal control. Gas discharge	9.86	
MK5025	ALARM. SNOOZE	5.60	9.00
MK50395	UP/DOWN Counter – 6 Decade	12.10	15.10
MK50396	UP/DOWN Counter – HHMMSS	12.10	15.10
MK50397	UP/DOWN Counter – MMSS 99	12.10	15.10
FCM7001	ALARM. SNZ. CALENDAR. 7 seg	9.00	12.50
FCM7002	ALARM. SNZ. CALENDAR. BCD	9.00	
CT7003	ALARM. SNZ. CALENDAR. Gas discharge	9.00	
FCM7004	ALARM. SNZ. CALENDAR. 7 seg	9.00	12.50
AY5. 1202	7 seg. 4 digit	4.76	
AY5. 1230	7 seg. ON and OFF ALARM	5.25	TBA

All above clock kits include clock PC board, clock chip, socket and CA3081 driver IC. MH15378 also includes crystal and trimmers. When ordering kit, please use prefix MHI, e.g. MHI 5309.

DISPLAYS

DL707, 704, 701 0.3"	1.70	Litronix class 2 product	
DL727, 728, 721 0.5" (2 dig.)	4.31	DL707E	0.85
		DL727E (2 dig.)	2.00
DL747, 750, 746 0.6"	2.82	DL747E	1.80

MHI DISPLAY KITS

MHI707/4 digit 0.3"	7.60	MHI707E/4	4.30
MHI707/6	11.00	MHI707E/6	5.70
MHI727/4 0.5"	9.70	MHI727E/4	5.30
MHI727/6	13.80	MHI727E/6	7.20
MHI747/4 0.6"	11.40	MHI747E/4	7.20
MHI747/6	17.30	MHI747E/6	9.90

Any one or two of the above MHI display kits will interface directly with any of the MHI clock kits

CASES (with perspex screen)

VERO 1. 8" x 5½" x 3"	3.00
VERO 2. 6" x 3¼" x 2¼"	3.00

SOCKETS

24, 28 or 40 pin	0.60
Soldercon strip skts. 50 pins	0.30

BITS & BYTES

74C00 Quad NAND	0.25	MM2102-2 1Kx1 RAM	2.11
74C04 Hex Inverter	0.25	MM2112-2 256x4 RAM	3.08
74C10 Triple NAND	0.25	MM74C920 256x4 CMOS RAM	11.83
74C42 BCD Decoder	0.95		
74C157 Quad Selector	2.25	XX2114 1Kx4 RAM	24.00
74C163 4 bit counter	1.15	MM1702Q 256x8 EPROM	11.90
74C164 PISO register	1.15	MM5204Q 512x8 EPROM	10.95
74C165 SIPO register	1.15	MM2708Q 1024x8 EPROM	31.15
74C173 3S Quad latch	0.95		
74LS139 Dual 2-4 Dec	1.50	EPROM prices for blank devices	
DM8095 3S Hex buffer	1.75	ER3401 1024 x 4 EAROM	28.85
DM8096 Inv 8095	1.75	MM5307AA Baud Rate Gen	12.68
DM81LS95 3S 8 bit buff	1.45	MM5303 (AY-5-1013) UART	6.34
DM81LS96 Inv 95	1.45	Xtal for 5307	TBA
DM81LS97 3S 4+4 buffer	1.45	DM8678 Char Gen	15.20
DM81LS98 Inv 97	1.45	(both CAB & BWF avail.)	

CLOCK MODULES

LT601 Alarm Clock Module, similar to MA1002	6.00
MTX1001 Transformer	0.90

OLDE CLOCKS

In kit form or built these clocks are based on designs hundreds of years old. Wood, stone and iron are used to reproduce authentic "olde worlde" wall clocks in full detail. The kits contain all you need including glue, screws, etc., and very comprehensive instructions. Stones for weights are excluded. For coloured brochure please send 15p stamps

PAYMENT TERMS

Cash with order, Access, Barclaycard (simply quote your number). Credit facilities to accredited account holders. 15% handling charge on goods ordered and paid for then cancelled by customer.
All prices exclude 8% VAT PLEASE SEND 30p POST AND PACKING

BYWOOD

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

electronics today international

SEPTEMBER 1977 Vol. 6 No. 9

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Projects

Data Sheet

News

Information

Offer

EDITORIAL AND ADVERTISEMENT OFFICE
25-27 Oxford Street
London W1R 1RF
Telephone 01-434 1781/2
Telex 8811896

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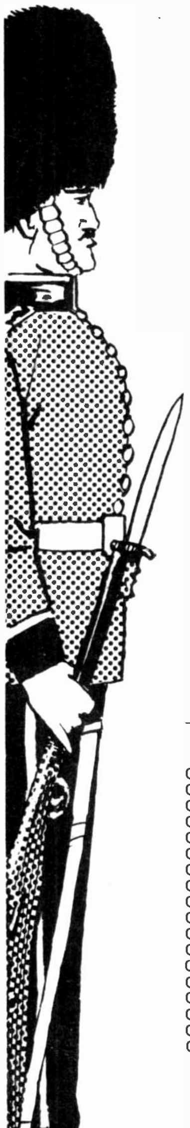


74 SERIES TTL IC'S

Type	Quantity 1 £ p	100 £ p	Type	Quantity 1 £ p	100 £ p	Type	Quantity 1 £ p	100 £ p
7400	0.09	0.08	7448	0.70	0.68	74122	0.45	0.42
7401	0.11	0.10	7450	0.12	0.10	74123	0.65	0.62
7402	0.11	0.10	7451	0.12	0.10	74141	0.68	0.65
7403	0.11	0.10	7453	0.12	0.10	74145	0.75	0.72
7404	0.11	0.10	7454	0.12	0.10	74150	1.10	1.05
7405	0.11	0.10	7460	0.12	0.10	74151	0.65	0.60
7406	0.28	0.25	7470	0.24	0.23	74153	0.70	0.68
7407	0.28	0.25	7472	0.20	0.19	74154	1.20	1.10
7408	0.12	0.11	7473	0.26	0.22	74155	0.70	0.68
7409	0.12	0.11	7474	0.24	0.23	74156	0.70	0.68
7410	0.09	0.08	7475	0.44	0.40	74157	0.70	0.68
7411	0.22	0.20	7476	0.26	0.25	74160	0.95	0.85
7412	0.22	0.20	7480	0.45	0.42	74161	0.95	0.85
7413	0.26	0.25	7481	0.90	0.88	74161	0.95	0.85
7416	0.28	0.26	7482	0.75	0.73	74163	0.95	0.85
7417	0.26	0.25	7483	0.88	0.82	74164	1.20	1.10
7420	0.11	0.10	7484	0.85	0.80	74165	1.20	1.10
7422	0.19	0.18	7485	1.10	1.00	74166	1.20	1.10
7423	0.21	0.20	7486	0.28	0.26	74174	1.10	1.00
7425	0.25	0.23	7489	2.70	2.50	74175	0.85	0.82
7426	0.25	0.23	7490	0.38	0.32	74176	1.10	1.00
7427	0.25	0.23	7491	0.65	0.62	74177	1.10	1.00
7428	0.36	0.34	7492	0.43	0.35	74180	1.10	1.00
7430	0.12	0.10	7493	0.38	0.35	74181	1.90	1.80
7432	0.20	0.19	7494	0.70	0.68	74182	0.80	0.78
7433	0.38	0.36	7495	0.60	0.58	74184	1.60	1.40
7437	0.26	0.25	7496	0.70	0.68	74190	1.40	1.30
7438	0.26	0.25	74100	0.95	0.90	74191	1.40	1.30
7440	0.12	0.10	74104	0.40	0.36	74192	1.10	1.00
7441	0.60	0.57	74105	0.30	0.25	74193	1.05	1.00
7442	0.80	0.70	74107	0.30	0.26	74194	1.05	1.00
7443	0.95	0.90	74110	0.48	0.45	74195	0.80	0.75
7444	0.95	0.90	74111	0.76	0.72	74196	0.90	0.85
7445	0.90	0.75	74118	0.85	0.82	74197	0.90	0.86
7446	0.80	0.75	74119	1.30	1.20	74198	1.90	1.80
7447	0.70	0.68	74121	0.28	0.26	74199	1.80	1.70

Devices may be mixed to qualify for quantity price. Data is available for the above series of IC's in booklet form **Price 35p.**

CMOS ICs

CD4000	£0.18	CD4022	£0.80	CD4046	£0.95
CD4001	£0.18	CD4023	£0.18	CD4047	£0.75
CD4002	£0.18	CD4024	£0.64	CD4049	£0.46
CD4006	£0.80	CD4025	£0.18	CD4050	£0.46
CD4007	£0.18	CD4026	£1.85	CD4054	£0.95
CD4008	£0.80	CD4027	£0.48	CD4055	£1.60
CD4009	£0.50	CD4028	£0.80	CD4056	£1.15
CD4010	£0.50	CD4029	£0.95	CD4069	£0.32
CD4011	£0.18	CD4030	£0.46	CD4070	£0.32
CD4012	£0.18	CD4031	£1.80	CD4071	£0.20
CD4013	£0.42	CD4035	£1.40	CD4072	£0.20
CD4015	£0.80	CD4037	£0.78	CD4081	£0.20
CD4016	£0.42	CD4040	£0.78	CD4082	£0.20
CD4017	£0.80	CD4041	£0.68	CD4510	£1.10
CD4018	£0.85	CD4042	£0.68	CD4511	£1.25
CD4019	£0.45	CD4043	£0.78	CD4516	£1.10
CD4020	£0.95	CD4044	£0.78	CD4518	£1.10
CD4021	£0.85	CD4045	£1.15	CD4520	£1.10

ORDERING

PLEASE WORD YOUR ORDERS EXACTLY AS PRINTED NOT FORGETTING TO INCLUDE OUR "J" NUMBERS.

V.A.T.

ADD 12½% TO PRICES MARKED * ADD 8% TO ALL OTHERS.

POSTAGE AND PACKING

ADD 25p FOR POSTAGE AND PACKING UNLESS OTHERWISE SHOWN. ADD EXTRA FOR AIRMAIL.
MIN. ORDER £1.00.

TESTED TRANSISTOR PAKS

All devices brand new, tested and coded

- **J1** 3 each AC128/AC176
- **J2** 10 off BC107
- **J3** 10 off BC108
- **J4** 10 off BC109
- **J5** 3 each BC148/149-2 BC147*
- **J6** 3 each* BC169/171/172
- **J7** 2 each BC177/8/9
- **J8** 2 each BC182/3/4*
- **J9** 2 each BC212/213/214*
- **J10** 2 × BC327 3 × BC328*
- **J11** 2 each BC337 3 × BC338*
- **J12** 2 each BF115 — BF167 — BF173
- **J13** 2 each BF194/5/6*
- **J14** 2 × BF258
- **J15** 2 × BFX29 3 × BFX84
- **J16** 2 each BFY50/51/52
- **J17** 6 × OC71
- **J18** 4 each ZTX108/9 2 × ZTX107*
- **J19** 2 each ZTX301/2 4 × ZTX300*
- **J20** 2 each ZTX500/1/2*
- **J21** 4 each 2N706/2N708
- **J22** 1 each 2N2218/19/21/22
- **J23** 2 each 2N2904/05
- **J24** 3 × 2N2907 2 × 2N2906
- **J25** 7 × 2N2926 G*
- **J26** 4 × 2N3053
- **J27** 2 × 2N3055
- **J28** 3 each 2N3702/03/04*
- **J29** 3 each 2N3904/06*

PRICE 60p PER PAK

TESTED DIODE PAKS

- **J30** 12 × OA81
- **J31** 12 × OA91
- **J32** 12 × OA200
- **J33** 12 × OA202
- **J34** 15 × IN4148
- **J35** 20 × IN4001
- **J36** 15 × IN4002
- **J37** 10 × IN4004
- **J38** 8 × IN4007
- **J39** 5 × IN5400
- **J40** 5 × IN5401
- **J41** 4 × IN5404
- **J42** 3 × IN5408

PRICE 60p PER PAK

OPTOELECTRONICS

J43	4 × DL707 + Data	£2.80
J44	5 × 125 Red LED	£0.50
J45	5 × 2 Red LED	£0.50
J46	5 × 2 and 125 mixed colours LED	£0.50
J47	3 × ORP12 equivalent	£1.20
J48	5 × OCP71	£1.00

THYRISTOR PAKS

J49	1 amp SCR 2 × 50 volt 1 × 400 volt 1 × 600 volt	£1.00
J50	5 amp SCR 1 × 500V 2 × 400V 1 × 600V	£1.50

UNIJUNCTION/F.E.T. PAKS

J51	6 × TIS43/UT46	£1.00
J52	4 × 2N3819	£0.60

P.C.B. PRODUCTS

J53	2 × etch resist pens	£1.00
J54	2 × etchant paks	£1.00

D.I.Y. PRINTED CIRCUIT KIT

CONTAINS 6 pieces copper laminate, box of etchant powder and measure tweezers marker pen, high quality pump drill, Stanley knife and blades 6in metal rule

FULL easy-to-follow instructions

J59 SALE PRICE £5.50

RESISTOR PAK

J55	240 first quality ⅛/¼w resistors-mixed from 100ohm-820k	£1.60*
J56	160 first quality ½w resistors-mixed from 100ohm-820k	£1.60*

ELECTROLYTIC PAK

J57	54 first quality miniature electrolytics from 47uF-1000uF	£1.20*

CERAMIC PAK

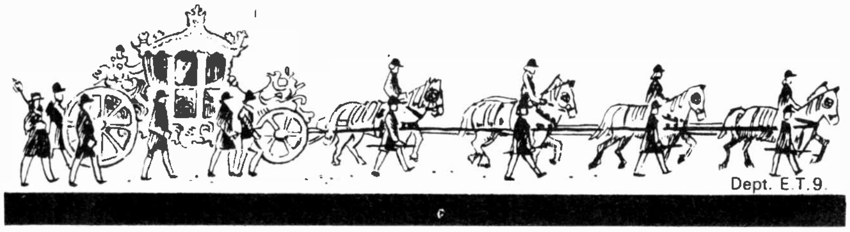
J58	93 first quality ceramic capacitors — mixed from 22pF-047uF	£1.60*

I.C. SOCKET PAKS

J60	11 × 8 pin DIL Sockets	£1.00
J61	10 × 14 pin DIL Sockets	£1.00
J62	9 × 16 pin DIL Sockets	£1.00

ZENER PAKS

J63	20 mixed value 400 mw zener diodes 3-10V	£1.00
J64	20 mixed value 400 mw zener diodes 11 33V	£1.00



Dept. E.T.9.

BI-PAK

P.O. BOX 6, WARE . HERTS

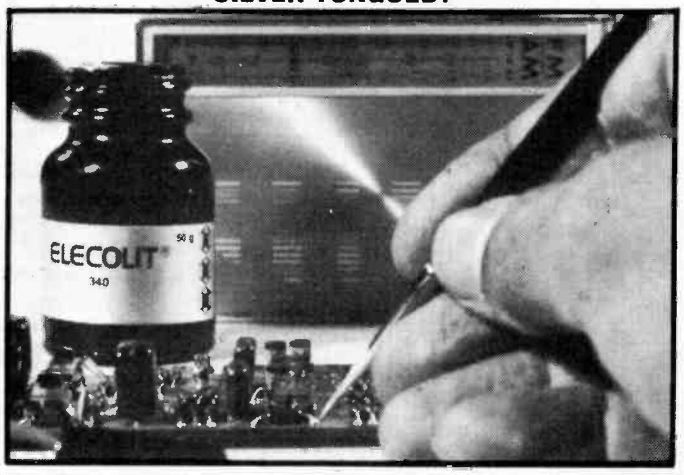
SHOP AT 18 BALDOCK ST., WARE, HERTS. OPEN 9 to 5 30 Mon/Sat

news digest

A CASE OF BEING GAME

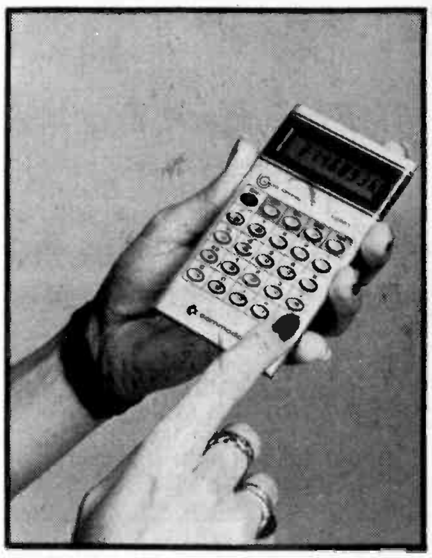
Videomaster have had the rather neat idea of putting their superscore T.V. Game into its proper perspective - boxed with all accessories. Called the Compendium, it is now sold complete with a very neat pistol, mains pack and hand controllers. Should be in your local stores about now. Price around £60.
VIDEOMASTER LTD., 14-20, Headfort Place, London. S.W.1.X. 7HN.

SILVER TONGUED?



After five years of selling to industry, Industrial Science Ltd., are now introducing ELECOLIT 340 into the consumer electronics market.
ELECOLIT 340 is a pure, silver filled, electrically conductive acryllic paint. It exhibits excellent con--ductivity because of the pure silver and enviromental protection due to its acryllic base. ELECOLIT 340 sets by solvent evaporation similar to most good lacquer systems. It forms a tough film with good adhesion to ceramics, glass, rubber, plastic and most plastic films.
Typical applications include R.F. shielding, printed circuit repair, use as a conductive ink, prototype circuit manufacture and one of the most interesting and unusual applications of all which is to repair the rear window demister of a car by means of painting over the existing track which may have either broken or shorted out.
Although ELECOLIT 340 is air drying, conductivity CAN be improved by heating and typical volume re--sistivity figures are 0.001 chm-cm. when cured at room temperature.
The shelf life is a minimum of 1 year in a closed container, and the operating temperature of ELECOLIT 340 is from - 60 degrees centigrade to +175 degrees centigrade.
Industrial Science Ltd., Leader House, 117-120 Snargate Street, Dover, Kent.

DIGITS ON A DIET



Made to slip into a pocket or handbag, this new CBM LCD calculator is only 1/4inches thick. Called the LC5K1 - and obviously aimed at the female half of the human race, the case is a nice 'posh' brushed beige metal. Based on a 3 volt CMOS chip, its power consumption is very low, giving the battery an anticipated life of 5,000 hours. (This means that if you left it on accidentally, it would still be work--ing seven months later - handy if you're prone to a long unexpected illness!).
The LCD display allows the figures to be seen even in strong sunlight, and the machine has the arthmetic functions plus square root, percentage and 4-key memory.
It is available at the RRP of £14.95.
CBM, 446, Bath Rd., Slough, Berks. SL1 6BB.

GETTING 10 BITS ON THE SIDE?

Precision Monolithics have announced two complete single chip mono--lithic 10-bit D/A convertors. The LAC-05 is a 10-bit plus sign DAC with a logic controlled polarity switch and the DAC-06 is a Two's comple--ment coded version with a bipolar offset circuit. Both devices have a voltage output, precision reference, R-2R resistor ladder network and a high speed (1.5uS settling time) output op amp included.
(Trimpot) Limited, Hodford House, 17/27, High Street, Hounslow, Middx. TW3 1TE.

HARVEST OF A QUIET EYE

BY ALAN MACKAY
EDITED BY MAURICE EBISON
PUBLISHED BY THE INSTITUTE OF PHYSICS.
PRICE £5.20

As a non technical member of the ETI staff, this lovely book would, I felt sure supply me with much needed ammun--ition against the dedicated ETI boffins.

(George Phillip (air vice marshal) Chamb-erlain 1905)

Boffin: A Puffin, a bird with a mournful cry, got crossed with a Baffin, a bird of astonishingly queer appearance, burst--ing with wierd and sometimes inoppor-tune ideas, but possessed of staggering inventiveness, analytical powers and persistance. Its ideas, like its eggs were conical and unbreakable. You push the unwanted ones away, and they just roll back

It's an eclectic compilation of quotes either by scientists, or appertaining to science and technology, happily Alan Mackay has decided to include graffiti in his selection. Thus:

'God is not dead: He is alive and well and working on a much less ambitious project.'

The quotations are arranged alphabet--ically by author and are numbered seperately on each page. The indispens--able 'first line' index is at the back. Personally, I can't wait to try some of these out. Sooner or later there's going to be the perfect opening for my favourite (after the second pint in the ETI local?)

'There are three roads to ruin; women, gambling and technicians. The most pleasant is with women, the quickest is with gambling, but the surest is with technicians'.

Would I have joined ETI if a kindly Uncle had let THAT one drop before I took the plunge?

The historical and cultural scope of the quotes in the book could not be wider, ranging from Thomas Aquinas to Nietsche to Lao Tzu, and from the flip to the profound. Whatever is YOUR particular hobby horse or hive of bees in the bonnet, there's a nicely primed verbal grenade ready for you to toss into the converasational battlefield.

Or is there?

Ralph Waldo Emmerson

'I hate quotations, tell me what you know'.

Well.... I know very little of electronics so I suppose I'll have to go on feeling like Alice;

'Can you do additional?' The white queen asked. 'What's one and one and one and one and one and one and one and one and one and one?'

'I don't know' said Alice 'I lost count'

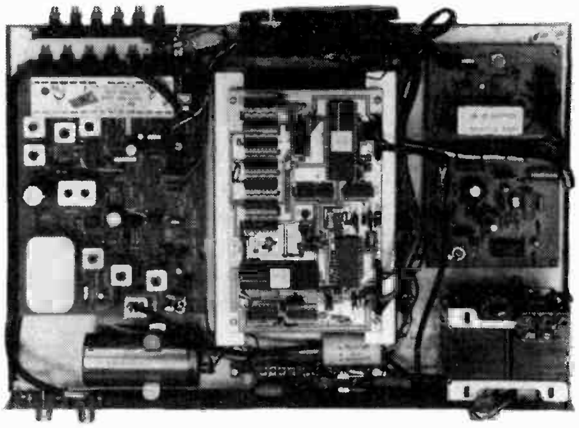
DAVID LAKE

BUBBLING OVER

Next year Rockwell are hoping to launch their now developed one--megabit bubble memory price? One millicent per bit!

Their device can operate up to 300kHz and measures 10 x 9.5mm and is designed for a 1.8 microm bubble diameter.

"PLUG IN TEXT"



A new reasonably easy to build kit has been produced for telextext decoding of the BBC's Ceefax and ITV's Oracle that plugs into the back of your set. Based on the Texas Tifax module. Manor Supplies have produced a kit that will allow those without the technical knowledge (or courage) to try direct modification of the £400 colour telly to pick up Teletext. The unit has its own tuner and i.f strip (prealigned) and after decoding the signal is remodulated to an unused channel. This format leads to a certain amount of colour degration of Teletext signals but on the set we saw was very acceptable. Rental companies will be much happier if you don't start rewiring their sets too! The unit has all the usual Tifax capabilities plus Teletext reversed out on the normal vision picture.

The kit will be £218. Manor Supplies, 172 West End Lane, London, NW6 1SD.

SOUNDS VANDALOUS!

Apparently electronic cigarette lighters are causing the manufacturers of these new fangled one armed bandits to get a little hot under the collar,

Some bright spark has figured out that that the electrical interference caused by striking these implements can cause spurious readings within the machine, and result in it paying out.

This latest show of British ingenuity has been dubbed 'Malicous Noise' by the flaming-mad manufacturers, and steps are being taken to defeat it.

In the main this consists of switching to MPU's.

All this has come to light because of an amazing difference in what works on a test bench and what is reliable in an enviroment such as fruit machines are liable to meet. One firm, Marian Electronics, cites the case of a Liverpool dockside pub. (Never a place for the faint of heart or incompetant knife-throwers).

A machine here will turn over £150 per week, but it is VERY likely to be subjected to 'Malacious Noise'.

Should it fail to pay-out at the correct time however, experience shows it will meet with anything from kicks to iron bars! On one almost poetic occassion a relluctant machine was bodily lifted from the bar by intoxi--cated dockers and given a seamans burial in the closest portion of the Irish Sea!

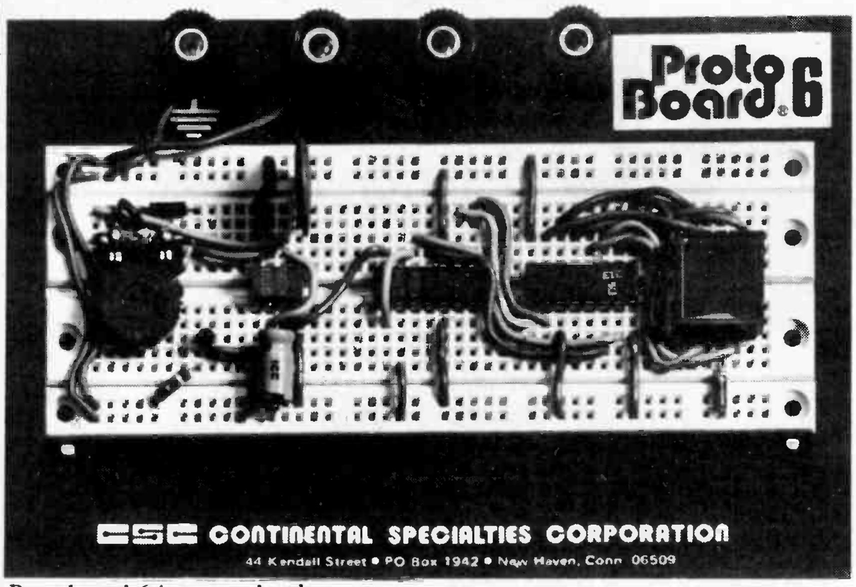
Those of you have ordered anything from Marshalls and have not yet received it — have patience! Mar-shalls have been trapped by the infamous Grunwick dispute, and are having severe postal difficulties. (To put it mildly!) They are doing their best so please — give them a chance. Don't forget that Marshalls do run a mail-order service from their Glas-gow and Bristol branches as well as Cricklewood Broadway, and these will be happy to process your orders.

WATCHES FACE COLLAPSE!

Five companies have dropped production of digital watches, due entirely to the price war raging around the product. Gruen, Benrus, Armin Litronix and Gillette have decided the wrist borne digit is not for them.

Those still there are sufferin too. Bulova are expected to make a loss this year. Gillette in fact pulled out before they pulled in, scraping well laid plans to burst into the 'marketplace' at the eleventh hour.

LESS BREAD MORE BOARD?



Protoboard 6 is a new development from the USA. At £10.45 Protoboard is claimed (by its manufacturer, who else?) to be the lowest priced bread-board kit available today. It holds 6 14-pin IC's for basic testing and building applications,
PB-6 includes one QT-47S socket - size 5 x 94 contacts, two QT-47B bus strips size - 2 x 40 contacts, four 5-way binding posts, a metal ground and base plate with rubber feet.
Available from: Continental Specialties, 44, Kendall Street, P.O Box 1942, New Haven, Connecticut, USA.

BIG BANDS!

The MC4558 and MC4558C dual operational amplifiers are, bandwidth excepted, performance and package compatible with the 'industry standard' MC1558/MC1458. Unity-gain band-width is increased to 2.5 MHz
MOTOROLA LTD., Semiconductor Products Division, York House, Empire Way, Wembley, Middlesex, HA9 OPR.

MEMORIES ARE MADE OF THIS

Aimed at the bulk memory market such as drum and disc, the MOS/CCD products division of Fairchild Camera and Instrument Corporation has a 65,536-bit CCD block addressable memory developed.
Typical data range is 5MHZ, with average latency of 400 micro-seconds. Power dissipation is less than five microwatts per bit in active mode and less than one microwatt in standby. The device is packaged in a standard 0.300 inch 16-pin DIP, and is the densest semiconductor memory now available.
The device, which will be available shortly in the UK, will cost around £70 (one off). 100-up quantity prices will be significantly less.
Fairchild Camera & Instrument (UK) Ltd., 230, High Street, Potters Bar, Herts. EN6 5BU.

A PICTURE OF SILENCE

The BBC has developed, and is currently testing, a digital signal-processing system designed to reduce the amount of noise transmitted with television pictures. Random video noise is usually seen on viewers' screens as a moving 'crainy' background and most of it is usually generated within the receiver, but some noise is inevitably transmitted with the picture, varying in level from source to source. The new equipment is designed to alleviate the effects of this TRANSMITTED video noise.
The BBC noise reduction equipment is the first to be successfully used with the PAL colour television system, and some formidable problems had to be overcome in achieving a satisfactory design. During recent trials, which have proved very succ--essful, the equipment has been used on a wide variety of programme material transmitted on both BBC-1 and BBC-2. Over a period of ten days about fourteen hours of live and recorded programmes were processed; these included a Silver Jubilee concert transmitted from the Royal Albert Hall where the difficult lighting conditions led to rather noisy pictures which were greatly improved by noise reduction processing.
The new system, uses a television picture store in a recirculating mode, so that many successive television pictures are added together. The effect of this operation is to reduce noise by integration. The wanted picture detail, being present on every picture, is reinforced relative to the noise, which is random, However this technique cannot be applied to areas of the picture containing rapid movement, because integra--tion of successive pictures would result in smeared images of moving objects. An additional problem is that the colour subcarrier would be reduced along with the noise because it is transmitted in a sequence of eight television fields.
Patent applications have been filed.

TOYING WITH THE IDEA!

A firm in America has produced a two inch solar cell to power toys instead of batteries. According to the firm, Solar Technology, a single cell will power most toy trucks etc in sunlight, and can be used to re charge cells for indoor use.

I'M SORRY I'LL PRINT THAT AGAIN

Tachometer:- July, 1977
Capacitor C2 should be 56n.
Formula for calibrating in conjunction with an amplifier should read
f = 2M/60.

Soil Moisture Indicator:- August, 1977
On the circuit diagram resistor R5 should be 100R as shown in parts list.

SYSTEM 68 VDU:- We are aware of the errors which are present on the PCBs for this project. A FULL list of these is being published on page 26 of this months System 68 article. Our thanks to those readers who drew our attention to these initially.

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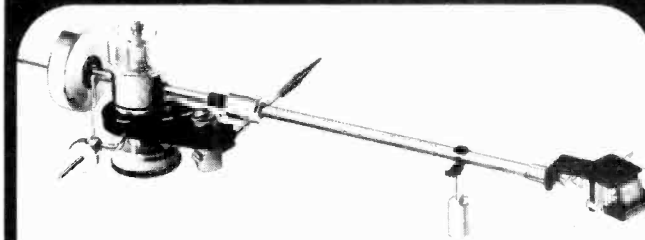

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'my Shure V15/3 has never sounded better, superb arm, speakers suddenly in phase.' *C. Tchalekian, Canada*
'using Sonus Blue Label the sound was best of all by a very wide margin over the finest other arms tried.' *R. S. Golombeck, USA*
'finest tonearm to date with ADC XLM Mk. 2 and SUPEX MMC' *Louis Kalamaras, USA*
'World's best tonearm, makes a Decca track (that ought to be enough)'. *Audiogram, USA*
'JVCX-1 fitted at last someone has designed a pickup arm complementary to the best cartridge available.' *B. B. Collyer, London*
'more listening pleasure than with any other tone arm used Stanton 681 EEE ADC 26 and Fidelity Research.' *Au Chu Chung, Singapore*
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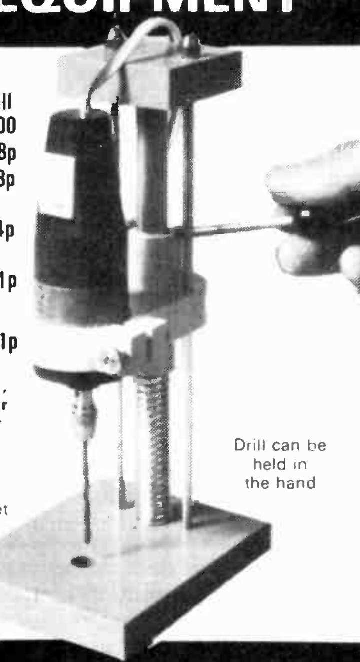

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The 'Bucket Brigade' are marching on the audio world, but what are . . .

CHARGE COUPLED DEVICES

Mark Sawicki considers this new technology

CHARGE COUPLED DEVICES represent a new and rapidly developing area of monolithic integrated circuit technology and are basically intended to delay analogue signals.

The principle is that CCD operates as a monolithic shift register, and is commonly referred to as 'Bucket-Brigade'. (The reason being that their operation is analogous to a chain of firemen passing buckets of water from hand to hand.)

In CCD 'buckets' correspond to the IC's capacitors and 'water' corresponds to the electric charge — being the analogue sample of an applied waveform. CCD IC's were first introduced by Philips Laboratory back in 1968, and the first papers dealing with this innovation were published by 'Philips Technical Review' and also in the 'I.E.E.E. Journal'.

The basic structure of the MOS CCD is shown in Fig. 1.

Early bucket brigade analog delay lines had many shortcomings with problem number 1 being poor transfer efficiency, (the amount of charge left behind decreasing at each transfer). In the early 70's these devices were improved at Philips with the introduction of a "tetrode" structure with a DC biased gate separating each clocked element from the next one as shown in Fig. 2.

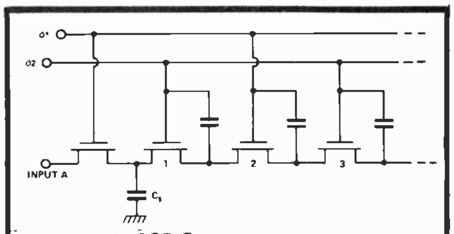


Fig. 1. Basic CCD Structure

The performance of this new structure was enhanced because these tetrodes in effect, reduced the MILLER capacitance (an analogy can be made to a tetrode grid in a vacuum tube).

Charge to couple

Simultaneous research was undertaken at Bell Telephone Laboratories who in turn produced a successful inovation of a CCD possessing much better performance than the old CCD The improved principles of operation and specific structure, were first published by W. S. Boyle and G. E. Smith.

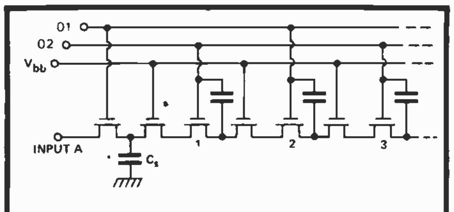


Fig 2. Philips improved tetrode structure.

The first steps in the development of CCD concentrated on general structure technology as well as processing techniques. The Reticon research team came up with many interesting ideas such as:

1. Self-aligned structures reducing parasitic capacitance and improving specific efficiency.
2. A decrease in substrate resistivity helping to minimise the sensitivity to voltage as well as clock wave shapes, with a very important reduction of the conductivity modulation of the region under the transfer gate. This has a general influence on specific transfer efficiency.
3. They felt that modern CCD structure should have the advantages of a high resistivity basic substrate for reduced junction capacitance but without any effect on modulation.
4. The idea that the ion implantation could be used to control thresholds so that N channel devices would become feasible, with the advantages of higher speed and transfer efficiency.

Bearing in mind point 4 as far as audio delay is concerned, the comparison of transfer efficiency for both N as well as P channels is shown in Fig. 3.

Table 1 gives a summary of the performance of some of these devices.

Practical Applications:

For amateur purposes, most of these devices are far too expensive. However, the Reticon SAD 1024 and 512D are very reasonably priced for the performance offered. (The SAD 1024 is easily obtainable, e.g. Herbert Controls and Instruments Ltd, Spring Road, Lethworth, Herts.)

The most important features of CCD for application as an audio delay lines are:

1. Wide bandwidth with flat frequency response
2. Large dynamic range with a good stability margin
3. Simplicity of practical applications and low cost

Until recently, the only delay system available for musicians and constructors was the electro-mechanical type (tape/spring). The spring type reverberation units reached a very high level of popularity thanks to their much lower production costs when compared

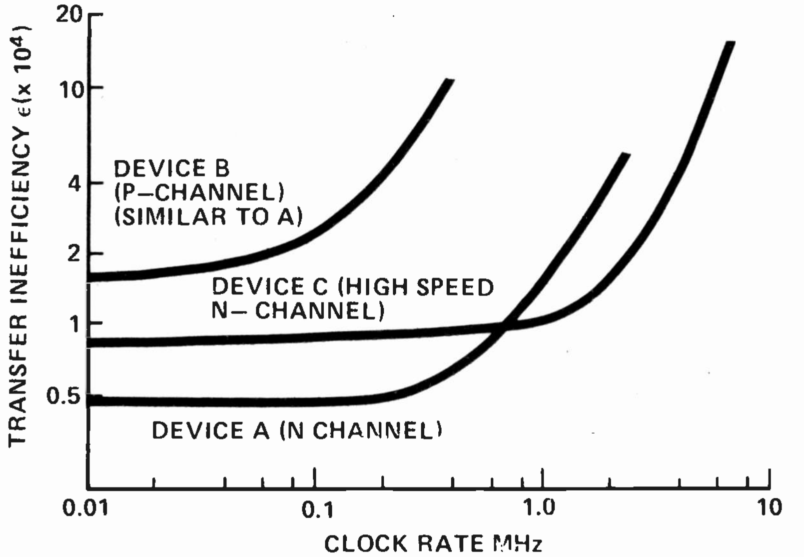


Fig 3. Transfer efficiency for both types of CCD, plotted against clock rate i.e. audio delay.

TABLE 1
PRODUCT SUMMARY ANALOG MEMORY PRODUCTS

	Tapped Analog Delay TAD-32	Audio Delay SAD-1024	Audio Delay SAD-512D
Maximum Sample Rate (f.)	5 MHz	1.5 MHz	1 MHz
Typ Retention Time (1% Loss, 25°C)	40 ms	200 ms	200ms
Aperture Time Jitter	< 20 ns	< 20 ns	< 20 ns
Signal/Noise ratio	60 db	70 db	70db
Distortion (Total Harmonic)	1%	1%	1%
Evaluation Circuit	TC32	SC1024	SC512D
Delay in-puts (Sample Periods)	1 to 32	512	256
Readout	Destructive	Destructive	Destructive
Package	40 pin DIP	16 pin DIP	16 pin DIP
Analog Signal Bandwith (Single Pole 6 db)	2 MHz	200 KHz	200KHz
Typical Applications	Discrete-time filters, Transversal filters, Recursive filters, Reverberation effects, Correlation, Pattern recognition, Active filtering	Analog time delay, Reverberation effects, Time-base correction, Transient recorder, Generate trace for oscilloscope, Flanger and audio effects	Low-cost audio-effects, Reverberation, Delay equalizer, Vibrato, Variable speed control

A summary of some of the most important parameters of the CCD devices discussed in this article and made by Reticon. The characteristics of the Mullard devices are given in Table 2 overleaf.

with tape units but both these types just *cannot* withstand CCD competition!

Electro-mechanical delay lines have many limitations and one of them as far as the spring type reverberation unit is concerned, is 'microphonic' distortion which causes unwanted 'metallic voice' and very often something worse — acoustic feedback.

Spring type reverberation systems are so delicate that they require quite a complicated suspension drive which can sometimes produce strange resonances and other uncalled for effects.

Employing CCD to produce synthetic reverberation with multi reflection paths is one of the major SAD 1024 applications. The basic block diagram is shown in Fig. 4.

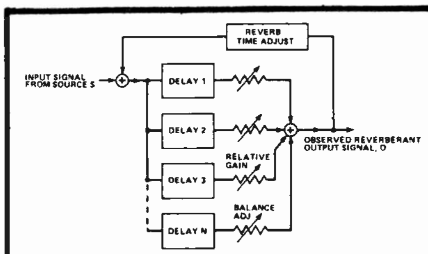


Fig 4. Reverberation achieved using CCD circuitry.

Differing path lengths are arranged using different delays. Specific attenuation in a path represents acoustic absorption loss which, by its adjustment, allows for the overall control of delayed reverberation time.

Audio reverberation is generally speaking the build-up of sound(s) in an enclosed space, at the same time as the direct result of the addition of sound components from simple/-multiple reflected pencils/rays of sound returned from the reflecting surfaces.

Reverberation time is defined as the time for the sound to decay (usually exponentially) to one-millionth of its initial energy level, a level of 60dB down. For single closed-loop paths this can be explained by a simple formula:—

$$T = 60 \frac{t}{\propto} \quad \text{(seconds)}$$

where: T = reverberation time in seconds

where t = time delay in seconds for one passage

$\propto$ = attenuation (in dB)

This relationship results in the following conclusions:

1. Shorter reverberation time T can be produced by introducing greater attenuation or shorter delay.

CHARGE COUPLED DEVICES

2. Longer reverberation time T requires longer path delay or less attenuation.

Also note that a 10 milliseconds delay corresponds to a room path length of less than 10 feet for one trip:

Stables bolted

As one of the most important problems is maintaining the stability, it is preferable to use relatively long delays with higher values of attenuation.

Coming back to Fig. 4, the O/P power is increased approximately in proportion to the number of paths N, with an overall system gain of 10 log N (dB), thus additional paths are added to maintain the same total reverberation time. In audio practice many parallel delay paths are required to simulate a 'real' reverberant room with a minimum number of four.

