Electronics Today

INTERNATIONAL MARCH 1981

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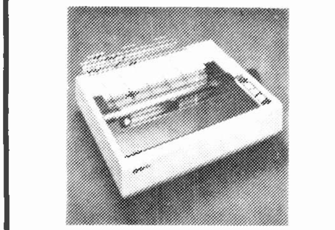

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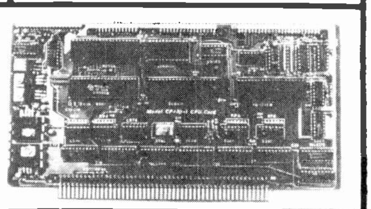

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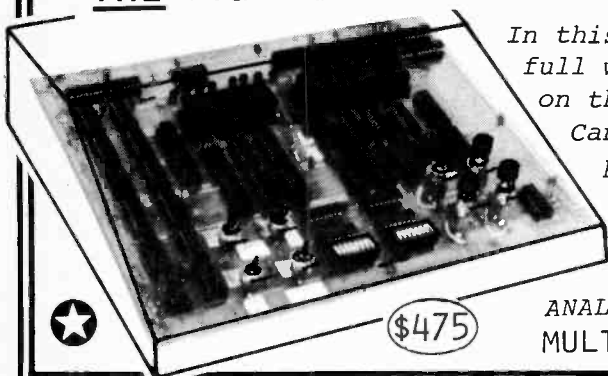

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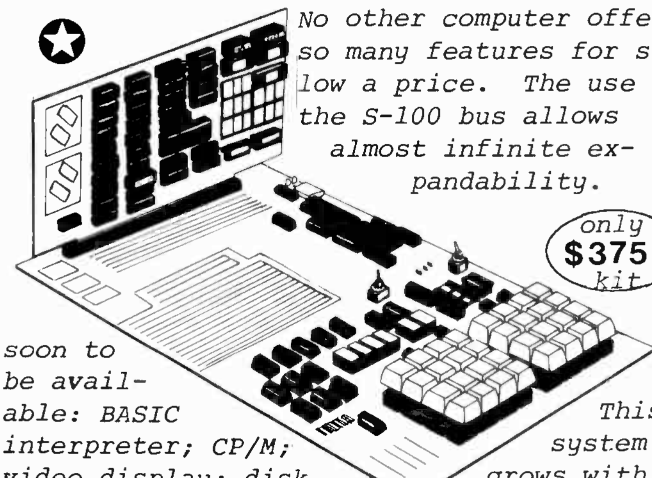

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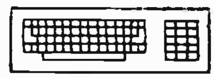

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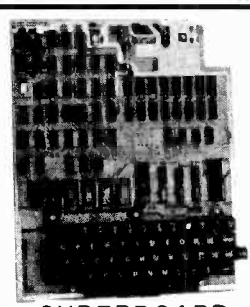

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Electronics Today INTERNATIONAL

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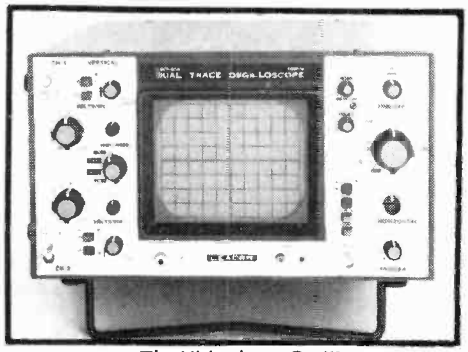

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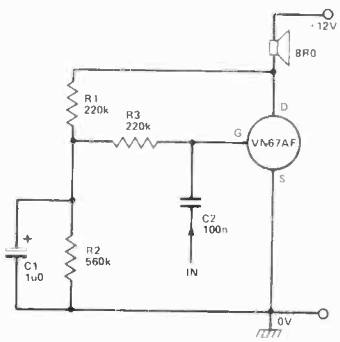

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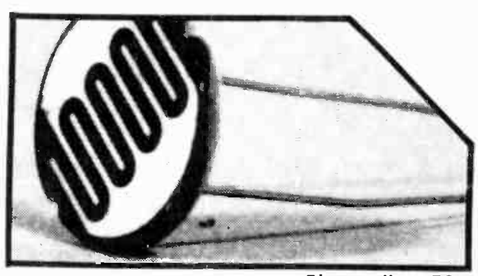

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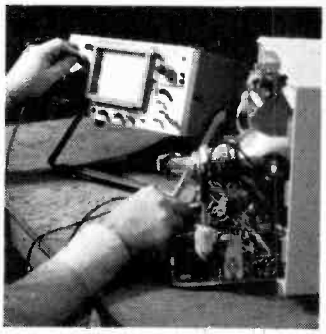

Cover: The 'scope is by far the most useful piece of test gear for most applications. See our feature starting on page 13. Thanks to R.H. Nichols of Downsview, Ontario for the loan of the Metermaster Model 6515 used on the cover.

ISSN 0703-8984

Drum Synthesiser 35
Triggered by a simple microphone inside an existing drum — or anywhere for that matter — this superb design will produce exactly the sound you're looking for.

Shark 41
An electronic game where you try to beat the machine to escape to safety.

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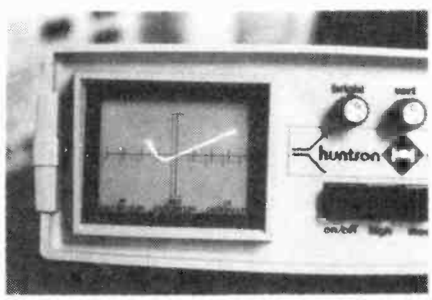

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ETI is available for resale by component stores. We can offer a good discount and quite a big bonus, the chances are customers buying the magazine will come back to you to buy their components. Readers having trouble in buying ETI could ask their component store manager to stock the magazine.

COMPONENT NOTATION AND UNITS
We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. ETI has opted for sooner!
Firstly decimal points are dropped and substituted with the multiplier, thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1uF is 100n, 5600pF is 5n6. Other examples are 5.6pF=5p6, 0.5pF=0p5.
Resistors are treated similarly: 1.8M ohms is 1M8, 56k ohms is the same, 4.7k ohms is 4k7, 100 ohms is 100R and 5.6 ohms is 5R6.

PCB SUPPLIERS
This magazine does not supply PCBs or kits but we do issue manufacturing permits for companies to manufacture boards and kits to our designs. Contact the following companies directly when ordering boards. NOTE, we do not keep track of what's available from who, so please don't write to us for information on kits or boards. Similarly, do not ask our PCB suppliers for project help.

K.S.K. Associates, P.O. Box 54, Morriston, Ontario N0B 2C0.
B&R Electronics, P.O. Box 6326F, Hamilton, Ontario, L9C 6L9
Spectrum Electronics, Box 4166, Stn 'D', Hamilton, Ontario, L8V 4L5
Wentworth Electronics, R.R. No.1, Waterdown, Ontario L0R 2H0
Danocinths Inc. P.O. Box 261, Westland, MI 48185. USA.
Exceltronix Inc., 319 College St., Toronto, Ontario, M5T 1S2
Arkon Electronics Ltd., 409 Queen St. W., Toronto, Ontario, M5V 2A5.
A-1 Electronics, 5062 Dundas St. West, Islington, Ontario M9A 1B9. (416) 231-4331.

ETI•Arkon READER OFFER

HIOKI 3208 Calcu Hi Tester

Regular Price

$359·95

ETI READER PRICE

$315·00

Inc postage + PST if applicable

This is one of the most interesting electronic 'goodies' we've come across. Essentially it's an excellent Scientific Calculator and Digital Multimeter, not only in the same package but even interactive.

Measuring 170 x 76 x 20mm in a really sturdy case, the Hioki 3208 boasts a large and detailed display. Describing all the functions here isn't easy — the instruction book comprises 45 crammed pages!