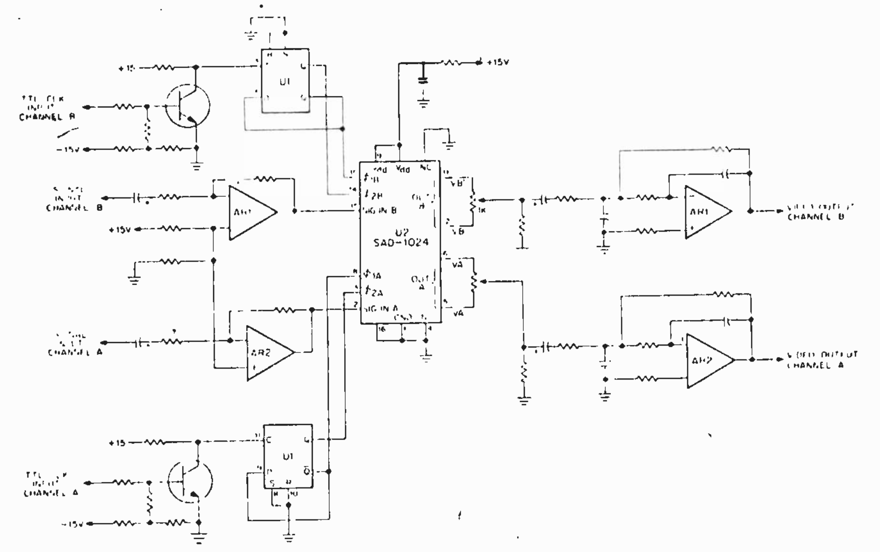


Fig. 5. This is the circuitry Reticon recommended for evaluation of the 1024 device. A PCB is available containing this circuit ready-built. All necessary facilities, i.e. clock buffering etc. are provided.

Reticon SAD 1024 CCD

For evaluation (and some applications) Reticon developed their SC 1024 Evaluation circuit. The basic design is presented in Fig. 5.

This circuit provides all the necessary buffering, power supply, input bias, TTL — clock input and input/output facilities. (Practically independently for both 512 stage halves of the device too.)

The SAD 1024 uses a single 15 volt power supply, input bias of +6 volts, and because of the existence of op-amps in this circuit, 0, ± 15 volts.

Analysing one section only of this evaluation circuit (Fig. 5), let's set the TTL clock input at a frequency input of 200 kHz and the audio signal input to a single sinusiodal tone at 5kHz. The SAD 1024 requires a "two-phase" signal 01 and 02 as the clock drivers are complementary pairs of associated waves. This is done by dividing the 'virgin' clock input rate employing both sections of 'flip-flop' chip. As the input was 200kHz dividing this by two gives waveforms of 100kHz rate with a 10μ sec. period.

Assuming that 01 is "high" the input N channel MOS transistor applies signal input A to C_s, the relevent op-amp (AR_2 in fig. 5) inverts the input signal, and superimposes it on an (approximate) 6 volt bias.

Meanwhile 01 changes its state to "low" and the input voltage level is charges the storage capacitor (C_s in Fig. 2). As 02 is at this moment "high" a connection between C_s and the first bootstrap capacitor of the output of Cell no. 1.

Cell no. 1 now accepts acharge from C_s and clock 01 goes "high" (02 — low) passing our charge to the next exchange cell. This completes one full cycle.

Cell locks

The SAD 1024 is built from 512 cells (in one section) with a clock frequency of 200 kHz as an example, the input signal appears at output after a 2.56 millisecond delay. Both outputs are connected to a 11 k balance potentiometer thus providing a summed signal with a continuity over the full clock period. Note that the output signal, and 02, in channel A, both cover the whole length of the cycle.

Finally, the output op-amps (AR_1/AR_2) invert the signal, and smooth the "stair-steps" discriminating against residual clock glitches.

The 512 stages of SAD 1024 are available separately under the commercial name of Reticon SAD 512.

Mullard TDA 1022

The TDA 1022 is a MOS monolithic integrated circuit with an internal structure and pin identification as shown in Fig. 6.

This particular device contains 512 stages and with the clock frequencies ranging from 5 kHz-500 kHz will produce a time delay from 51.2-0.512 m.sec.

The package is a 16 lead plastic dual-in-line and amongst its many applications are:-

Variable delays of analogue signals, E.Q. — speech delay in P.A. systems, instruments: Vibrations / chorus / echo effects / reverberation.

Variable compression / expansion of speech in tape-recorders.

Specifications of the device are shown in Table 2.

Last year during the 9th International Exhibition of APRS 76 (International Association of Professional Recording Studios), the MANTIS Echo Unit from Carlsbro sound equipment was presented. This employs in its construction eight Mullard TDA 1022s.

The MANTIS construction is a commercial example of successful TDA 1022 application, and as seen in this case several TDA 1022's work in a series configuration. A practical diagram from the Mullard Application Report (Ref. 6) shows a completed circuit using 2 CCD's. Fig. 7.

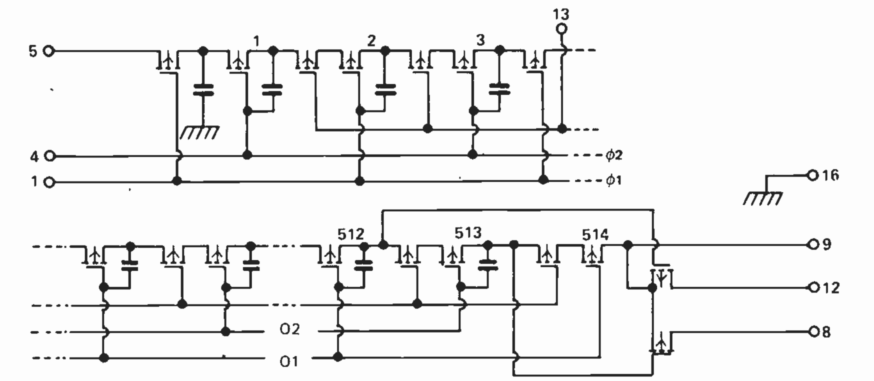


Fig 6. Internal circuitry of the Mullard TDA 1022 Bucket Brigade chip. The pin functions are as follows: Clock input (V_{CL2}). 2. NC. 3. NC. 4. Clock input (V_{CL2}). 5. Signal input. 6. NC. 7. NC. 8. Output 513. 9. V_{DD}. 10. NC. 11. NC. 12. Output 512. 13. Tetrode gate. 14. NC. 15. NC. 16. Ground.

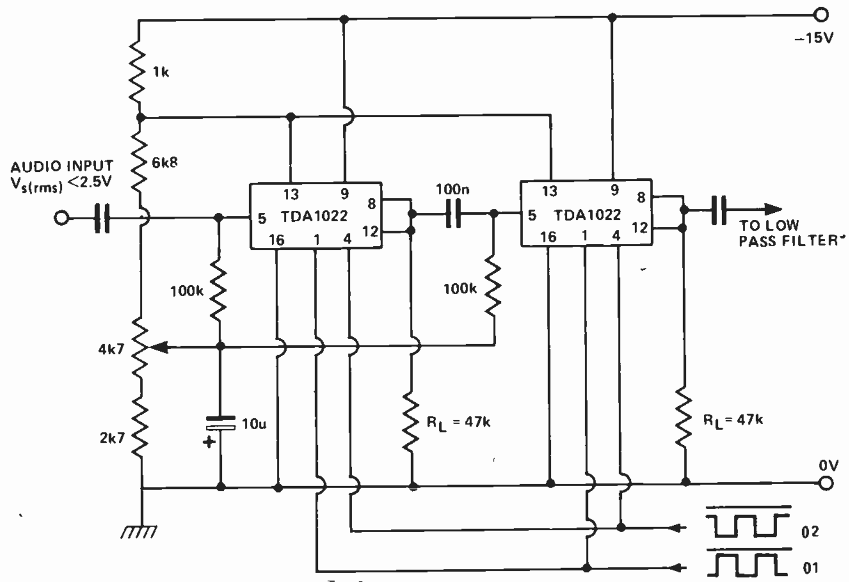


Fig 7. A Mullard circuit for general purpose use of the TDA 1022. Here two units are connected in series to obtain a longer delay time between input and output. No clock circuitry is shown.

Supply voltage (pin 9)	−15V
Clock frequency	5 ÷ 500 kHz
Number of buckets	512
Signal delay range	to 0.512 m.s
Signal frequency range	to 45 kHz
Input voltage (at pin 5) /peak-to-peak value/	typ. 7V
Line attenuation	typ. 4dB
Output current	0 to 5mA
Signal input voltage at % o/p voltage distortions (r.m.s.)	2.5V
Noise o/p voltage (r.m.s.) with f4 = 100 kHz	typ. 0.25mV
Signal/noise ratio at max. o/p voltage	typ. 74dB
Load resistance	> 10 Kohms typ. 47 Kohms

***TABLE TWO:** Specification for the Mullard TDA 1022 Charge Coupled Device.*

Clock Oscillators for SAD 1024 and TDA 1022

Both CCDs reviewed here are pure analogue "clocked" devices and require a relevant incorporated oscillator facility. As far as TDA 1022 is concerned, up to 10 chips can be operated with the system configuration recommended by the manufacturer and shown in Fig. 8.

The circuit consists of an all IC clock oscillator capable of generating the frequency O/P signal from a range of 5-500 kHz by suitable choice of components, and a BC 327/337 driver system.

Power requirements are standard (0 ± 15V) and any choice of frequency (see Table 3) is simple using easily obtainable components. Clock pulse rise/fall time is better than 100 ns.

f kHz	C	R kΩ
5	8n4	10
10	3n9	10
30	1n3	10
100	330 p	10
300	68 p	10
500	30 p	10

***TABLE THREE:** Setting the clock frequency for the TDA 1022 by selecting component values. R and C are referred back to Figure 8. Altering this changes f as shown above.*

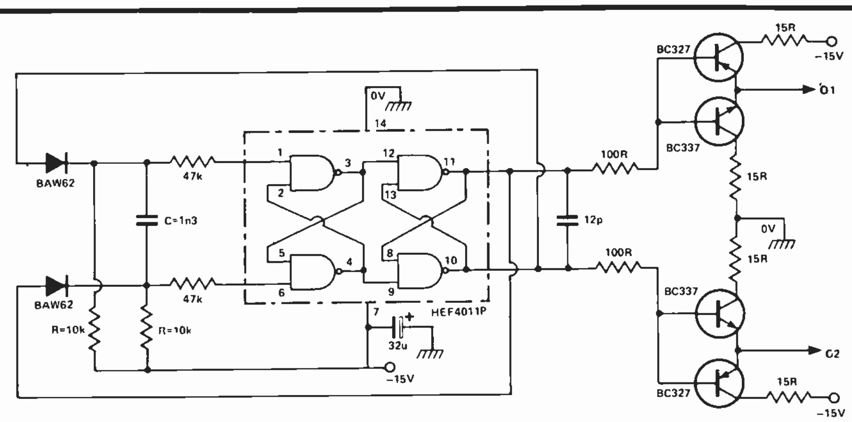
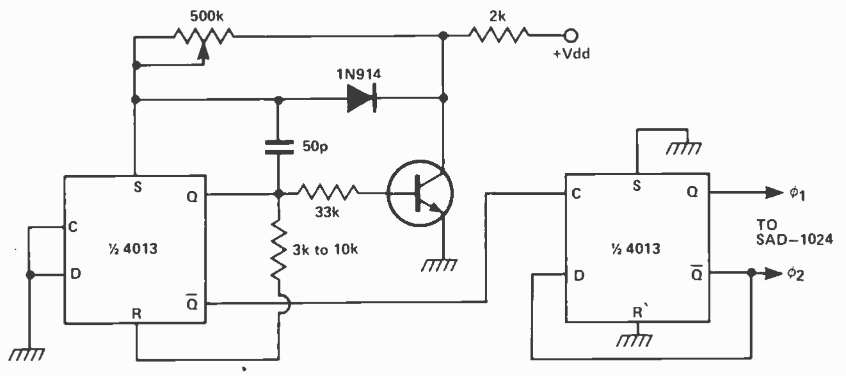


Fig 8. A fairly sophisticated clock driver circuit for use with the Mullard TDA 1022. This configuration will drive up to 10 CCD chips, and provides both O1 and O2

Returning to the Reticon SAD 1024 or SAD 512, the manufacturer's data contains two simple clock constructions (Fig. 9) recommended when using these Bucket Brigade devices. The first one is based on an IC400 and is simple in design with a variable frequency adjustment using a 250k potentiometer.

The second variable frequency clock generator is slightly more sophisticated and consists of a 4013 IC and a single NPN transistor. Both halves of the 4013 are coupled in series producing the required clock signal and dividing the waveform into the complementary train of pulses. A single 500k lin potentiometer acts as the frequency adjustment element.

CHARGE COUPLED DEVICES



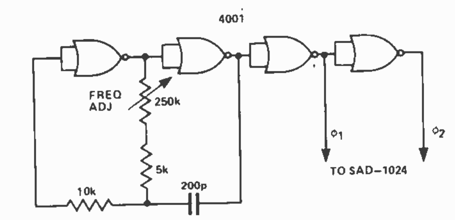


Fig 9. The two Reticon clock oscillator circuits. Both will work satisfactorily, and provide variable clock frequency. The simpler of the two (left) is O.K. for general use, and the top one is to be recommended for more exacting work.

Acknowledgements to Herbert Controls, Mr. Andy Longford, and Mullard's Technical Information Department for providing information, data, technical papers and other significant contributions. ●

REFERENCES

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STEREO SIMULATOR

Make more of mono with this ETI project team design

IF YOU ARE a member of that illustrious band — the hi-fi enthusiast — read no further. The suggestions contained below are not for your eyes.

If, however, you are a normal human being who wants to get as much fun out of life as possible, read on.

The stereo simulator is designed to take a mono signal, from a mono cassette recorder or, via an isolator please, your TV set, and turn it into a pseudo stereo signal.

It does this by splitting the input into two signal paths and then filtering each signal. The high frequencies are fed to the left input of your stereo amplifier and the low frequencies to the right hand channel.

While this may not sound too exciting, we here at ETI were amazed at the extra *something* this circuit added to many different types of music.

Now they say that one picture is worth a thousand words (hence all the lovely pictures in ETI) and we are sure that somewhere, someone, sometime has said the same sort of thing about sound (no not a picture, silly), so if you want to appreciate the effect of our stereo simulator, please build it and try it. We think you will be amazed too.

Picking Up The Pieces

The circuit should be assembled according to our component overlay. Make surè the quad op-amp is correctly positioned before soldering. The input lead from SK1 was earthed at both ends but the leads to SK2 and SK3 should only be earthed at the socket end (to prevent earth loops). Current consumption should be about 2.5mA per battery. The power supply switch, SW1, was a double pole switch to switch both supply batteries, the common of the batteries being 0V.

HOW IT WORKS

The circuit is based on two second order filters built around IC1(b) and IC1(d).

IC1(b) is a low pass filter with component values chosen to give a break point of about 2kHz ICI(d) is a high pass filter with, again, a break point of 2kHz.

Thus the output at SK2 will consist of the low frequency portion of the input (bass) and SK3's output will consist of the high (treble) portion of the input signal.

The mono input from SK1 is fed via unity gain input buffers to each filter element. This is to avoid loading the filters which might degrade their performance.

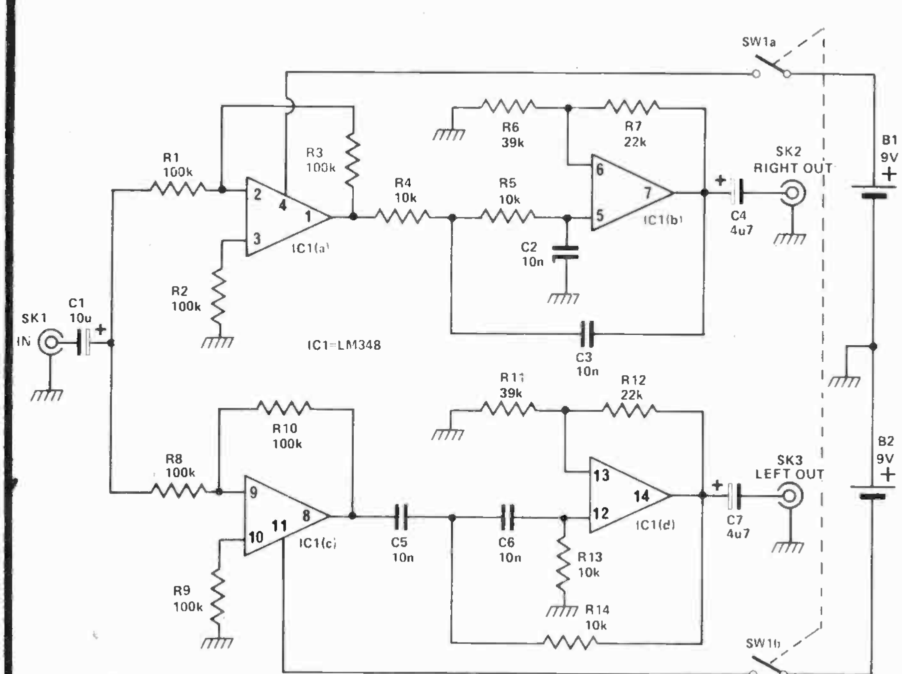
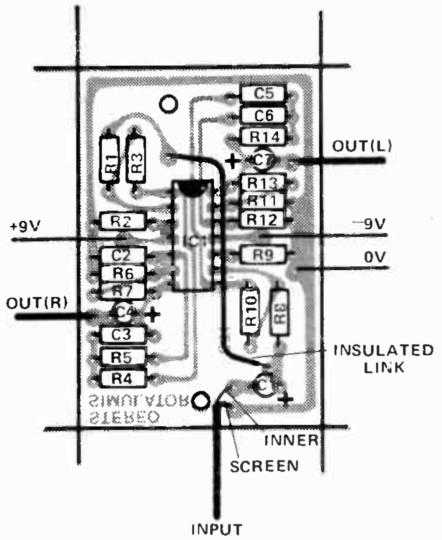
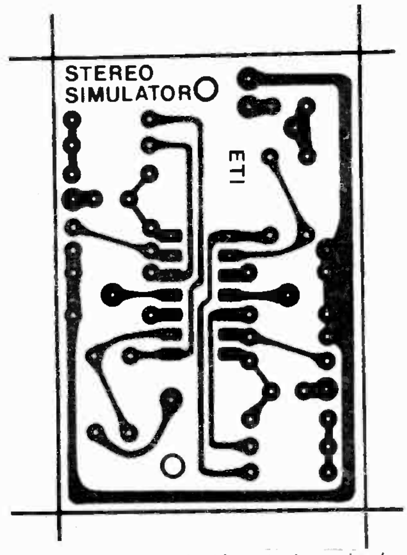


Fig. 1. Circuit diagram of the stereo simulator.





Shown full size (60x40mm) above is the foil pattern for the stereo simulator. To the left is the component overlay.

PARTS LIST

RESISTORS (all ¼ W 5%)

R1,2,3,8,9,10	100k
R4,5,13,14	10k
R6,11	39k
R7,12	22k

SEMICONDUCTOR

IC1	LM348 quad 741 op amp

CAPACITORS

C1	10u 16V electrolytic
C2,3,5,6	10n polyester
C4,7	4u7 2V electrolytic

SOCKETS

SK1 ,2,3	Panel mounting phono sockets

SWITCH

SW1	Double pole on-off, slide or toggle

CASE

Norman: Type AB9

MISCELLANEOUS

P.C. Board as pattern, nuts bolts, spacers etc. single screened wire, flex
Two 9V batteries and clips

BUY LINES

The only component that may be difficult to obtain is the LM 348. This device is however available from Marshalls at 40-42 Cricklewood Broadway London N.W.2 at £1.62.

The cost of constructing the project is about £4.50.

Playing The Part

Connect up the stereo simulator to your stereo amp and to a mono signal source. The effect of the circuit can be modified by use of the amplifiers tone controls (giving a sort of width control) and the balance control.

Have fun.

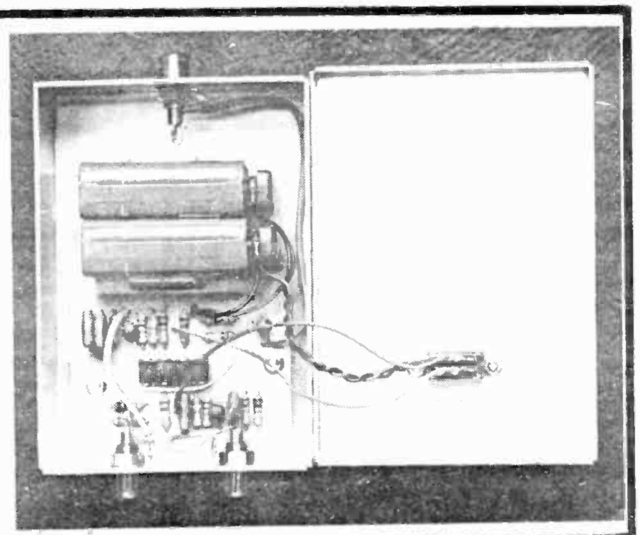


Fig. 2. Interior view of the stereo simulator showing the compact layout obtained when using the LM348 quad op-amp.

A mains transformer is often the single most expensive item in a project — H. E. Clayton of Reading Windings takes a close look at this often neglected item.

TRANSFORMERS ARE USED to increase or decrease either an AC voltage or an AC current level.

All transformers change both AC current and voltage levels simultaneously, but no transformer significantly changes power levels, as the input power equals the output power plus losses which are in general, negligible. Transformers can also be used to transform impedance from one level (in the primary circuit) to another level in the secondary circuit, the impedance transfer ratio being the square of the transformer turns ratio.

It is often possible to use transformers in the opposite mode to that for which they were designed e.g. by feeding into the secondary of a step down transformer and using it to step up in voltage. This will, however, usually give an output voltage below the rated value because the turns ratio is normally made less than the rated transformation ratio to compensate for voltage drops in the windings.

Power transformers can usually be operated at frequencies higher than that for which they were designed, e.g. a 50Hz transformer can be used at 60Hz, but not vice versa.

What we want is . . .

Before deciding on a transformer for a particular application, it is helpful to list one's requirements and to have some idea of what options there are it is hoped that the following outline will help.

RMS input voltages and supply frequency: In addition to the nominal input voltage the maximum value to which this can rise should also be considered. Most transformers will operate satisfactorily at about 6% overvoltage for short periods of time but if it expected to exceed this figure it is advisable to increase the rated input voltage. Primary windings can be tapped to cater for several voltages but this adds considerably to the cost of the transformer and may detract from performance. Twin series — parallel windings on the other hand, although adding a little to the cost, do not substantially interfere with efficiency as all of the winding is in use for both series and parallel connections. They are however limited to dual input voltage applications where one voltage is twice the other e.g. 240/120V.

Output Currents and Voltages: Unless otherwise agreed, the nominal or rated output voltage is that at full load output current based on resistive load. Again, several voltages can be provided by tapping and, unlike the primary taps, several secondary tappings can be used simultaneously to supply a number of loads. If, however, there is a significant difference between the load currents at different tappings, it may be preferable to have separate windings.

NB: The information above is the minimum which must be decided by the user, all the following requirements may remain unspecified unless circumstances demand otherwise, always remembering that special features can add considerably to a transformer's cost.

Regulation (usually Maximum Value): The regulation is defined as the difference between a secondary terminal voltage on open circuit and the secondary terminal voltage at rated full load current.

Maximum permissible Temperature rise: This is often decided by the manufacturer rather than the user as it may depend on the materials used. Higher standard temperature rises are associated with lower ambient temperatures.

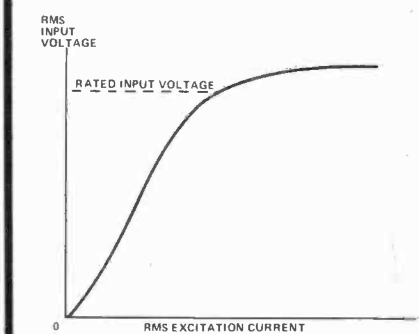


Fig. 1. Plot of excitation currents vs. RMS input voltage for typical transformer. The transformer should not be operated for long periods above the 'knee' of this curve.

Input Current (or Excitation or Magnetising Current): The no load input characteristic is shaped as in Fig. 1 and care should be taken not to use the transformer for long periods with voltages much higher than the "knee" of the curve.

Electrical requirements: Limitations to distortion of secondary waveform, any special phasing requirements etc.

Insulation requirements: The basic standard requirement is for a 2kV RMS test between the input and output windings and between any winding and the core if accessible.

Impregnation etc: Transformers without hygroscopic materials (those that absorb moisture) are often varnish dipped while those using absorbent materials such as paper are varnish impregnated. Both of these processes are effective for minimising lamination vibration and sealing against ingress of moisture.

Dimensions: Any limiting dimensions and/or fixing centres.

Construction: Some of the common alternatives are described below.

What Core

Interleaved laminations are widely used for small power transformers, the most common shape being the no-waste 'E' and 'I' in which the 'I's are cut from the 'E's (see Fig. 2) and the coils assembled over the centre limb (shell type construction). These are available in .50mm and .355mm thickness in various grades of hot rolled silicon iron and in 0.355 mm grain-orientated silicon iron.

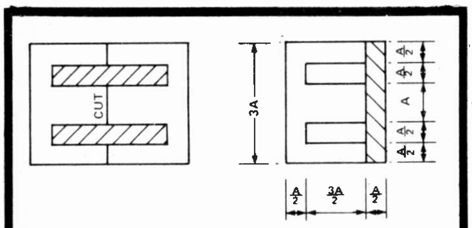


Fig. 2. No-waste E and I construction of transformer laminations.

Toroids and 'C' cores are made of 0.355 and 0.10 mm thickness, the thicker material being used in the 50-60Hz devices. Toroids have a highly efficient magnetic circuit and by virtue of their circular shape, low leakage flux. They are sometimes chosen because they can be used to make a "low profile" i.e. low height transformer.

Because the cost of toroidal transformers can be three times that of an E and I laminated transformer, a compromise between the two which is sometimes used for low profile units uses U and I laminations with the coils on the long limbs of the 'U'. (Core type construction).

Winding Things Up

Moulded bobbins are widely used for smaller transformers. They have the advantage that they can be wound on high speed machines. Insulation thickness between windings and core and between windings can be assured. The winding space factor (ratio of area occupied by active copper and total winding area) is high and terminal tags can be mounted on the bobbin cheeks. Certain bobbins may be fitted with shrouds encasing the windings and giving good mechanical and electrical protection.

Ending It All

The cheapest terminations are solder tags on the bobbin cheeks. For applications where solder connections are not convenient terminal blocks can be mounted on the transformer. For larger transformers terminal panels with turret lugs or bolted connections are used.

Mounting Up

Mounting brackets are available for the range of standard no-waste E and I laminations. They take the form of 'U' clamps with two hole fixing which are crimpled on to the smaller sizes (up to about 50VA) and flanged and frames secured to the larger transformers with core bolts and providing four fixing slots on each of their four sides (universal mounting). At the small end of the range (up to about 5VA) pin terminations can be used for PCB mounting.

Electrical Performance

In its simplest form a transformer consists of an input and output winding magnetically coupled with an iron core. The windings represent an impedance in series with the load and the core can be considered to be an impedance shunting the load. The winding impedances cause voltage drops proportional to the load current and a watts (copper) loss proportional to the square of the load current. The core impedance does not directly produce a voltage drop but is associated with an energy (iron) loss approximately proportional to the square of the volts per turn for a fixed supply frequency. The total losses (copper and iron) determine the operating temperature rise of the transformer which is usually the most important factor limiting the use of the transformer.

Watts A VA

Although the transformer total losses depend on both voltage and current, they are independent of the phase factor. For this reason transformers are rated in maximum VA and not in watts although with resistive loads VA = watts.

Transformer windings also have "self inductance" which can be thought of as a reactance in series with the winding resistance and the load and is usually referred to as the "leakage reactance". This does not usually effect the performance of small power transformers (below about 100 VA size) particularly when used with resistive loads.

Physical Performance

As transformers increase in VA rating and physical size, the working flux density and the winding current density are reduced, but even over a relatively large range of sizes, the variation is small enough to assume that they are constant.

With this premise, it is interesting to consider the effect on various parameters of change in physical size for the same overall shape.

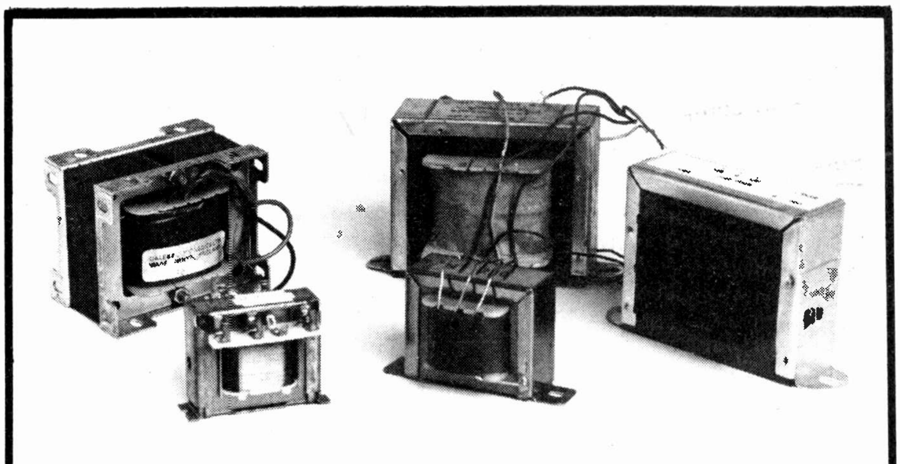


Fig. 3. A collection of some of the more common transformer types. Some of the wide variety of constructions and terminations available can be seen in this photograph.

TRANSFORMERS

We can show that

1) The regulation of small transformers with resistive loads decreases in inverse ratio to the increase in any linear dimension and
2) The reactive voltage drop increases while the resistive drop decreases linearly with dimensions.

Figure 4 shows the relationship between transformer VA rating, volume (or weight) and regulations. The volume here is the length × width × height, not the displacement. This is based on mains transformers using E and I no waste laminations and operating at 50 Hz.

It is often possible to increase the output current of a power transformer beyond the rated value if one can accept a temperature rise higher than the designed value. Overloading the transformer in this way will, however, cause the output voltage to fall because of the increased voltage drops in the windings.

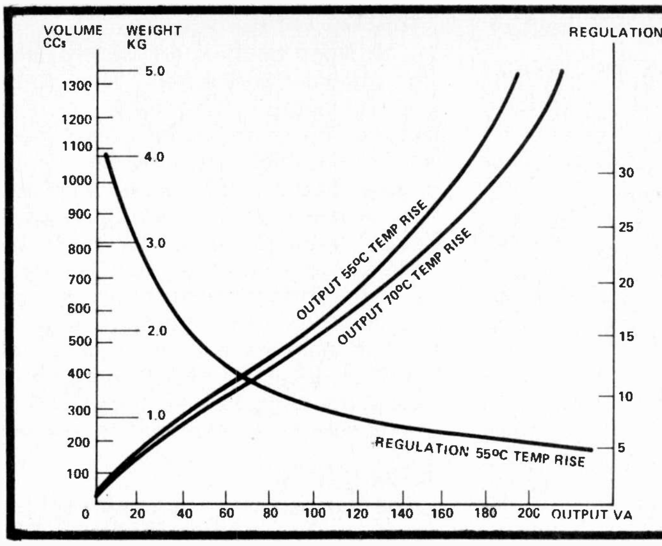


Fig. 4. Graph showing relationship between transformer VA rating and both volume (or weight) and regulation. These curves are based on E and I no-waste laminations operating at 50Hz.

Trying Time

The following tests can be used to establish basic transformer characteristics.

Turns Ratio: Apply a known voltage, less than the rated value, to the primary winding and measure the secondary voltage. Care should be taken, especially with transformers below about 20VA rating, that the instrument used does not impose a significant load on the transformer.

Excitation Characteristic Connect as in Fig. 5 and apply the rated input voltage to primary terminals and measure input current and voltage.

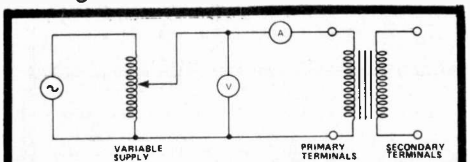


Fig. 5. Connections for the excitation or open-circuit test. The rated input voltage is applied to the primary and the excitation current is shown by A.

Winding Resistance Measure the primary and secondary DC winding resistances with a multimeter or Wheatstone bridge.

Phasing. Where windings can be interconnected e.g. with series/parallel designs, it is important to establish the relative polarity of terminations. This can be done by connecting the windings concerned in series, applying an alternating voltage to one and measuring the overall voltage (Fig. 6). If this measured voltage is greater than the applied voltage, then the windings are in phase. Conversely, if the measured voltage represents the difference of the two winding voltages the connection is in anti-phase.

It Takes All Sorts

Transformers Feeding Rectifiers. A common application for small transformers is to supply full wave rectifier circuits including capacitor input filters. The most common are the bridge amd bi-phase circuits shown in Fig. 7.

For the same power rating, the transformer for the bi-phase circuit will be larger than that for the bridge circuit because its secondary produces twice the voltage and carries current during each half cycle only. Ideally the secondary winding for the bi-phase transformer occupies $\sqrt{2}$ times the space of the primary winding. Although transformer cost is higher, rectifier costs are lower for the bi-phase circuit.

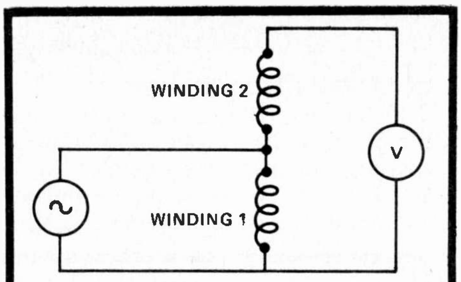


Fig. 6. Connections for the relative polarity test.

The relationship between the average DC voltage and the RMS secondary voltage is complex and is dependent on the smoothing capacitance, the supply frequency, the transformer series impedance and the load impedance. Curves illustrating this and other relevant relationships are published by rectifier manufacturers but neglect the effect of transformer leakage reactance which may be significant on some larger transformers. Because the waveform of the transformer current is very 'peaky' the effective reactive volt drop is greater than may be expected by considering RMS values.

Autotransformers have a single tapped winding to provide both input and output circuits. With transformation ratios near unity, autotransformers can be much smal-

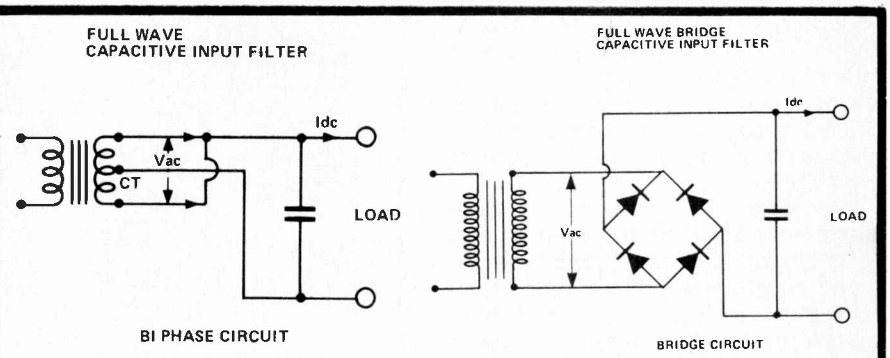


Fig. 7. Two of the most common rectifier circuits for use with capacitive input filters.

ler than similarly rated double-wound transformers

A disadvantage of autotransformers is that there is a direct electrical connection between primary and secondary circuits so that both circuits share a common relationship to earth.

Isolating Transformers usually have a 1:1 transformation ratio and are provided specifically to electrically isolate the secondary circuit from any earth connection in the primary circuit e.g. 'mains' circuits.

Inverter Transformers (e.g. for switched mode power supplies). These usually operate in the kilohertz range of frequencies and are supplied with square wave-form voltages.

High Impedance Transformers are used for a variety of purposes a few of which are mentioned below.

Short-Circuit Proof transformers are designed to continue in operation without damage when the secondary terminals are short-circuited. Small transformers (below about 5VA size) are sometimes made with sufficiently high winding resistances to restrict the short circuit current but with larger transformers an adjacent winding structure is used with an intermediate magnetic shunt. This gives an output characteristic as

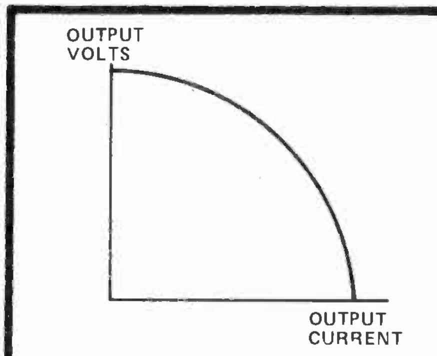


Fig. 8. Relationship between output current and output volts of high reactance transformer with resistive load.

shown in figure 8 when used with resistive loads.

High Frequency Transformers. The foregoing is concerned with transformers operating only at a constant supply frequency and with sinusoidal waveforms. Transformers used in communication circuits are required to handle a wide range of frequencies and waveforms, although any repetitive waveform can be expressed as a series of sine wave components. Such transformers are often used in an *impedance matching* role. It is well known that to transfer the maximum amount of energy into a load from a voltage source the load impedance should equal the source of impedance.

SCREENING

Stray magnetic fields produced by power transformers can cause hum in high gain amplifiers in the same locality. Screening around the power transformer is not normal because a large percentage of the stray flux, which is emitted in all directions, would strike the screen at right angles and pass through it rather than be diverted. On the other hand input (e.g. microphased transformers are often enclosed in a screen of magnetic material to reduce pick-up).

PRODUCTION METHODS

Coil winding techniques and machinery have improved immensely in recent years. Unfortunately it is not always possible to make the best use of these improvements which are mainly geared to high volume production of standard products. Although some degree of standardisation in small transformers has been achieved equipment designers still expect transformers to be tailor-made, often in small quantities, to their particular electrical and dimensional requirements.

Summarising, before seeking a special transformer, consider first if readily available standard transformers can be used. It will often be cheaper to use two or more standard transformers than one special unit. ●

6800 CPU CARD

Designed by John Miller-Kirkpatrick

THE MOTOROLA 6800 is a monolithic 8 bit microprocessor which requires only an oscillator and a few bytes of ROM and RAM to become a simple MPU system. For the System 68 6800 control card card we have added these parts plus some bus buffering to a 6800 chip to give the basic unit of a 4K system which can readily be extended up to the full 65K potential of the MPU chip.

Data Plus

If you are intending to use the 6800 in system 68 it would be advisable to obtain copies of some of the data manuals for the 6800 series. The 'M6800 system design data manual' contains full data on the 6800 MPU chip and other 6800 series support chips, while the 'M6800 programming manual' provides useful information for those wanting to write software for System 68.

6800 MPU Chip

The 6800 has a 16 bit address bus, an 8 bit bi-directional data bus and a number of 'special function' input and output pins. Some of these functions are not used in System 68 at this stage whereas others have to be used in any minimum 6800 system.

Memory requirements

The 6800 uses top locations in memory to access the starting addresses of subroutines for reset or interrupts. For this reason at power-on reset the MPU would expect to find non-volatile memory (PROM) at these locations (rather than RAM which would power-up with rubbish). In an extended system it would be possible to have a switch to enable RAM at these locations to be used in non-standard interrupts but in our basic system we have allocated a 512 byte PROM to these top areas of memory.

A set of 6800 instructions can access the first 256 bytes in a 6800 system as RAM with a 2 byte instruction rather than a 3 byte instruction. In order to make use of this fact we must allocate machine addresses 0000-00FF as RAM.

The memory decoding on the CPU card enables these memory devices at the appropriate locations. This decoding is carried out with 74LS 139 2-4 line decoders.

In order to allow for easy expansion of the basic system the devices on the control card (with the MPU and clock excepted) are enabled by a signal external to the card. In the extended system this signal would be decoded from the address lines to enable the card only when the correct 4K page was selected.

Control Signals

The CPU card provides a number of signals for control of the reset of the system and for user control of MPU operation.

Four signals are brought out to front panel switches (SW1-4). These are the $\overline{RESET}$, $\overline{IRQ}$, $\overline{NMI}$ and a TRI-STATE control input switch. The first three are biased to the run state to allow normal operation and upon operation allow manual resetting or interrupting. The TRI-STATE control can be omitted in most applications but is a must if DMA work is envisaged.

The CPU card also generates a $\overline{HALT}$ signal, this is not brought out as a front panel control as the $\overline{HALT}$ status cannot be used to check the status of the buses as it causes them to go TRI-STATE.

As well as the above control signals the CPU card provides $\overline{RDS}$ $\overline{WDS}$ (read and write strobes) and a NAND of the VMA and Clock 2 output. These three signals are used for control of peripheral devices or in memory decoding.

Buffering Buses

To allow for expansion we have also included data and address buffering on the control card. The devices used are TRI-STATE chips and could thus be enabled by the card enable signal if required. This can lead to over complexity at this stage so that we have permanently enabled the address bus with the DATA buffers dependant only of the READ/WRITE strobes.

Other MPUs

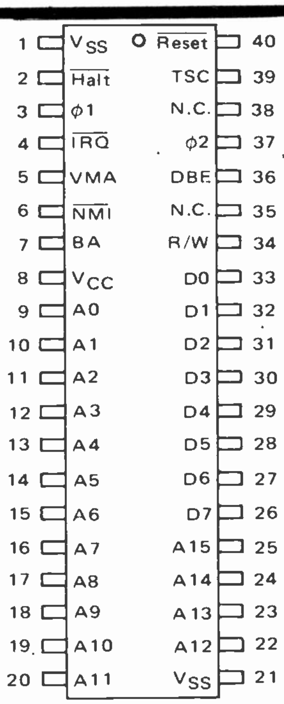
The specifications for the CPU card described above would apply to a card based on any MPU, with only minor changes to cater for the requirements of a specific MPU. A SC/MP card will be described later in the series while a Z80 card is to be developed.

Clocking on — Clocking off

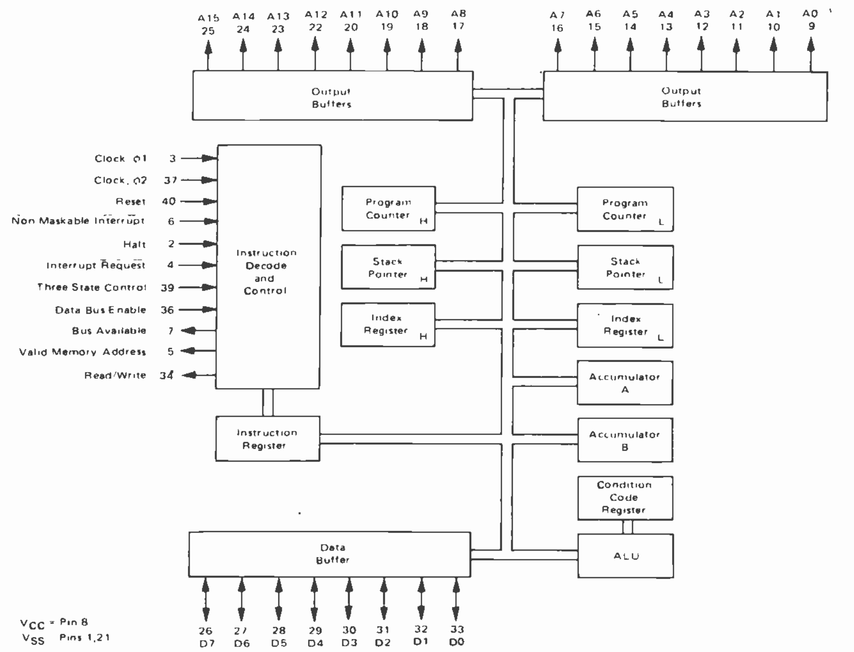
The main problem encountered in the design of a M6800 system is the provision of a suitable system clock. While many MPUs will accept a crystal, or even capacitor, tied between two pins as a complete clock driver the 6800 will not. It requires the clock signal to be within

DATA SHEET

MC 6800 MPU—THE HARDWARE



PIN ASSIGNMENT



BLOCK DIAGRAM

HALT. When this input is in the low state all activity in the MPU is halted at the end of the current instruction. The output buses go TRI-STATE.

IRQ (Interupt Request). When this input is taken low the MPU will go into its interrupt service routine if the interrupt bit is not set. This routine stores registers on the software stack and then branches to a software routine at an address which is specified at location FFF8-FFF9.

VMA (Valid Memory Address). This output goes high to indicate to peripherals that a valid and steady address is now on the bus.

NMI (Non-maskable Interrupt). Similar to IRQ except that it causes a non-maskable interrupt. The software vector is at FFFC-FFFD.

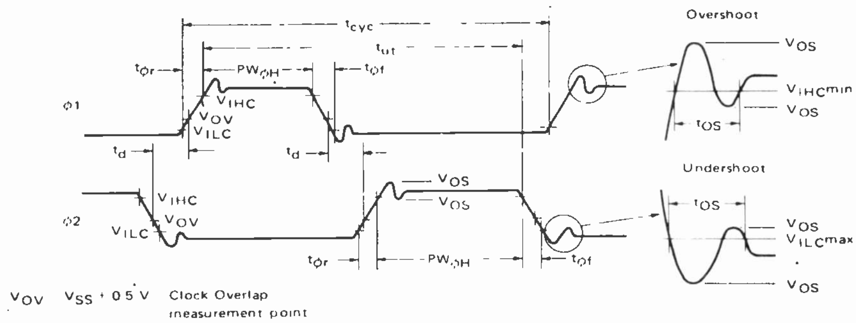
BA (Bus Available). This output goes high if MPU is in wait status. All TRI-STATE outputs are in a high impedance state enabling other equipment to use the system buses.

R/W (Read/Write). This output goes low when the MPU wishes to write to a peripheral.

DBE (Data Bus Enable). This input enables the data bus when in the high state. In normal operation it is driven by φ2 clock.

TSC (Tri-State Control). This input has the same effect as DBE except that it affects the status of the address and R/W lines.

RESET. A low on this input causes the MPU to enter a restart routine which resets all internal counters and then branches to a software routine starting at FFFE-FFFF.



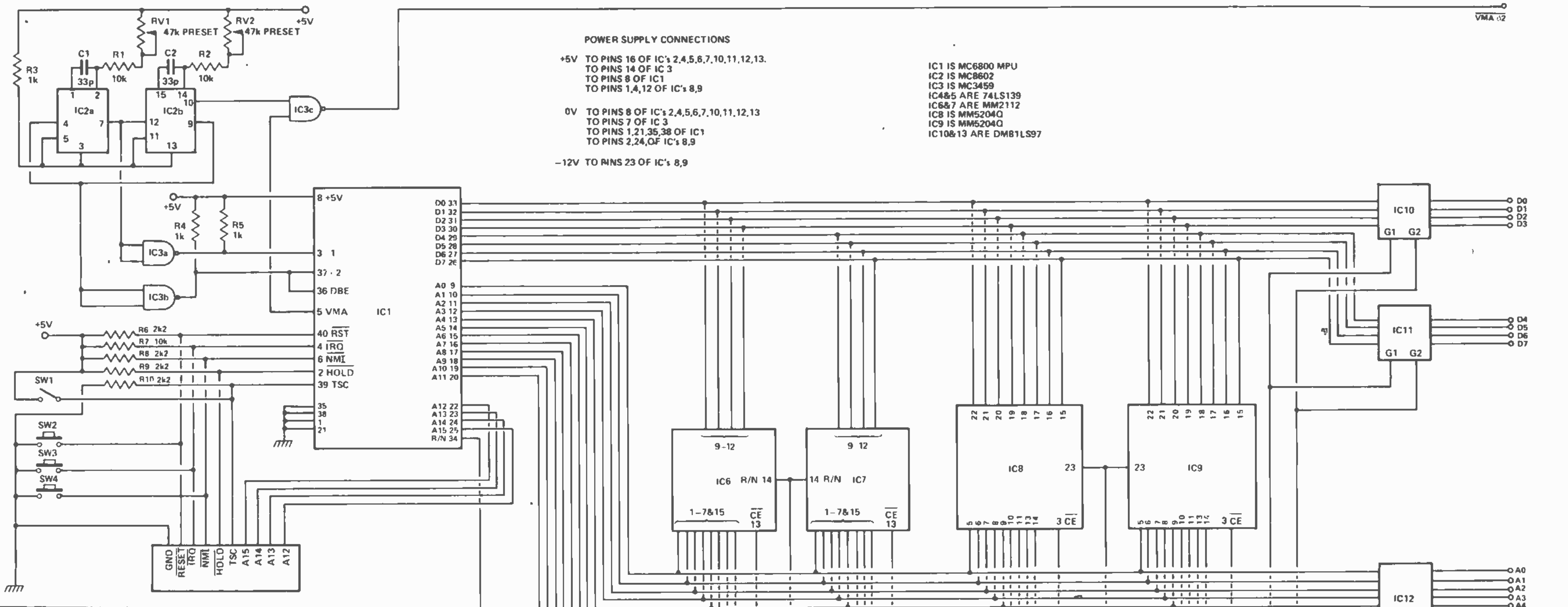
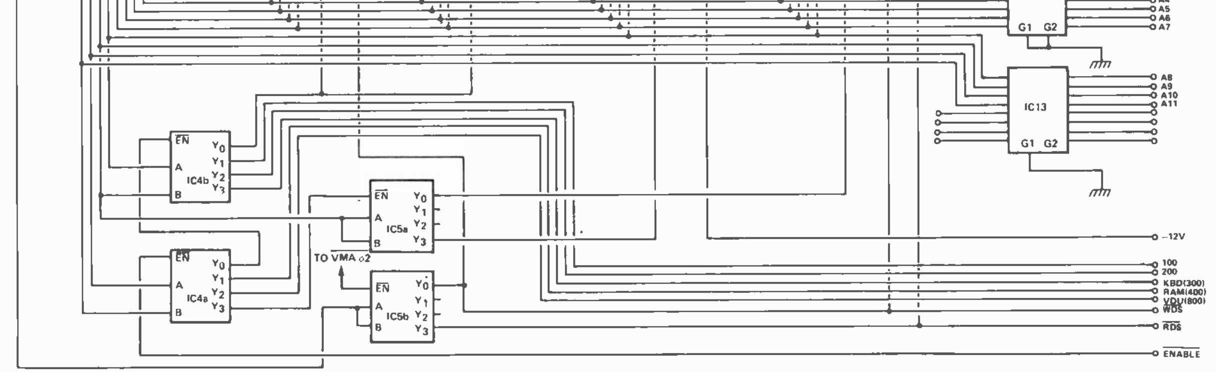
CLOCK TIMING WAVEFORMS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	–0.3 to +7.0	Vdc
Input Voltage	V_{in}	–0.3 to +7.0	Vdc
Operating Temperature Range	T_A	0 to +70	°C
Storage Temperature Range	T_{stg}	–55 to +150	°C
Thermal Resistance	θ_{JA}	70	°C/W

This device contains circuitry to protect the input against damage due to high static voltages; however, it is advised that normal precautions are taken to avoid application of voltages higher than those shown under maximum ratings.

6800 CPU CARD

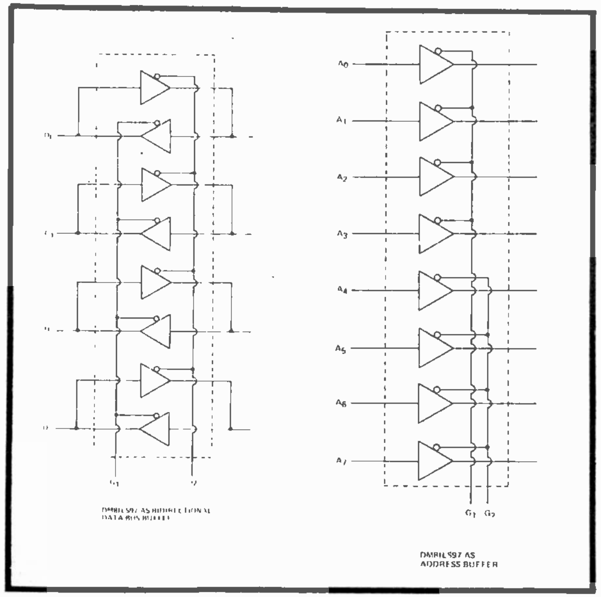


Fig. 1. The full circuit diagram of the system 68 CPU card is shown above. About 6 decoupling capacitors of 100n should be used on the 5V lines near IC1. NOTE:- There are two conventions adopted to show an active low strobe signal — i.e. active low read strobe may be shown as NRDS or RDS. In line with Motorola literature we have adopted the latter style on the CPU card.

Circuit details of the address and data bus buffers (IC10-13) are shown on the left.

HOW IT WORKS

The CPU card may be treated as a number of different sections. The most important of these is the 6800 MPU itself. We shall discuss the operation of this (from the software side) later in this series.

The next section is the system clock generator circuit which is centred on IC2 together with IC3a and IC3b.

The CPU card also provides some system memory. This is of two types, READ ONLY (IC8, IC9) and READ/WRITE (IC6, IC7).

Memory decoding is carried out in IC4 and IC5a while IC10, IC11, IC12, IC13 carry out buffering of the address and data buses.

Finally a number of control signals to and from the MPU are processed by various gates and switches on the card.

We shall now move on to deal with each of the sections mentioned above in greater detail.

CLOCK GENERATOR

The clock generator for the system is formed by the two sections of IC2 (8602), a dual retriggerable monostable. The total cycle time of the clock signal may be varied between 1µS and 10µS but the relationship between the two waveforms ($\phi1$ and $\phi2$) specifies that each pulse can be high for only 45% of this cycle. The clock generator is thus in theory quite complicated with the timing sequence being $\phi1$ high for 0-45, low for 46-100 with $\phi2$ low for 0-50, high for 51-95, returning low for 96-100; where the counts represent percentage time slots of one cycle.

The 8602 dual monostable is used to generate two pulses each to represent 45% of a cycle, the two 5% clock overlaps (or more correctly – clock non-overlaps) rely on the propogation delays inherent in the 8602.

A typical propagation delay for this device is 40nS and thus with a monostable output pulse of 460nS duration, the timing requirements would be met. The timing of the output pulse depends on the values of the external R/C components connected to pins 1, 2, and 14, 15.

The pulse width is given by the formula

$$t = 0.31\ RxCx(1 + 1/Rx)$$

where t is in seconds
Rx is in ohms
Cx is in farads.

Substituting Cx = 33pF and rearranging we obtain

$$t = 10.23(Rx + 1) \times 10^{-12}$$

to get t = 460nS we require

$$460 \times 10^{-9} = 10.23(Rx + 1) \times 10^{-12}$$

$$Rx = \frac{460 \times 10^{-9} - 1}{10.23 \times 10^{-12}}$$

$$= 45K$$

To allow for component tolerances and to give an adjustment range RV1 and RV2 should be 47K or 50K preset types with a 10K series resistor.

The outputs of the two monostables are directed through IC3 which acts as an inverter and NMOS driver giving the rise times and logic levels required by the 6800.

MEMORY REQUIREMENTS

The 6800 requires two different types of memory – some non-volatile memory located in the top region of addresses and some read/write memory which may start at any address.

The read only memory is supplied by IC8 and IC9. These are the MM5204 4096 bit (512×8) PROMS. They do not lose their data content when power to the CPU card is removed (non-volatile). The fact that they are read only memories means that the MPU cannot write to the 5204 with a write operation – instead the 5204 must be programmed with an additional piece of hardware or, alternatively, be supplied with the required data content.

The second type of memory is READ/WRITE. This is supplied by IC6, IC7. The devices used are MM2112 types, a 1024 bit (256×4) device, two are used to provide the 256×8 bit bytes required by the system. This memory can be written to by the MPU but will lose its data when power is removed.

With both types of memories the data presented to the chips output drivers will depend on the particular address that is presented to its input. The devices are, however, TRI-STATE and this means that the output drivers will not be enabled, presenting the data to the data bus, unless the chip enable line is low.

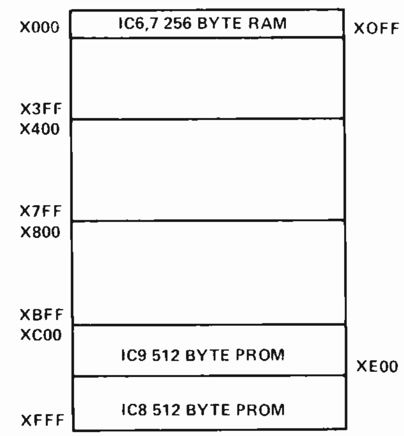
In this way more than one driver can share the buses with only the "selected" chip outputting to the data bus.

MEMORY DECODING

A look at the pin descriptions for the 6800 will show that it uses the top range of addresses to access the starting addresses of subrouting for reset or interrupts.

For this reason the MPU would expect to find non-volatile memory in these regions (rather than volatile types which would power up with rubbish). We therefore need to enable the 5204 PROMS in top regions of memory.

To make use of the fact that the 6800 can address the first 256 bytes of memory with a two, rather than three, byte instruction, we need to enable RAM for the first 256 bytes. The above requirements are represented on the memory map shown and the decoding is carried out in IC4 and IC5a.



X=PAGE NUMBER
(NOT DECODED IN BASIC SYSTEM)

The address lines 12-15 are ignored in decoding device addresses and thus accessing FFFE is the same as accessing 0FFE, 1FFE, 2FFE etc.

The decoding of lines 0-11 is carried out with 74LS139 ICs. The internal configuration of this IC was shown in Fig. 3 last month. Each half is a complete 2 to 4 line decoder with active low outputs and an enable line. As can be seen from the truth table the enable line has to be low to enable the outputs.

IC4a is enabled by the external card enable line and uses address lines A10 and A11 for its A and B input. Y0 of IC4a will go low in the address range X000-X3FF, Y1 for X400-X7FF etc, where X is the page number selected by the card enable input.

IC4b is enabled from the Y0 output of IC4a and uses address lines A9 and A8 as its A and B inputs. The outputs are thus enabled by the MPU for addresses X000-X0FF, X100-X1FF, X200-X2FF and X300-X3FF i.e. into four 256 byte lumps.

The first of these outputs is used to enable the RAM at location X000-X0FF as required by the software.

The Y3 output of IC4a is used to enable IC5a which uses address line A9 as both the A and B inputs. This therefore produces an enable output at IC5a Y0 for MPU addresses XC00-XDFF and an output at Y3 for XE00-XFFF. This latter output is used to enable the PROM at the locations required by the MPU. IC5a output Y0 is used to enable IC9. This IC is not required in the basic system.

BUS BUFFERING

The bus buffering is provided by DM81LS97 devices. These contain 8 TRI-STATE buffers enabled as two groups of four, In the case of the address bus all twelve lines are buffered with four gates unused. In the basic system these buffers are permanently enabled.

The data bus buffering needs to be bi-directional. The READ and WRITE strobes (described below) are used to enable the gates so as to allow data flow in the required direction.

CONTROL SIGNALS

A number of control signals are produced by the MPU and processed by the CPU card. The VMA output of the MPU is NANDED with the $\phi2$ clock phase to produce an active low strobe to enable peripheral drives or for further address decoding. This VMA. $\phi2$ output is combined with the R/W MPU output in IC5b to produce the $\overline{WDS}$ and $\overline{RDS}$ strobes.

The logic involved means that $\overline{WDS}$ is low only if VMA and $\phi2$ are high and R/W is low. These conditions mean that a valid write operation is to be undertaken.

$\overline{RDS}$ is low if VMA and $\phi2$ are high with R/W high. A read operation is then indicated.

The five input control signals are biased to the run state and four of these can be brought out as front panel switches. The $\overline{RESET}$, $\overline{IRQ}$, and $\overline{NMI}$ input lines are biased to logic 1 by R6-8 and are also connected to switches SW2 ($\overline{RESET}$), SW3 ($\overline{IRQ}$) and SW4 ($\overline{NMI}$) to enable manual resetting or interrupting.

The TRI-STATE control (TSC) switch can be omitted in most applications.

very tight specifications and does not tolerate any degrading of these specs.

We tried many clock circuits that were simpler than the final design but none would meet both the level and rise time requirements of the clock signal. The final design is based on a clock generator used by Motorola in some of their 6800 based systems.

We could not find out why the 8602 dual monostable could not be replaced with a 74123 which is an almost identical but cheaper device. Both IC2 and IC3 are expensive chips but the only alternative is a clock driver chip from Motorola which may be more expensive or difficult to obtain.

PARTS LIST

INTEGRATED CIRCUITS

IC1	MC6800 MPU
IC2	MC8602
IC3	MC3459
IC4,5	74LS139
IC6,7,	MM2112
IC8	MM5204Q
IC9 (not required for basic system)	MM5204Q
IC10,11, 12,13	DM81LS97

RESISTORS

R1, R2	10k
R3,4,5	1k
R6	2.2k
R7	10k
R8	2.2k
R9	2.2k
R10	2.2k

POTENTIOMETERS

RV1, RV2	47k Preset

CAPACITORS

C1,C2	33pF
C3,4,5,6,7,8	100n

SWITCHES

SW1 (not required for basic system)	1p 1 way toggle
SW2,3,4	simple push on, release off,

SOCKETS

1 X 40 pin
1 X 14 pin
6 X 16 pin
4 X 20 pin
2 X 24 pin

Full Circuit

The final circuit of the CPU card is shown in Fig. 1. This is assembled on a Eurocard sized PCB which will be described next month.

Next Month

Completing the CPU board plus the software monitor, ETI BUG. ●

CORRECTIONS

VDU Board A:-
PCB layout omits ground connections on IC2, IC4.

Link from IC10 Pin 1 to IC 9 Pin 6 is omitted on component overlay.

Circuit diagram shows LS connected to IC5/c. This should be connected to IC 5/d — PCB is correct.

LS DISEN is shown connected to IC 7/d. This should be connected to IC 7/c. PCB is incorrect and must be altered for VDU to operate correctly.

VDU Board B:-
IC 24 Pin 16 and IC 28 pin 7 should be linked on PCB layout.

GRAPHIC EQUALISER

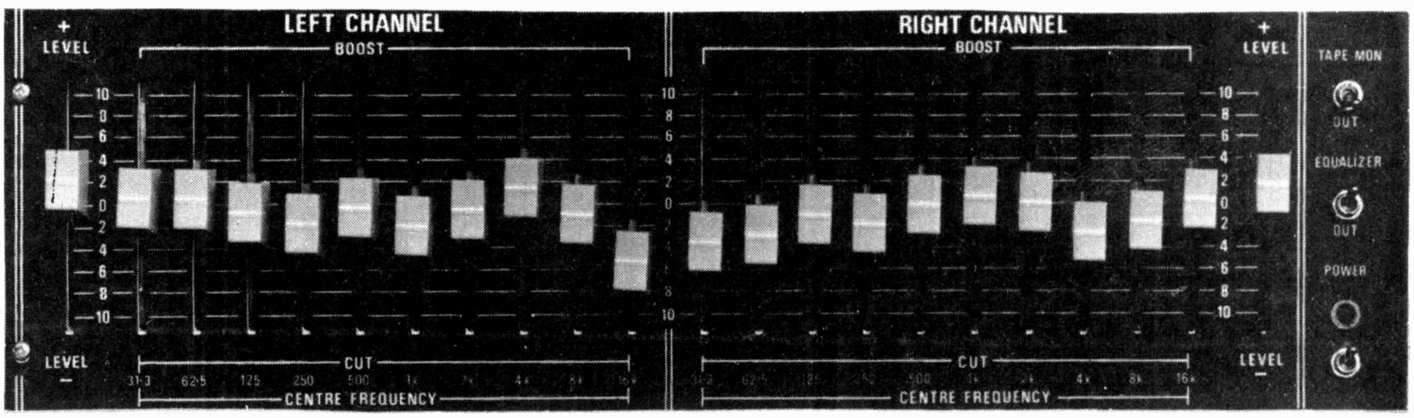
GRAPHIC EQUALIZERS are popular with both the professional and domestic user alike. However until the presentation of our earlier equalizer (ETI 427) the cost of such a device was very high and this limited its wide use. We have now redesigned the equalizer to simplify the construction and it now has no coils and one additional filter has also been added.

available cannot give correct reproduction in an inadequate room. It is a sad fact that very few rooms are ideal, and most of us put up with resonances and dips, convinced that this is something we have to live with.

Whilst the octave equalizer will not completely overcome such problems, it is possible to minimize some non-

particular system. One adjusts the equalizer to provide a uniform response, the settings of the potentiometer knobs then graphically display the areas where the speaker etc is deficient.

There is a snag, however, one must have an educated ear in order to properly equalize a system to a flat response. It is not much use equalizing to your own preference of peaky bass



The advantages of an equalizer are not generally well known but are as follows.

Firstly an equalizer allows the listener to correct deficiencies in the linearity of either his speaker system alone, or the combination of his speaker system and his living room.

As we have pointed out many times in the past, even the best speakers

linearities of the combined speaker/room system.

In a concert hall it is also possible to use the unit to put a notch at the frequency where microphone feedbac occurs, thus allowing higher power levels to be used.

Thirdly, for the serious audiophile, an equalizer is an exceedingly-valuable tool in evaluating the deficiencies in a

etc in order to evaluate a speaker.

Ideally, a graphic equalizer should have filters at 1/3 octave intervals, but except for sound studios and wealthy pop groups, the expense and size of such units are too much for most people.

The equalizer described here has 10 octave spaced filters but if desired it could be modified to give 1/2 or 1/3

GRAPHIC EQUALISER

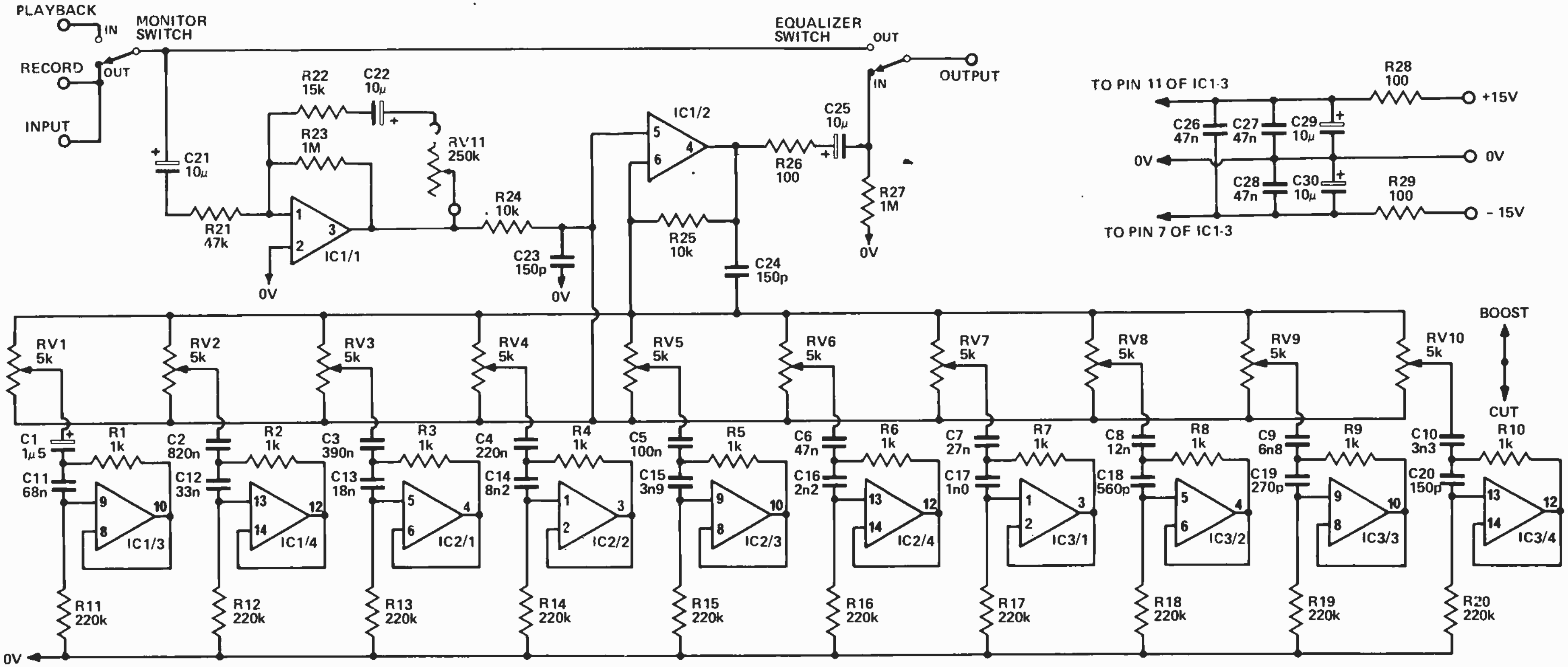


Fig. 1. Circuit diagram of one channel of the equalizer.

HOW IT WORKS

This equalizer is basically similar to that used in the previous unit with the addition of an extra filter in each channel. The previous unit also used coils (inductors) – these have been replaced by gyrators to simplify construction. We will explain more about gyrators later but at the moment just assume that they are an inductor.

The equalizer stage is a little unusual in that the filter networks are arranged to vary the negative feedback path around the amplifier. If we consider one filter section impedance of the LCR network will be 1 k ohms at the resonant frequency circuit.

With the slider of the potentiometer at the top end (Fig. A) we have 1 k ohms to the OV line from the negative input of the amplifier, and 5 k between the two inputs of the amplifier. The amplifier, due to the feedback applied, will keep the potential between the two inputs at zero. Thus there is no current through RVA. The voltage on the positive input to the amplifier is therefore the same as the input voltage since there is no current through, or voltage drop across resistor RA.

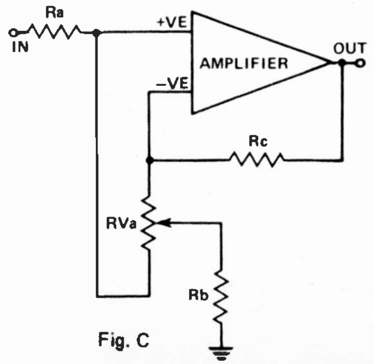
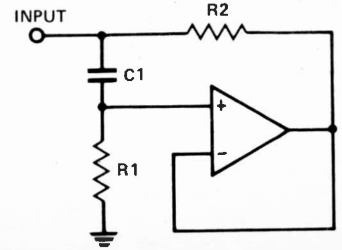


Fig. C

of the amplifier. The use of a second amplifier will increase the resistance to many megohms while the same formula holds for inductance.



of the network. At either side of resonance the impedance will rise (with a slope dependant on the Q of the network which is 3) due to the uncancelled reactance. This will be inductive above resonance and capacitive below resonance. We can therefore represent the equalizer stage by the equivalent circuit below.

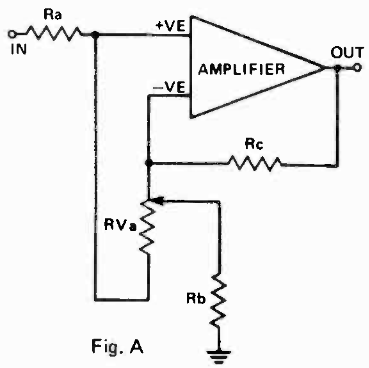


Fig. A

It must be emphasized that this equivalent circuit represents the condition with one filter only, at its resonant frequency. Additionally letters have been used to designate resistors to avoid confusion with components in the actual

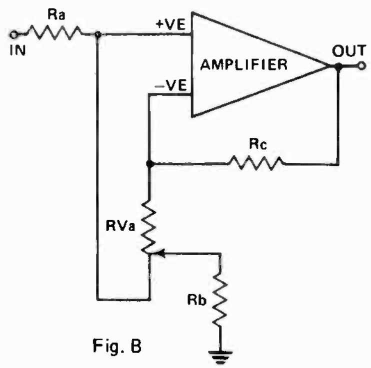


Fig. B

The output of the amplifier in this case is approximately the input signal times (10 000 + 1000)/100 giving a gain of 20 dB. If the slider is at the other end of the potentiometer, (Fig. B), the signal appearing at the positive input, and thus also the negative input is about 0.1 (1000/(10 000 + 1000)) of the input. There will still be no current of the potentiometer and in RC, thus the output will be 0.1 of the input. That is, there will be a loss of 20 dB.

If the wiper is midway, both the input signal and the feedback signal are attenuated equally, and the stage will have unity gain.

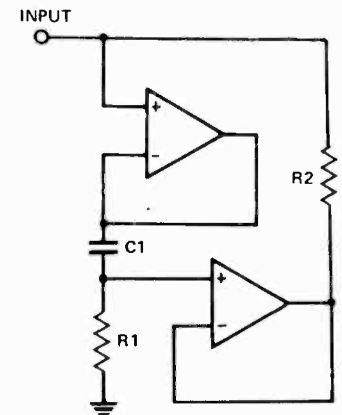
With all filter sections in circuit the maximum cut and boost available is reduced, but ± 14 dB is still available.

In the actual circuit we have used the first op-amp (IC1/1) as a buffer for the input and also as the overall gain control stage. With the values shown the gain is adjustable over a range of –9 to +14 dB. By replacing R22 by a link RV11 will act like a normal volume control. Now to the gyrator.

The only difference between an inductor and a capacitor – electrically, that is, not mechanically – is the phase relationship between the current and voltage. In the gyrator we use an op-amp to reverse the phase relationship of a capacitor and make it appear like an inductor. In the circuit below the inductance is given by the formula

$L = R1 \times R2 \times C1$ H where C is in Farads

Like a real inductor there is a series resistance (winding resistance) or R2 and a parallel resistance R1 (in a coil this is due to winding capacitance). The lowest value of R2 depends on the amplifier used but for standard op-amps it would be about 100 ohms. At the high end the value of R1 is limited by input current.



octave spacing as large values of inductance are easily obtained with gyrators (active inductors).

Construction

Assemble the PCB's as per the overlays, leaving off the sliders for now. Check everything carefully to make sure it's correct, as once they are mounted onto the board you'll never be able to get to anything!

To fit these potentiometers, solder a generous 2 inch length of tinned wire to each of the end contacts, and one of the slider pins. Offer up the pot to the board, push the wire through the board from the back and solder to the pc pins, such that the board itself is spaced away from the board by about an inch.

Make sure the wire does not short across any of the tracks as it passes through the PCB. It's a good idea also now to ensure that once you've fitted all the pots, they still line up with the metalwork holes for mount-ing.

If you're using the Maplin kit, the sliders have to be spaced away from the chassis. We found that this was best done by using four washers between the body of the pot and chassis.

If this is not done, the tang fouls the bolt within the body, and limits the travel.

The volume controls mount straight onto the chassis, and can easily be wired in once the board assemblies are fitted into the box.

Now build up the PSU, and test it throughly before wiring it to the boards. Mount the transformer as far from the circuit boards as possible, and if possible screen it with a metal enclosure. On the original shallow metalwork shown here screening the PSU added considerably to the overall quality of sound.

Third octave filters

While we have not built up a third octave unit we see no reason why it will not work. Additional stages can simply be added except that the Q of the circuits must be changed to narrow the band. At the moment the impedance of the capacitor and inductor (gyrator) is about 3000 ohms at the centre frequency and this should be increased to about 8000 ohms for the third octave unit. The capacitors and inductors can be calculated by

$$C = \frac{1}{2\pi f X_C} \qquad L = \frac{X_L}{2\pi f}$$

where $X_C = X_L = 8000\Omega$
and f = centre frequency

It is recommended to reduce loading IC1/2 that the potentiometers be increased to 10k.

GRAPHIC EQUALISER

PARTS LIST

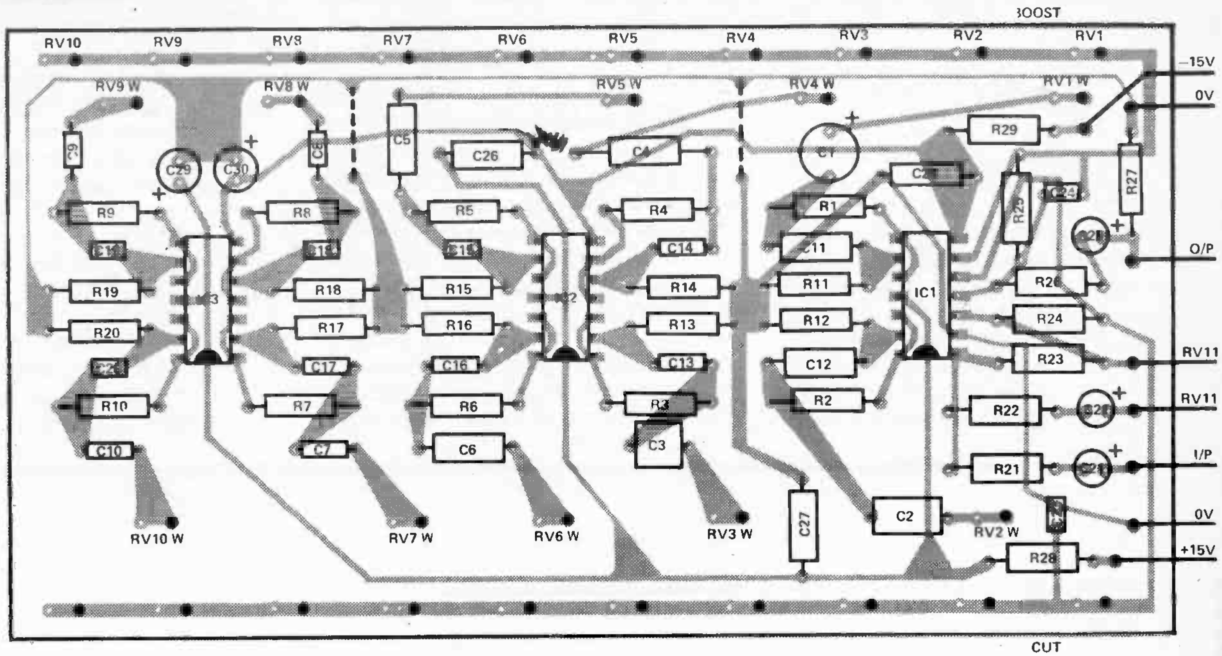
RESISTORS all ½W 5%	
R1-R10	1k
R11-R20	220k
R21	47k
R22	15k
R23,27	1M
R24,25	10k
R26,28,29	100
R30	1k8
POTENTIOMETERS	
RV1-RV10	5k lin
RV11	250k log
CAPACITORS	
C1	1u5 tantalum
C2	820n polyester
C3	390n "
C4	220n "
C5,33,34,35,36	100n "
C6	47n "
C7	27n "
C8	12n "
C9	6n8 "
C10	3n3 "
C11	68n "
C12	33n "
C13	18n "
C14	8n2 "
C15	3n9 "
C16	2n2 "
C17	1n0 "
C18	560p ceramic
C19	270p "
C20,23,24	150p "
C21,22,25,29,30	10u 25V
C26-C28	47n polyester
C31,32	1000u 25V
SEMICONDUCTORS	
IC1-IC3	4136
IC4	4195
LED 1	TIL 209

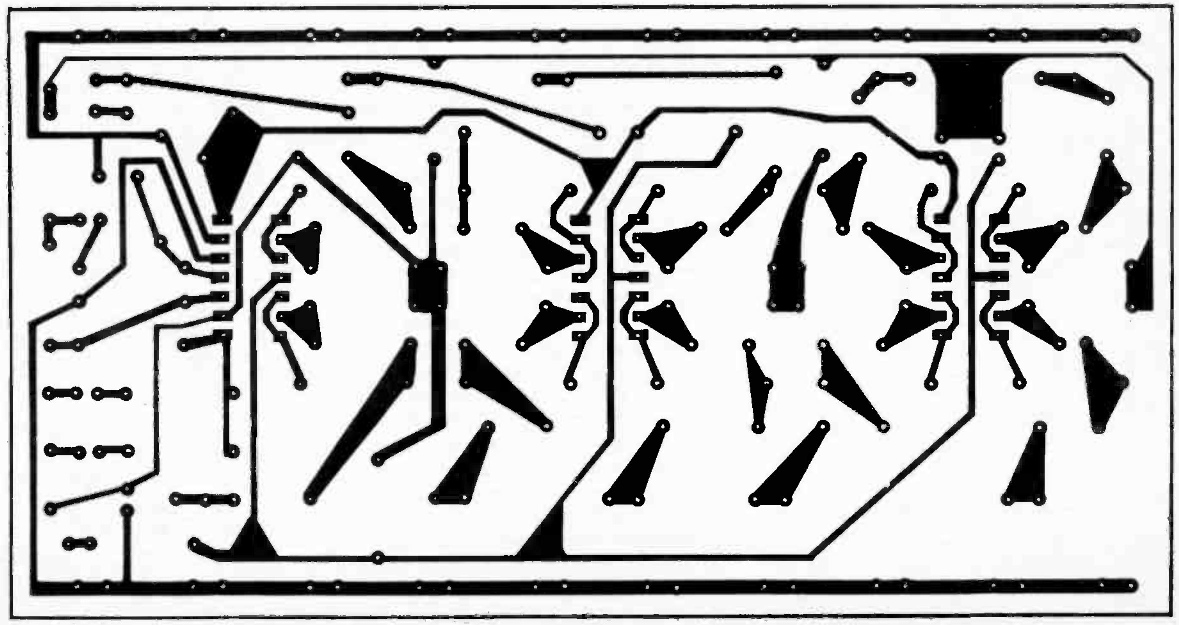
TRANSFORMER

T1 240/12-0-12 at 100mA or more

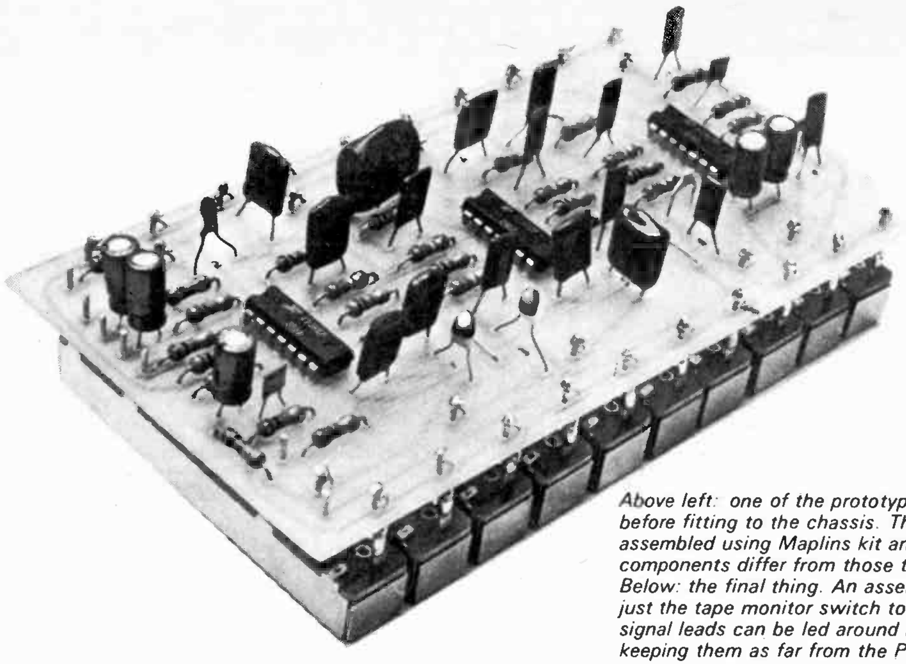
MISCELLANEOUS

Metalwork and case to suit
Three DPDT toggle switches
Three core flex and plug
For stereo operation double quantity of all components except PSU parts.