This extraordinary instrument has only just been launched at a regular price of $359.95. However, we at ETI were so impressed with it, we've made special arrangements in conjunction with Arkon Electronics to supply it direct to ETI readers at $315.00 using the coupon below.

SPECIFICATIONS

DMM Specifications

Display: 3½ digits LCD, autopolarity.
Ranging: Automatic and manual plus over-range indication.
Sample rate: Two samples per second
Battery Life: 100 hours continuous (2 x AA batteries)
Maximum Input: Voltage, 1000V DC, 750V AC; Ohms & mA 0.3A (fuse protected) plus diode protection.
Accessories: High quality test leads and carrying case.
Ranges: VDC, 200mV, 2V, 20V, 200V, 1000V; VAC, 2V, 20V, 200V, 600V; DC mA, 20mA, 200mA, AC mA, 20mA, 200mA; Ohms, 200, 2k, 20k, 200k, 2M; Low Power Ohms (less than .5V applied), 2k, 20k, 200k, 2M; Diode check; Continuity Check on Ohms and LP Ohms ranges.

Calculator Specifications

Display: 8 digits LCD (separate from DMM). With exponent, 5 in mantissa, 2 in exponent. Operating digits number 11 in mantissa and 2 in exponent.
System: Arithmetical
Round Off: Rounds up or down according to convention, does not drop last number.
Functions: Four arithmetical, automatic constant and parentheses.
Memory: Single independent register
Scientific Functions: Square Root, Pi, inverse no., square, trigonometric and inverse trig functions, logs, y^x, $x\sqrt{y}$, permutation, combination and factorical.
Statistical Functions: Standard deviation, fraction, mean, sum and sum of squares.
Conversion Calculations: Coordinate axes and degrees, minutes and seconds.

MAIN FEATURES

- ☐ Multimeter with a scientific function calculator.
- ☐ DMM display with one - touch keying into calculator.
- ☐ Low power ohms for in - circuit measurements.
- ☐ AC/DC 10 Megohm (minimum) impedance.
- ☐ Beeper for continuity tests.
- ☐ Alarm indicates range and function selection.
- ☐ Diode check range.

To: Hioki Offer, ETI Magazine, Unit 6, 25 Overlea Blvd, Toronto, Ont, M4H 1B1.

Please send me a Hioki 3208 Calcu Hi Tester. I enclose my payment (payable to ETI Magazine) of $315.00 (Ontario Residents add 7% PST).

Name. . . . .
Address . . . .
City. . . . . Province . . . .
Code . . . . Date . . . .

Offer expires April 30th 1981

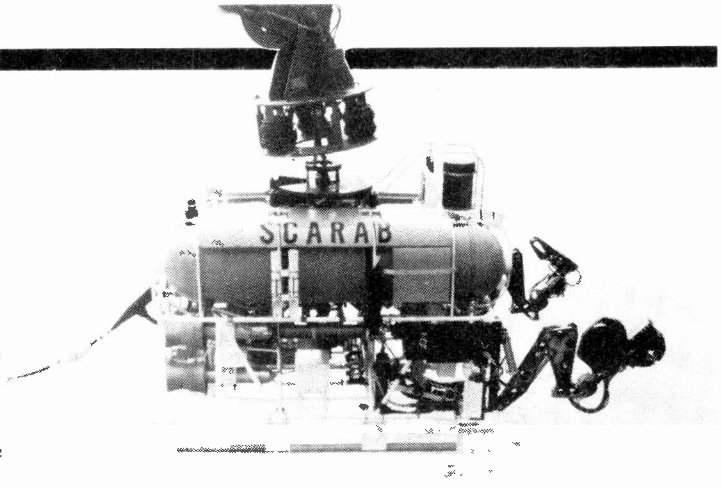
NEWS

Ultimate Bathtub Toy?!

An unmanned submersible craft was delivered recently to Teleglobe Canada's cable depot at St. John's, Newfoundland. Called SCARAB, an acronym for submersible craft assisting repair and burial, it is owned jointly by a consortium of telecommunications authorities. Perfected by Bell Labs of New Jersey. SCARAB has been designed to dive to and operate at a depth of 6000 feet.

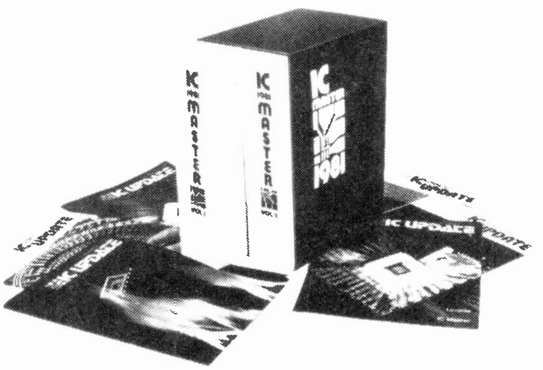
SCARAB can detect a buried undersea telecommunications cable by means of a special tone transmitted through the cable, uncover the cable at the damaged point with jet streams of water from a high-pressure pump, grasp the cable with two hydraulically powered "arms", and then cut it with a specially developed circular saw and finally attach a lift line to each cut end. The accompanying cable ship crew can then haul the two ends of the cable onto the ship, replace the damaged portion and return the repaired cable to the seabed. Subsequently SCARAB can be used to bury the repaired cable by "jetting".

The multi-million dollar SCARAB will also be used for seabed surveillance of the buried sections of transatlantic cables, for preventive maintenance of buried and unburied cables (burying the latter where necessary), and possibly to assist with the laying of planned cables. The submersible also has a future as a research and development platform for other cable repair and maintenance tools. Because SCARAB is unmanned, it is readily available for service and for 24-hour operation, ensuring timely maintenance work and cable repair.



SCARAB, the unmanned submersible craft used in the location and maintenance or repair of undersea telecommunication cables, is lowered into the ocean depths by AT&T's cable ship, Long Lines, during intitial trials off the coast of New Jersey. SACRAB's home base is in St. John's, Newfoundland, where it will work with the CCGS John Cabot.

Teleglobe Canada provides Canadians with international telecommunication services via submarine cables and satellites. It currently operates four cables in the North Atlantic, CANTAT I and CANTAT 2 between Canada and Britain; CANBER between Canada and Bermuda; and ICECAN between Canada and Iceland. One cable in the Pacific, COMPAC, is nearing the end of its lifespan and plans are underway to replace it by 1984 with a new cable called ANZCAN linking Canada, Hawaii, Fiji, Norfolk Island, Australia and New Zealand.



Need an IC? Got a Source?

Anybody associated with electronics knows how hard it can be to find a manufacturer. Similarly, trying to figure out what a device is supposed to do can also pose a problem.

United Technical Publications' new 1981 IC Master can solve these problems. The IC Master consists of two volumes of eight selection guides. Devices can be traced by means of type, function and key parameters.

The 1981 IC Master is available from any Future Electronics office. For more information write to Future Electronics Inc. 5647 Ferrier St., Montreal, Quebec H4P 2K5.

Win a Computer II

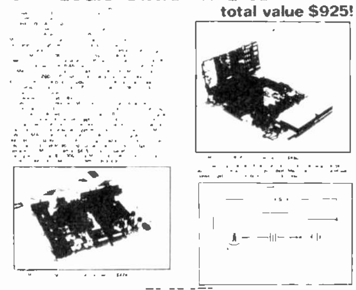
We are pleased to annouce the winners of our December 1980 contest first prize goes to G.F. Pierce of Peterborough, Ontario and second prize went to Ray Hill of MacGregor, Manitoba. Congratulations to both winners.

What was the answer? A dead short. Our problem was submitted to us by Steven K. Roberts who says:

"The circuit in the box consists of nothing more than a wire connecting the two terminals. As the second 10 volt battery is switched into the circuit, so is its internal resistance, nullifying the effect upon the current.

Since this was never described as an "ideal circuit" with lumped constants, the physical reality of the components has to be considered."