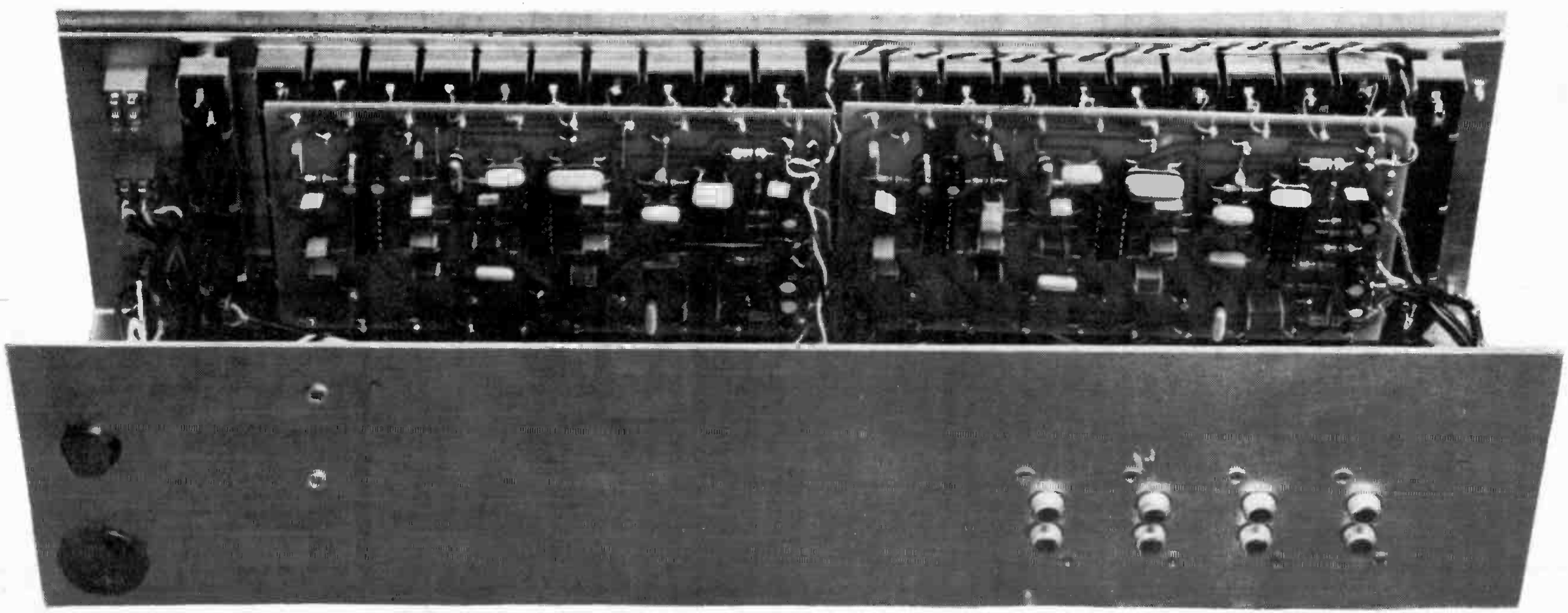
Component overlay and foil pattern for the main pcbs in the equaliser. Two of these are required for stereo. The pins are to be wired to the slider controls once everything is fitted onto the board. Foil pattern shown full size at 152mm width.



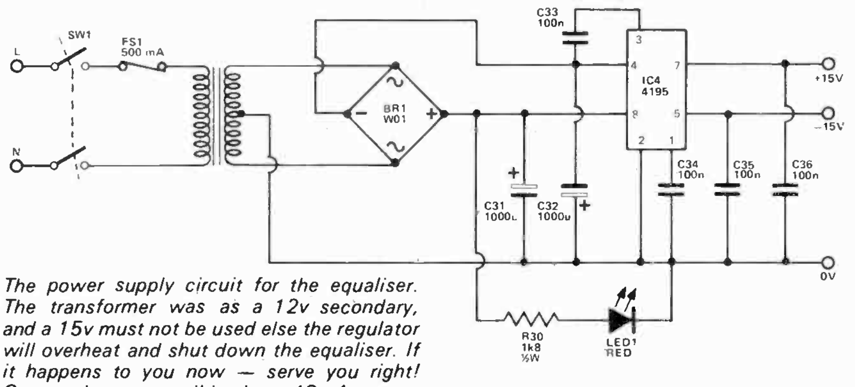
Above left: one of the prototype board assemblies before fitting to the chassis. This was not assembled using Maplins kit and so the components differ from those they will supply. Below: the final thing. An assembled equaliser with just the tape monitor switch to be wired in. All the signal leads can be led around beneath the sliders, keeping them as far from the PSU as possible. This one was built from the kit — so now you know what it looks like!

SPECIFICATION

Frequency response				
Equalizer out			Flat	
Equalizer in and all controls at zero	10Hz – 20kHz		± ½dB	
Range of controls				
Individual filters			± 13dB	
Level control			+ 14dB	– 9dB
Maximum output signal at <0.1% distortion			6 volts	
Maximum input voltage			10 volts	
Distortion				
at 2 volts out, controls flat	100Hz 0.02%	1kHz 0.02%	6.3kHz 0.04%	
Signal to noise ratio re 2 volts out, controls flat			82 dB	
Input impedance			47 k	
Output impedance			100 ohms	



GRAPHIC EQUALISER

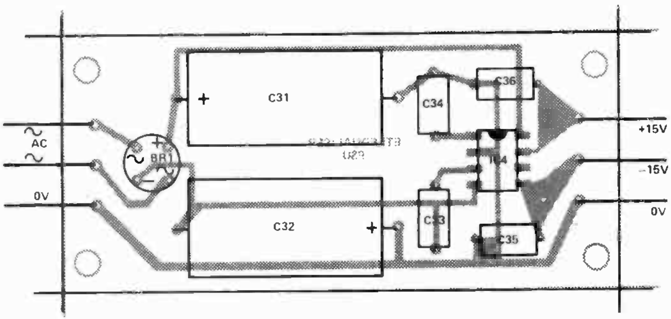


The power supply circuit for the equaliser. The transformer was as a 12v secondary, and a 15v must not be used else the regulator will overheat and shut down the equaliser. If it happens to you now — serve you right! Current drawn per rail is about 48mA.

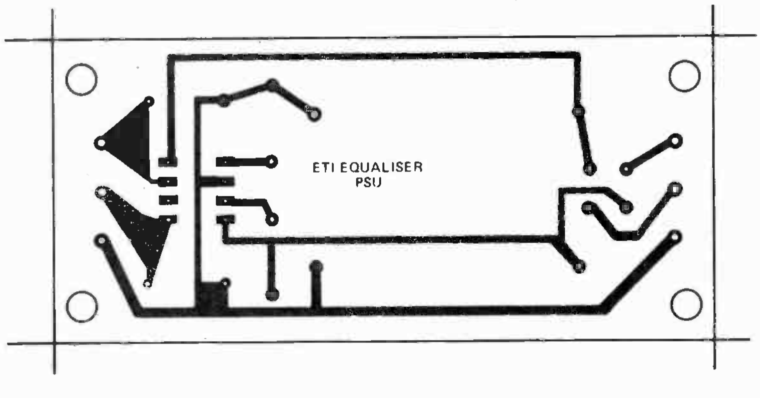
BUY LINES

Maplin are producing a full kit, including metalwork, for this project at a cost of £65 all inclusive. All components will be available separately. Note that we have not given metalwork dimensions ourselves, since sliders vary greatly in dimensions and mounting requirements. Maplin are also working on a wooden sleeve to suit their kit, and details will be available shortly. See ad on back cover for address etc.

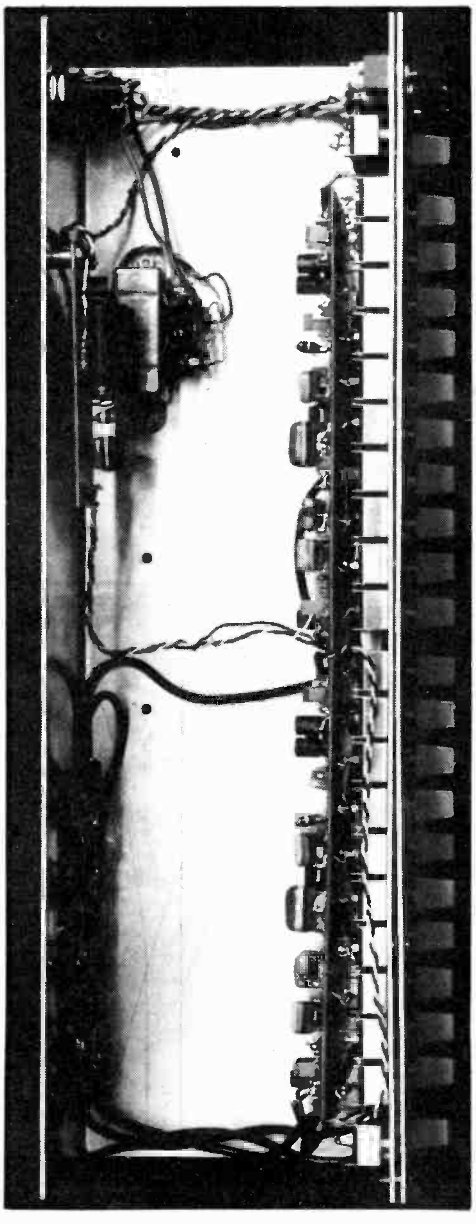
The 4136 op-amp can be bought from Eurosem International Ltd., Haywood Hse., Pinner, Middx. HA5 5QA (phone or write for price) if you are one of these people who don't like kits!

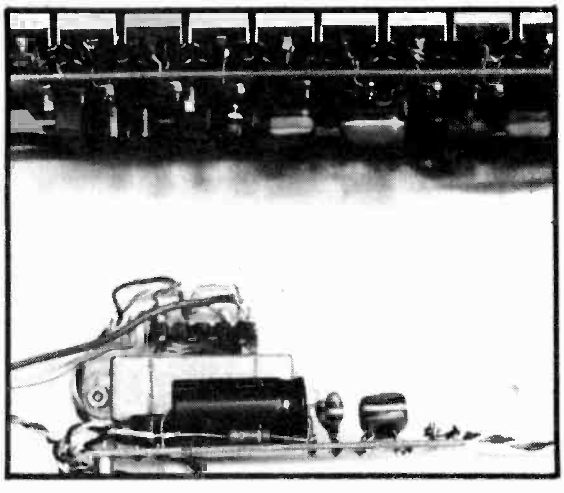


Component overlay and foil pattern for the power supply. The LED dropper resistor is wired from C32. The foil pattern is shown full size i.e. 88mm width.



Below: The beast assembled and lying beneath our camera. Note that here the screening has been removed from around the power supply so you can see what's gone where. The LED wiring can be seen as a twisted pair running from the regulator board top left.





The power supply board in situ. Note the LED dropper resistor wired from the reservoir capacitor. The support pillars are missing from one end of the pcb here, as they help support the screen around the transformer and this had to be removed. For some reason our camera wouldn't work through aluminium.

LASER LIGHTSHOWS

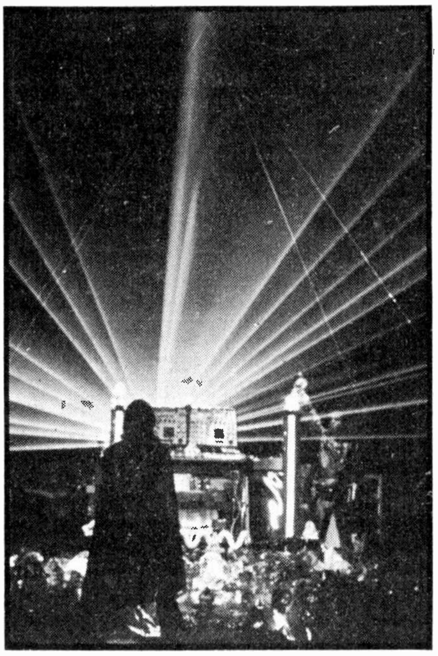
Lasers for entertainment looked at by starry-eyed Jim Perry

"AND ON THE FIRST DAY there was light, but it was incoherent . . . . it was a long time before coherent light was produced, July 1960, the birth of the Laser. The first laser was produced by Theodore H. Maiman, while working at the Hughes Aircraft Research Laboratories in Malibu, California. This first laser was a Pulsed Ruby type.

Lasing mediums currently in use include Chromium (Ruby lasers); Neon, Argon, Krypton and CO_2 (gas lasers), organic dyes (liquid lasers), and recently, certain semiconductors. The method of pumping energy into the medium determines whether it will be a pulsed or continuous laser. Optical pumping, focussing a bright light source such as Xenon flashtube on the lasing medium, is used with Ruby and liquid lasers providing a pulsed laser output. Continuous lasing is possible with gas lasers, where electron collision pumping, sending an electrical discharge through the gas filled tube, is used.

Early Experiments

Even though lasers have now been around for 17 years, very few people have actually seen one! Apart from the scientific and industrial uses, lasers also are amazing just to look at (not directly into the beam though!). This was realised as early as 1967, when people started artistic experimentation with lasers, projecting the beam through various transparent materials (such as crystal cut glass) to produce abstract patterns, and moving effects.



Laser light is an impressive sight, because of the dynamic-almost tactile-purity of it. The air in fact can appear to be solid, if dust is present in the path of the beam. The early experimental laser lightshows used this property, in conjunction with smoke machines, to produce numerous shafts of red 'solid air' moving over peoples heads.

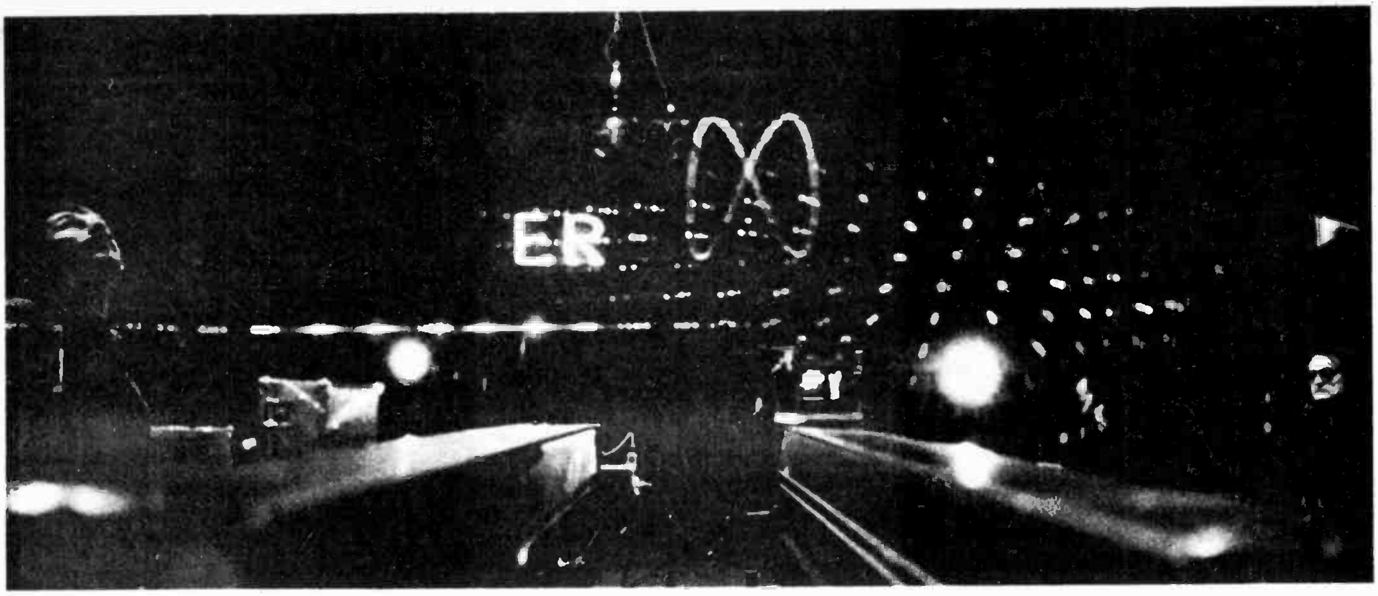
It was soon realised that vibrating mirrors could be used for more complex images. One of the earliest uses was at the 1970 World Exhibition in Osaka. Pepsi-Cola commissioned Lavell Cross, Carson Jeffries and David Tutor (from Mills College, U.S.A.), to build Video/Laser II for use in the Pepsi-Cola Art and Technology Pavilion. This system produced complex Lissajous type patterns within the confines of the Pavilion, and was more sophisticated than the simple "mirrors stuck on a loudspeaker" approach used previously, but still relatively crude.

As well as being simple mechanically, the early laser shows tended to use separate small lasers, as powerful Krypton lasers were prohibitively expensive. So now for details of some modern Laser lightshows and their background.

Crystal Machine

Tim Blake (synthesiser player extraordinaire) joined the band Gong in 1972, he started using small Helium Neon (red) lasers for special effects during concerts. He teamed up with Patarice Warrener (technical boffin extraordinaire) and they called themselves Crystal Machine. The lasers used were replaced with slightly more powerful ones (2.5mW instead of 1.5mW) of the same type, most of the effects were produced by diffraction gratings, mirrors on loudspeakers and manual manipulation.

Crystal Machine left Gong and moved to Paris, with the loan of 6 new 20mW lasers (from Spectra Physics of California), they started mixing conventional light show techniques with Laser techniques. One memorable event was at a Parish church, with no place to hang a screen they projected an Argon (blue) laser onto the clouds, to the sound of Tim playing his huge synthesiser bank! Crystal Machine also built laser light show equipment for Yes, and still performs as a total

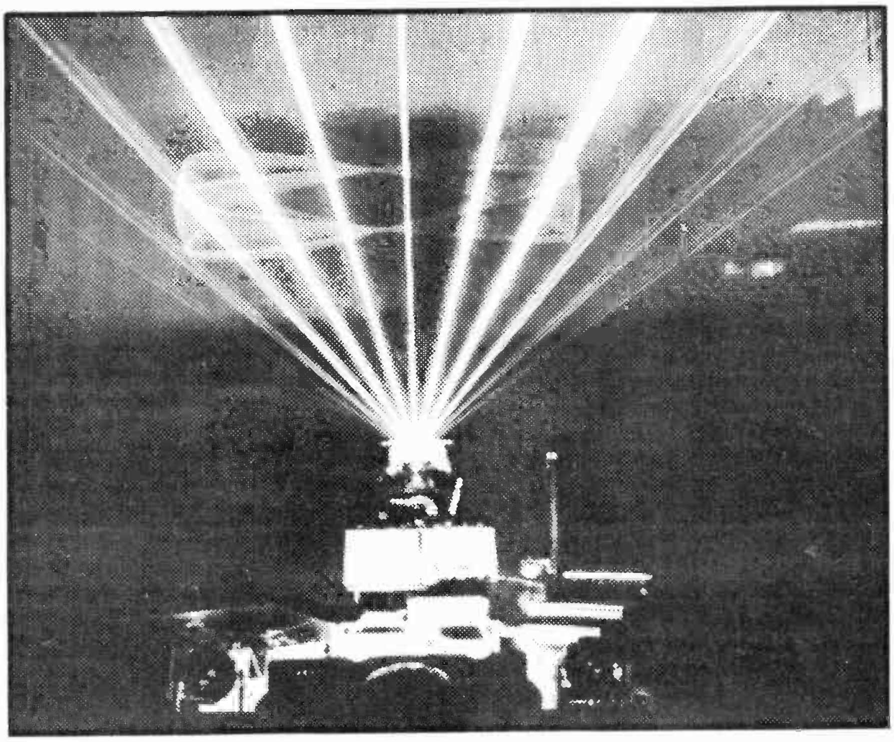


sound light experience — one not to be missed if you get a chance!

Light Fantastic

Was the name given to a recent exhibition cum laser show at the Royal Academy in London. This was mainly to let the public see the results of recent research in Holography and special laser effects by Nick Phillips, Anton Furst and John Wolff — collectively known as Holoco. The show consisted of dozens of Holograms, of different types, and an automated light show every 15 minutes — over the heads of the public — to the accompaniment of classical music. The main attraction for passing crowds, was the EiiR symbols lased into the London sky over the Royal Academy.

Light Fantastic was a tremendous success with huge queues all the time, in fact it seems to have sparked off the recent upsurge in Lasers as good things to watch! John Wolff is also the technical manager for The Who, and has been using powerful lasers at their concerts for some time. His own show is due to open in August at the New London Theatre, using 9 lasers each 4W in power. In fact John probably has the biggest collection of lasing power outside of industry, some of his big (one new one is 60W) lasers vapourised the mirrors used to deflect them!



General Scanning

In 1975 Jean 'Coco' Montagu of General Scanning Incorporated, Massachusetts, became the first man to develop a Laser Projector capable of reproducing graphically alpha-numeric symbols as well as the more familiar and simplistic abstract patterns. He demonstrated this development in a dramatic way. Using his Laser Skywriter PCX101 the logo of the magazine Industrial Research was "written" on the clouds over Cambridge, Massachusetts, as were other graphics, including a 'flying-saucer'.

Since then General Scanning Inc. (who happen to be the main manufacturers of scanners in the world), have developed a unique type of laser projector. What makes this type of Laser Projector different and far in advance of other such Laser Projectors used in the field of Entertainment is that in addition to being able to describe abstract patterns and shapes it has the capability not only of creating alpha-numeric images but also moving line drawings of amazing diversity. At the time of writing no other Laser Image-Making Machine has quite the same advanced capabilities.

Top photograph was taken in Holoco studios, when they were preparing for the Royal Academy show "Light Fantastic". The EiiR symbol was projected above the Royal Academy during the show. (Photo: Theo Bergström.)

On the left is a view of Crystal Machine in full flight, the massive synthesiser bank can be easily seen.

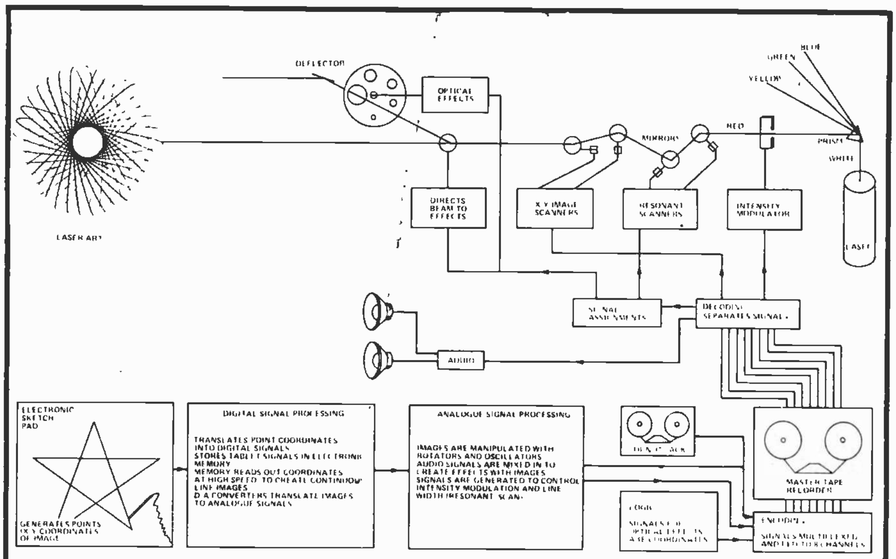
Lovelight

Realising the possibilities of the General Scanning machine, Gerd Stern — of Intermedia Systems — devised and produced Lovelight. With a team of over 50 people (technicians, artists and musicians) the master tape took about 9 months to produce. They literally had to start at the drawing board. The drawings were then processed via an X-Y pad into digital form, the basic system can be seen in the drawing on the left.

The original idea was to produce a laser musical, in fact they ended up with a tape and a machine — instead of a live production. The world premiere of Lovelight was on February 2nd 1977, at the Charles Hayden Planetarium in Boston, U.S.A.

The difference between Lovelight and all other laser shows is that graphics are projected as well as the spectacular effects produced by other systems. The colour photograph on our front cover is one such mixture, a spider climbing a laser web! A second machine was built and is being used in England, producing an identical show to its Boston twin. The English Lovelight is being staged at the Metropole Laser Theatre (formerly a cinema) in Victoria, London. This show is being put on by Laser Visuals Ltd in association with Rank Leisure Services Ltd and the American producers.

The Hewlett Packard instrumentation recorder has its 8 tracks multiplexed, to give an effective capacity of 32 information channels. The stereo sound track is recorded separately on a Teac 3340, with a third track providing sync pulses to keep everything together. The response of the resonant scanners (which provide control beam width and intensity) is up to a phenomenal 8kHz, the X-Y scanners have a more normal 2kHz response. This may not seem very impressive, but up until fairly recently controlled response up to 1kHz was difficult to obtain.



Schematic of the system used in Lovelight. This is the most advanced system in use at the moment. The scanner network is duplicated for the three other colours shown.

The laser used is made by Control Laser of Florida, and is a 1.2W Krypton/Argon type. A 42 foot diameter, parabolic aluminium screen is used as the projection surface (the largest ever built in England). Watching the show one has the same feeling that was probably felt by early cinema audiences. The overall effect is that of watching a computer generated animation film, but the figures are simple — even childish — in comparison to genuine computer animations. Nevertheless, it is an interesting experience, to be seen if you get a chance.

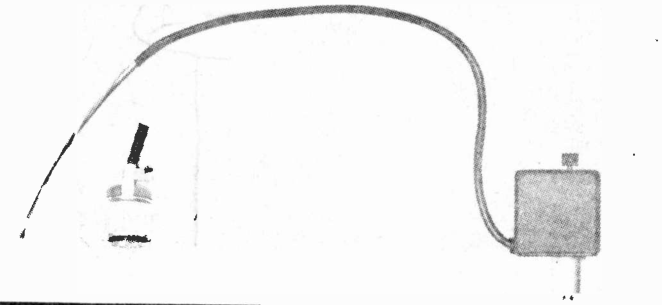
Laserium

Laserium was created in America by Ivan Dryer, a Californian film-maker and photographer, who developed the idea after seeing a laser projection technique demonstrated at the California Institute of Technology in 1970. He made a film of it (Laserimage) but recognised that film could not adequately capture the vivid effect of live laser beams. His years as a guide at the Griffith Observatory, Los Angeles, prompted him to choose a planetarium as the ideal environment and in 1971 he formed Laser Images Inc to explore the applications of lasers in entertainment.

Laserium was first presented at the Griffith Observatory in late 1973, since then it has been playing in 14 other centres, including Kyoto, Japan, where a specially constructed Laserium dome was opened in March 1976. Recently Laserium opened at the Planetarium in London as well.

The system used by Laserium is based around a 1W Spectra Physics Krypton laser.

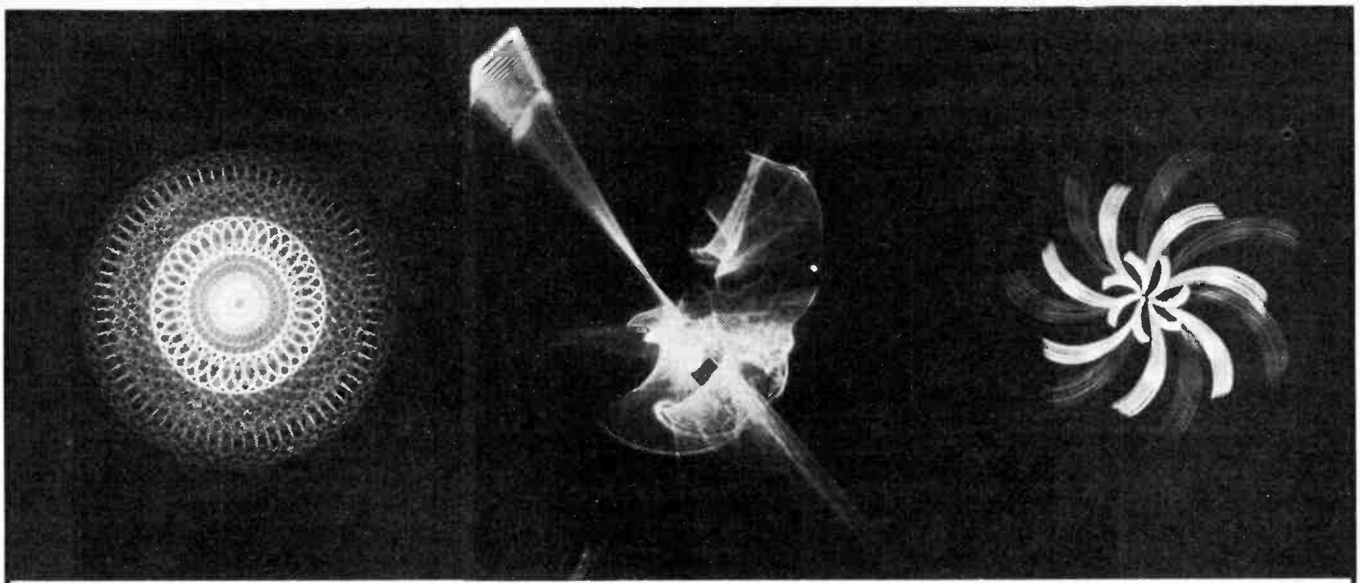
The greenish white beam is



A General Scanning G-100PD scanner as used by most of the systems described in the text, cost is about £400 for the standard model.

Scanners are mirrors mounted on galvonometers which describe a special and particular arc of rotation. The laser beam is guided into the mirror and thus reflected onto the projection surface. When the mirror moves, the laser beam is seen to move. The mirror movement is very rapid and the beam when deflected at anything over 20 times a second will appear to the viewer as a persistent and unbroken line, the path of the laser beam. At that speed of deflection our eyes can no longer perceive a single point of light.

With two mirrors mounted at right-angles to each other with perpendicular rotational axis, it becomes possible to guide the laser beams to any point in a two-dimensional field. This technique is known as X-Y scanning.



Three effects produced by the Laserium system. On the left is the basic type of geometric pattern produced by simple (but sophisticated!) X-Y scanning. Centre is the strange sort of effect produced when passed through a sheet of clouded glass, with deformation of the geometric pattern. Right is a "chopped" pattern, all of these patterns are continually changing.

passed through a prism, which splits the beam into red, yellow, green and blue beams. Each of these beams is processed via modulators, scanning mirrors etc, to produce multicoloured images on the Planetarium dome. Sound tracks and basic control signals are provided from a pre-recorded tape (played on a Teac 3340 four channel machine), but the main modulation signals are mixed and blended live, by an operator called a Laserist. Even though far less sophisticated than Lovelight's system, the effect is far more vivid, and no two performances are ever the same.

Other developments

So with all the laser shows at present, London seems to be the laser capital of the world. The only drawback to more people experimenting with similar systems is cost, most of the systems described have cost at least £100,000 and the laser itself is about £4,000.

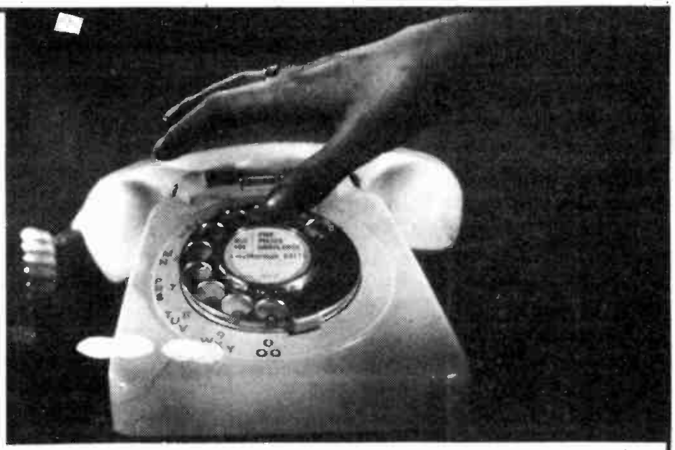
However, if you fancy playing with lasers Holographic Developments Ltd may have the answer. They are developing a small ½mW laser for home use, which is expected to cost less than £200, also they are working on cheap scanning and effect attachments to stick on the end — the home laser light show may be just around the corner.

So lasers have become not only a tool for measuring, cutting, welding, and burning, but also an imaging device. As a contribution to visual displays and media, scanning projection is very appealing. These projections are not confined to a frame, as are film and television, nor to a particular projection surface. Lasers can be aimed at walls, clouds, balloons, or mountains, and can be safely used in indoor environments when not aimed directly at the audience, but reflected from a surface such as a planetarium dome.

Stop Press:

The Science Museum is staging a laser exhibition in November for three months — are lasers contagious?

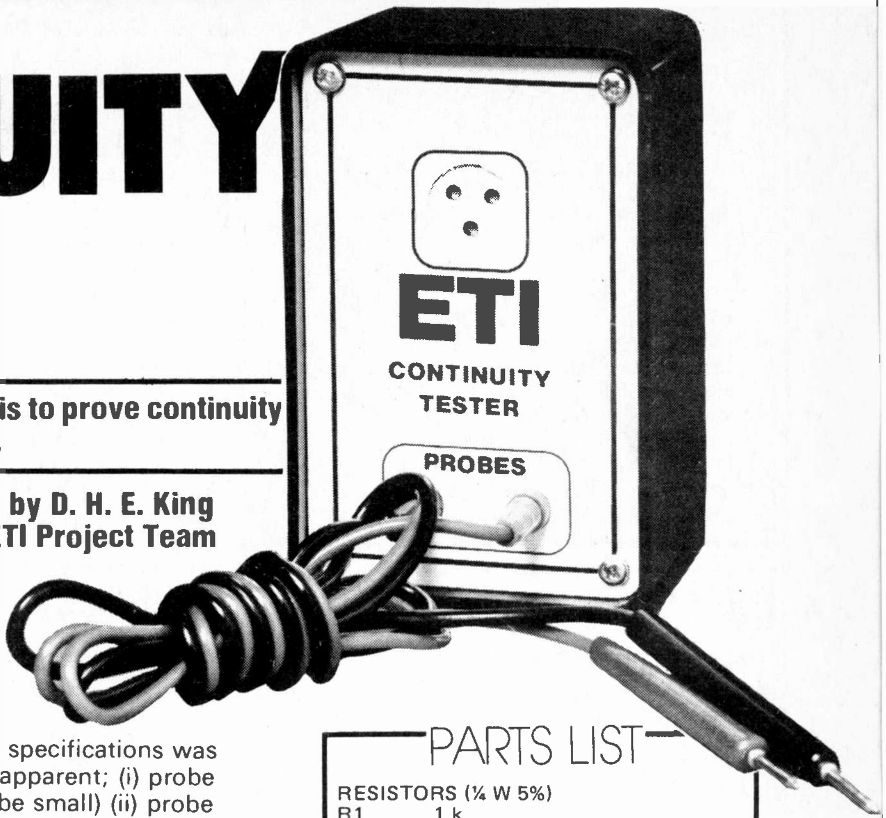
Special thanks for help in research on this article to: Tim Blake (Crystal Machine), Wilf Eggers (General Scanning Inc.), Carolyn Fairley and Brian Scott (Laser Visuals Ltd.—Lovelight), Ivan Dryer and Roger Helm (Laser Images Ltd. — Laserium), Theo Bergström, Holoco and Andy Harris (Holographic Developments Ltd.).



Left, part of a John Wolff show, of the type used in Who concerts. Right is a hologram shown at the Light Fantastic exhibition — the phone looked so real that some people tried to use it! (Both photos by Theo Bergström.)

Short Circuit

CONTINUITY TESTER



One of the commonest uses of a multimeter is to prove continuity — it's not the best way of doing it however.

Designed by D. H. E. King
Built by ETI Project Team

THE PROBLEM WAS IN A TV receiver; a loom of wires connecting one section to another had duplicate colours within the loom so that amid the usual amount of dirt and dark corners it was impossible to trace the course of one particular wire. The answer to the problem was a straightforward continuity tester, a multi-range ohmmeter may be suitable but could cause some trouble in differentiating between zero and a few hundred ohms and also in reading ''through'' a semiconductor that was in circuit and giving misleading readings.

In the course of servicing a variety of apparatus this question of continuity occurs over and over again; the absence of firm points available for contact clips often means that pointed probes must be pressed into a small joint or onto part of a printed circuit, and while concentrating on the probes it is of course difficult to keep an eye on the meter pointer and in particular to read the value of resistance — or the lack of it.

Design Considerations

Several simple circuits were tried — a lamp, battery and probes still demanded the attention of the eyes; replacing the lamp by a buzzer was more successful but needed some three to four volts and gave no indication of a series semiconductor junction if the polarity was ocrrect while the current flow was large enough to damage the more delicate devices within the circuit under test. An extension of the principle to operate an astable (multivibrator) type of oscillator gave good audiblity but would operate from zero through to several thousands of ohms and so was too general an indication.

A set of specifications was becoming apparent; (i) probe *current* to be small) (ii) probe *voltage* to be as low as possible, preferably less than 0.3V to avoid seeing germanium or silicon junctions as a continuous circuit; (iii) no on-off switch to be used.

The circuit was the result and several dozen have been constructed and are earning their keep for both ''heavy'' electricians and electronic technicians.

The output from the speaker is not loud but is more than adequate for the purpose. We used a surplus telephone insert which are often available from component retailers. Small transistor radio loudspeakers with impedances of 25-80 ohms are also available. In both cases the resistance should be brought up to 300 ohms by adding series resistor R8.

PARTS LIST

RESISTORS (¼ W 5%)

R1	1 k
R2	2k2
R3,4	22k
R5	2k7
R6,7	56 k
R8	See Text

CAPACITORS

C1,2	22 n polyester or ceramic

SEMICONDUCTORS

Q1	BC178 or similar
Q2,3,4,5	BC108 or similar
ZD1	8V2 Zener Diode, 400mW
D1,2	1N4148 or similar silicon diode

LOUDSPEAKER

LS1	25-80 R, See Text

CASE

DORAM type M2 (984-510)

MISCELLANEOUS

Two 2mm sockets, plugs and probes to suit, connecting wire, PP3 9V battery and clip, Nuts, bolts, pcb spacers. PCB as pattern.

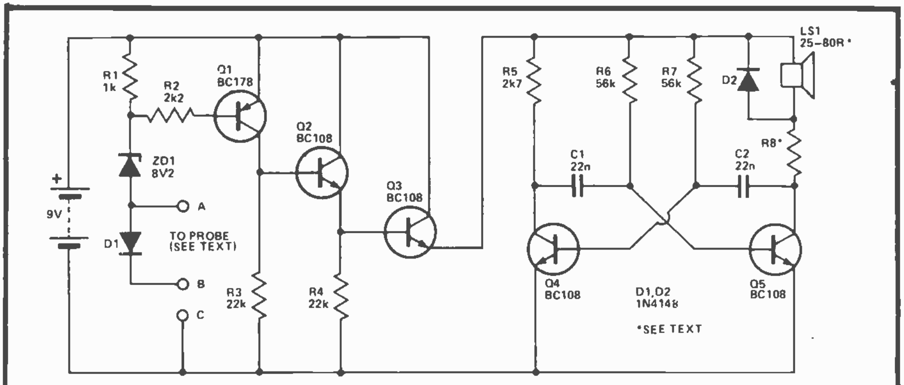


Fig. 1. Circuit of the continuity tester; note that an on-off switch is unnecessary. D1 is used when the battery is brand-new and giving over the nominal 9V Q1, Q2 and Q3 act as the switch for supplying power to the multivibrator.

HOW IT WORKS

Starting with a 9 V supply, when the probes are short-circuited there is 8V2 (8.2 V) dropped across the zener diode ZD1 leaving a maximum of 0V8 (0.8 V) across R1. Application of Ohms law shows that a maximum current of 0.8/1 000 = 0.8 mA flows via the probes and this satisfies the first design requirement of low probe current.

Q1 is a silicon type and the base-emitter voltage will need to be about 0V5-0V6 (0.5-0.6 V) to forward-bias the junction and initiate collector current. With a maximum of 0V8 available across R1 it is seen that if a semiconductor junction or resistor is included in the outside circuit under test and drops only 0V3 then there will be 0V5 remaining across R1, barely enough to bias Q1 into conduction.

Assuming that the probes are joined by nearly zero resistance, the pd across R1 is 0V7 - 0V8 and Q1 turns on, its collector voltage rising positively to give nearly 9 V across R3. Q2 is an emitter follower and its emitter thus rises to about 8V3 and this base voltage on Q3 (a series regulator circuit or another emitter-follower if you prefer it) results in some 7V7 being placed across the Q4 - Q5 oscillator circuit. All the transistors are silicon types and unless the probes are joined, only leakage current flows from the battery thus avoiding the need for an on-off switch. When not in use, the battery in the tester has a life in excess of a year.

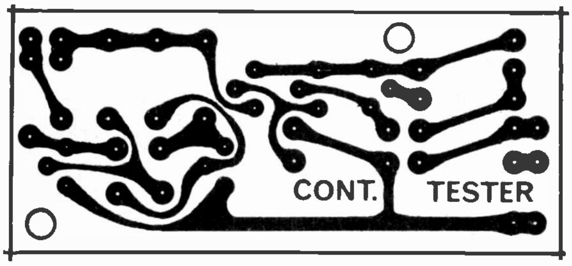


Fig. 2. The pcb pattern shown full size (73mm x 33mm).

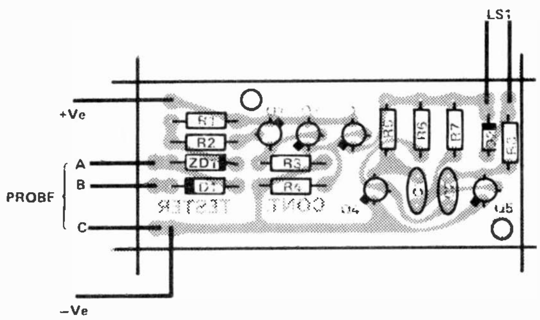
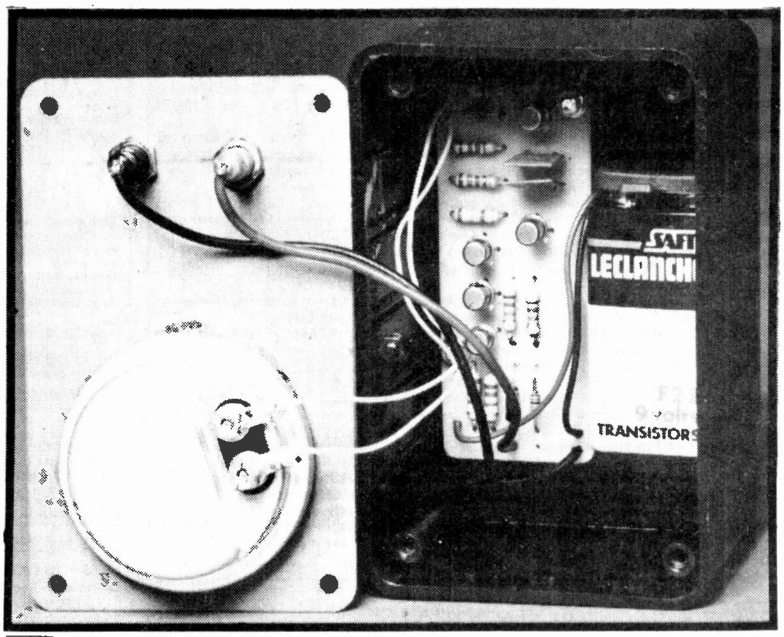


Fig. 3. The component overlay on the pcb and other wiring.



Inside view of our unit built into a small plastic box with metal top.

BUY LINES

All components should be available as standard items from most stockists. LS1 can be between 25 and 80 ohms although the 80 ohm types are generally 2½ –2¾" in diameter and these will not fit into the case that we used.

The speaker used in the prototype was a GPO type earpiece from a handset; these are available from some surplus suppliers. See note about R8.

The total cost of this project should be £3.50 – £4.00 depending on the case and the speaker used.

An experiment worth doing is to select the value of either C1 or C2 to produce a frequency of oscillation that coincides with the mechanical resonant frequency of the particular earpiece transducer in use. Having chosen the correct value, which probably lies in the range 10n-100n, the tone will be louder and more piercing. A "freewheel" diode D2 is connected across the transducer since the fast switching action of the oscillator circuit can produce a surprisingly high back e.m.f. across the coil and these high voltages might otherwise lead to transistor damage or breakdown.

Zener diodes do *not* provide an absolutely constant volt-drop regardless of current; at the 0.8mA design current an 8.2V diode will quite possibly give only about 8.0V drop since test current for zener selection and marking is typically 5mA or more. A further possible source of error is the battery; the one suggested *nominally* provides 9V but a brand-new specimen may perhaps provide some 9.5 to 9.8V until slightly run-down and this "surplus" voltage, combined with an "under-voltage" zener volt-drop will leave considerably more than the forecast voltage available at the probes. A silicon diode D1 is therefore connected in series with the zener to decrease the probe voltage by a further 0.6V or so. During final test and just before boxing the completed circuit, the most suitable connection, A or B, is selected for the positive probe wire. The aim is to have the circuit oscillating with short-circuited probes but to stop oscillation with the least amount of resistance or the inclusion of a diode (try both ways) between the probes.

No sensitivity control is fitted although it would be possible to take R2 from the slider of a control replacing R1. It was not thought worthwhile, however, to spoil the simplicity of the apparatus with anything external other than just the two probes.

There is no easy way to proof the unit against connection to the mains supply. Be careful if checking mains wiring and *switch off first*. In a similar way, if checking electronic apparatus for unwanted bridging between Veroboard tracks, for instance or a suspected crack in a printed circuit track *switch off first*.

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ANNOUNCEMENT

FURTHER INFORMATION ON Z80 COMPUTER SYSTEMS AVAILABLE SOON FROM SINTEL

We will be offering two different packages. The first system, the **RESEARCH MACHINES 380Z**, will be available built and tested and also in kit form. This is a fully independent computer system when used in conjunction with a television and cassette recorder.

The second system, the **RESEARCH MACHINES 280Z**, will be available in uncased kit form, with a low cost keyboard. The RESEARCH MACHINES 280Z is designed to set a new low in computer system pricing and it will bring a full computer system within reach of many more private computer enthusiasts.

(These computers are designed and manufactured in Oxford by SINTEL's parent company RESEARCH MACHINES LIMITED, and will be sold through SINTEL.)

RESEARCH MACHINES 380Z will have the following specifications:

ALPHANUMERIC DISPLAY The 380Z has a UHF output which plugs into the aerial socket of a **completely unmodified** domestic television. The TV screen will then display 24 rows of 40 characters (960 characters). The unit can display the 128 character ISO7 set, including upper and **lower** case ASCII.

GRAPHICS DISPLAY The 380Z can display graphics on the TV screen on a matrix of 80 (horizontal) x 72 (vertical). Graphics and alphanumeric characters can be intermixed.

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CASSETTE INTERFACE CUTS, Kansas City standard, 300 bits per second.

CPU SPEC. Z80 Microprocessor. Fully buffered bus.

RANDOM ACCESS MEMORY 4K bytes dynamic RAM minimum. The system can accommodate up to 32K bytes without adding any memory PCBs. Using a page select mode, the computer memory can be expanded indefinitely.

FIRMWARE (This means software supplied and available at Switch-On, in ROM, otherwise known as the MONITOR.)

MONITOR COMMANDS: List Memory, Modify Memory, Load From Cassette, Dump on Cassette, Single Step 'Trace,' Go To User Programme, Breakpoint, etc.

SOFTWARE We will be offering: Extended Monitor, Various Basics, Text Editor with both a sequential and immediate mode, Machine Language Graphics Subroutines, Games Packages, Resident Assembler.

HARDWARE CONFIGURATION Computer is housed in an instrument case with power supply, and a lot of room for expansion. Keyboard is in a separate case. All connections between units are made with unpluggable connections.

RESEARCH MACHINES 280Z

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40mm x 205mm x 140mm

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This kit is also available with Battery Backup which will maintain timekeeping during disconnection from mains supply, and with Crystal Control to improve accuracy

ACK+BBK+XTK **£34.33**

The Kit is complete less mains plug, cable and battery.

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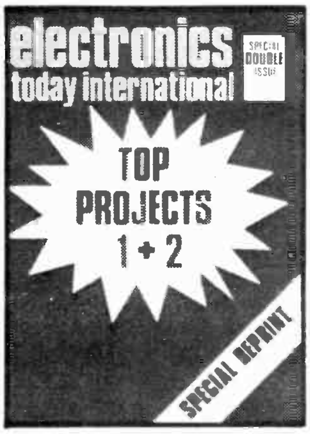

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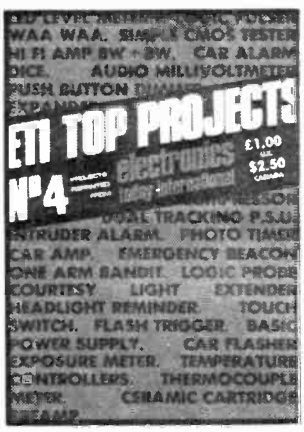

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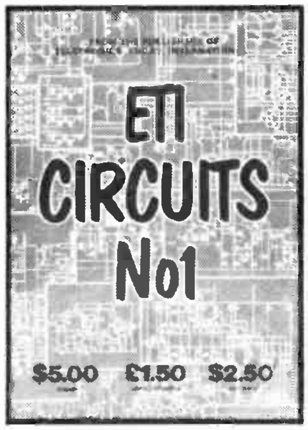

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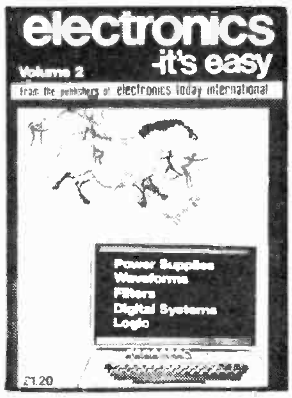

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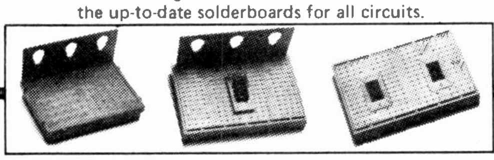

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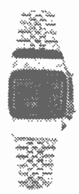

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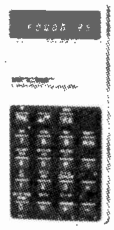

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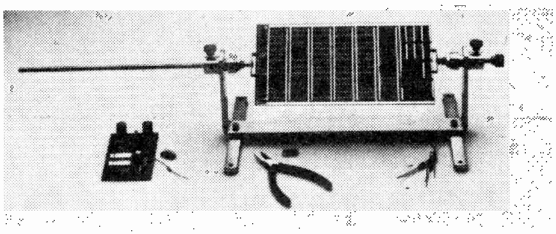

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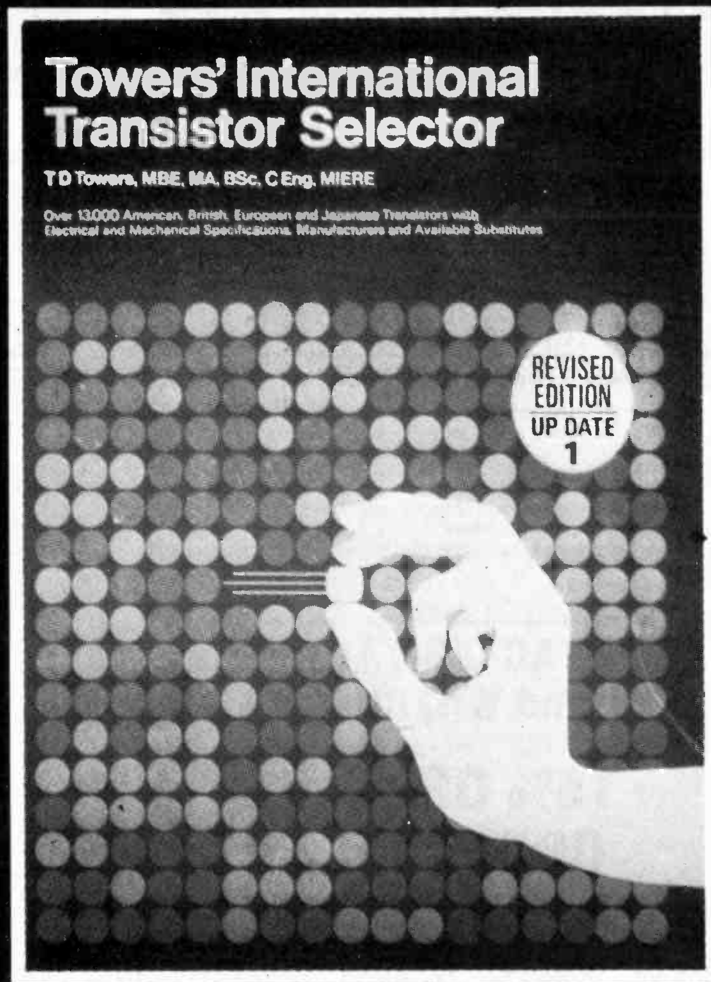

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RF CHOKES

Part 13 of our component series examines the differing styles of RF chokes and the important parameters connected with their design.

RADIO FREQUENCY chokes are used to prevent the passage of radio energy (hence the term 'choke') while allowing direct current or lower-frequency signals (eg, audio) to pass. This sort of application is principally one of decoupling; that is, isolating the RF – carrying portions of a circuit by providing a high RF impedance between two portions of the circuit. The principle also applies in RF interference suppression applications. For example, in reducing RF 'hash' from SCR or Triac motor speed controllers, light dimmers, etc.

RF chokes are also used widely in a variety of filter applications, eg, low-pass and high-pass filters. They are also used in pulse-forming networks and as frequency compensation components in wideband amplifiers (eg, video amplifiers).

RF chokes are also referred to as 'minichokes', 'microchokes' and 'video peaking chokes'.

Construction

The general range of construction styles employed are illustrated in Fig. 1. The different winding styles have particular advantages and characteristics on which we will elaborate shortly. RF chokes are generally made in values according to the preferred series E6, E12, and E24, in tolerances of 5%, 10% and 20%.

Regardless of the form of the winding or the encapsulation, RF chokes are wound on bobbins consisting either of a phenolic or plastic material (non-magnetic), powdered iron or ferrite material. The last two materials, because of their high permeability increase the inductance of the winding effecting a decrease in the number of turns required as well as influencing the other characteristics of the choke.

The bobbin generally has integral pigtail leads moulded into the material to which the winding is terminated. Axial leads are the most common form although radial-lead RF chokes are obtainable – principally intended for printed-circuit mounting.

A form of construction that reduces the external magnetic field of the choke to negligible proportions is illustrated in Fig. 2. This form of construction completely encloses the winding with the result that it has a very weak stray field, reducing 'crosstalk', or coupling, between the choke and adjacent components. In fact, two chokes can be mounted so that they touch each other over the full length of the bobbin – and crosstalk attenuation is quoted as 60 dB.

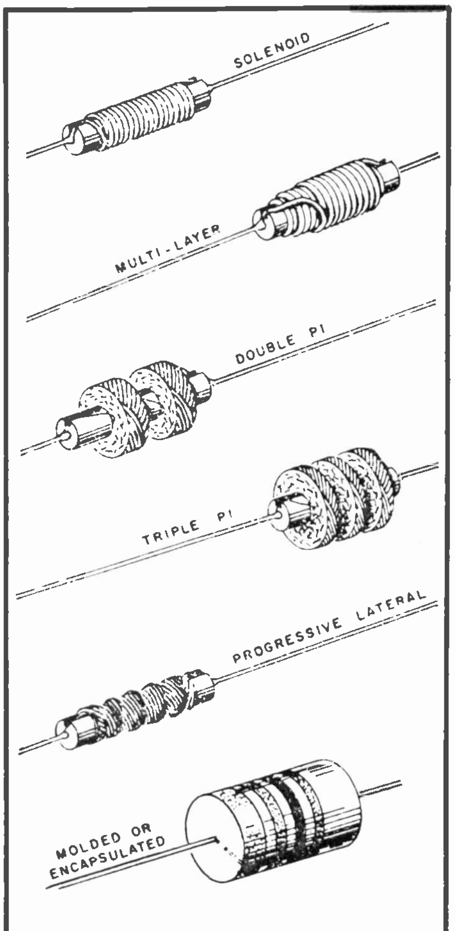

Fig. 1. General range of constructor styles of RF chokes. The particular style employed depends on the required or allowable component size, the inductance, the application and the required characteristics.

Low inductance RF chokes are usually 'solenoid' wound, whereby a single layer of wire is closewound on the bobbin. Chokes in the range 0.1 µH to 200 µH are generally solenoid-wound. The very low inductance types below 10 µH are generally wound on a non-magnetic bobbin. Powdered iron bobbins are generally used for chokes between about 5 µH and 100 µH, ferrite for the higher inductances to 200 µH or so.

Higher inductance chokes are obtained by overlapping several closewound layers on the bobbin. There is a limitation to this as the self-capacitance of the winding increases, decreasing the frequency range over which the choke is effective. This is discussed later. Chokes in the range 20 µH to 10 mH are often multilayer wound, generally on powdered iron or ferrite bobbins.

The Philips series of 'micro-chokes' cover the inductance range from 0.1 µH to 100 mH and employ solenoid or multilayer windings on the enclosed ferrite bobbins as illustrated in Fig. 2.

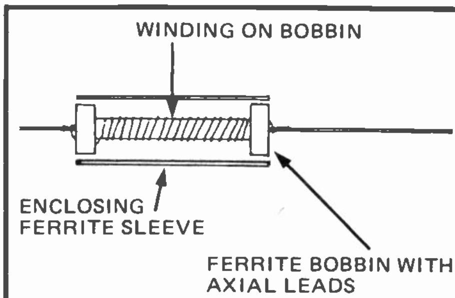

Fig. 2. Construction of fully-enclosed style of RF choke. Philips' 'microchokes' are made in this style.

RF CHOKES

RF chokes from around 47 μH through to 100 mH are often 'pie-wound'. This is a form of winding where the wire is zig-zagged around the circumference of the bobbin and built up in many layers. The individual turns are not colinear — lying alongside the adjacent turns — but the wires cross at an angle due to the zig-zag winding, thus reducing the total self-capacitance of the coil. A multilayer winding wound in this way is termed a 'pie', the method of winding is also referred to as 'universal' winding.

Pie-wound RF chokes may have 1, 2, 3 or as many as 5 or 6, pies making up the inductance. Generally the pies are of the same width, diameter and number of turns but some types for special applications, or where special characteristics are required, are wound with a number of pies, each having a smaller diameter but a greater width than the preceding pie. This achieves a more uniform impedance characteristic over the desired frequency range.

A variation on the pie winding is the 'progressive lateral' type where the zig-zag winding is progressively moved along the bobbin rather than building a high, multilayer pie. This technique reduces the inherent self-capacitance of the winding and provides a more uniform impedance characteristic across the required frequency range.

Encapsulated chokes are generally of solenoid or multilayer construction, and are encapsulated in an epoxy or other suitable material. Pie-wound chokes are sometimes encapsulated although they are more usually wax-impregnated. Heat-shrink tubing is also used to enclose and protect RF chokes.

Characteristics

RF chokes are an inductance that is required to have a high value of impedance over a wide range of frequencies.

In practice, an RF choke has inductance, distributed capacitance, and resistance. At low frequencies, the distributed capacitance has negligible effect and the electrical equivalent of the choke will be as shown in Fig. 3(a). With increasing frequency the effect of the distributed capacitance becomes more evident until at some particular frequency it becomes a parallel resonant circuit. The equivalent circuit at and around this frequency is

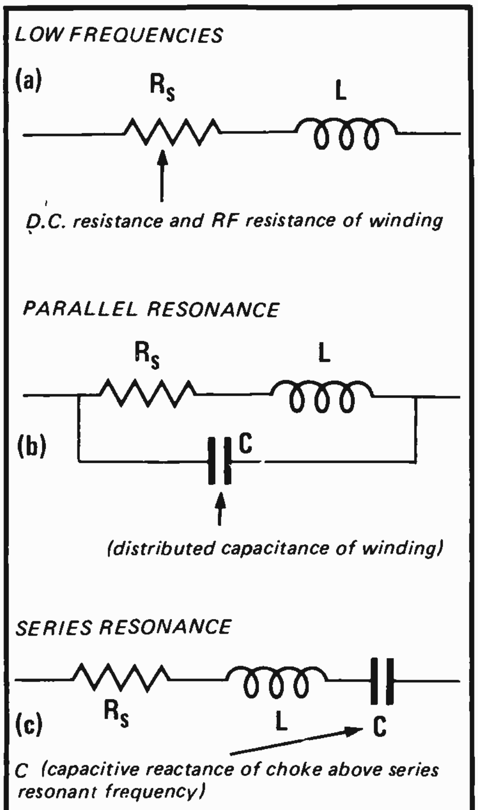

Fig. 3. Equivalent circuits of an RF choke over a wide frequency range.

illustrated in Fig. 3(b). At frequencies beyond this the overall reactance of the choke becomes capacitive and eventually the choke becomes a series resonant circuit, as shown in Fig. 3(c).

The cycles of parallel resonance-reactance, series resonance, etc, repeat with increasing frequency, the overall impedance of the choke rapidly becoming lower past the initial cycles. This sort of characteristic is illustrated in Fig. 4.

The lower the self capacitance of a particular style of winding, the higher will be the series resonant frequency (also referred to as the self-resonant frequency), thus allowing the choke to operate over a wide frequency range. Special windings, such as the progressive lateral, have extremely low distributed capacitance as well as less variation in impedance across the frequency range, compared to other styles. The variation in self resonant frequency versus choke inductance for three different bobbins and winding styles is illustrated in Fig. 5.

The equivalent series resistance of a choke is made up of the actual dc resistance of the winding plus the RF resistance of the wire used due to 'skin effect'. The actual dc resistance of the choke may need to be taken into account in a circuit, particularly in high current circuits or with high inductance chokes. The latter may have dc resistances up to 500 or 600 ohms.

The equivalent series resistance (also called the 'apparent resistance') varies with frequency, reaching a peak before decreasing due to the shunting effect of the distributed capacitance of the winding. The variation of R_S with frequency for a range of inductances is illustrated in Fig. 6.

Naturally enough, RF chokes have a limit to the amount of dc current they can carry without either overheating or effecting a change in the inductance outside the specified tolerance limits. Manufacturers specify a maximum dc current for their chokes.

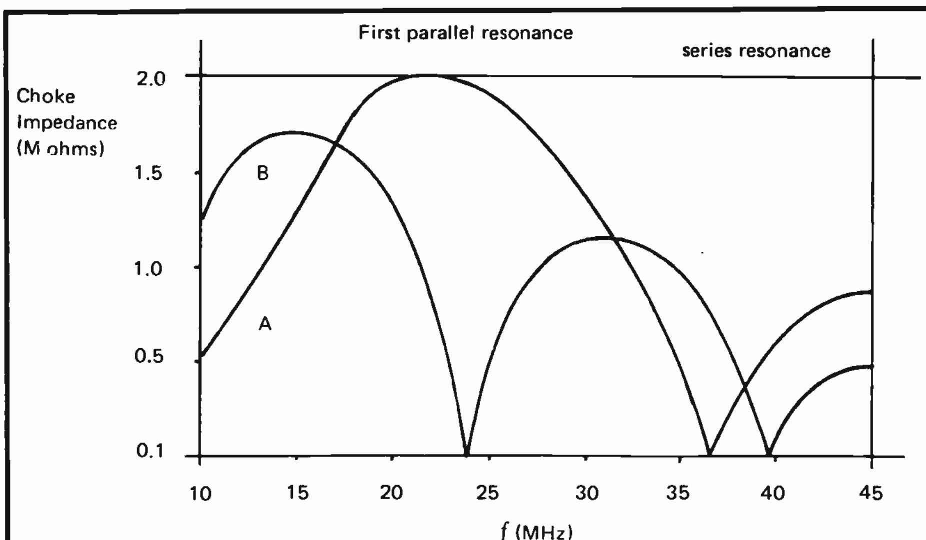

Fig. 4. Typical behavior of two RF chokes (A = around 10 μH, B = around 40 μH) over a range of frequencies.

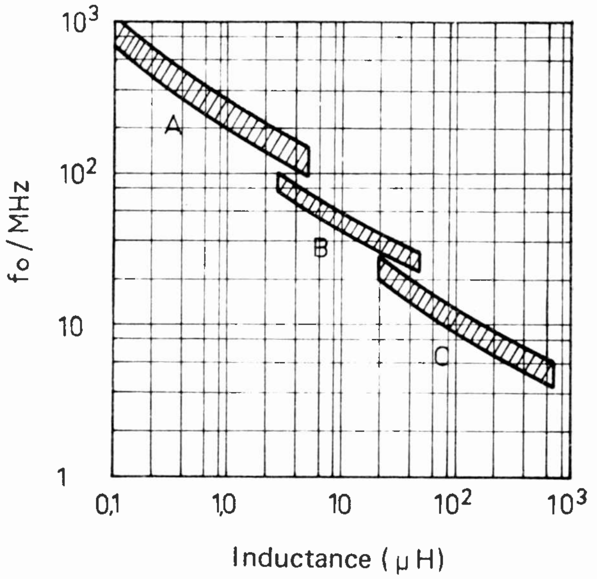

Fig. 5. Typical variation of self-resonant (or series-resonant) frequency against choke inductance for three different styles of choke construction.
A = non-magnetic bobbin
B = solenoid wound (single layer) chokes on powdered iron and ferrite bobbins
C = Multilayer chokes on powdered iron and ferrite bobbins.

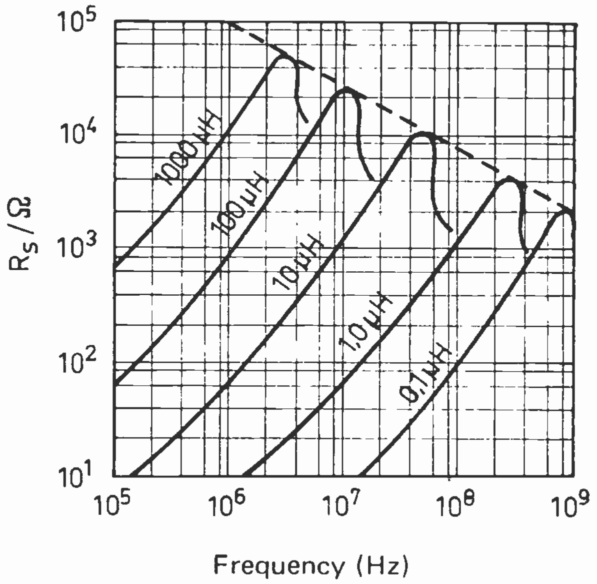

Fig. 6. Typical variation or equivalent serves resistance of a range of RF chokes against frequency.

RF chokes are generally low Q components. The actual Q specified by a manufacturer is generally the minimum Q, measured at a particular frequency, generally in the manner illustrated for several values and two sizes in Figure 7.

Markings

RF chokes are marked with their value and tolerance with the standard colour code or typographic code, in much the same way that resistors and some capacitors are marked.

The nominal inductance value is always indicated in microhenries (μH).

Where a typographic code is employed it is generally of a quite simple form, similar to that used on resistors. The nominal inductance value, again, is always expressed in microhenries (μH). The value is identified as follows:—

Nominal inductance values less than 100 μH are identified with three (3) numbers representing the significant figures, the letter R being used to designate the decimal point.

eg, 0.68 μ H = R680
4.7 μH = 4R70
33 μH = 33R0

Nominal inductance values of 100 μH and above are identified by a four digit number. The first three (3) digits represent the significant figures of the value and the last digit specifies the number of the following zeroes,

eg, 680 μH = 6800
4700 μH 4701 (4.7 mH)
33000 μH 3302 (33 mH)

In addition, a single letter may be added to indicate the tolerance, as follows:

J = ± 5%
K = ± 10%
M = ± 20%

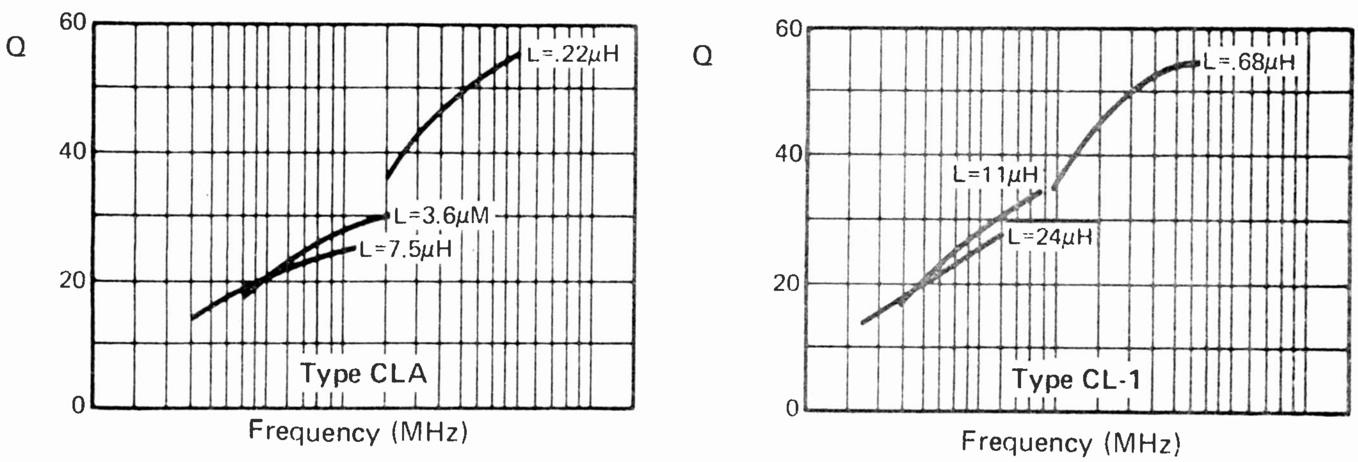

Fig. 7. Typical Q values versus frequency for several values of two different sizes of moulded RF chokes (From IRH).
CLA = 6.4 mm dia. x 78 mm long.
CL1 = 6.4 mm dia. x 27 mm long.

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MICROFILE

Gary Evans compares one of the latest development kits with a soon to be launched "home" computer.

The new MEK 6800 D2 development kit from Motorola together with the announcement, that a leading manufacturer of kits for the home constructor is to launch a home computer kit, has prompted us to take a look at some of the differences between development and computer kits.

Development of a development

First though, lets just think back to the early days of MPU activity and trace the origins of the development kit. In those early days the MPU was seen as a control system, replacing many of the then, and still, standard TTL chips of a hard wired system. The manufacturers of Micros had to sell them to industrial users and stressed, not only the small size, low power etc of these devices, but also the ease with which the control characteristics of a system could be altered by simply plugging in a new PROM.

To enable the manufacturer to develop the software for any particular system, a means of readily building up a program in some form of memory was required. To write and debug software it was recognised that the minimum requirement was for some form of keyboard entry of data, in hex or octal codes, together with the ability to examine and modify locations as development proceeded and bugs were identified.

The development kits were designed to fulfil this role. The early kits were quite simply an MPU plus clock chip, small amount of RAM together with a PROM storing the minimum monitor routine. These routines were often configured with a TTY ⅛/? routine reliable for an industrial user this was the easiest form in which to input and record data. The provision of a TTY was not a problem for the majority of industrial users.

The development systems small amount of on-board RAM could be augmented by additional RAM cards, but in most cases the partial memory decoding used on the development kits board limited the amount of uniquely addressable locations, to a fraction of the full range of the MPU. This was, again, not a serious disadvantage to the men in industry as most control applications do not equire the full 64K byes range of most 8 bit processors.

Home market

When development kits on the lines described above first became available in the States it was soon realised that many were being bought by private individuals who were interested in this new product. It became evident that a vast new market was being opened up.

One of the major advances in development kits, from the amateurs point of view, was when the manufacturers realised that not every home hobbyist had a TTY. This was when the first LED displays and hex keyboards became available and allowed anybody with a power supply to get a system up and running.

The new Motorola kit has all these features, plus a few more. Data can be entered via a hex keyboard at any location in the 256 Byte RAM supplied with the kit, the data together with address is displayed on a series of 7 segment LEDs. To aid development of software, breakpoints can be inserted in a program, returning control to the systems monitor routine. The program may also be single stepped to allow the user to find any obstinate bug.

These features make the monitor program a very good example of its kind, allowing fast, painless development of software. It has the additional feature of allowing the user to dump sections of the systems memory to a cassette tape using the CUTS standard. These sections can then be loaded back to the system at any desired point in memory.

The D2 then represents one of the most versatile and easy to use development kits available at present. It does however have its limitations. These lie mainly in the area of system expansion.

The means by which memory decoding is undertaken means that a great deal of thought has to be given to the way in which additional memory is added to the system. There is also the fact that although the board is EXORciser compatible, which suits industrial users, it does not by any means have a nice simple bus structure which, it is agreed, is almost a must for any Micro-computer system.

New kit — New bus

The new computer kit combines the best features of the development kits with a good bus structure and flexible individual units.

The kit, called the H8, is to be launched by Heathkit in the States very soon. It is based on the Intel 8080 MPU, and will come with a 1K monitor program in ROM together with data entry and display devices. Data is entered via a bank of switches with display in an Octal Format. Dump and load functions will be available, again using CUTS.

The kit will come complete with a cassette tape of an 8K BASIC interpreter. To run this it will be necessary to obtain a memory card which is also part of the system.

The system uses a bus structure based on a Heath design and is a 50 way bus. It is interesting to note that Heathkit have rejected the S-100 bus more usually associated with the American Hobby fields. They have done this both on technical grounds and also on financial grounds, the cost of a hundred way connector being excessive in their view.

These features, together with the proposed addition of VDU and keyboard input modules, mean that the H8 is the perfect base on which to build a powerful and versatile home computer and, lets face it, thats what most MPU users want to finish up with.

Cut a record

Last month you may remember that we discussed bar coding of data for the home computer user. This enabled large scale, low cost, distribution of software. This month we have come across another system for this type of software trading with all the advantages of the bar code.

The new system is a disc (as in L.P.) that has the data recorded in CUTS and which can be played back on most record players. It overcomes the main drawback to distributing CUTS encoded cassette tapes, namely that of cost. It also means that there is no need to invest in a bar code reader plus software to interpret the input. ●

DESIGNING & USING PART 3
ACTIVE FILTERS

Concluding our detailed examination of this particular building block Tim Orr takes a good look at band pass and band reject circuits.

Band reject (notch) filters

SO FAR NOTCH FILTERS have been realised in this article by two methods: by mixing a bandpass signal with the original or by mixing the low and high pass outputs. There are of course, many other methods of obtaining a notch.

Firstly, the Twin T circuit, Fig. 1.

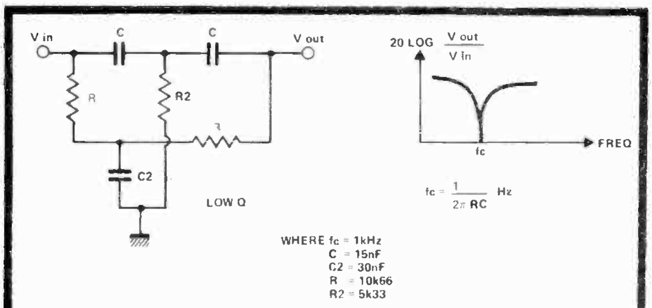


Fig. 1: Twin-T band notch filter configuration.

This is interesting, in as much as by using only resistors and capacitors, a notch response can be obtained! However, as this filter is passive, only a low Q is possible. This circuit is not used very much, because it has *six* components that determine its notch frequency. However, it is of interest to note that, when the Twin T is placed in the feedback loop of a high gain inverting amplifier, a bandpass response is obtained. Also if R is made variable it is possible to move the centre frequency, although in doing so, the Q varies. This has been the basis of many Wah Wah effects pedals, Fig. 2.

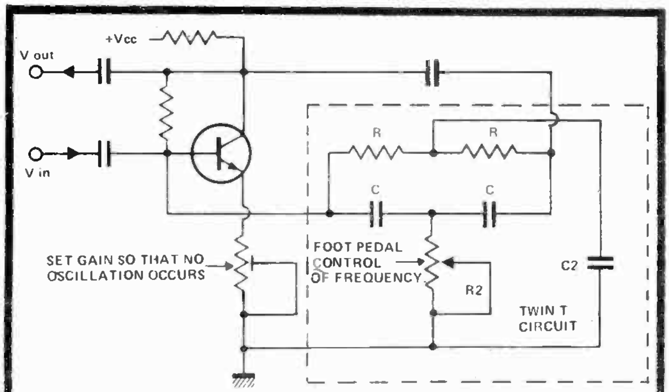


Fig. 2: Block Diagram of a typical Waa-Waa Pedal.

Another method of obtaining a notch is to use the 'Allpass' filter, Fig. 3. The frequency response shows that its output is flat! Not much of a filter I hear you saying. However, it suffers a phase shift which goes from 180°, through 90° at fc, to 0°. By cascading two of these filters, the phase shift is doubled.

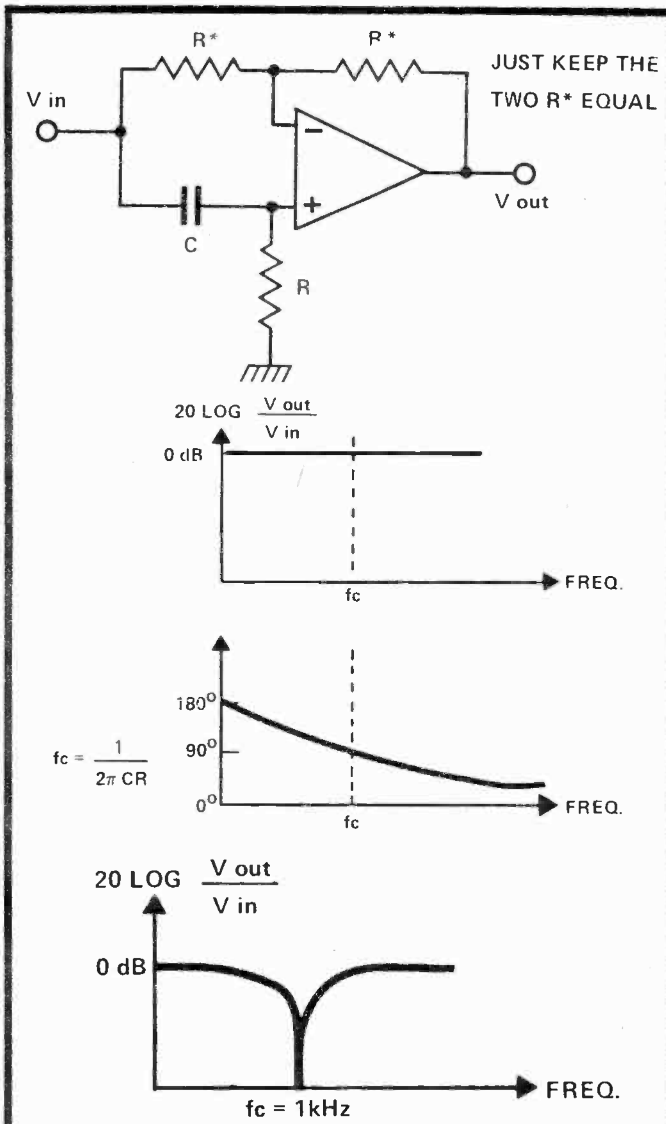


Fig. 3: All-pass filter. At the top is the circuit for such a device. Its frequency and phase responses are shown below it, with the obtainable notch at the bottom.

If we then mix the phase delayed signal with the original, a notch response is obtained. This is because at fc the two signals have the same magnitude, but the opposite phase and so they cancel each other out.

If the notch is to be made tuneable, then the RC time constants must be varied. For a small tuning range just one R can be varied, for a large tuning range then the R's must be realised with a 'stereo' pot.

All change

If lots of Allpass filters are cascaded then several notches can be produced. This type of filter is known as a comb filter. Note that it takes two Allpass filters to produce a usable 180° phase shift, and therefore every notch in the comb requires two Allpass sections. By making the R's variable then the notches can be made to move up and down in frequency. This filter forms the well known 'phasing' effect unit, widely used in the music industry to produce colouration!