ETI–Exceltronix Contest
WIN A MULTIFLEX Z80A COMPUTER OR A LOGIC STATE ANALYZER
total value $925!



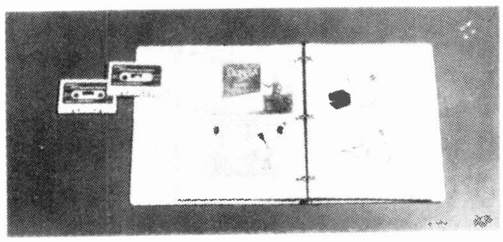
That's the way it is. All you guys with ganged switches, inductors, and capacitors, lose. Special thanks to Exceltronix for providing the prizes.

The Basics

Heathkit has introduced a new Basic Electricity course for those who want to learn the fundamentals of electricity.

The EE-3100 Basic Electricity Course text is written in a programmed-instruction format. Clearly designed visuals and two audio cassettes aid in the logical, step-by-step learning process, while unit review examinations reinforce the concepts presented in the text.

Basic electrical concepts taught in the course include Ohm's law, power, series and parallel circuits, electromagnetism, types of current, motors, generators and meters. If students want to expand their knowledge of electricity and electronics further,



this course serves as an introduction to the Heathkit Basic Electronics Series (EE-3100 through EE-3105).

The EE-3100 Basic Electricity Course is priced at $44.95; and is available from Heathkit Electronic Centres in Vancouver, Edmonton, Calgary, Winnipeg, Mississauga, Ottawa, Montreal or from Heath Company, 1480 Dundas St. E., Mississauga, Ont. L4X 2R7.

Custom ICs

Plessey Semiconductors now offers Microcell, a comprehensive approach to designing and building custom integrated circuits. This new service reduces development costs and shortens turnaround times considerably over conventional methods.

Developed and proven after two years of internal use at Plessey, Microcell combines both an extensively developed library of NMOS circuit fabrication techniques and advanced CAD (computer-aided design) capabilities. The result is a service that meets the rapidly growing needs for cost-effective custom digital ICs for industrial use.

Much of the savings accrue from the use of fully-qualified, highly-reliable library of circuit cells to design the entire circuit. With this simplified modular approach a designer can produce chips that will work the first time in silicon, and are easy to test.

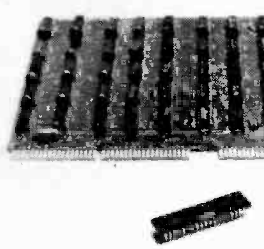
Microcell provides up to 1500 gate equivalents; – chip complexities up to 1500 gate equivalents; – 18 week (and less) turnaround from logic diagrams to prototypes; – metal, ceramic or plastic packages with pinouts up to 40; – 8 MHz clock-rate circuitry, operating from a single +5V source.

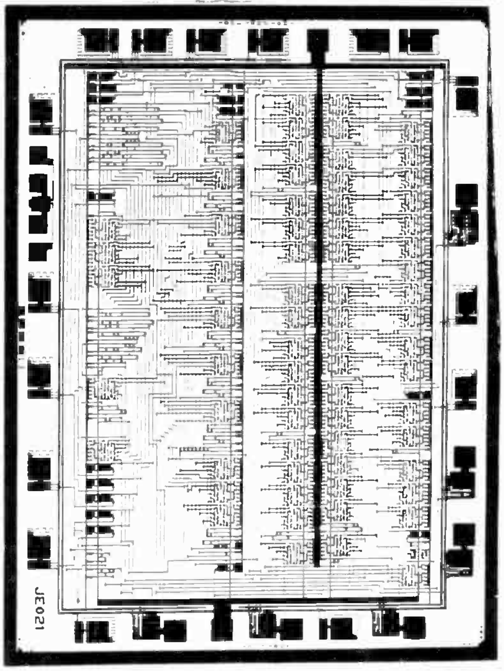
Plessey has completed more than 30 catalogue and custom parts using Microcell and nearly a dozen Microcell IC designs are now in progress. Input and output interfaces for Microcell parts are compatible with both TTL and CMOS logic.

The first step in Microcell is to translate a designer's logic diagram for the part into a symbolic digital diagram that can be input to the Plessey CAD system. This system then creates a schematic diagram reconstructed from the digitized information. Microcell software also provides simulation capability, so a designer can test the logic completely before the actual production cycle begins.

The final CAD-produced design is then forwarded to the Plessey factory for fabrication of the ICs. The digitized information produced by the Microcell CAD system provides the data required for mask fabrication, test routines and drawing checks during the LSI production process.

Normally all design activities can be achieved within eight weeks. Another ten weeks is usually required in the manufacturing cycle to generate masks, process wafers and to assemble the prototypes.





Plessey semiconductors has introduced a new IC design service that combines a library of proven circuit cells, Plessey - developed CAD (computer aided design) software and years of LSI process experience. Called Microcell, the service reduces custom - IC design and production turnaround times substantially, as well as providing considerable development and fabrication cost reductions. Above, the package in foreground can replace the printed circuit behind it. At right, a typical mask.

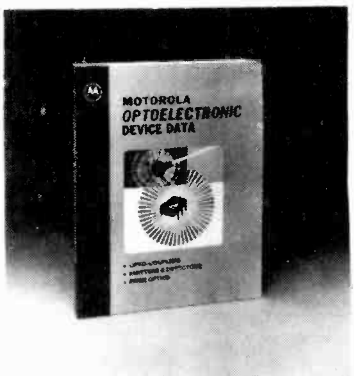
New Optoelectronics/ Fiber Optics Manual Offered By Motorola

A 286-page Opto Electronics and Fiber Optics Data Manual, has been published by Motorola.

Motorola has concentrated on infrared GaAs emitters, silicon detectors, high technology opto coupler/isolators and an innovative approach to fiber optic components, modules and links. The manual includes the entire family of high-technology, opto-triac drivers and the new SCR couplers.

The fiber optic section is intended principally to address fiber optic communications systems in the computer, industrial controls, medical electronics, consumer, and automotive applications. The manual points out that analog and digital modulation schemes, at bandwidths through 50 MHz and system lengths through several kilometers, may be achieved using currently available Motorola fiber optic devices.

The data book, titled "Motorola Optoelectronics Device Data" may be ordered, at $3.25 each through Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036.

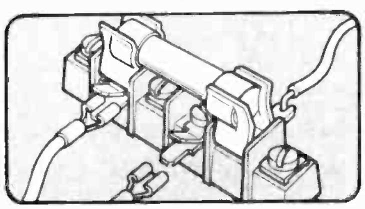


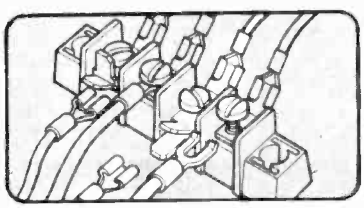
Terminal Problems?

Magnum Electric, manufacturers of thermoplastic terminal strips, have introduced their new short form catalogue.

The brochure describes the five different styles of terminal strips: Surface Wired, Point-to-Point, Wiring Harness, Circuit Board, and Machine Wire Wrap. Also described are various wiring accessories.

Magnum Electric is represented in Canada by Atlas Electronics Limited, 50 Wingold Ave., Toronto, Ontario M6B 1P7.





Mikeless Modem

ESE Limited announces the addition of the Universal Data Systems 103 O/A LP modem to its product line.

The 103 O/A LP Modem is a full-duplex, direct-connect, 300 bps originate and answer modem which takes its operating power directly from the telephone line to which it is connected.

A switch on the back panel of the modem allows the selection of either originate or answer transmit/receive bands. The modem is controlled by a rocker switch on the front panel that selects either a normal voice conversation mode or a data communications mode of operation. An LED gives a visual indication of the data communications mode.

For more information, contact: ESE Ltd, 1780 Albion Rd, Rexdale, Ontario M9V 1C1.