Fig. 4 shows a small section of just such a unit. A CMOS chip is used to provide a MATCHED set of six MOS FETS. A common voltage is used to control the MOS FETS channel resistance. Thus as the control voltage varies then so do the six MOSFET resistors, and the three notches move in unison along the frequency axis.

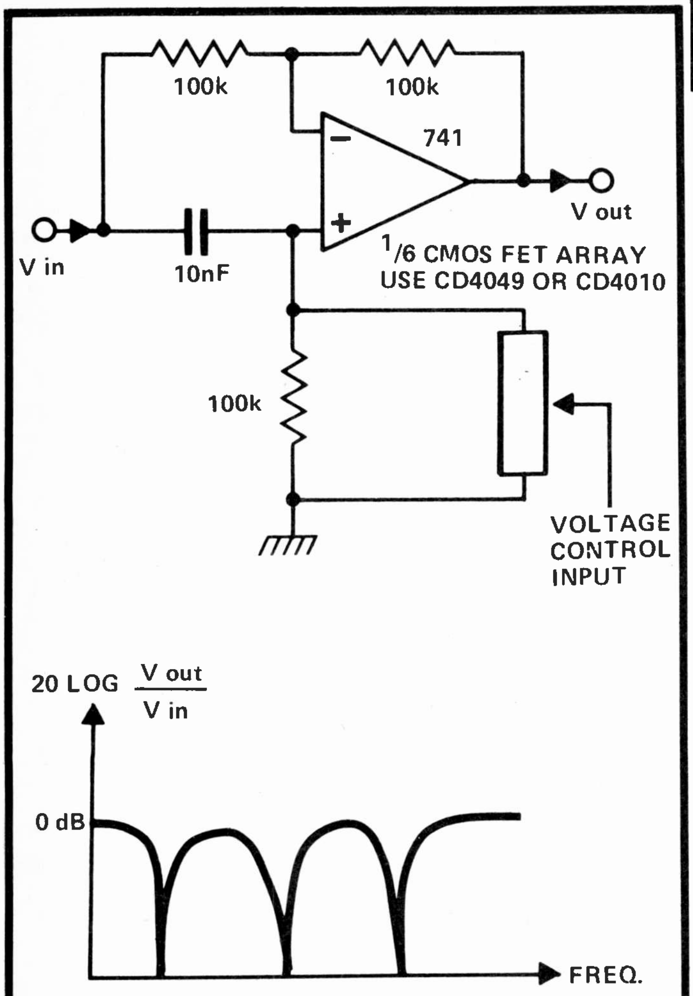


Fig4: One section of a comb filter. The response produced by the full (six times above) circuit is shown below the circuit.

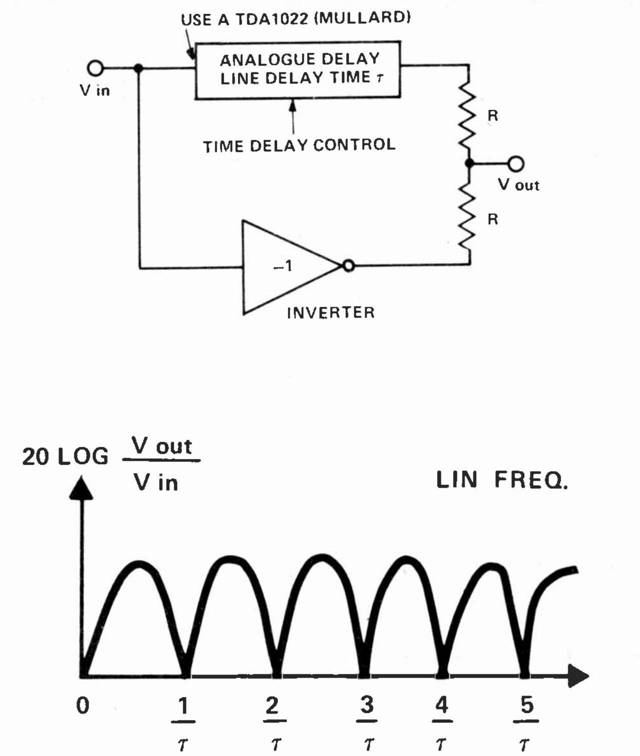


Fig. 5: Alternative method of producing a comb filter using a Mullard delay line.

Another form of comb filter is shown in Fig. 5.

Instead of a phase delay line, a time delay line is used. This produces a large number of notches which are linearly spread along the frequency axis. Their spacing being determined by the delay time.

A bucket brigade delay line can be used to implement the time delay and this can be made variable. This type of filter is known as a Flanger, which is a superior type of phasing unit, and is used to generate high quality phasing effects. An even more impressive sound can be produced by adding some feedback around the delay line. A multi peak, high Q filter is formed which makes very interesting musical sounds when swept.

Variable Tuning

Very often a variable centre or cut off frequency is wanted. This causes problems in filters of order greater than two, simply because getting ganged potentiometers with more than two sections is difficult. One well known manufacturer uses four presets mounted on a common spindle to produce a fourth order Rumble and scratch filter. For manually controlled filters, the resistors are made variable by using ganged potentiometers or switched resistor networks.

The switches can be mechanically operated or electronically controlled, Fig. 6. An alternative method of switching control is to use mark/space modulation, Fig. 7. This has the advantage of being a continuously variable control with a useable sweep range of 100 to 1. Also, lots of sections can be used, and they will *all* track. Therefore, if two CD4016 packs were used, then an eighth order (4 transmission gates per pack), variable frequency filter could be constructed. There are of course, problems;

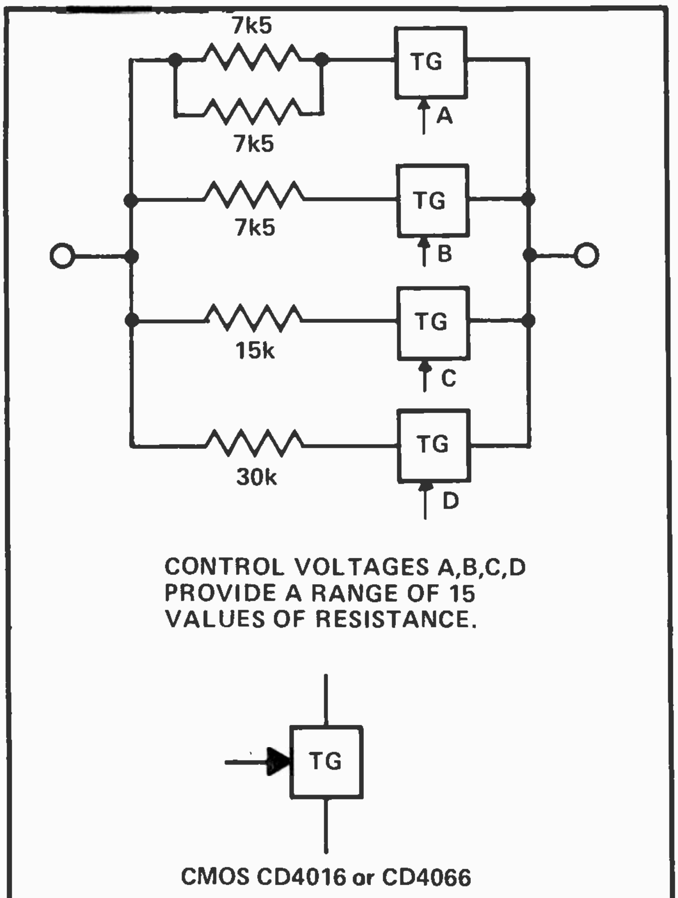


Fig. 6: Varying the tuning of an active filter by use of CD4016 transmission gates (TG) to switch in different resistor values.

1. The switching waveform must be several times higher in frequency than the highest frequency to be filtered.
2. More circuitry, to generate the switching waveform is required.
3. Switching noise is generated.

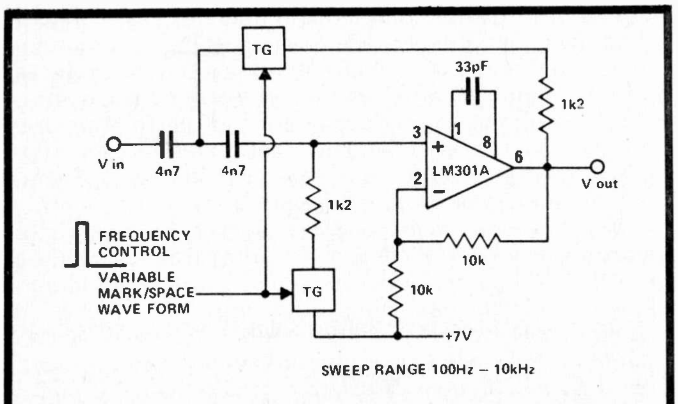


Fig. 7: Another method of varying the notch frequency, mark/space ratio modulation, and has the advantage of possessing a wide range.

Multiplying FETS

Voltage controlled resistors can be used. These take the form of junction or MOS FETS, where the gate voltage controls the channel resistance, Rds. The problems with this method are that the characteristics from FET to FET vary considerably and also the RDS does not have a predictable relationship to the gate voltage. Also, to avoid distortion, low signal levels must be used. Nevertheless, FETS are used in many variable filters such as phasing units.

A set of six MOS FETS having matched characteristics can be obtained from a CD4049 or a CD4010 pack. Alternatively LED photo conductor arrays can be used. The LED produces light which controls the photo conductor's resistance, the two devices being housed in a lightproof box. Large signals can be handled with very low distortion and low noise generation.

Again there are drawbacks. The units are quite expensive, the relationship between LED current and photo conductor resistance is rather unpredictable and the photo conducter's characteristics drift. Another method of varying a filter frequency is to use electronic multipliers. A two quadrant multiplier function can be used to vary the gain of a stage and so produce frequency scaling.

Some Audio Circuits

Active filters have found great use in equalising audio signals, from tone controls on a domestic Hi-Fi to Parametric equalisers in recording studio. Fig. 8

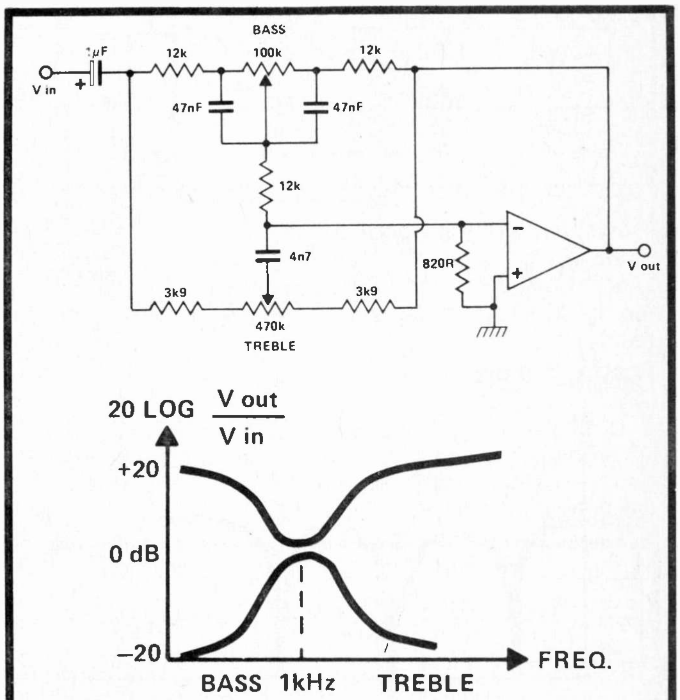
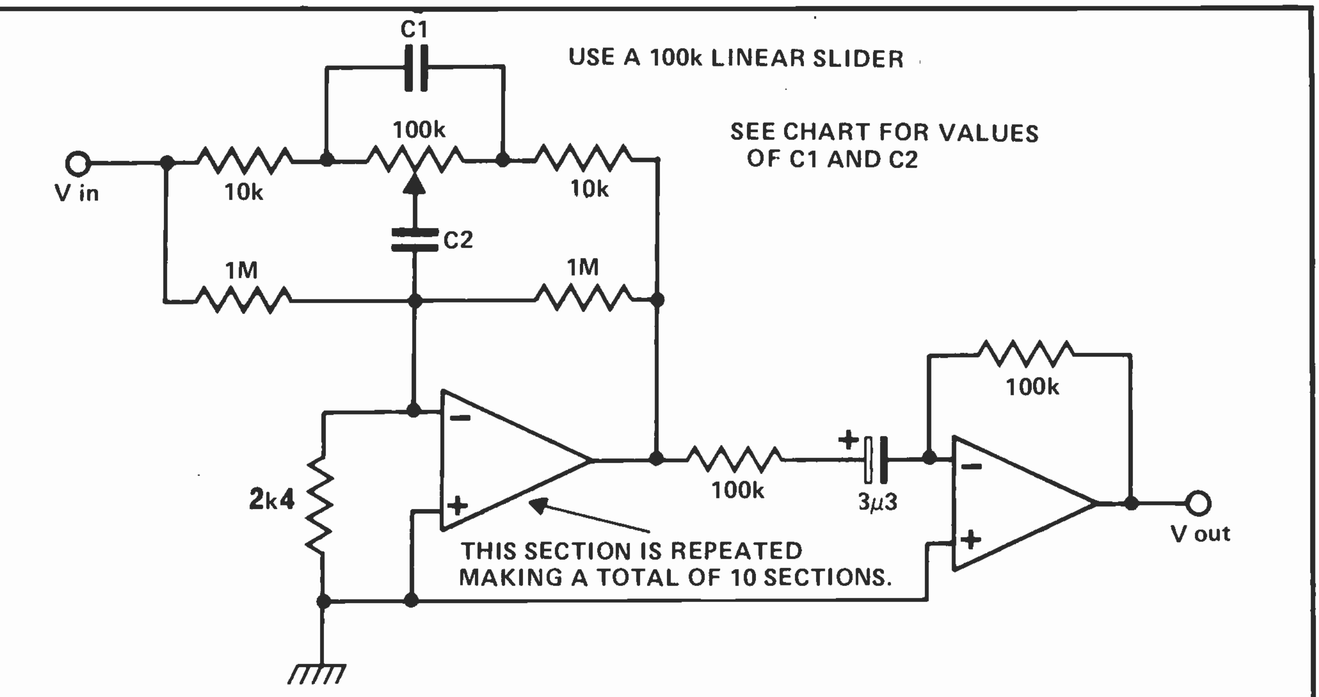
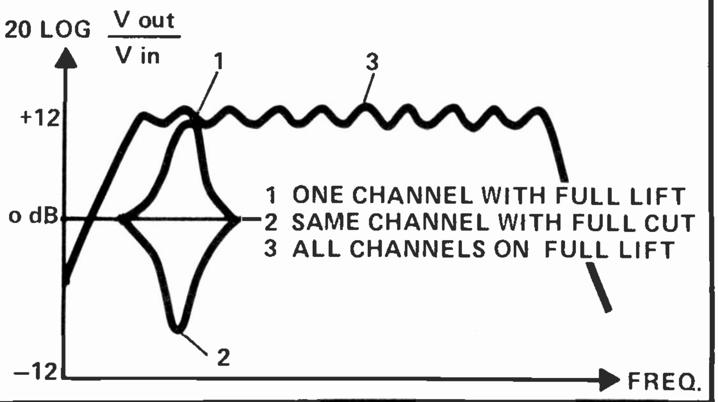


Fig. 8: Simple tone control circuit, with the lift and cut responses shown beneath it.



CHANNEL CENTRE FREQ. IN Hz	C1	C 2
32	180n	18n
64	100n	10n
125	47n	4n7
250	22n	2n2
500	12n	1n2
1000	5n6	560p
2000	2n7	270p
4000	1n5	150p
8000	680p	68p
16000	360p	36p

Fig. 9: A design for a graphic equaliser, using active filters. The above circuit is repeated however many times you wish. Use the table on the left to calculate values.



shows a common tone control with just bass and treble functions. Again cut and lift ranges are 20dBs. If a more flexible control of the spectrum is needed then a ten band graphic equaliser (Fig. 9) could come in handy.

Testing Designs

Once the process of designing active filters has been reduced to a simple procedure, testing them should also be made as easy as possible. The most basic is to use a swept sinewave oscillator (Fig. 10).

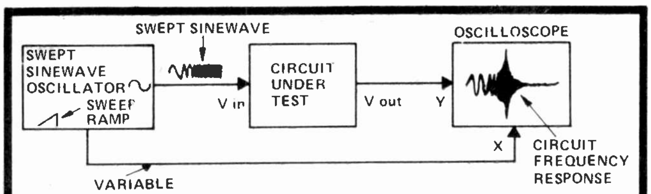


Fig. 10: Testing active filters using a sweep oscillation

An XY oscilloscope is used to display frequency log) against amplitude linear). The ideal display would be log. amplitude, but this is not so easy to obtain. The beauty of this method of testing is that the display is real time and so any changes made to the filter, like varying one of the capacitors, appear instantly on the oscilloscope. If high Q's or rapid roll offs at low frequencies are involved, then the sweep time will have to be reduced, otherwise the effects of Ringing, will 'Time smear' the display. The harmonic distortion of the sinewave can be quite large, 0.5 to 2.0% without causing *too* much of a display problem for most filter designs. ●

TIM ORR, THE AUTHOR OF THIS SERIES, IS EMPLOYED BY EMS LTD IN THE DESIGN OF AUDIO EFFECT CIRCUITS.

Make yourself heard with our

LOUD HAILER

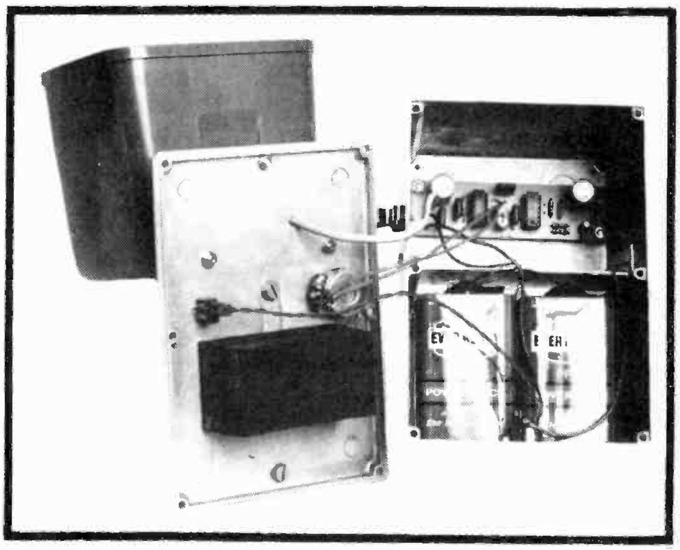
"COME IN NUMBER SIX" is the call heard at boating lakes, however you need large lungs and good health to shout as loud as the professionals. A simpler way for electronics enthusiasts is to build our Loud-Hailer, guaranteed to make you heard above the general noise at fetes, street parties, etc. Most commercial designs are expensive and need to be held up like a megaphone, ours is cheap and can be used in a variety of ways. The electronics and batteries, complete with speaker, are separate from the microphone — this enables you to hold the heavy part in one hand at a comfortable position, and talk through the microphone. You can also hand the microphone to some other person or even conduct an interview!

The diecast box used makes the unit impervious to 3 inches of water if placed on the ground, and the stick-on rubber feet stop it scratching the paint, if placed on a car bonnet or roof. When held in the hand the volume control can be operated with a thumb (to prevent acoustic feedback), also if the microphone used has no on/off switch the unit's switch can be used. In fact acoustic feedback with our system is not a great problem, as the microphone can be up to 100 feet from the loudspeaker!

Design

A low impedance microphone was used for a couple of reasons, firstly you can use far longer cable without noise and hum pickup. Second reason is that virtually all cassette recorders are supplied with low impedance microphones, so most of our readers will have one!

The first prototype used 12V as a supply, the final version (shown here) uses 18V. Power output is about 3W at 18V, and if run off a car battery (12V) will give out 2W — still quite loud. A socket can be fitted for external power source if needed with a changeover switch. The output of 3W may not seem very much, but the HDB4 speaker specified is very efficient, and sounds very loud!



Internal view of the completed loud hailer. Note foam to hold batteries in place

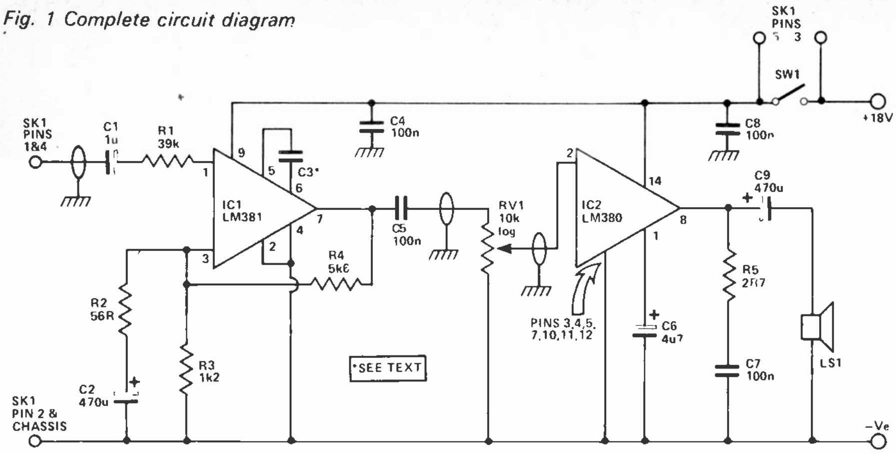


Fig. 1 Complete circuit diagram

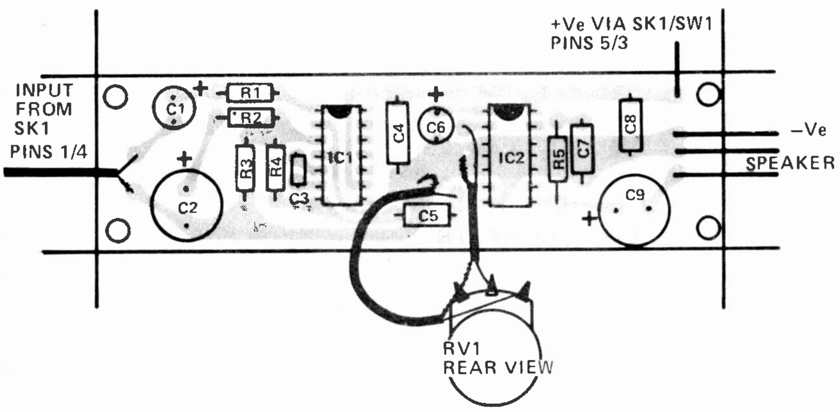


Fig. 2 Compnent overlay and interwiring

Construction

The microphone we used (Eagle DM82), and most others, is fitted with 3.5 and 2.5 mm jack plugs — these are changed for a 180 5 pin din plug, this is to stop earthing problems with miniature jack sockets. Pin connections (for plug and socket) are as follows: Pins 1 and 4 live microphone connection. Pin 2 screen of microphone and equipment earth. Pins 3 and 5 used for remote on/off on microphone switch.

Toggle switch SW1 is connected across pins 3 and 5, to act as another on/off control if your microphone has no switch (or you want to use very long single screened cable). Screening is important, pin 2 on the din socket is shorted to the earth tag on the socket. The input screen is also taken to the board input, the output screen from the LM381 is looped, via the earthy end of RV1, to the input screen of the LM380 ie: back to itself. RV1 itself is not earthed separately, just bolted tight to the case. This might seem strange to Hi-Fi boffins, but prevents instability in the circuit — we know because we did it!

The rest of the construction is reasonably straightforward. A large piece of foam is glued to the lid, to prevent the batteries from rolling around inside the box. Finishing touch is a clip for the microphone.

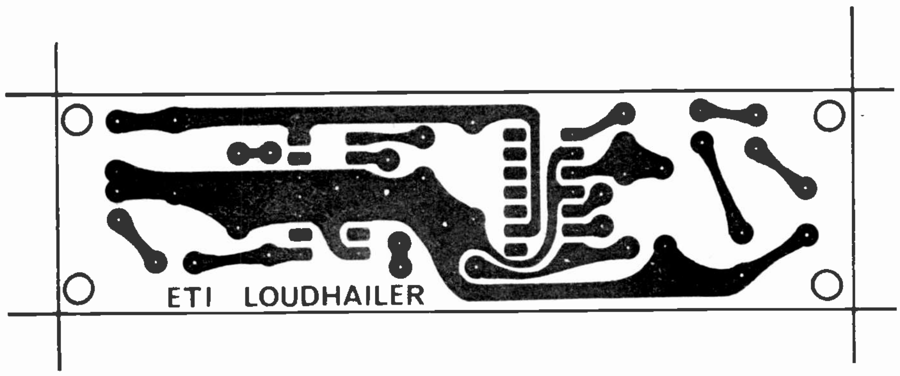


Fig. 3 PCB pattern (105mm x 30mm)

HOW IT WORKS

The LM381 is a dual low noise preamplifier – only half is used in this application. Most of the compensation network is inside the chip, hence the low parts count outside! Resistors R4 and R5 provide negative input bias current, and establish the dc output level at one-half the supply voltage.

Gain is set by the ratio of R4 to R2 which in this design is 100. C2 establishes the low frequency –3dB point, the value of 470µF used stops the system sounding "boomy". For more bass C2 can be reduced to 100µF.

High frequency roll off is set by C3, with the DM82 no capacitor was needed. With a condenser electret microphone 100pF was required to reduce the high frequency gain, so if you use a different type C3 can be varied between 10pF and 100pF for best response.

C1 reduces the effect of 1/f noise currents at low frequencies.

The output of the LM381 passes through C5 and RV1 to the LM380 general purpose power amp. R5 and C7 act as a Zobel network on the output to stop instability, when driving reactive loads (like P.A. horn speakers!).

PARTS LIST

RESISTORS All 1/4w 5% except where stated

R1	39k	R4	5k6
R2	56R	R5	2R7 1/2w 5%
R3	1k2		

CAPACITORS

C1	1u0 25v
C2, 9	470u 16V
C3	See text
C4, 5, 7, 8	100n polyester
C6	4u7 16V

POTENTIOMETER
RV1 10k log rotary

SEMICONDUCTORS
IC1 LM381
IC2 LM380

SWITCH
SW1 Subminiature SPST

LOUDSPEAKER & MICROPHONE
LS1 Eagle PA type HDB4
Microphone Eagle DM82

CASE & HANDLE
Diecast box 171 x 121 x 106mm (509-743)
Handle 107 x 12.7 x 27.4mm (509-917).

MISCELLANEOUS
5 pin din plug and chassis socket (180), PCB to pattern, nuts, bolts, spacers, etc. Screened wire, knob, foam, microphone clip. Batteries (2 x PP9) and connectors, 4 stick-on feet and connecting wire, etc.

BUY LINES

Most parts are readily obtainable from mail order, or your local component shop. Numbers in brackets on parts list are Doram stocknumbers, the handle may be difficult from other suppliers. The loudspeaker and microphone both came from Eagle, HDB4 and DM82 respectively, if any difficulty phone Eagle at 01-902 8832 and ask sales distribution for your nearest stockist.

Total cost of construction should be about £25, which is at least half the commercial price of a similar unit.

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LM 3911 TEMPERATURE CONTROLLER — NATIONAL

The LM3911 is a highly accurate temperature measurement and/or control system for use over a $-25°C$ to $+85°C$ temperature range. Fabricated on a single monolithic chip, it includes a temperature sensor, a stable voltage reference and an operational amplifier.

The output voltage of the LM3911 is directly proportional to temperature in degrees Kelvin at 10 mV/°K. Using the internal op amp with external resistors any temperature scale factor is easily obtained. By connecting the op amp as a comparator, the output will switch as the temperature transverses the set-point making the device useful as an on-off temperature controller.

An active shunt regulator is connected across the power leads of the device to provide a stable 6V8 voltage reference for the sensing system. This allows the use of any power supply voltage with suitable external resistors.

The input bias current is low and relatively constant with temperature, ensuring high accuracy when high source impedance is used. Further, the output collector can be returned to a voltage higher than 6V8 allowing the circuit to drive lamps and relays up to a 35V supply.

The LM3911 uses the difference in emitter-base voltage of transistors operating at different current densities as the basic temperature sensitive element. Since this output depends only on transistor matching the same reliability and stability as present op amps can be expected.

The device is available in three package styles — a metal can 4-lead TO-5, a metal can TO-46 and an 8-lead epoxy mini-DIP. In the epoxy package all electrical connections are made on one side of the device allowing the other 4 leads to be used for attaching the device to the temperature source. The LM3911 is rated for operation over a $-25°C$ to $+85°C$ temperature range.

Applications

- Thermometer
- Over/Under temperature alarm
- Fish tank controller
- Photographic development systems
- Greenhouse controller
- Weather station transducer
- Fire alarms

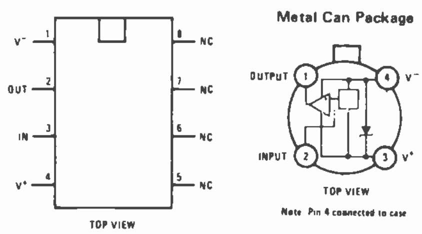
Absolute Maximum Ratings

Supply Current (Externally Set)	10mA
Output Collector Voltage	36V
Feedback Input Voltage	0V to +7V0
Output Short Circuit Duration	Indefinite

Features

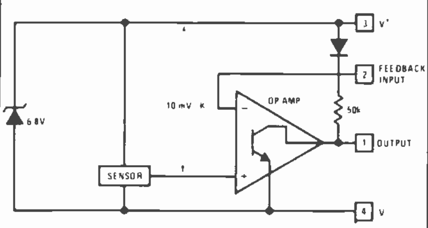
- Uncalibrated accuracy ±10°C
- Internal op amp with compensation
- Linear output of 10mV/°K (10mV/°C)
- Can be calibrated in degrees Kelvin, Celsius or Fahrenheit
- Output can drive loads up to 35V
- Internal stable voltage reference
- Low cost

Dual-In-Line Package — Metal Can Package



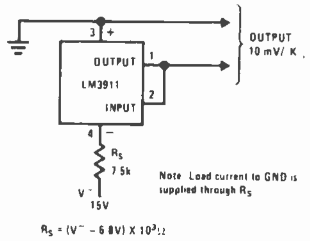
Order Number LM3911N — Order Number LM3911H

Block diagram



All pin numbers are Metal Can

Basic Thermometer for Negative Supply



Temperature Conversion

$T_{CENTIGRADE} = T_C$

$T_{FAHRENHEIT} = T_F$

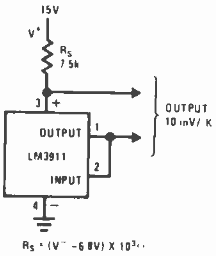
$T_{KELVIN} = T_K$

$T_K = T_C + 273$

$T_C = (40 + T_F)\frac{5}{9} - 40$

$T_F = (40 + T_C)\frac{9}{5} - 40$

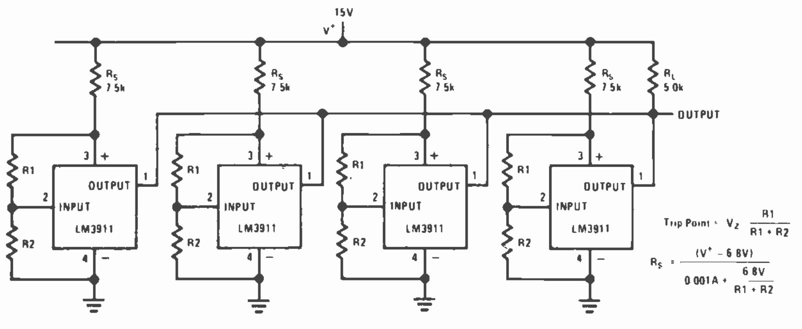
Basic Thermometer for Positive Supply



Application Hints

As with any temperature sensor, internal power dissipation will raise the sensor's temperature above ambient. Nominal suggested operating current for the shunt regulator is 1 mA and causes 7 mW of power dissipation. In free, still air this raises the package temperature by about 1.2°K. Although the regulator will operate at higher reverse currents and the output will drive loads up to 5 mA, these higher currents will raise the sensor temperature to about 19°K above ambient — degrading accuracy. Therefore, the sensor should be operated at the lowest possible power level.

Over Temperature Detectors With Common Output



Heat Sinks

With moving air, liquid or surface temperature sensing, self-heating is not as great a problem since the measured media will conduct the heat from the sensor. Also, there are many small heat sinks designed for transistors which will improve heat transfer to the sensor from the surrounding medium. A small finned clip-on heat sink is quite effective in free-air. It should be mentioned that the LM3911 die is on the base of the package and therefore coupling to the base is preferable.

The internal reference regulator provides a temperature stable voltage for offsetting the output or setting a comparison point in temperature controllers. However, since this reference is at the same temperature as the sensor temperature changes will also cause reference drift. For application where maximum accuracy is needed an external reference should be used. Of course, for fixed temperature controllers the internal reference is adequate.

Features

- Accuracy: ±0.05% of Reading ±1 Count
- Voltage Ranges: 1.999 V and 199.9 mV
- Up to 25 Conversions per second.
- Z_{in}>1000 M ohm
- Auto-Polarity and Auto-Zero
- Single Positive Voltage Reference
- Standard B-Series CMOS Outputs
- Uses On-Chip Clock, or External Clock
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- Supply Range: ' ± 4.5 V to ±8.0 V.
- Overrange and Underrange Signals

Pin Functions

ANALOG GROUND (V_{AG}, Pin 1)
Analog ground at this pin is the input reference level for the unknown input voltage (V_x) and reference voltage (V_{ref}). This pin is a high impedance input.

REFERENCE VOLTAGE (V_{ref}, Pin 2)
UNKNOWN INPUT VOLTAGE (V_x, Pin 3)
This A/D system performs a ratiometric A/D conversion; that is, the unknown input Voltage, V_x, is measured as a ratio of the reference voltage, V_{ref}. The full-scale voltage is equal to that voltage applied to V_{ref}. Therefore, a full-scale voltage of 1.999 V requires a reference voltage of 2.000 V while full-scale voltage of 199.9 mV requires a reference voltage of 200 mV. Both V_x and V_{ref} are high impedance inputs. In addition to being a reference input, pin 2 functions as a reset for the A/D converter. When pin 2 is switched to V_{EE}, the system is reset to the beginning of a conversion cycle.

EXTERNAL COMPONENTS
(R_I, R_I/C_I, C_I; Pins 4, 5, 6)
These pins are for external components for the integration used in the dual ramp A/D conversion. A typical value for the capacitor is 0.1 µF (mylar) while the resistor should be 470 kΩ for 2.0 V full scale operation and 27 kΩ for 200 mV full scale operation. These values are for a 66 kHz clock frequency which will produce a conversion time of approximately 250 ms.

OFFSET CAPACITOR
(CO1, CO2; Pins 7, 8)
These pins are used for connecting the offset correction capacitor. The recommended value is 0.1 µF.

DISPLAY UPDATE INPUT (DU, Pin 9)
If a positive edge is received on this input prior to the ramp-down cycle, new data will be strobed into the output latches during that conversion cycle. When this pin is wired directly to the EOC output (pin 14), every conversion will be displayed. When this pin is driven from an external source, the voltage should be referenced to V_{SS}.

CLOCK (Clk I, Clk O, Pins 10, 11)
The MC14433 device contains its own oscillator system clock. A single resistor connected between pins 10 and 11 sets the clock frequency. If increased stability is desired, these pins will support a crystal or LC circuit. The clock input, pin 10, may also be driven from an external clock source which need have only standard CMOS output drive. For external clock inputs this pin is referenced to V_{EE}. A 300 kΩ resistor results in clock frequency of about 66 kHz.

NEGATIVE POWER SUPPLY
(V_{EE}, Pin 12)
This is the connection for the most negative power supply voltage. The typical current is 0.8 mA. Note the current for the output drive circuit is not returned through this pin, but through pin 13.

NEGATIVE POWER SUPPLY FOR OUTPUT CIRCUITRY (V_{SS}, Pin 13)
This is the low voltage level for the output pins of the MC14433 (BCD, Digit Selects, EOC, OR). When this pin is connected to analog ground, the output voltage is from analog ground to V_{DD}. When connected to V_{EE}, the output swing is from V_{EE} to V_{DD}. The allowable operating range for V_{SS} is between V_{DD} −3.0 volts and V_{EE}.

END OF CONVERSION (EOC, Pin 14)
The EOC output produces a pulse at the end of each conversion cycle. This pulse width is equivalent to one half the period of the system clock (pin 11).

OVERRANGE (OR, Pin 15)
The OR pin is low when V_x exceeds V_{ref}. Normally it is high.

DIGIT SELECT (DS4, DS3, DS2, DS1; Pins 16, 17, 18, 19)
The digit select output is high when the respective digit is selected. The most significant digit (½ digit) turns on immediately after an EOC pulse followed by the remaining digits, sequencing from MSD to LSD. An inter-digit blanking time of two clock periods is included to ensure that the BCD data has settled. The multiplex rate is equal to the clock frequency divided by 80. Thus, with a system clock rate of 66 kHz, the multiplex rate would be 0.8 kHz.

BCD DATA OUTPUTS (Q3, Q2, Q1, Q0; Pins 20, 21, 22, 23)
Multiplexed BCD outputs contain 3 full digits of information during DS2, 3, 4, while during DS1, the ½ digit, overrange, underrange and polarity are available.

POSITIVE POWER SUPPLY (V_{DD}, Pin 24)
The most positive supply voltage pin.

Simple DVM

The 3½ digit voltmeter of Figure 4 is an example of the use of the MC14433 in a system with a minimum of components.

In this circuit the MC14511B provides the segment drive for the 3½ digits. The MC75492 or MC1413 provides sink for digit current. (The MC75492 or MC1413 are devices with 6 or 7 darlingtons respectively with common emitters.) The worst case digit current is 7 times the segment current at ¼ duty cycle. The peak segment current is limited by the value of R. The current for the display flows from V_{DD} (±5 V) to ground and does not flow through the V_{EE} (negative) supply. The minus sign is controlled by one section of the MC 75491 or MC1413 and is turned off by shunting the current through R_M to ground, bypassing the minus sign LED. The minus sign is derived from the Q2 output. The decimal point brightness is controlled by resistor R_{DP}. Since the brightness and the type and size of LED display are the choice of the designer, the values of resistors R, R_M, R_{DP}, and R_R that govern brightness are not given.

During an overrange condition the 3½ digit display is blanked at the BI pin on the MC14511B. The decimal point and minus sign will remain on during a negative overrange condition. In addition, an alternate overrange circuit with separate LED is shown. There are leftover sections in either the MC75492 or MC1413.

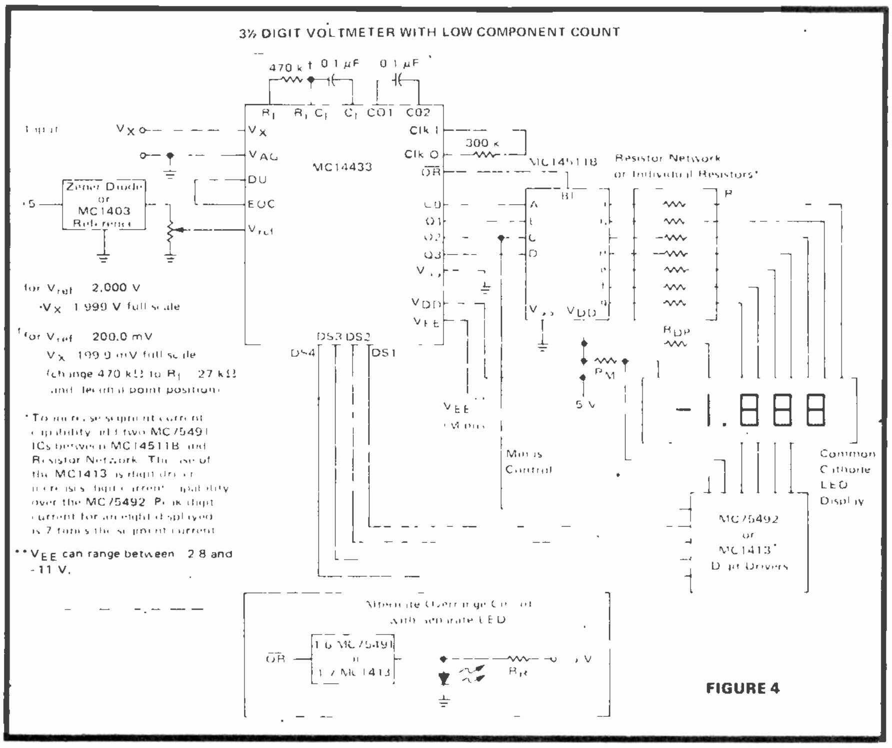
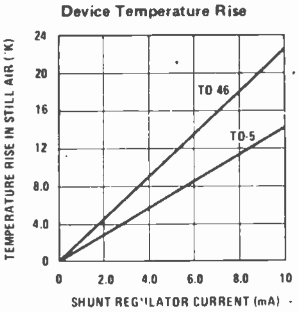
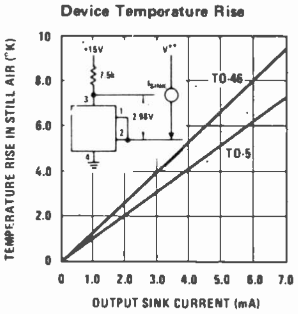
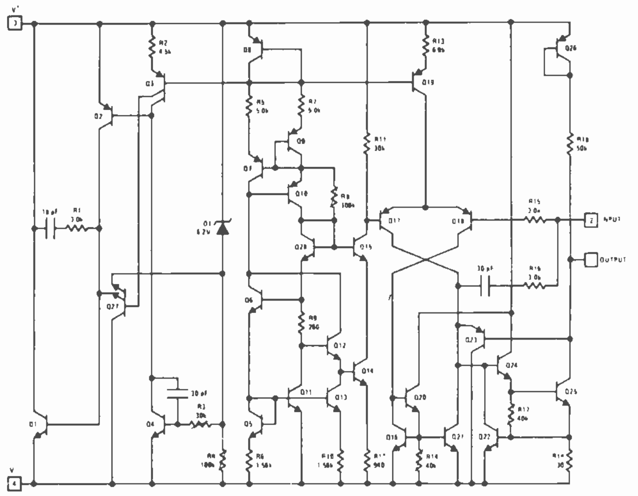


FIGURE 4

The MC1433 is available ex-stock from **Celdis Ltd., 37-39 Loverock Road, Battle Farm Estate, Reading, Berks.** Plastic package is **£12.53**, ceramic package is **£14.95.** Both prices are for 1 off inclusive of small order charge, for further prices contact Celdis direct.







CIRCUIT DIAGRAM OF DEVICE

The LM3911 is available from National stockists. Tandy shops also stock it under the name RS3911 (part number 276-1706). For the address of your nearest Tandy store contact **Tandy Corporation, Bilston Road, Wednesbury, W. Midlands WS10 7JN.** Phone **021 556 6101.** Cost for the DIL 8 pin package is about **£1.80.**

MC 14433 3½ DIGIT A/D CONVERTOR — MOTOROLA

A high performance, low power, 3½ digit A/D converter combining both linear CMOS and digital CMOS circuits on a single monolithic IC, the MC14433 is designed to minimize use of external components. With two external resistors and two external capacitors, the system forms a dual slope A/D converter with automatic zero correction and automatic polarity.

The MC14433 is ratiometric and may be used over a full-scale range from 1.999 volts to 199.9 millivolts. Systems may operate over a wide range of power supply voltages for ease of use with batteries, or with standard 5 volt supplies. The output drive conforms with standard B-Series CMOS specifications and can drive a low-power Schottky TTL load.

Absolute Maximum Ratings

Supply voltage 18V
Pin current 10mA
$V_{EE} \leqslant$ (Vin or Vout) $\leqslant V_{DD}$

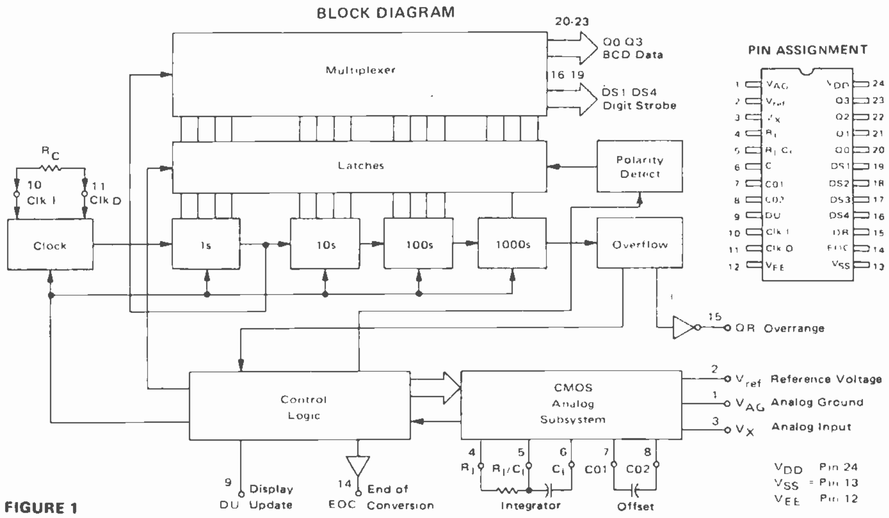


FIGURE 1

Circuit Operation

During each conversion, the offset voltages of the internal amplifiers and comparators are compensated for by the system's autozero operation. Also each conversion "ratiometrically" measures the unknown input voltage. In other words, the output reading is the ratio of the unknown voltage to the reference voltage with a ratio of 1 equal to the maximum count 1999. The entire conversion cycle requires slightly more than 16000 clock periods and may be divided into six different segments. The waveforms showing the conversion cycle with a positive input and a negative input are shown in Figure 2. The six segments of these waveforms are described below.

Segment 1 — The offset capacitor (C_O), which compensates for the input offset voltages of the buffer and integrator amplifiers, is charged during this period. Also, the integrator capacitor is shorted. This segment requires 4000 clock periods.

Segment 2 — The integrator output decreases to the comparator threshold voltage. At this time a number of counts equivalent to the input offset voltage of the comparator is stored in the offset latches for later use in the autozero process. The time for this segment is variable, and less than 800 clock periods.

Applications

- DVM/DPM
- Digital scales
- Digital thermometers
- Remote A/D and D/A systems
- MPU based interface
- Current and resistance meters

Segment 3 — This segment of the conversion cycle is the same as Segment 1.

Segment 4 — Segment 4 is an up-going ramp cycle with the unknown input voltage (V_x) as the input to the integrator. Figure 3 shows the equivalent configuration of the analog section of the MC14433. The actual configuration of the analog section is dependent upon the polarity of the input voltage during the previous conversion cycle.

Segment 5 — This segment is a down-going ramp period with the reference voltage as the input to the integrator. Segment 5 of the conversion cycle has a time equal to the number of counts stored in the offset storage latches during Segment 2. As a result, the system zeros automatically.

Segment 6 — This is an extension of Segment 5. The time period for this portion is 4000 clock periods. The results of the A/D conversion cycle are determined in this portion of the conversion cycle.

INTEGRATOR WAVEFORMS AT PIN 6

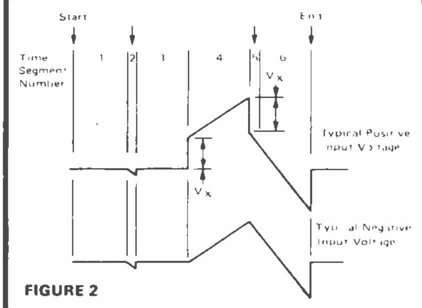


FIGURE 2

EQUIVALENT CIRCUIT DIAGRAMS OF THE ANALOG SECTION DURING SEGMENT 4 OF THE TIMING CYCLE

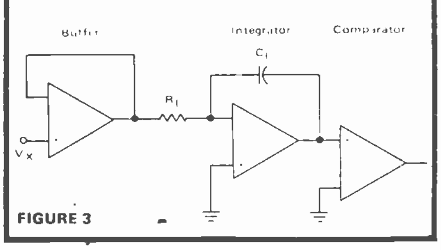


FIGURE 3

ELECTRONICS —it's easy! PART 43

Control of power

This is the 43rd and last part of this series.
The intention has been to provide introductory information about modern electronics for intelligent people who had no prior training in the subject.

Electronics Today International wishes to give its heartiest thanks to the very many companies who provided information and illustrations used. We are most grateful for their willing and prompt cooperation.

WHEN DISCUSSING THE TYPES of amplifiers, we briefly mentioned the power stage found at the output end of electronic systems. Typical devices requiring amplifiers to drive them are loudspeakers, electric motors, and heaters.

The power handling capability of the various designs of these special amplifiers can range from one watt to many kilowatts. In this final part we introduce the special semiconductors and techniques used in electronic power control.

HEATSINKS

As some power is lost as heat in power transistors they may usually be recognized by the large heatsinks on which they are mounted. A rectifier stage using flat-plate heatsinks is shown in Fig. 1. These metal structures are needed to rapidly conduct away and dissipate to the air the heat generated at the junction of the device — this is a critical design requirement. The approach to designing heatsinks is common to all power components.

All semiconductors used in analogue control will have heat losses (the power lost as heat equals the current through the device multiplied by the voltage drop across it) which will cause the junction temperature to rise above the case outer temperature. For example, a transistor power amplifier stage may have at half output power (say) 10 V drop and 10 amp collector current. The heat loss is, therefore, 100 W and this must be liberated in order to keep the transistor temperature lower than its recommended maximum value.

All materials resist the conduction of heat to some extent — this property is called 'thermal resistance' and its value depends upon the material (copper is less resistive to heat flow than iron) and the cross-sectional area (increasing the area decreases the resistance). In practice catalogues for power components usually quote the thermal resistivity θ (which has units $^{o}C/W$) between two points on the device. For example, typical measured temperatures for a certain power transistor mounted on a heatsink are as shown in Fig. 2. From these temperatures we can see that:—

$$\theta_{J\text{-}C} = (95 - 79.5)/20 = 0.77\ ^{o}C/W$$
$$\theta_{C\text{-}H} = (79.5 - 75)/20 = 0.23\ ^{o}C/W$$
$$\theta_{H\text{-}A} = (75 - 25)/20 = 2.5\ ^{o}C/W$$
$$\theta_{J\text{-}A} = (\theta_{J\text{-}C} + \theta_{C\text{-}H} + \theta_{H\text{-}A}) = 3.5\ ^{o}C/W$$

Where J = junction, C = case of device, H = heatsink and A = air.

From this example we can see that the thermal resistance within the device — the parameter the user has

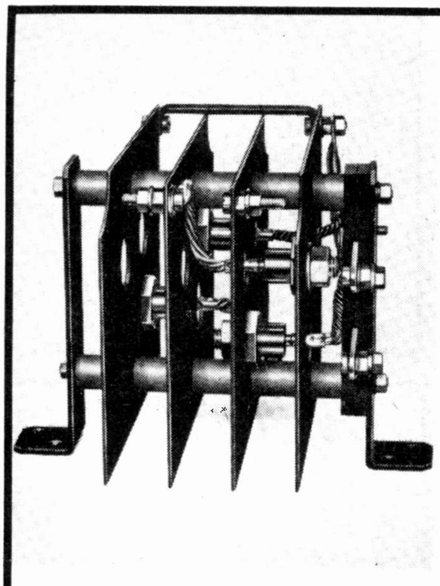


Fig. 1. Power handling stages are easily identified by the heatsink assemblies on which they are mounted — a 35 A, 60 VDC rectifier stack is shown here.

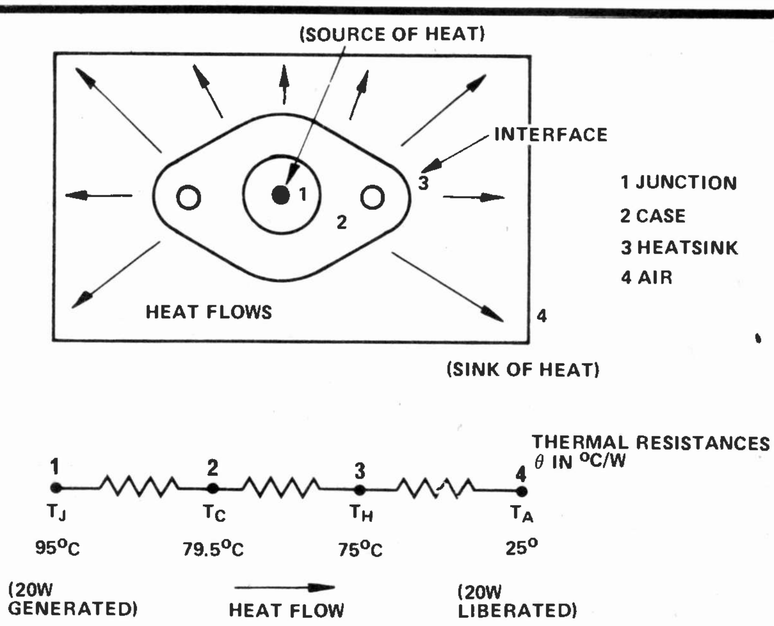


Fig. 2. Thermal resistances for a 20 W power transistor.

no control over — is larger than the case-to-the-heatsink value. This means it is not worth improving the contact and heatsink material. The important thermal resistance is that between the junction and the air (presumed to be at constant ambient value); in many cases a different shape heatsink, one that transfers heat better to the air (finned for example) would make an improvement. The thermal restivity (heatsink to air) can also be reduced by forcing air past the heatsink and/or by increasing the heatsink surface area. The latter measure, however, also has its limits because the thermal resistance between the device connection point and extremities of larger plates rises with increasing dimensions (reducing the effectiveness of outer areas).

The above example illustrates how a heatsink stage can be designed using the concept of series thermal resistances. In practice the design procedure must be worked in reverse. The aim is to ensure that the junction temperature remains less than a specified maximum limit. Beyond this quoted value the junction will be destroyed. A practical difficulty is that the junction temperature cannot be measured to ensure that the design is adequate so selection of mounting and heatsink type must be made with care using manufacturers' quoted thermal resistance values as the basis of a design. The following steps are given as a guide but full detail should be sought from more detailed accounts —

Step 1: Assess the maximum power (W max) to be dissipated by the device. This will be the worst case of V.I product remembering to allow for temperature effects and maximum values. In switching designs the base to emitter junction voltage of a transistor is significant.

Step 2: Establish $T_J$max, $T_A$max from data sheets and expected ambient conditions. This enables the minimum required value of $T_{J\text{-}A}$ to be calculated.

Step 3: Calculate the overall thermal resistivity needed from $\theta_{J\text{-}A} = T_{J\text{-}A}/W_{max}$.

Step 4: Establish $\theta_{J\text{-}C}$ and $\theta_{C\text{-}H}$ from device table charts and the mount thermal resistivity for the device clamping method. Fig. 3 lists typical θ values for various clamping methods.

Step 5: Calculate $\theta_{H\text{-}A}$ required
$\theta_{H\text{-}A} = \theta_{J\text{-}A} - (\theta_{J\text{-}C} + \theta_{C\text{-}H})$

Step 6: Use heatsink tables to find suitable design having $\theta_{H\text{-}A}$ value or smaller.

In general if $\theta_{H\text{-}A}$ needs to be less than 2 to 5 °C/W the heatsink becomes prohibitively bulky. Design of the

TABLE 1

Material used between device and heat sink (for insulation)	Thermal Resistance Dry	$\theta_{C\text{-}H}$ in °C/W with heat conducting grease
Direct contact (TO3)	0.20	0.10
Teflon insulator shim (TO3)	1.45	0.80
Mica shim (TO3)	0.80	0.40
Anodized aluminium (TO3)	0.40	0.35
0.25in stud mount (direct)	0.40	0.25
0.50in stud mount (direct)	0.12	0.07
0.75in stud mount (direct)	0.07	0.04

Fig. 3. Table of thermal resistances $\theta_{C\text{-}H}$ for typical mounting methods. Values can vary widely.

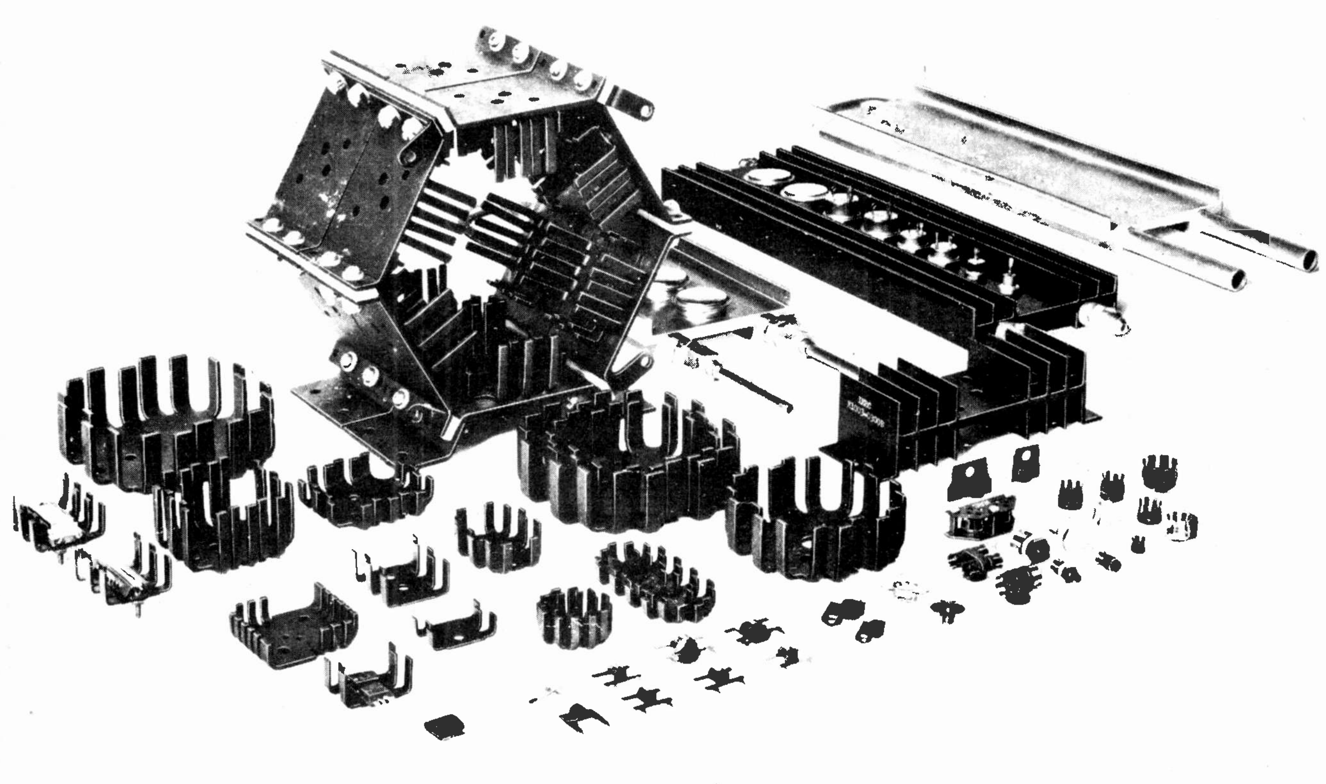


Fig. 4. Range of heatsinks for dissipating excess heat in semiconductors over a range from milliwatts to kilowatts.

whole system is usually limited by the manufacturer's value of $\theta_{J\text{-}C}$, which cannot be reduced. The interface coefficient $\theta_{C\text{-}H}$ is usually around 0.15–0.20 °C/W for direct contact using the recommended heat conducting silicon grease. Mica insulation degrades this value a little, poor heat conducting insulators should be avoided as they contribute a quite high value of $\theta_{C\text{-}H}$.

Heatsinks for analogue control power units will need to be much larger than those of switching designs such as the switching regulator and normal rectifier stacks. This is because the latter need only dissipate the V.I product of the two extremes of V and I. The voltage drop across a power diode running at many amperes is around one volt: when reverse biassed the voltage is high but the current negligible.

Figure 4 shows a wide selection of heatsinks including units for fluid cooling applications. Fins should always be positioned to assist the vertical convective flow of air over the surfaces. Total immersion of the electronic circuit in cooling liquid is not used.

POWER TRANSISTORS

Power transistors are little different to small-signal devices in their basic semiconductor principle of operation: the distinguishing factors are the heavy-duty design which enables high collector currents and voltages to be controlled. The junction areas are much larger and the case design is made to keep the thermal resistivity as low as possible (around 0.8 °C/W) in order that the losses can be removed. Collector currents being higher and the gains being lower than small-power transistors means the base currents are also large. Thus, high power stages have to have lesser power stages driving them. They are available for several hundred volts operation and current levels exceeding a 1000 A. Cut-off frequencies into the gigahertz region are available (with less gain than that of lower frequencies). At RF frequencies gains range from 4-13 dB for powers in the range 0.1–80 W. There are few power applications that transistor devices cannot handle. In practice, however, certain other semiconductor devices are often a better choice.

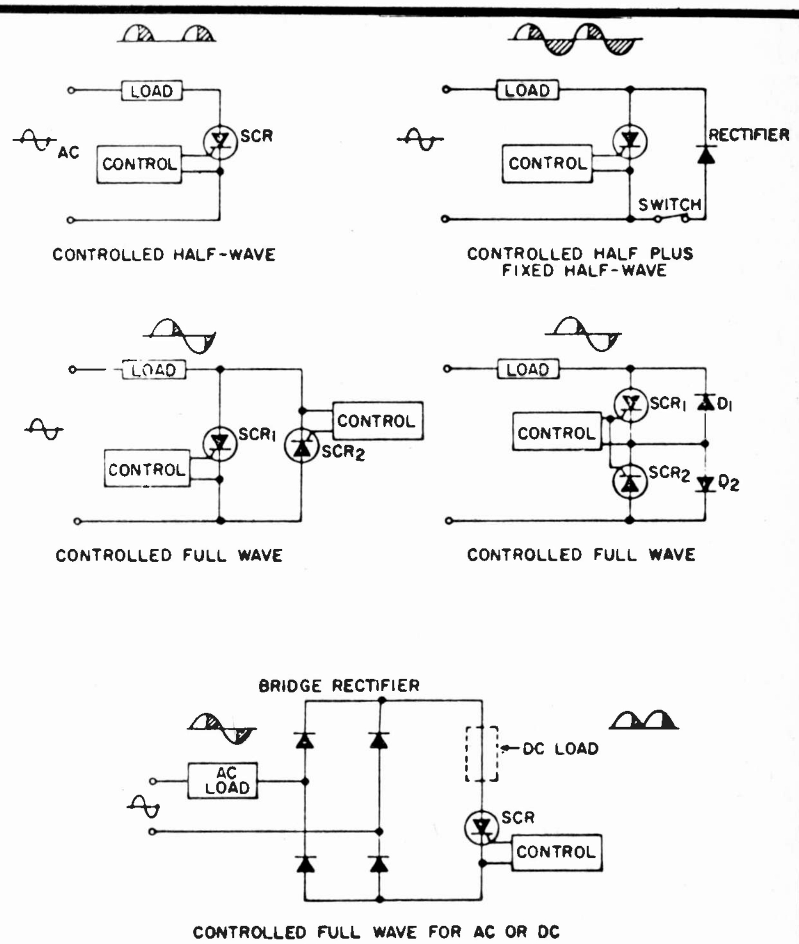


Fig. 5. Five arrangements by which a load can be fed with power flow controlled by SCR devices.

SCRs, THYRISTORS AND TRIACS

Semiconductors and diodes have one p-n junction and transistors have two junctions, p-n-p or n-p-n. A logical progression is the three-junction device, p-n-p-n. This family contains such devices as the silicon-controlled rectifier SCR, the silicon-controlled switch SCS, the gate-turn-off switch GTO, the light-activated, silicon-controlled switch LASCS, and the Shockley diode. Of these, the SCR (also called a thyristor) mainly concerns us as it is able to control high-power levels (they were introduced in Part 16). The SCR has an anode and cathode and a gate lead (which when held positive prevents the unit from conducting).

By controlling the gate voltage it is possible to control when power begins to flow during an ac cycle. Once the SCR is triggered (or fired) it remains on until the anode-cathode voltage falls to zero again. SCRs are, therefore, extremely useful when an alternating current source is available as this automatically provides the necessary switch-off conditions at each half cycle.

TRIACS are special SCRs that can be switched on to allow both positive and negative half cycles to pass. This action can also be arranged by using two SCRs.

This class of device cannot control the flow of dc power from a dc source, because once turned on they remain on, acting like an adequately low-resistance contact. They are, however, invaluable for controlling loads which can be energised by ac power – heating coils, motors, lighting and furnaces.

The operating circuitry for an SCR is designed to provide the appropriate gate on-voltage level at the correct time during the half cycle. Fig. 5 shows five basic forms of phase control. A typical trigger circuit is given in Fig. 6. One difficulty in this kind of control is that large line transients are generated, along with RF interference, when the power begins to flow during each cycle.

A more refined type of control derives the required average output power as the mean of a series of complete whole-cycles rather than as the mean of many partial cycles. This method generates substantially reduced line transients and RF interference because switching always occurs at the zero voltage condition: Figure 7a shows one form of proportional zero-voltage-switching controller using a TRIAC to control the heat produced in the element. Figure 7b is a typical output signal burst of gradually increasing power.

Capabilities of SCR devices range to hundreds of amperes, reverse voltages to as much as 2000 V. The maximum voltage drop across the turned-on SCR lies in the range 1.3–2.5 V, with leakage currents being in the region of 40 mA in the turned-off state.

These characteristics may make SCR devices appear extremely robust. Design of reliable, high-power, units, however, is a matter for a specialist. Many pitfalls can occur if their operation is not understood in detail. Designed properly they will, however, give utmost reliability.

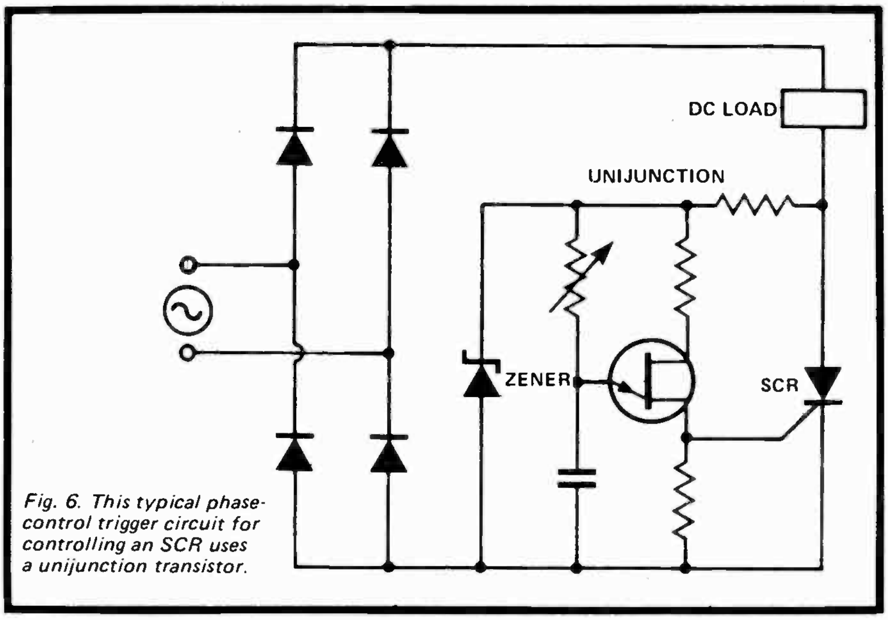


Fig. 6. This typical phase-control trigger circuit for controlling an SCR uses a unijunction transistor.

Fuses for SCR circuitry also need special consideration because semiconductor junctions when overloaded will blow more rapidly than simple wire fuses or electromagnetic circuit breakers. The criterion is that the I^2t rating of the SCR must be greater than that of the fuse. I^2t values are usually provided in maker's data sheets. During the turn-on period of the SCR this value may drop significantly. Selection of adequate protection fuses is a matter that must be studied in some depth. Care must be taken to mend blown fuses in SCR units with the correct replacement – this invariably means carrying the correct spare ready to use.

SWITCHING REGULATORS AND CONTROLLERS

For small power levels - a few watts - the series regulator and zener diode arrangements are acceptable because the power they dissipate is not an economic factor. The controlling transistor (as is shown diagrammatically in Fig. 8) may, however be used as a switch varying the on-to-off time ratio (mark-space is the term used) in order to vary the average dc power obtained after smoothing.

The switching method has the significant advantage of very small losses in the regulator stage. The transistor is either fully-on (high current but very low voltage) or fully-off (highest voltage but minimal current).

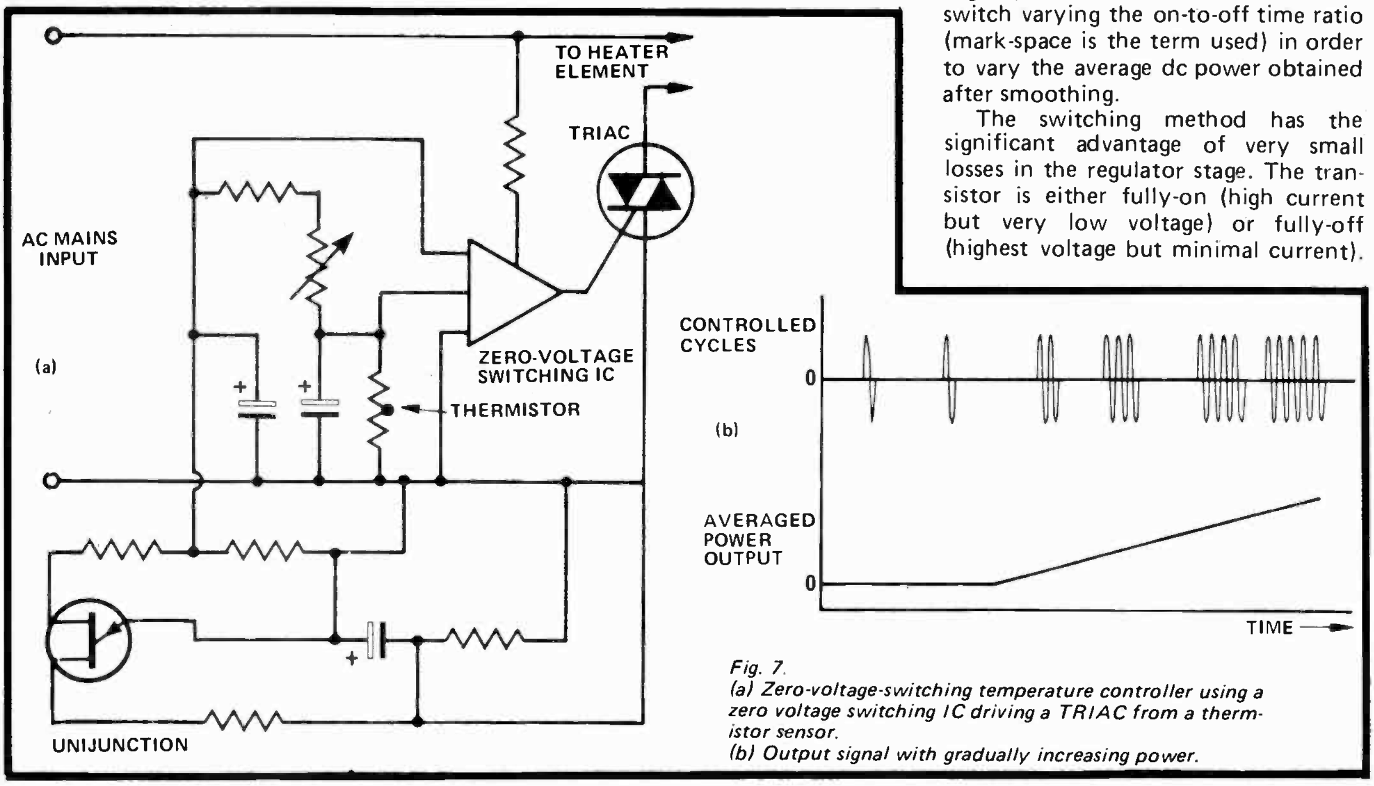


Fig. 7.
(a) Zero-voltage-switching temperature controller using a zero voltage switching IC driving a TRIAC from a thermistor sensor.
(b) Output signal with gradually increasing power.

As well as reducing the losses the method also can use a smaller capacity transistor. The price paid is the need for a filter stage and for a pulse generator to drive the switch.

Switching regulators are especially necessary when the voltage drop between the source and the load requirements becomes large.

Modern designs often make use of an integrated circuit as the basic control unit adding an additional switching transistor to cope with the output current needed. Fig. 9 is a high-current switching regulator which can supply 3 A continuously at 30 V input with losses sufficiently small to allow the use of quite small heatsinks.

Switching is also a suitable method to efficiently control output loads — the difference between this and regulator design is that the feedback loop (dotted in Fig. 8) is not used; the mark-space ratio of the generator being controlled instead by the input signal to be amplified. This principle is used in high-current dc motor control and in advanced forms of audio amplifier.

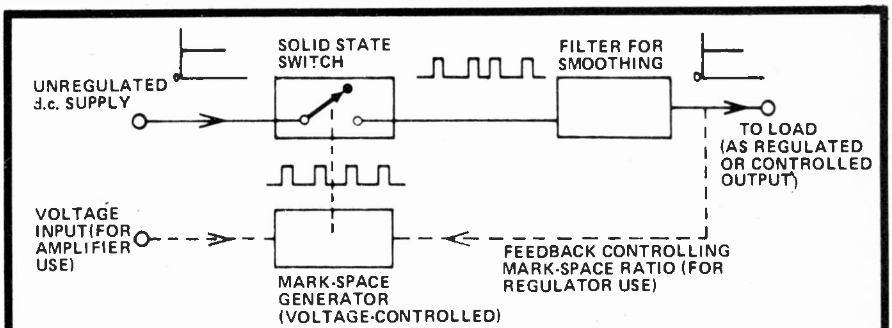


Fig. 8. Schematic of switching regulator or controller (see text).

INVERTERS AND CONVERTERS

A converter, in the electrical power engineering sense, is a machine (or a circuit) that changes current from one kind to another, or from one frequency to another. An inverter, in the same sense, is a machine that specifically converts dc to ac — being one kind of converter. Originally rotating machines were used but today the trend is to use static solid-state equipment.

There are many instances where these are required — providing a 240 V ac 50 Hz supply when only 12 V batteries exist, providing a 200 V dc supply from 12 V dc and to change frequency such as where a 240 V ac 50 Hz mains might be needed to drive aircraft equipment operating at 400 Hz.

The basic principles used in each are based on the technology discussed before in this part. These are now summarised with examples of the procedures used.

AC to DC: This conversion path has been discussed when we dealt with rectification. A transformer is used to obtain the required ac voltage; this is then rectified with diodes and smoothed to provide dc.

DC to AC: This path first changes the dc into a suitable ac signal which can then be transformed to the desired signal level. The frequency of the ac signal is decided by the output load requirement for once produced it must remain at that frequency. (In some cases it is preferable to make use of a higher frequency than 50 Hz). Figure 10 shows a number of configurations used to produce ac power from a dc supply.

Switching produces square-wave energy after inversion and in many instances this roughly square-wave output waveform is satisfactory. Where the output must be sinusoidal more complex circuitry is required to obtain an undistorted wave shape. When choosing a commercially made inverter it is important to verify if the output waveshape is suitable for the task.

Crystal oscillators can be incorporated into an inverter design where the output frequency must be kept within exacting limits.

DC to DC: The procedure here is to first form the dc to ac conversion. After transformation to the correct voltage (usually the need is a voltage increase) with a double-wound transformer the output is full-wave rectified

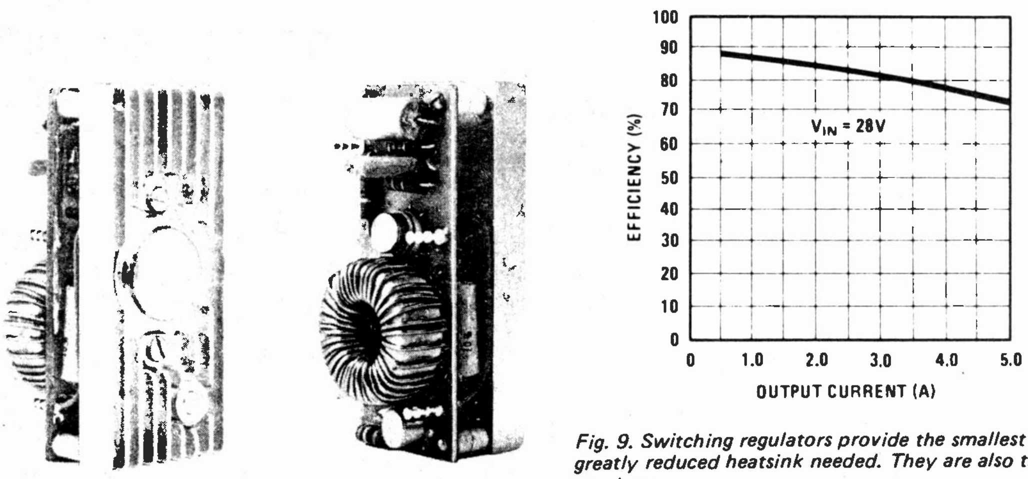


Fig. 9. Switching regulators provide the smallest overall package due to the greatly reduced heatsink needed. They are also the most efficient form of regulator.

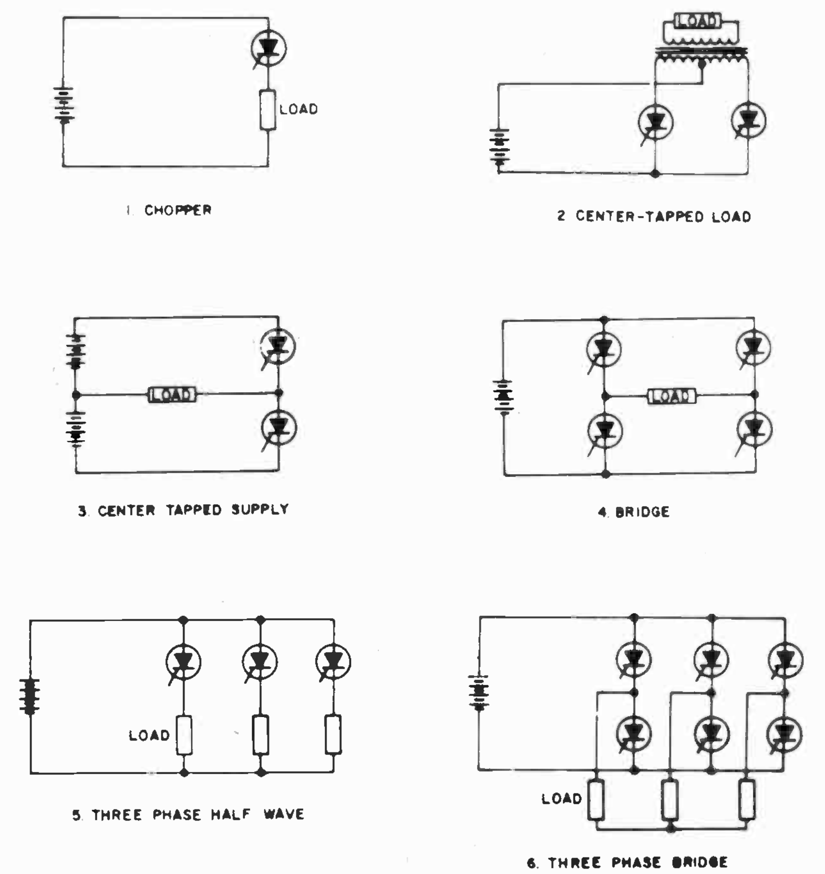


Fig. 10. Various inverter configurations using SCR switches. Triggering methods have been omitted for clarity.

and smoothed. The transformers used use special iron laminations material to get the best out of the square-wave input waveforms.

AC to AC: Some mains equipment can run on either 50 or 60 Hz frequency with little change in performance. Occasionally, however, it is necessary to use the correct frequency specified. To change frequencies the simplest procedure is to convert the original ac supply to a suitable dc value inverting this back to ac at the other frequency. This procedure is easiest to implement because it makes use of standard rectification and inverter packages.

The cost of semiconductor converters has fallen rapidly over the 1970 decade. This has brought about new philosophies in power electrical engineering. In the future there will be more use made of dc electrical transmission. Speed-changing motors are becoming easier to implement using frequency-varied supplies to drive conventional ac machines. Large dc motors are also becoming useful again because regenerative braking of large units — using them as a generator driving into a load — can be put to use to charge power into the ac mains by the use of dc to ac inverters.

Revolutions have occurred in both power and signal electronics. Attitudes to problem solving are now quite different to just a decade ago. No doubt this trend will continue. ●

MURPHY'S LAW

IT HAS LONG BEEN the consideration of the author that the contributions of Edsel Murphy, specifically his general and special laws delineating the behaviour of inanimate objects, have not been fully appreciated. It is deemed that this is, in large part, due to the inherent simplicity of the law itself.

It is the intent of the author to show, by references drawn from the literature, that the law of Murphy has produced numerous corollaries. It is hoped that by noting these examples, the reader may obtain a greater appreciation of Edsel Murphy, his law, and its ramifications in engineering and science.

As is well known to those versed in the state-of-the-art, Murphy's Law states that "If anything can go wrong, it will". Or, to state it in more exact mathematical form:

1 + 1 ☞ 2

where ☞ is the mathematical symbol for hardly ever.

Some authorities have held that Murphy's Law was first expounded by H. Cohen when he stated that "If anything can go wrong, it will during the demonstration". However, Cohen has made it clear that the broader scope of Murphy's general law obviously takes precedence.

To show the all-pervasive nature of Murphy's work, the author offers a small sample of the application of the law in electronics engineering.