535 Yonge Street,
Toronto, Ont. M4Y 1Y5
Phone (416) 922-1818
No collect calls please

DOMINION

KITS

LIGHTING EFFECTS

- *3 channel 500 watt Colour Organ $21.95
- *3 Channel 1500 watt Colour Organ $32.95
- *16 Channel Light Chaser ... $22.95 (up-down-pulse)
- 16 Channel 8-mode Programmable Light Chaser ... $32.95

AUDIO KITS

- * 1 watt Audio Amp 17.95
- * 5 watt Audio Amp $19.95

POWER SUPPLY KITS

- * 0-24 volts 1 amp .... $ 39.95
- * ±5 volt and +12v @ 1 amp .. $14.95
- * ± 12 volts and +5v @ 1 amp . $14.95

* Kits come with etched, drilled and plated P.C. boards.

RESISTORS

Values from 1 ohm to 10 meg. 1/4 or 1/2 watt. Still Only 3½¢ each.

CAPACITORS NISSEI POLYESTER FILM

	Price	uF	Price	uF	Price
.0010	.20	.012	.20	.0027	.20
				.027	
.0012	.20	.015	.20	.0033	.20
.0015	.20	.047	.30	.0039	.20
.0018	.20	.056	.30	.0047	.20
.0022	.20	.068	.30	.0056	.20
.0068	.20	.082	.30	.018	.25
.0082	.20	.10	.30	.022	.25
.010	.20				

CAPACITORS ELNA ELECTROLYTIC AND TANTALUM CAPACITORS

AXIAL LEAD

uF	WV(SV) 16 (20)	WV(SV) 25 (32)	WV(SV) 50 (63)
1			.25
2.2			.25
3.3			.25
4.7			.25
10	.25	.25	.30
22	.30	.30	.35
33	.30	.35	.35
47	.35	.35	.35
100	.35	.40	.50
220	.35	.40	.55
330	.40	.50	.65
470	.45	.55	.75
1000	.60	.70	1.00
2200	.75	1.05	
3300	1.05	1.35	
4700	1.65	1.95	

DIPPED SOLID TANTALUM
Capacitance Tolerance +/-20%

uF	WV(SV) 16 (20)	WV(SV) 25 (32)	WV(SV) 35 (46)
0.22			
0.33			
0.47			.35
0.68			.35
1.0			.35
1.5			.35
2.2			.35
3.3			.35
4.7	.35		.35
6.8	.35		.35
10	.45	.50	.55
15	.50	.55	.85
22	.55	.65	1.35
33	.65	1.20	2.25
47	1.95	2.75	
68	2.75		
100	3.50		

RADIAL LEAD

uF	WV(SV) 16 (20)	WV(SV) 25 (32)	WV(SV) 50 (63)
1			.25
2.2			.25
3.3			.25
4.7		.25	.25
10	.25	.25	.25
22	.25	.25	.25
33	.25	.25	.30
47	.25	.30	.35
100	.30	.30	.35
220	.30	.35	.45
330	.35	.40	.60
470	.40	.50	.85
1000	.60	.75	
2200	1.00		

POWER SUPPLY

1400		16	.65	6800	Com	25	6.95
1600		16	.65	15000	RPE	10	4.50
2200		16	.75	12000	COM	40	6.95
2300		10	.65	14000	COM	40	7.50
1000	Can	16	1.50	15000	RPE	10	4.50
4700	Elec	40	1.75	15000	Can	16	4.90
4700	COM	100	8.95	15000	CAN	25	5.50
6800	RPE	25	6.95	15000	Com	50	11.95
				44000	Com	35	14.95
				80000	Com	20	14.95

Edu Kit's

LOGIC TRAINER $74.95
MODEL DLT01
A new development package for a BASIC DIGITAL LOGIC COURSE. Four gates and a counter. Circuit is included along with an in-depth manual. Protoboard included.

STEREO PHONO PREAMP KIT $11.25
MODEL EK80SP001
Anyone with a ceramic input receiver can enjoy the quality of a magnetic cartridge with this simple but very effective Stereo Phono Preamp.
Specification: Standard RIAA, Frequency Response: 20Hz to 2KHz + 1.5dB. Input Sensitivity: 5mv input for 500mv output. Maximum Ouput: 700mv rms. Input Overload: 100mv rms. S/N Ratio: Greater than 60dB.

16 CHANNEL MULTI-MODE LED CHASER KIT $32.95
MODEL EK80LCM16
We're proud to add this to our line. It's similar to our 15 channel LED chaser but with many extra features. There are over 60 selectable modes. A few: Up, Down, Skip, Pulse, Scramble, Single Pulse, Multi Pulse and many more. An optional 120 vac board is avaliable. (Extra)

STROBE LITE KIT $21.95
MODEL EK80SL001
Fantastic for special effects. Variable speed Xenon flash gives you a "STILL MOTION" effect. A real attention getter.

CRYSTAL RADIO KIT $8.95
MODEL EK80CR001
A self powered radio which uses a resonant circuit and detector for AM radio reception. An ideal project for the beginners.

1.5 to 24v POWER SUPPLY KIT $24.95
MODEL EK80PS024
A variable Power Supply suitable for many digital and linear applications. Delivers an output current of 100ma. from 1.5v to 15v and 500ma. from 16v to 24v.

0.28 VOLT POWER SUPPLY KIT $39.95
MODEL EK80PS028
A true 0 to 28 volts capable of delivering 1 amp continuous. Full wave rectification, filtering and capacitance multiplication provides a clean dc source for sensitive audio and digital work. An ideal supply for the experimenter.

STEREO AUDIO MIXER KIT $49.95
MODEL EK80AM001
Inputs 2 phono, 1 aux. Master control. Expandable. Frequency response 20Hz–20kHz; 5v output, 0.01% distortion.

16 CHANNEL LED CHASER KIT $22.95
MODEL EK80LC016
A very familiar sight seen at discos, department stores, and on neon signs. 16 LED's flash in sequence up-down or alternate. Adaptable to 120 vac. (Extra)

POWER SUPPORT 120 ... $24.95
MODEL EK80PLC120
A 120 volt power board which allows you to connect regular lamps to our LED Chaser Kits. 8 channels are supplied per board with 150 watts per channel. They can be easily interfaced for 16 channels.

5 WATT IC AUDIO AMPLIFIER KIT $19.95
MODEL EK80A00S
A general purpose 5 watt amplifier with Thermal Overload and Short Circuit Protection. Because of its low operating voltage and high

PC BOARD SPECIALS

Epoxy Base PC

- 6"x6½" .... 25¢ ea.
- 13"x4" .... 35¢ ea.
- 13"x6" .... 50¢ ea.

ETCHANT

- 16 oz .... $ 2.25
- 32 oz .... $ 4.25
- 140 oz $14.95

TTL (DIGITAL) IC's

7400	.43	7423	.55	7472	.55	74123	1.10
7401	.45	7425	.65	7473	.70	74125	.98
7402	.45	7426	.65	7474	.70	74141	1.15
7403	.40	7427	.55	7475	.98	74150	2.50
7405	.75	7430	.45	7476	.70	74151	.98
7406	.85	7440	.45	7485	1.40	74154	2.50
7407	.95	7441	1.35	7486	1.50	74160	1.75
7408	.75	7442	1.35	7490	1.15	74164	1.25
7409	.45	7446	1.45	7491	1.15	74177	1.45
7410	.39	7447	1.65	7492	.85	74190	1.65
7411	.55	7448	1.75	7493	.85	74191	1.60
7412	.55	7454	.65	74121	.65	74192	1.55
7413	.85	7460	.40	74122	.90	74193	2.95
7420	.45						

4000 SERIES CMOS IC's

4000	.50	4015	1.50	4026	2.35	4044	1.05
4001	.45	4016	.50	4027	.85	4045	1.78
4002	.45	4017	1.50	4028	1.50	4047	1.09
4006	1.25	4018	.75	4029	1.25	4049	.45
4007	.20	4019	1.65	4030	.40	4050	1.50
4008	1.15	4020	1.25	4033	1.95	4069	.45
4010	.75	4021	1.95	4040	1.29	4510	1.95
4011	.65	4024	1.25	4041	2.05	4511	1.95
4013	.65	4025	.40	4043	1.30	4516	1.35
4014	.90						

Micro-Processor IC

LS SERIES	PRICE						
74LS00	.85	74LS32	.80	74LS109	.80	8080	8.95
74LS04	.60	74LS33	.60	74LS125	1.00	8212	3.00
74LS08	.65	74LS38	.80	74LS132	1.40	8216	3.50
74LS10	1.50	74LS74	.70	74LS151	1.60	8224	8.95
74LS11	.75	74LS75	1.10	74LS155	1.10	8228	6.25
74LS20	.70	74LS86	.70	74LS247	1.18	8255	8.95
74LS30	.65	74LS90	.95	Z80	14.95	4116	7.95

1 Watt zener diodes

49¢ EA

TYPE #	VOLTAGE	WATTAGE			
BZX61-C75	3.3V	1W	IN758A	10	1W
IN4623	4.3	1W	IN759A	12V	1W
IN751A	5.1	1W	IN964B	13	.5
IN4733A	5.1	1W	3E216D5	14	1W
IN4734	5.6	1W	IN966	16	1W
14-515-04	6.2	1W	BZX61-C18	18	1W
114574	6.2	.5	HZ20C	20	1W
IN753A	6.2	1W	BZX61-C20	20	1W
IN754A	6.8	1W	GE502B	20	.1W
IN752A	5.6	1W	14-515-31	22	.5
17-515-35	6.8	1W	IN4751A	30	1W
HZ7B	7	1W	BZX61-C30	30	1W
IN755A	7.5	1W	BZX79C36	36	½W
IN4738A	7.5	1W	BZX61-C56	56	1W
IN757A	9.1	½W	1N5045	56	5W
IN4739A	9.1	.5	BZX61-C68	68	1W
BZX61-C9V1	9.1	1W	IN4764A	100	1W
IN757A	9.1	1W	1N5593B	183	1W

Transistor replacement list

PART No.	REPLACE	DLR. PRICE						
2N2906 -	ECG - 159	1.79	AD161 -	ECG - 155	4.95	2SC940 -	ECG - 283	11.95
BF-245 -	ECG - 133	1.99	2SC1025-	ECG - 175	2.95	2SC939 -	ECG - 163A	12.95
2N3391 -	ECG - 199	1.15	2SC1304-	ECG - 124	2.59	BF245A -	ECG - 133	2.25
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2SC1505-	ECG - 198	2.95	2SC1160-	ECG - 175	3.50	2N6558 -	ECG - 191	4.25
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2SC1507-	ECG - 198	2.95	2SC1106-	ECG - 162	9.95	2SB77 -	ECG - 102A	1.99
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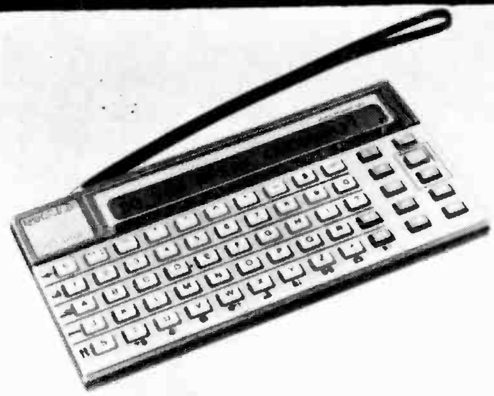

LCD Translator

The Sharp IQ-3100 is capable of translating three languages in its basic format and up to five. . . . English, German, French, Spanish and Japanese . . . By changing modules. Other language modules will be added in future. Each contains 152 sentences and approximately 1,800 to 2,000 words.

Travellers or businesspersons on-the-go can use the IQ-3100 to search (automatically) for the appropriate sentence from its 14 specially-chosen categories, such as transportation, restaurant and conversation. Sentences can be easily modified by substitution of words in the brackets shown on the 23-character liquid crystal dot matrix display.

Lightweight (180g) and long-lasting (700 hours on the internal batteries), the IQ-3100 is a useful addition to the overseas traveller's baggage.

The basic translator has a suggested retail price of $229.95 (language modules, $49.95 each) at Sharp calculator dealers and selected retailers across Canada.

Adjustable Regulator

Silicon General now offers the SG150A, a new 3 amp positive adjustable regulator designed as a pin-for-pin upgraded replacement for the National LM150.

The SG150A offers a 50% improvement in reference voltage accuracy over the LM150. Exceptionally easy to use, the SG150 series requires only two external resistors to set the output voltage between 1.2V and 33V. Full overload protection is included in the devices, including current limiting, thermal shutdown and safe operating area protection. Reference voltage, which is trimmed to ±1% at room temperature, is guaranteed to be within ±2% over all operating conditions. Line regulation is typically 0.005 5%/V with ripple rejection typically 86bB.

High-voltage applications can be accommodated by using the SG150 as a floating regulator, provided the maximum input-to-output differential is not exceeded. The series is available in standard TO-3 transistor packages. Silicon General is represented by Future Electronics Ltd, 5651 Ferrier St., Montreal, Quebec H4P 2K5.

A Printer By Any Other Name

Centronics Data Computer (Canada) Ltd. has been renamed Centronics Canada Inc.

Looking Back

Guitar Practice Amplifier November 1980

Major error in the Parts List here; Q1-4 should be 2N3904s while Q5 is a 2N3906. These numbers were reversed in the original article.

Digital Test Meter December 1980

Another Parts List error. The third SW1 listed (SW1 a-f), should be SW2 a-f.

Ultrasonic Burglar Alarm February 1981

As promised last month we have arranged a source of ultrasonic transducers in Canada.

Arkon Electronics will be stocking Matsushita 40kHz tranducers. These are EFR-RSB40K2 (receiver) and EFR-0SB40K2 (transmitter). Write to Arkon Electronics 409 Queen Street W., Toronto, Ontario M5V 2A5.

This transducer will also work with the Utrasonic switch described in June 1978.

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30 MHz delayed sweep – NEW

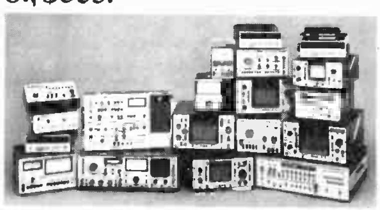
LBO-515B is a compact, precision oscilloscope at a moderate price. Using a PDA 4-inch CRT with parallax-free internal graticule, it features 5 mV sensitivity and delayed sweep for viewing and measuring complex waveforms. Also has 120 ns signal delay, trigger hold-off and x-y operation at full sensitivity.

30 MHz with signal delay – $1585.

LBO-520 combines a 11.7 ns rise time with 5 mV sensitivity and 120 ns signal delay lines. Has single shot triggering, X10 sweep magnifier and bright, sharp PDA CRT. Triggers to 50 MHz.

20 MHz dual and single trace – $1100., $865.

LBO-508A and LBO-507A give you versatility at low cost. Rise time is 17.5 ns with 1 MΩ (35 pFd) input impedance. Automatic or external triggering, X5 sweep magnifier, 10 mV/cm sensitivity and add/subtract modes.



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LBO-514 has both vertical and horizontal X5 magnifiers. Sensitivity is from 1 mV/cm to 10 V/cm. Sweep speeds from 0.2 s/cm to 0.1 μs/cm. Auto or normal triggering. Z-axis modulation. (Single trace version, LBO-513. $775.)

Circle No. 22 on Reader Service Card.

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THE UBIQUITOUS OSCILLOSCOPE

There's no substitute for 'looking inside' a circuit when you really want to know what's going on. The oscilloscope must surely be the most versatile electronic instrument ever invented. Les Bell and Roger Harrison take you on a guided tour, from how they work to how to buy.