Engineering

I.1 The more innocuous a design change appears, the further its influence will extend.
I.2 Firmness of delivery dates is inversely proportional to the tightness of the schedule.
I.3 Dimensions will always be expressed in the least usable term. Velocity for example, will be expressed in furlongs per fortnight.
I.4 An important Instruction Manual or Operating Manual will have been discarded by the Receiving Department.

Mathematics

II.1 Any error that can creep in, will. It will be in the direction that will do the most damage to the calculation.
II.2 All constants are variables.
II.3 In any given computation, the figure that is most obviously correct will be the source of error.
II.4 A decimal will always be misplaced.

Prototyping

III.1 Any wire cut to length will be too short.
III.2 Tolerances will accumulate unidirectionally toward maximum difficulty of assembly.
III.3 Identical units tested under identical conditions will not be identical in the field.
III.4 The availability of a component is inversely proportional to the need for that component.
III.5 If a project requires n components, there will be n-1 units in stock.
III.6 If a particular resistance is needed, that value will not be available. Further, it cannot be developed with any available series of parallel combination.
III.7 A dropped tool will land where it can do the most damage. (Also known as the law of selective gravitation.)
III.8 A device selected at random from a group having 99% reliability, will be a member of the 1% group.
III.9 When one connects a 3-phase line, the phase sequence will be wrong.
III.10 A motor will rotate in the wrong direction.
III.11 The probability of a dimension being omitted from a plan or drawing is directly proportional to its importance.
III.12 Interchangeable parts won't.
III.13 Probability of failure of a component, assembly, sub-system or system is inversely proportional to ease of repair or replacement.
III.14 If a prototype functions perfectly, subsequent production units will malfunction.
III.15 Components that must not and cannot be assembled improperly will be.
III.16 A dc meter will be used on an overly sensitive range and will be wired in backwards.

General

IV.1 After the last of 16 mounting screws has been removed from an access cover, it will be discovered that the wrong access cover has been removed.
IV.2 After an access cover has been secured by 16 hold-down screws, it will be discovered that the gasket has been omitted.
IV.3 After an instrument has been fully assembled, extra components will be found on the bench.
IV.4 In an instrument or device characterized by a number of plus-or-minus errors, the total error will be the sum of all errors adding in the same direction.
IV.5 In any given price estimate, cost of equipment will exceed estimate by a factor of 3.
IV.6 In specifications, Murphy's Law supercedes Ohm's.

The man who developed one of the most profound concepts of the twentieth century is practically unknown to most engineers. He is a victim of his own law. Destined to a secure place in the engineering hall of fame, something went wrong.

His real contribution lay not merely in the discovery of the law but more in its universality and in its impact. The law itself, though inherently simple, has formed a foundation on which future generations will build.

In fact, the law first came to him in all its simplicity when his bride-to-be informed him that his boss had 'gazumped' him to the altar.

This hitherto unpublished photograph of Edsel Murphy was taken just after he had heard his ex-fiancée's news.

ELECTRONICS TOMORROW

by John Miller-Kirkpatrick

Many months ago I mentioned the idea of using a calculator chip with a microprocessor to enable some comprehensive maths routines to be used by even the simplest of MPU chips. The solution was rather complicated and involved using the MPU first of all as a key entry simulator and then as an LED reader. The problem was set up in RAM storage and then the calculator interface routine executed, at the end of the execution lo and behold a result of the calculation in RAM.

It seemed that a fully scientific calculator chip would be required to give as many 'instant' functions as possible and at the time calculators of this type were in the £70 price area — much too expensive to experiment with. A second problem at that time was the expense of the PROM to store the rather complicated program would have added another £35 or more to the overall cost. These two problems have now become insignificant with the recent drop in price of some PROMS and the announcement of the MM57109 number cruncher.

Crunching Digits

The feature of the MM57109 include up to 8 digit mantissa plus 2 digit exponent, memory and stack registers, trigonometric and logarithmic functions, conditional and unconditional branching, simple clock input and low power consumption. In effect it is a cross between a standard scientific calculator chip and a simplified SC/MP MPU.

All internal clocks are generated from the single external oscillator which can be provided by a simple CMOS oscillator running at about 400KHz. The processor is reset by applying 5v to the POR input and then setting it to —4v (this input is not TTL compatible). The chip will then set the various outputs to their proper levels and then produce three strobes at the ready (RDY) output. This sequence sets up the processor and indicates to peripheral devices that it is ready to accept input data or instructions.

The RDY output goes high whenever the processor is ready to accept another 6 bit instruction (or data which is a form of instruction). This output works with the HOLD input to allow handshaking with MPUs or peripherals, when RDY goes high with HOLD high the processor will enter a wait state until the HOLD input is taken low, it will then accept the instruction on the input pins, store and execute that instruction and then signal RDY again for the next instruction. In a stand-alone system the RDY output would be used as a clock pulse to increment a counter which in turn addressed a PROM or other form of stored instruction sequence — this counter is called a Program Counter (PC). In an MPU system RDY is used to inform the MPU that the processor is ready for the next instruction and the HOLD input is used to allow the MPU time to respond to the MM57109.

The control logic decides whether the data input is an instruction or digit and routes it accordingly. Digital data is routed to the X register where it is stored with up to 8 mantissa digits, 2 exponent digits, decimal point position, mantissa sign and exponent sign. The X register is used for input and output storage and is one of 5 similar internal registers (X, Y, Z, T and M). If the processor is in floating-point mode then digital data is input as mantissa digits, mantissa sign and DP position, in scientific notation the data is input as mantissa digits, exponents digits, signs and DP position.

There are three ways of entering digital data into the processor, firstly by inputing digits as instructions as one would with a calculator keyboard and also by executing an IN or AIN instruction. The AIN instruction will input one digit each time that it is executed whereas the IN instruction will input a complete number of up to 8 digits from a RAM or similar I/O device. The OUT instruction will store a complete number in the RAM in a similar method. The RAM or other device is addressed by four Digit Address lines (DA1 - DA4), a R/W line and either or both of the Digit Input lines (I1 - I4) or Digit output lines (DO1 - DO4).

Some of the instructions are two word instructions where the second word is an address to indicate a register (high RAM address) for the IN and OUT instructions or a PC address for the branch instructions. It would seem to be possible to use a 256 byte RAM to add an extra 16 registers to the basic processor assuming that each register requires 16 four bit bytes.

MM57109 plus MPU

The MM57109 can be added to an MPU in one of two ways. Firstly it would be possible to give the 57109 a fixed proram to work on in its own PROM or in a RAM which has been preset by the MPU with a sequence of instructions. The I/O would then be handled by DMA sharing of the RAM mentioned earlier with the MPU regularly HOLDing the 57109 and accessing the data in the RAM. This type of application would seem to be suitable for Linear Programming where a 'correct' result is not usually possible and the program continues to narrow down the problem until the result is within specified tolerances. In this application both processors are considered to be independantly 'intelligent' and could possibly be used separately with the independent keyboards for each.

The second method of interfacing the 57109 with an MPU is for the MPU to communicate via a single port and to pass digital data and instructions in serial form to the 57109 and then collect results in a similar manner via another port. In this form the MPU would use the 57109 as if it had a keyboard simulator attached and would thus enter the data in the same way as one would enter data from a calculator keyboard. The software routine in the MPU would presumably have the data stored as a mathematical statement such as X = A + B — cos C / log D. Such a sequence could be from a BASIC or similar language statement or could have been input from the MPU keyboard for immediate execution. The software would check the text of the statement for syntax and then execute the statement in the correct sequence (Brackets, exponent, multiply, divide, add, subtract). The variables A,B,C,D could appear as numbers or as labels in which case the MPU would look up the number associated with that variable before outputing it to the 57109. At the end of the calculation an Out instruction would be executed and the data read back into the MPU from the DO1 - DO4 lines of the 57109, this data would then in our example be assigned to the variable labelled by X.

Execution times vary from the input of digits or simple instructions which require about 200 microcycle times to SIN and COS instructions which in worst case conditions can take nearly 100,000 microcycles. With a clock speed of 400KHz this latter figure would take only ¼ second to execute and our example would be solved for X in less than one second.

National Semiconductors do a very comprehensive data sheet on the MM57109 and if you send an SAE to them at 19 Goldington Road, Bedford, I am sure they will send you a copy. The price of the MM57109 is still not fixed but a good guestimate would be in the £15 to £20 price range.

EAROMS at Last

After a couple of false starts General Instruments appear to have debugged the ER3400 series of Electrically Alterable ROMs. These devices are made as a 1K x 4 bit memory array which can be used as a non-volatile memory in an MPU system or in any other system requiring the facilities of a RAM with the unpluggable facilities of a ROM. Unlike some of the earlier EAROMS the ER3400 and ER3401 require a simple set of pulses to Read, Write or Erase the data held in the ROM. Any one of four operating modes can be selected by setting up the correct binary code on the two mode control inputs C0 and C1, the four modes are READ, WRITE, BLOCK ERASE and WORD ERASE. When in the READ mode data is read during the Chip Enable pulse, a WRITE ENABLE pulse informs the device that the data on the DO-D3 lines is valid and can be latched internally for use during the WRITE operation. Both Write and Erase require a dummy Read operation to follow, this can be used to confirm the Write or Erase has been successfully completed.

The timings of the devices require a slowish MPU or an MPU with additional interfacing to allow for a slow I/O device. As an example the chip enable pulse width has to be between 650nS and 2000nS, this is approximately double that found in most MPUs and so the MPU must be run at half speed for easiest interface, in most applications this would not be a problem. The ER3400 is the faster of the two devices with an access time of 650nS the more readily available ER3401 has an access time of better than 950nS.

Power requirements are +5 at 12mA, —12 at 7mA and —30v at 3mA; the —30v line could be derived from an inverter powered from the —12v line.

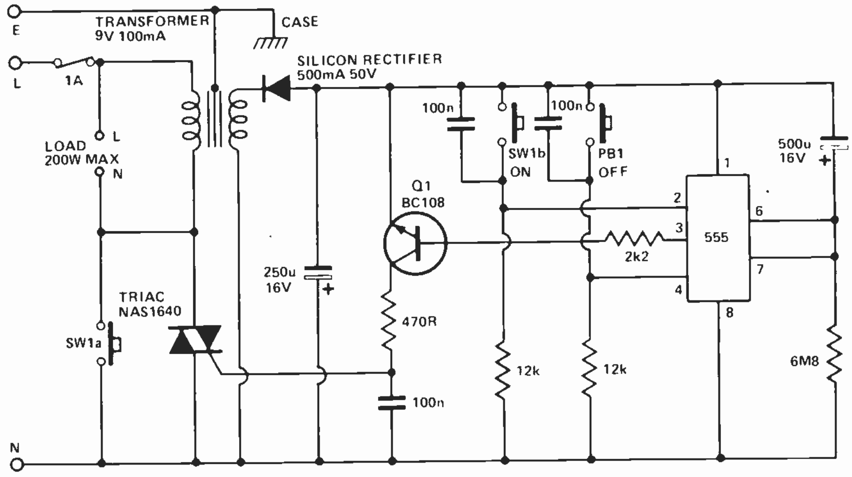
No particular order of power supply sequencing is needed as circuits are provided to force the device into READ mode during power turn on. Erasing and Writing are inhibited if Vdd or Vgg are not at the correct operating levels. With no power supply the device will retain the data for 10 years and can be erased and re-written up to 10^5 times per word. At about £30 per chip for the ER3401 the price compares favourably with the price per 1K bytes of 4K STATIC RAMs or 4K PROMS. Data on the ER3401 can be obtained from GI at 57/61 Mortimer St, London W1N 7TD. ●

tech-tips

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 ETI TECH-TIPS, Electronics Today International, 25-27 Oxford St., London W1R 1RF.

Automatic Night Light

C. N. Harrison



This circuit was devised to turn off a bedroom light after a period of an hour. It could, however, be used to control any load up to a maximum of 200W. At the end of the period the unit switches off both itself and the load.

The timing period is generated by a standard 555 timer in monostable mode controlled by SW1b and PB1. For reliable operation timing capacitor C should be selected for low leakage. The output of the timer switches Q1 which in turn controls the gate current for the triac. During the timing period the triac is fully turned on so there is no degradation of the waveform across the load or RFI due to switching transients.

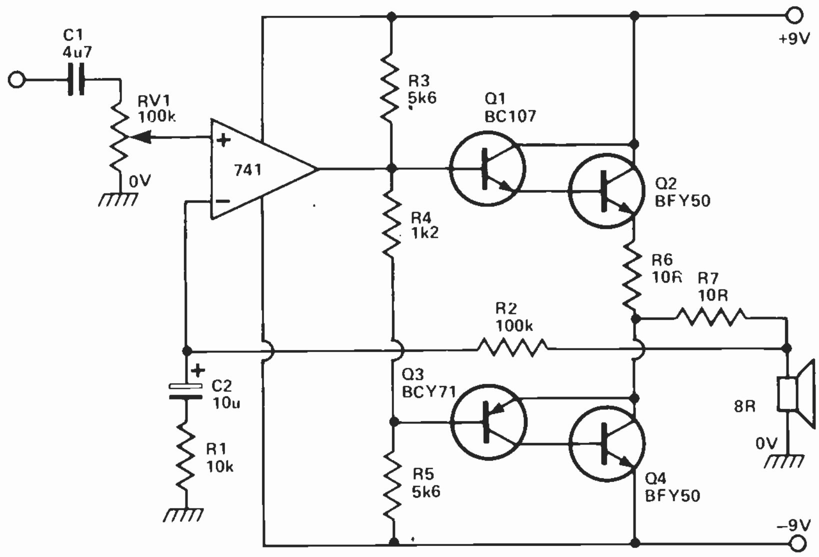
To initiate the timing period mains must be applied to the transformer to provide a DC supply for the timing circuitry. This is achieved by momentarily bypassing the triac with one pole of the ON switch, SW1a. Because this switch must also provide power to the load it must be rated accordingly. SW1b is used to trigger the 555 and start the timing period. Q1 will then be turned on, providing gate current to turn on the triac. When SW1 is released the supply and the load is maintained until the end of the timing period. PB1 is provided so that the load can be switched off at any time. It may be omitted if this feature is not required.

Great care must be exercised with this circuit as all components are connected to mains neutral even when inactive.

Headphone Amplifier

J. Macaulay

ONE CHANNEL ONLY SHOWN



The circuit will deliver full 'orchestral' levels to four pairs of stereo headphones connected in parallel across the output.

Input signals are coupled to the non inverting input of a 741 op amp via the volume control RV1.

This IC is used to drive a quasi-complementary output stage consisting of Q1-4.

Quiescent current in the output transistors is provided by the voltage drop across R7 and local feedback provided by R6 in Q2's emitter circuit.

R6 is included to render the whole amplifier short circuit proof (to protect Q2 and Q4). Overall feedback is applied from the 'earthy' end of R6 so this component has negligible effect on the damping factor of the amplifier.

With the components shown the frequency response is —3dB at 4Hz and 100KHz, distortion below 0.1% at 1KHz (50mW out, 8Ω load), and sensitivity 60mV.

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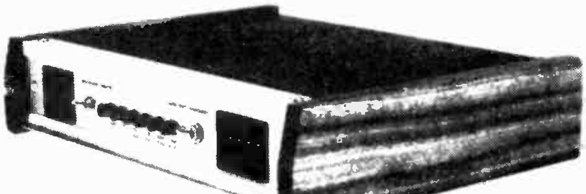

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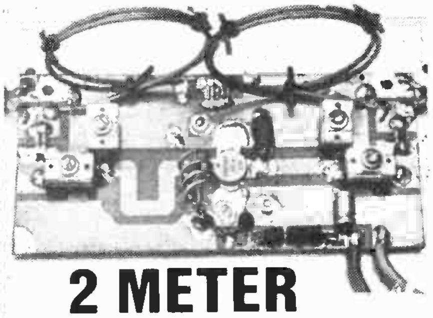
Reprint of "Wireless World" articles at £1.50 + large 15p s.a.e. (included in kit).



2 METER POWER AMP as described SEPTEMBER 1976 ISSUE (page 19)

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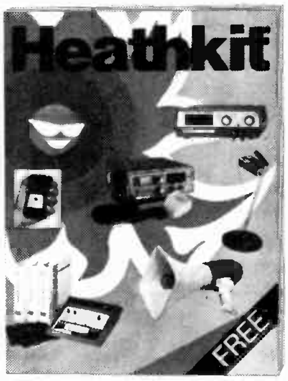

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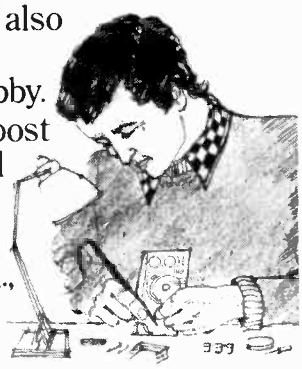

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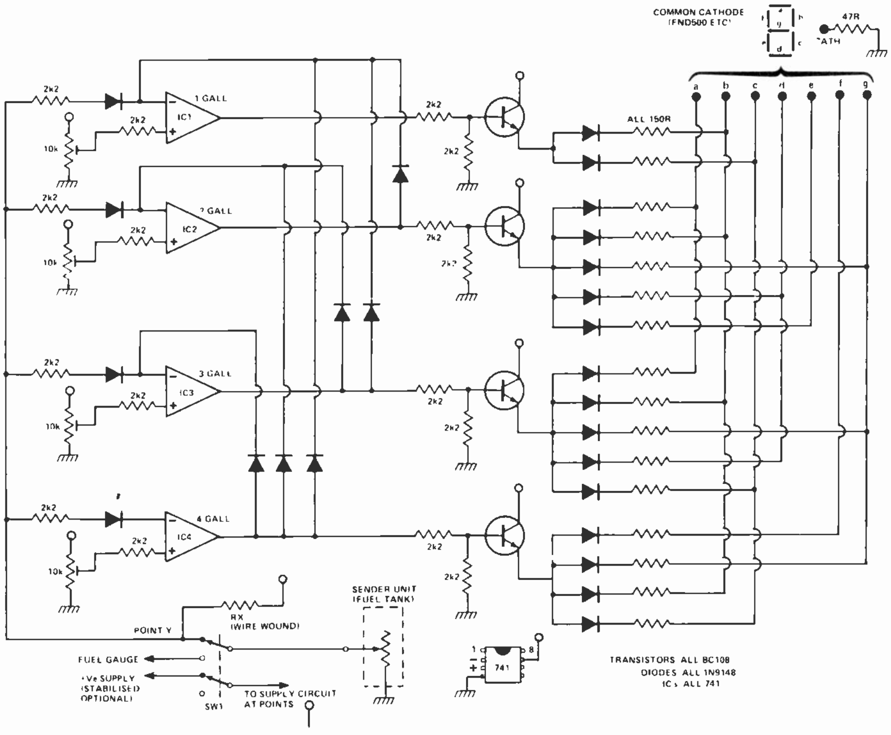


This circuit will give a digital readout of tank capacity in gallons, up to the 4 gallon mark. As the sender is of a log. nature, and knowing you have at least 4 gallons in the tank I did not find it necessary to provide a greater figure display.

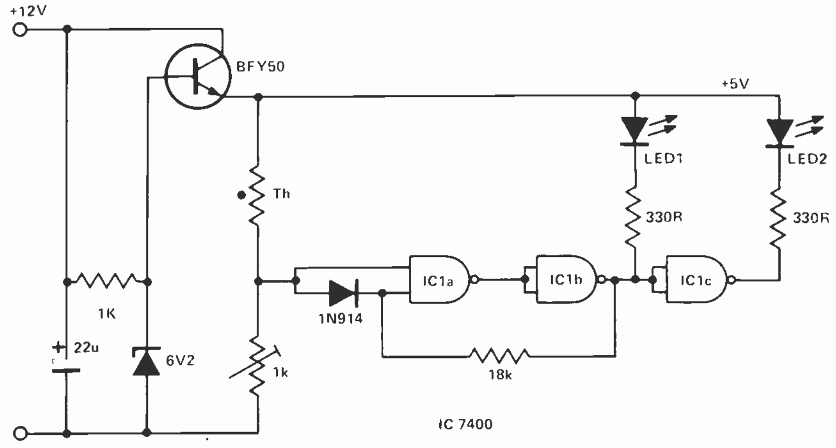
The switch is a means of switching to fuel gauge. The voltage across the sender unit *must not exceed five volts,* thus, the resistance of RX must be 2.5x resistance of sender, when the tank is empty, presuming that the resistance is high on an empty tank. Disconnecting the output of a sender unit on a car fuel tank, and wiring it in series with a resistor RX we create a positive potential at point Y, relative to earth, which varies in relationship to the fuel level. Connecting point Y to the inverting input of a 741 op. amp., and using a trimmer at the non-inverting input, a condition is created whereby the output of the IC is either + or —, depending on the fuel level. A corresponding voltage, which represents X gallons, can be set at pin 3, and a drop in fuel will give an increase in potential at pin 2, which will result in a negative output, at pin 6. In the circuit above, voltage drop may cause one particular IC to go negative, but still be at a level to give another IC a positive output.

In the case of IC4 (representing 4 gallons), the voltage at point Y may be of a level to give IC4 a + output, but also be lower at pin 3 on ICs 3, 2 and 1. This would mean that the non-inverting inputs would, in each case, also be positively biased, giving a positive output from each IC. To overcome this positive feedback from pin 6, of any IC which has a positive output, is fed to inverting inputs to preceding ICs causing those particular ICs to 'turn off'.

The outputs from pin 6 of each IC may then be used to drive individual indicators, or the discrete decoder which drives a seven segment display as shown in the circuit.

'Warmth' Indicator

C. J. Cooksey



A simple indicator was required for a gas fridge in a caravan to show when the pilot light had gone out. The sensing element used was a thermistor, attached to the outlet which is 'warm' when the pilot light is on. A rod-type thermistor was used for cheapness, with a resistance of about 3k at 20°C.

Two gates of the 7400 provide a Schmitt trigger with a low hysterysis (determined by the 18k feedback resistor) and the third gate inverts that output. When the pilot light is on, the input of IC1a is high, IC1c output is logic 0 and LED2 (green) is on. If the pilot light fails, the temperature falls, all gates change state, LED2 goes off and LED1 (red) comes on.

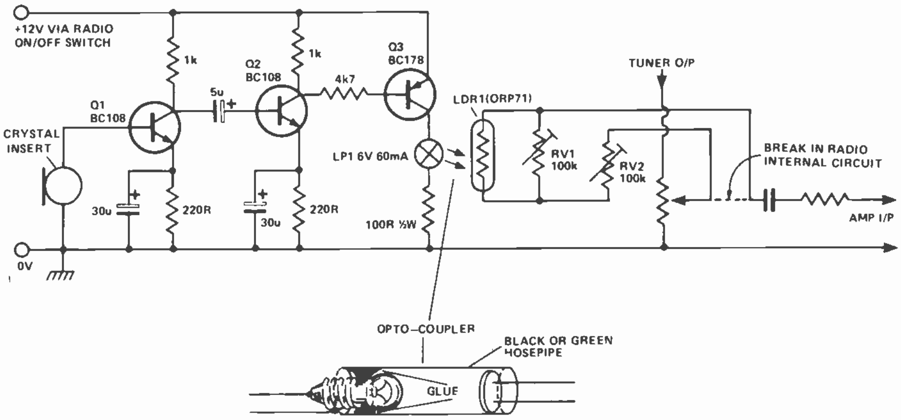
The temperature at which the changeover takes place is set by the 1k preset.

74C73—58p
74C90—91p

Car A.V.C.

R. Johnson

As the noise from the engine increases the lamp LP1 is lit by Q3 which causes the resistance of LDR1 to decrease. This change in resistance controls the volume of the radio. A home-made opto-coupler is used to reduce circuit cost, and the LDR is connected as shown. Adjustment of RV1 and RV2 is necessary so that the increase in engine noise corresponds to an approximately equal increase in radio volume.



Time Delay Switch

T. Huffinley

IC1a is provided with resistive and capacitive feedback to form an integrator with initial conditions. IC1b is in an "open loop" mode so that its output is either high or low depending on its inputs, and changes state when the output of IC1a goes more negative than the voltage set at ZD2. When the output of IC1b goes positive the transistor Q1 biases hard on switching the SCR on. Diodes D1-D4 are to make the SCR conduct on both halves of the mains wave form.

The delay period is set by the components ZD1, ZD2, C, RV1, and R. If ZD1 is chosen to be 0V5 and ZD2 at 5V, then the maximum delay period is given by T = 10.C.R.

$$RV1 = \frac{ZD2}{ZD1} \times R \leqslant 10.R$$

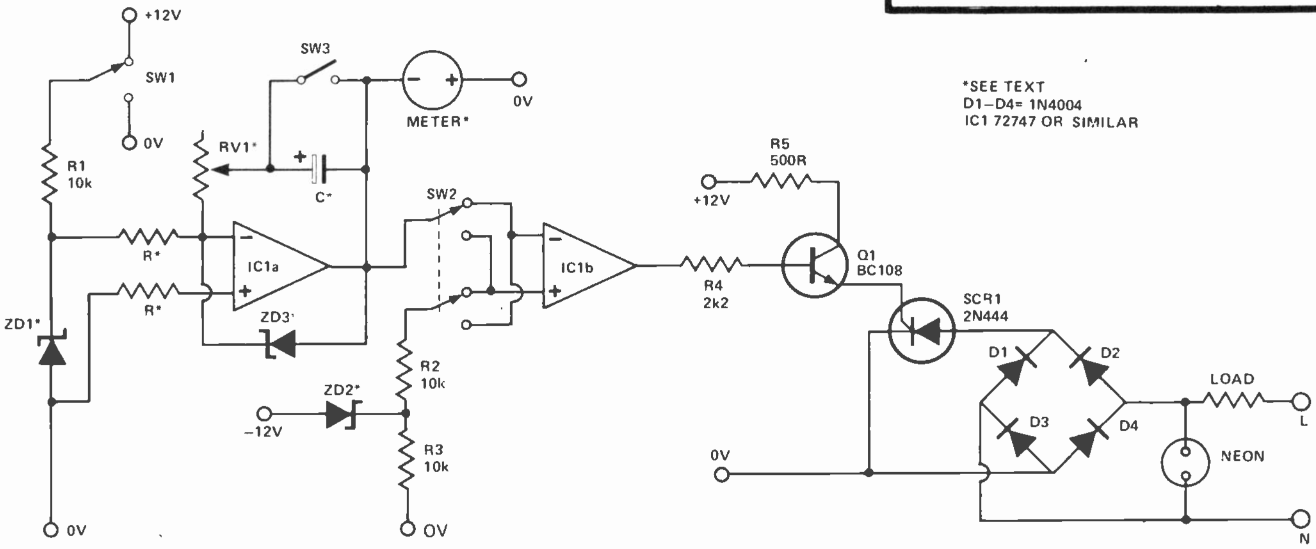
The meter is a voltmeter with a fsd equal to the value of ZD2. The switch then operates when the meter reaches fsd. The meter can therefore be calibrated to show remaining delay with 0V equal to T and fsd equal to zero.

SW2 changes round the inputs of the op-amp so that the output either swings from high to low, or, low to high. SW3 is to reset the time delay which it does by discharging the capacitor. ZD3 should be chosen to be a value slightly higher than ZD2, this is to stop the capacitor charging beyond a set limit and therefore overloading the meter. SW1 is the run-hold switch. When the switch is at +12 volts the integrator charges the capacitor. When the switch is set to 0V the charging of the capacitor is stopped until the switch is set back to 12 volts.

Q1 is a buffer to avoid loading on the IC and to trigger the SCR. The supply voltage should be 12-0-12 and does not need to be well smoothed as the zener diodes set the timing function.

Warning

The circuitry is not isolated from the mains and should therefore be isolated from the enclosure.



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HY5
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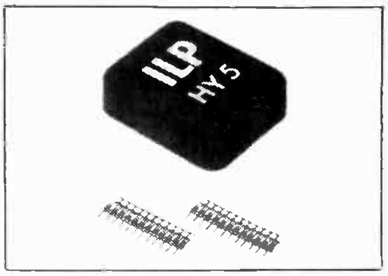

The HY5 is a mono hybrid amplifier ideally suited for all applications. All common input functions (mag Cartridge, tuner, etc.) are catered for internally, the desired function is achieved either by a multi-way switch or direct connection to the appropriate pins. The internal volume and tone circuits merely require connecting to external potentiometers (not included). The HY5 is compatible with all I.L.P. power amplifiers and power supplies. To ease construction and mounting a P.C. connector is supplied with each pre-amplifier.
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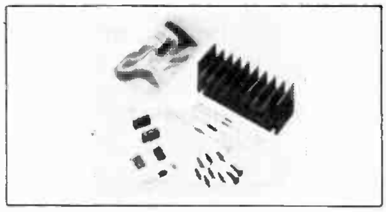

The HY30 is an exciting New kit from I.L.P., it features a virtually indestructible I.C. with short circuit and thermal protection. The kit consists of I.C., heatsink, P.C. board, 4 resistors, 6 capacitors, mounting kit, together with easy to follow construction and operating instructions. This amplifier is ideally suited to the beginner in audio who wishes to use the most up-to-date technology available.
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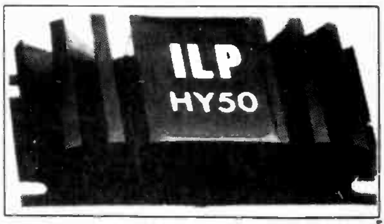
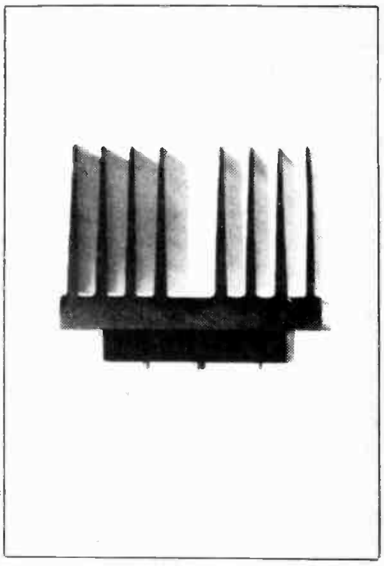
APPLICATIONS: Updating audio equipment — Guitar practice amplifier — Test amplifier — Audio oscillator.
SPECIFICATIONS:
OUTPUT POWER 15W R.M.S. into 8Ω. DISTORTION 0.1% at 15W.
INPUT SENSITIVITY 500mV. FREQUENCY RESPONSE 10Hz-16kHz — 3dB
SUPPLY VOLTAGE ± 18V
Price £5.22 + 65p VAT P&P free.

HY50
25 Watts into 8Ω



The HY50 leads I.L.P.'s total integration approach to power amplifier design. The amplifier features an integral heatsink together with the simplicity of no external components. During the past three years the amplifier has been refined to the extent that it must be one of the most reliable and robust High Fidelity modules in the World.
FEATURES: Low Distortion — Integral Heatsink — Only five connections — 7 Amp output transistors — No external components.
APPLICATIONS: Medium Power Hi-Fi systems — Low power disco — Guitar amplifier
SPECIFICATIONS: INPUT SENSITIVITY 500mV.
OUTPUT POWER 25W RMS in 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.04% at 25W at 1kHz.
SIGNAL/NOISE RATIO 75dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB.
SUPPLY VOLTAGE ± 25V. SIZE 105.50.25mm.
Price £6.82 + 85p VAT P&P free

HY120
60 Watts into 8Ω



The HY120 is the baby of I.L.P.'s new high power range, designed to meet the most exacting requirements including load line and thermal protection, this amplifier sets a new standard in modular design.
FEATURES: Very low distortion — Integral Heatsink — Load line protection — Thermal protection — Five connections — No external components
APPLICATIONS: Hi-Fi — High quality disco — Public address — Monitor amplifier — Guitar and organ.
SPECIFICATIONS:
INPUT SENSITIVITY 500mV
OUTPUT POWER 60W RMS into 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.04% at 60W at 1 kHz.
SIGNAL/NOISE RATIO 90dB. FREQUENCY RESPONSE 10Hz-45kHz —3dB. SUPPLY VOLTAGE ±35V.
Size: 114 x 50 x 85mm.
Price £15.84 + £1.27 VAT P&P free.

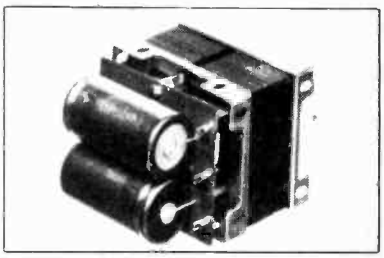
HY200
120 Watts into 8Ω

The HY200, now improved to give an output of 120 Watts, has been designed to stand the most rugged conditions, such as disco or group while still retaining true Hi-Fi performance.
FEATURES: Thermal shutdown — very low distortion — Load line protection — Integral Heatsink — No external components.
APPLICATIONS: Hi-Fi — Disco — Monitor — Power Slave — Industrial — Public address
SPECIFICATIONS:
INPUT SENSITIVITY 500mV
OUTPUT POWER 120W RMS into 8Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.05% at 100W at 1kHz.
SIGNAL/NOISE RATIO 96dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB. SUPPLY VOLTAGE ±45V
SIZE 114 x 100 x 85mm.
Price £23.32 + £1.87 VAT P&P free.

HY400
240 Watts into 4Ω

The HY400 is I.L.P.'s "Big Daddy" of the range producing 240W into 4Ω! It has been designed for high power disco or public address applications. If the amplifier is to be used at continuous high power levels a cooling fan is recommended. The amplifier includes all the qualities of the rest of the family to lead the market as a true high power hi-fidelity power module.
FEATURES: Thermal shutdown — Very low distortion — Load line protection — No external components.
APPLICATIONS: Public address — Disco — Power slave — Industrial
SPECIFICATIONS:
OUTPUT POWER 240W RMS into 4Ω. LOAD IMPEDANCE 4-16Ω. DISTORTION 0.1% at 240W at 1 kHz.
SIGNAL/NOISE RATIO 94dB. FREQUENCY RESPONSE 10Hz-45kHz — 3dB. SUPPLY VOLTAGE ±45V
INPUT SENSITIVITY 500mV. SIZE 114 x 100 x 85mm.
Price £32.17 + £2.57 VAT P&P free.

POWER SUPPLIES



PSU36 suitable for two HY30's **£5.22** plus 65p VAT P/P free
PSU50 suitable for two HY50's **£6.82** plus 85p VAT P/P free
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PSU90 suitable for one HY200 **£12.65** plus £1.01 VAT P/P free.
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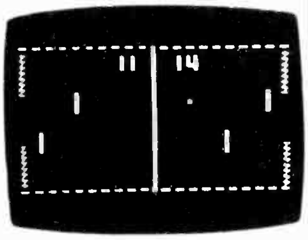

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4002	**0.20**	4029	**1.27**	4053	**1.04**	4085	**0.80**
4006	**1.31**	4030	**0.60**	4054	**1.29**	4086	**0.80**
4007	**0.20**	4031	**2.46**	4055	**1.46**	4089	**1.74**
4008	**1.07**	4032	**1.19**	4056	**1.46**	4093	**0.89**
4009	**0.60**	4033	**1.55**	4057	**29.81**	4094	**2.08**
4010	**0.60**	4034	**2.11**	4059	**6.20**	4095	**1.16**
4011	**0.20**	4035	**1.31**	4060	**1.24**	4096	**1.16**
4012	**0.20**	4036	**3.09**	4061	**25.60**	4097	**4.13**
4013	**0.60**	4037	**1.06**	4062	**10.10**	4098	**1.22**
4014	**1.12**	4038	**1.20**	4063	**1.22**	4099	**2.03**
4015	**1.12**	4039	**3.09**	4066	**0.69**	40101	**1.76**
4016	**0.60**	4040	**1.19**	4067	**4.13**	40102	**2.16**
4017	**1.12**	4041	**0.93**	4068	**0.24**	40103	**2.16**
4018	**1.12**	4042	**0.93**	4069	**0.24**	40104	**2.26**
4019	**0.60**	4043	**1.12**	4070	**0.65**	40107	**0.66**
4020	**1.24**	4044	**1.04**	4071	**0.24**	40108	**6.18**
4021	**1.12**	4045	**1.56**	4072	**0.24**	40109	**2.21**
4022	**1.07**	4046	**1.48**	4073	**0.24**	40181	**4.30**
4023	**0.20**	4047	**1.01**	4075	**0.24**	40182	**1.73**
4024	**0.87**	4048	**0.60**	4076	**1.71**	40194	**2.26**
4025	**0.20**	4049	**0.60**	4077	**0.65**	40257	**2.26**
4026	**1.92**	4050	**0.60**	4078	**0.24**		

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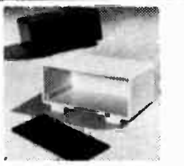
14160	**1.18**	14175	**1.04**	14415	**7.35**	14450	**2.67**
14161	**1.18**	14194	**1.17**	14419	**2.67**	14451	**2.67**
14162	**1.18**	14410	**5.70**	14422	**4.98**	14490	**6.51**
14163	**1.18**	14411	**9.54**	14435	**7.93**		
14174	**1.08**	14412	**17.07**	14440	**11.58**		

14500 Series (RCA/Motorola)

14501	**0.20**	14518	**1.39**	14537	**13.17**	14561	**0.70**
14502	**1.38**	14519	**0.57**	14539	**1.24**	14562	**5.59**
14503	**0.75**	14520	**1.39**	14541	**1.62**	14566	**1.67**
14505	**4.38**	14521	**2.77**	14543	**1.82**	14568	**3.15**
14506	**0.57**	14522	**2.15**	14549	**4.10**	14569	**3.72**
14507	**0.60**	14526	**2.15**	14552	**10.50**	14572	**0.27**
14508	**3.08**	14527	**1.76**	14553	**4.66**	14580	**8.35**
14510	**1.51**	14528	**1.22**	14554	**1.67**	14581	**4.30**
14511	**1.74**	14529	**1.72**	14555	**1.01**	14582	**1.64**
14512	**1.03**	14530	**0.95**	14556	**1.01**	14583	**0.84**
14514	**3.47**	14531	**1.74**	14557	**4.65**	14584	**0.71**
14515	**3.47**	14532	**1.39**	14558	**1.25**	14585	**1.10**
14516	**1.51**	14534	**8.15**	14559	**4.10**		
14517	**4.02**	14536	**4.00**	14560	**2.17**		

74C00 Series (National)

74C00	**0.26**	74C86	**0.69**	74C173	**1.21**	74C910	**7.20**
74C02	**0.26**	74C89	**4.65**	74C174	**1.21**	74C914	**1.50**
74C04	**0.26**	74C90	**0.92**	74C192	**1.49**	74C918	**2.90**
74C08	**0.26**	74C93	**0.92**	74C193	**1.49**	74C920	**9.84**
74C10	**0.26**	74C95	**1.31**	74C195	**1.31**	74C921	**9.84**
74C14	**1.51**	74C107	**1.31**	74C200	**7.20**	74C925	**8.28**
74C20	**0.26**	74C150	**4.17**	74C221	**1.50**	74C926	**8.28**
74C30	**0.26**	74C151	**2.63**	74C901	**0.74**	74C927	**8.28**
74C32	**0.26**	74C154	**3.93**	74C902	**0.74**	74C928	**8.28**
74C42	**1.20**	74C157	**2.36**	74C903	**0.74**	80C95	**1.20**
74C48	**2.37**	74C160	**1.49**	74C904	**0.74**	80C96	**0.92**
74C73	**0.74**	74C161	**1.49**	74C905	**7.71**	80C97	**0.87**
74C74	**0.63**	74C162	**1.49**	74C906	**0.74**	80C98	**0.92**
74C76	**0.74**	74C163	**1.49**	74C907	**0.74**	88C29	**6.21**
74C83	**1.97**	74C164	**1.31**	74C908	**2.63**	88C30	**6.21**
74C85	**1.97**	74C165	**1.31**	74C909	**1.74**		



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CA3130

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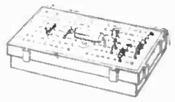

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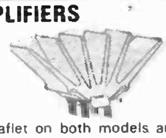

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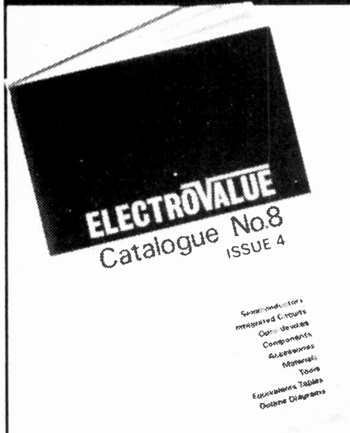

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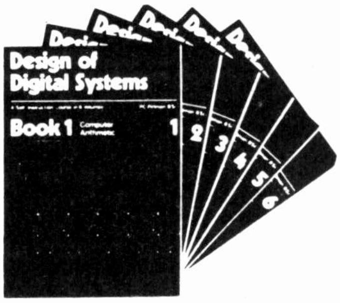

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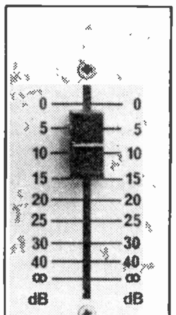

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