ONE OF THE BIGGEST barriers people face when they take up electronics is cultivating the ability to visualise what is happening in a circuit. It is fairly easy to work out the DC conditions in a circuit, but the electronic circuits are generally dynamic in nature; that is, the voltages and currents in a circuit change according to an applied signal or function of the particular circuit (as in amplifiers and oscillators).

The problem is, you can't *see* what's happening! The "good books" may tell you what happens *ideally*, but the real world is often quite different.

What's needed is some kind of 'window' into the circuit, to enable you to 'see' what's happening, to get that intuitive 'feel' which will make understanding that much easier. That window is, of course, the oscilloscope. Without it, the circuit designer may very well be 'blinded'.

Oscilloscope Basics

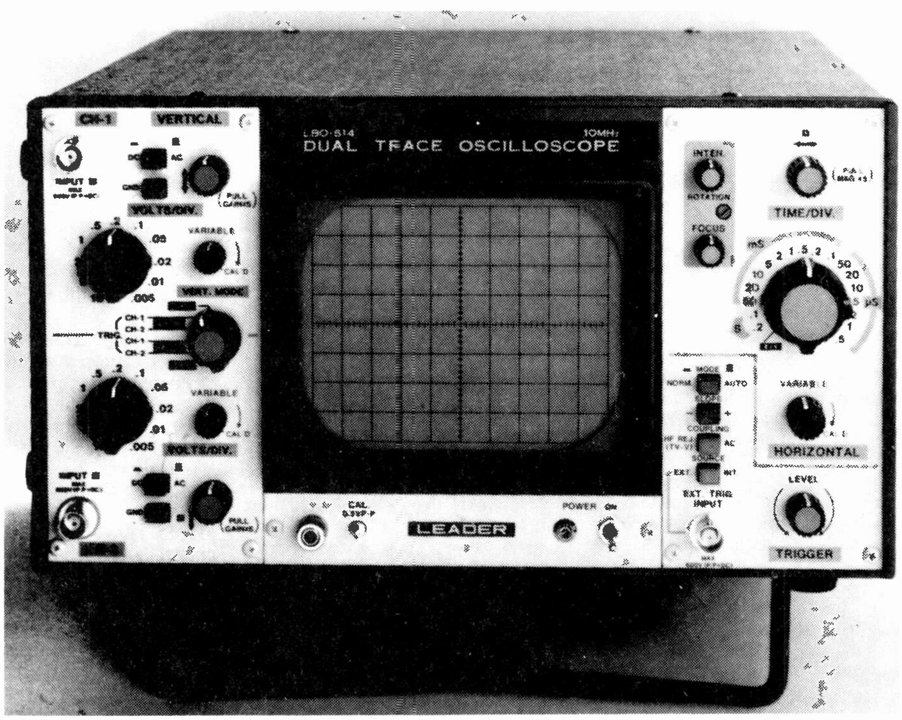
The heart of a Cathode Ray Oscilloscope, is the *cathode ray tube.* Its construction and basic operation are explained in the accompanying box. There are two basic types of cathode ray tube – those employing electrostatic deflection and those employing magnetic deflection.

Electrostatic deflection types are commonly employed in measuring instruments as they offer much greater bandwidth operation than magnetic deflection tubes which are principally limited by yoke inductance. On the other hand, electrostatic deflection tubes are limited to beam deflection angles less than 20° off axis while electromagnetic systems can achieve a maximum deflection of ±55°. This is why oscilloscope tubes (electrostatic types) are so much slimmer than TV tubes (which use magnetic deflection) of similar length.

Some demonstration and teaching oscillopes use standard TV tubes with magnetic deflection. While the display is massively larger than a standard oscilloscope, the bandwidth limitations only allow them to display signals generally less than 100kHz maximum. Oscilloscopes using electrostatic CR tubes may have bandwidths of 10MHz commonly, and up to 100MHz without using special techniques.

The general purpose of an oscilloscope is to examine voltages (or sometimes, currents) as they change with time. There are other modes of operation, but as this is the fundamental one, let's start with it.

In order to display a waveform that is varying with time, we must draw the 'spot' across the face of the tube, from left to right, return to the starting point and repeat. To do this, the voltage impressed on the X deflection plates is increased at a linear rate with time, to draw the spot from left to right, then



A modern general purpose oscilloscope from Leader.

reduced to zero (or the starting voltage) suddenly to return the spot to the starting point, and so on.

This establishes a 'time base' as the spot takes a known amount of time to travel from left to right across the screen.

At the same time, the waveform to be examined (suitably amplified) is applied to the Y deflection plates. The spot will then trace out a graph of the waveform on the CR tube screen as shown in Fig. 1.

If the time taken for the spot to travel across the screen has a definite relationship to the frequency of the waveform being examined, and if the start of the trace (at the left hand side) is arranged to commence at some definite point on the waveform (ie. synchronised), then a stable trace will result on the screen.

For example, say we wish to display two cycles of a 60Hz, line voltage. The horizontal deflection, or timebase, would have to 'sweep' the spot from left to right in the length of time it takes to complete two cycles at 60Hz – 33.3 milliseconds. The time base would make sweeps per second: that is, it would be running at 30Hz.

In a practical oscilloscope, during the 'return' sweep of the X. deflection (sometimes termed the 'flyback'), the electron beam of the CR tube is turned off, or 'blanked' so that it is not displayed – otherwise, the resultant squiggle would become confused with the desired display!

The signal applied to the X deflection plates of the CR tube is often referred to as the 'sweep' voltage, or just 'the sweep', although the term 'timebase' is generally more common.

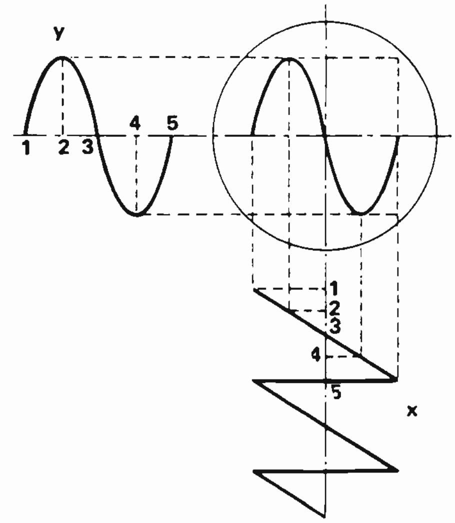
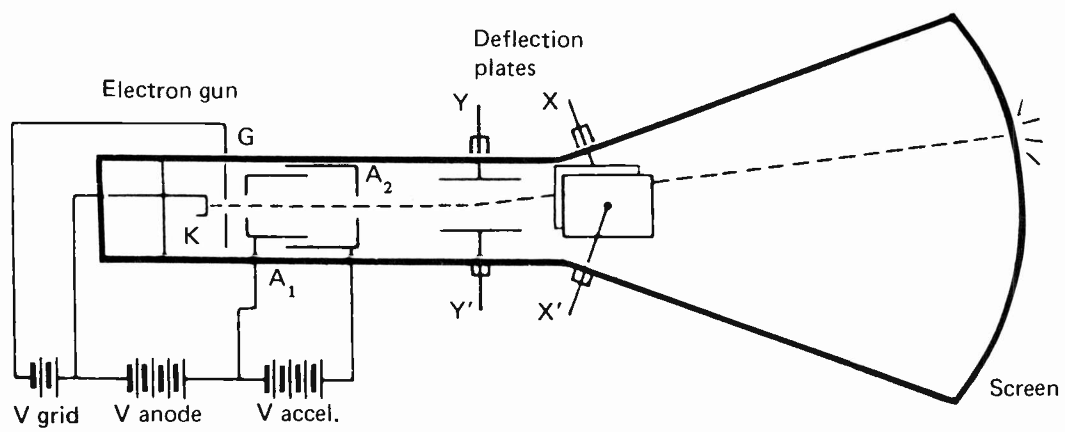


Fig. 1. Showing how the deflection waveforms applied to the X and Y plates of a cathode ray tube cause the electron beam spot to trace out a faithful replica of the Y-input waveform.



The cathode ray tube

The component at the heart of the oscilloscope is the cathode ray tube. It consists of an evacuated, tubular glass envelope, flared at one end. In the tubular portion, or the neck, is an "electron gun". This generates a narrow, focussed beam of fast-moving electrons which are directed towards the flared end, past a set of parallel plates (the deflection plates), the large end of the tube being covered in a special coating (on the *inside*) called the 'phosphor'. When the electrons strike the phosphor, it emits light ('fluoresces') and you see a spot. Spot deflection is achieved by varying the electrostatic field between the deflection plates. Some CRTs use electromagnetic coils around the neck of the tube for spot deflection (TV tubes for example!)

The electron gun contains a *heated cathode* (K) which 'boils' off electrons. These are attracted to an *anode* (AI) which is very much more positive than the cathode, at least several thousand volts. As they accelerate towards the anode, the electrons pass through a *control grid* (G) which is a cap of metal around the cathode and somewhat negative with respect to it. This electrode is used to control the brightness of the spot. If the negative potential on G (with respect to K) is increased, fewer electrons will pass and the spot brightness will decrease, and vice-versa.

Between the control grid and the focussing grid there may be a second grid, the *screen grid*, which is usually around 300 V positive. Following the *focussing anode* (AI) there is usually a *second anode* (A2). Voltage on the final anode is very high – usually several kV. Alternatively, between the control grid and the second anode, there may be an *Accelerator* electrode (sometimes called a "pre-accelerator") at the full final anode voltage. This arrangement constitutes a focussing scheme called an 'einzel lens'. Varying the potential between K and A1 will vary the spot size. This is used to focus the spot.

The electron beam passes between the plates, in order to be deflected, but after the first set of plates the beam can be anywhere in quite a large area. This means that the second set of plates must be larger, with an associated increase in capacitance. Usually, the vertical deflection plates come first, since the Y channels require greater bandwidth, while the X channel or timebase requires a lower bandwidth.

The result of all this acceleration and focussing is a well-focussed, high-energy beam of electrons travelling straight down the centre of the tube. In order to deflect the electron beam and create a display, a pair of electrostatic deflection plates are provided for each axis (X and Y). An electric field will deflect the electron beam, providing spot movement over the face of the tube.

Following the deflection electrodes, many electrostatic CRTs have a *post-deflection accelerator* which usually takes the form of a graphite spiral around the envelope funnel between the neck and the face of the tube.

The use of electrostatic deflection is necessary because it offers a wider bandwidth than electromagnetic deflection systems which are limited (principally) by yoke inductance. Electrostatic deflection requires much longer tubes for a given screen size as beam defocussing limits deflection angles to less than 20° off axis, while electromagnetic systems can deflect up to ±55°.

Oscilloscope manufactuters include a 'graticule' on the screen of their instruments as a convenient reference, enabling quite accurate time and amplitude measurements to be made. The graticule may be a transparent plastic cover placed over the CR tube face, scored with grid lines at convenient intervals (generally 10mm) or, as in the more expensive types, it may be scored directly on the face of the CR tube during manufacture. The latter provides a more accurate reference than having a separate external, graticule.

The general form of most general-purpose oscilloscopes is shown in Fig. 2. As you can see, there are four basic components: the Cathode Ray Tube, the Vertical Circuits, the Horizontal Timebase Circuits and the Power Supplies.

We have already spoken of the CR tube in some detail, so that's out of the way. The power supplies provide the various anode, grid, screen and accelerator voltages (plus heater) for the CRT and supply rail voltages for the vertical and horizontal circuits. Straightforward.

Now that's out of the way, let's get down to the interesting bits.

The Timebase and X Amp

So that waveforms of widely varying frequencies can be displayed the timebase must be variable over a very wide frequency range. Accordingly, oscilloscopes are made having the timebase 'range' switched at convenient increments. The actual ranges included on an instrument depend on the applications for which it is intended, but typically the minimum sweep rate may be 20 seconds for a full sweep (generally 2 s/division) ranging up to a maximum of one microsecond for a full sweep (0.1 us/division). The range steps generally go in intervals of 5, 2, 1. A vernier control is always provided so that a display may be varied for some convenient purpose.

The timebase generator provides a 'sawtooth' waveform (as that's what it resembles) for the X deflection. This is amplified and applied to the X plates of the CRT. The 'width' of the timebase deflection on the CRT face depends on the amplitude of the sweep waveform.

Thus, a *width* control may be provided by having a potentiometer to control the gain of the X amp. A DC voltage, or bias, applifed to the X plates will determine the horizontal *position* of the trace on the CRT face. Thus, a potentiometer to vary the DC bias on the X plates is provided as a *horizontal position* control.

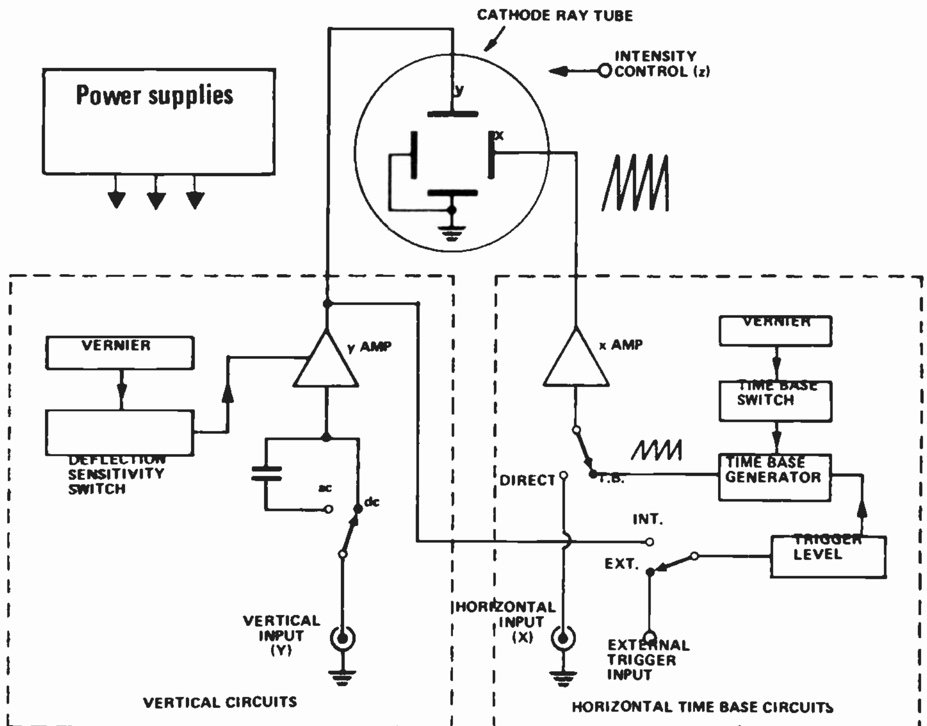


Fig. 2. Schematic diagram of essential sub–systems added to the CR tube to make it a measuring instrument.

So that the timebase generator may be synchronised to the waveform being examined (to provide a stable trace as explained previously), a 'trigger' circuit is included. The timebase may be triggered internally by sampling some of the signal going to the Y deflection plates or from an external signal. This is very convenient in particular applications which are explained later.

For some particular applications (phase measurement, frequency comparison) a sawtooth sweep is undesirable for X deflection, so direct access to the X amp is required. For this purpose the input to the X amp can be switched to a front panel socket, generally marked *horizontal input* or an abbrevation of same.

The Vertical or Y Amp

The signals one may wish to examine might range from microvolts to hundreds of volts! The lower level signals will require amplification (as the deflection voltages required may be tens to hundreds of volts), the higher level signals will require attenuation. Accordingly, a *sensitivity* switch is provided ahead of a high gain, low distortion amplifier — the Y amplifier.

The most sensitive range of common oscillopes is typically 5mV to 10mV per centimetre (one graticule division). More expensive types may have a maximum sensitivity as high as 10uV/cm. The insensitive end of the range will generally be around 50V/cm for run-of-the-mill 'scopes but special instruments (eg: those used for electrical supply applications) provide for levels as much as ten times higher. As with the timebase range control, sensitivity steps are generally in 5, 2, 1 intervals.

A *vernier* sensitivity control is provided for convenience.

The bandwidth of the Y amp is an important factor in the selection and application of an oscilloscope. A general purpose instrument may have a bandwidth extending from DC to 10MHz or 15MHz. Inexpensive units may only extend to 3MHz. Magnetic deflection units (generally for demonstration or teaching applications) may only reach 20-50kHz, few struggle as high as 100kHz.

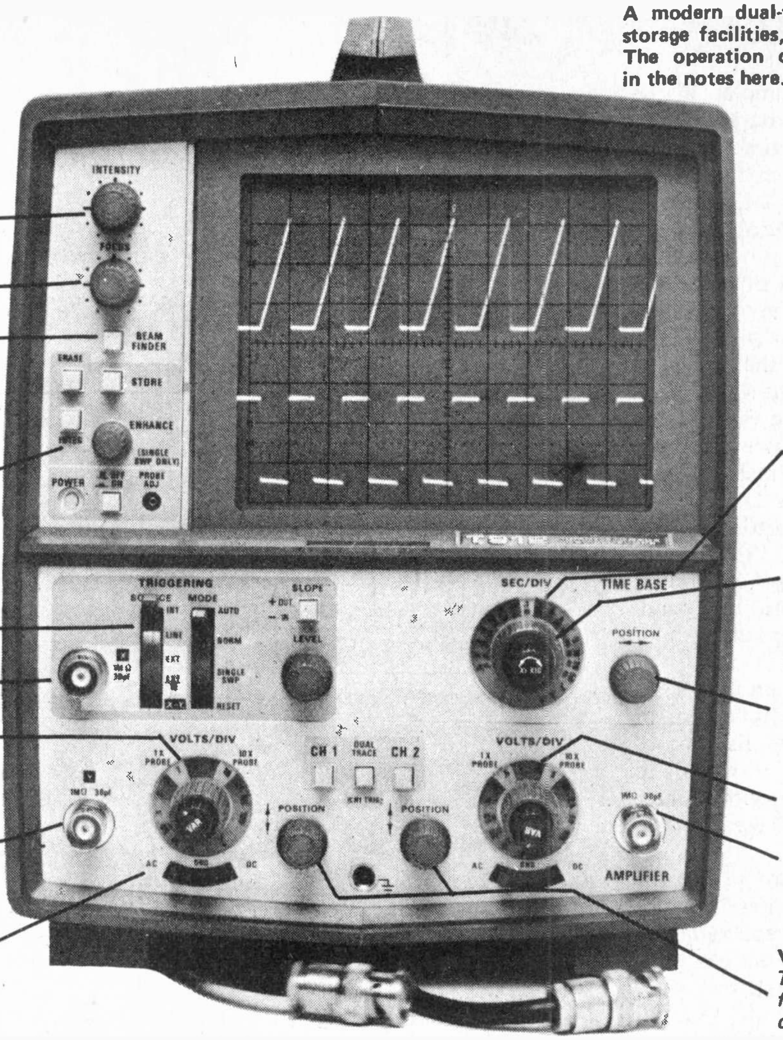
High quality instruments ($$$$!) may have bandwidths as great as 350MHz. Special instruments, using 'sampling' techniques, may reach 1GHz (1000MHz!).

To examine AC waveforms superimposed on a DC voltage, the Y amp must be AC-coupled. Accordingly, a switch is provided that inserts a capacitor in series with the input.

The range of the input sensitivity may be extended by the use of *probes* which can provide such facilities as very high voltage attenuation and increased input impedance.

The *vertical position* of the trace is

A modern dual-trace oscilloscope with trace storage facilities, the Tektronix model T912. The operation of the controls is explained in the notes here.



determined by a DC bias applied to the Y plates of the CRT, in the same manner as for the X plates.

The Z Input

If 'Y' represents the vertical axis and 'X' represents the horizontal (time) axis, then what on Earth is the 'Z' axis?

The only thing left to vary on a CRT display, after moving the spot vertically and horizontally, is the intensity of the spot. Accordingly, most CROs will include a Z *input*. In general this allows for display or for making particular types of measurements.

That completes the description of your 'basic' oscilloscope.

Dual-trace Operation

It is often helpful to be able to display two waveforms at the same time — for example, to measure the phase change on a signal passing through an amplifier stage. This can be achieved in two different ways.

One can simply build two completely separate guns and two sets of deflection plates into a single CRT envelope. These dual-beam CRTs are complex and expensive, and they require two completely separate sets of drive amplifiers — more expense.

The alternative, used in most modern dual-beam scopes, is 'dual-trace' operation, in which a single-beam tube is used to display two traces by switching between them. Two methods of beam-switching are used; one can either switch between traces at the end of each sweep, which is suitable for high-frequency waveforms, or at lower frequencies one can switch alternately between the waveforms as the sweep progresses across the display.

The first method is called *alternate trace*, the second is *chopped trace operation*.

These basic principles apply to all oscilloscopes, except some types which are intended for specialised applications. Of course, oscilloscopes are more complex than this in practice, and perhaps the best way to see some of the more sophisticated facilities is through the controls on the front panel of an oscilloscope of medium complexity.

Choosing (Not Using) a 'Scope

There comes a time in every man's life when he can't figure out what on earth that circuit's doing, and then he decides to buy an oscilloscope. Of course everyone has different requirements — digital circuitry, RF, high fidelity, process control, computer equipment — these applications all have widely varying characteristics — so what should one look for when evaluating the performance of a 'scope.

The most obvious consideration is bandwidth. The bandwidth of a general purpose oscilloscope is the frequency at which the total gain of the oscilloscope in 3dB down on its mid-band performance. There are several limitations on the bandwidth of an oscilloscope, ranging from the bandwidth of the amplifier stages themselves to the time which the electron beam takes to pass between the deflection plates and the amount of energy required to make the phosphor glow. For example, if the input waveform goes through a complete cycle during the time that an electron is passing between the plates, then the deflections will average out, giving a net deflection of zero!

In the DC mode, there is no problem with low frequencies right down to the DC, particularly when using long-persistence phosphors. The bandwidth figure given in specifications is therefore the upper frequency limit of the scope.

Closely related to bandwidth is the risetime of the scope. This is the time taken for an input square (really square) wave edge to go from 10% to 90% of its value on the screen. Unfortunately, on high performance CROs, this is well-nigh impossible to measure, and it is usually calculated from the bandwidth instead, using the formula:

$$tr=0.35/BW.$$

The vertical amplifier system of a 'scope should ideally have a risetime five or more times faster than the risetime of the fastest signal it is intended to examine. In this case, risetimes measured on the 'scope will have less than 2% error.

It is generally important to get the highest bandwidth and fastest risetime your money will allow. When examining a square wave signal, for example, Fourier analysis tells us that the square wave is actually composed of a series of harmonics of the fundamental frequency.

If the vertical amplifier and tube of a 'scope lop off the fifth and higher harmonics, the square wave will be noticeably rounded. In this case, risetime measurements will be virtually meaningless.

Glitches in digital circuitry will virtually disappear on a narrow bandwidth CRO, rendering it well nigh useless for digital troubleshooting. Thus, although you may be working with quite slow logic, a high speed 'scope is still very useful. For normal purposes with no specific requirements or interests, a 15MHz oscilloscope would probably be ideal.

Probes

A point to watch for, particularly with high frequency 'scopes, is the selection of suitable probes. The capacitance of the probe leads can severely limit the bandwidth of an instrument so it is essential to use the appropriate probes.

Most oscilloscopes have an input resistance of 1M ohm, and x1 probes will give this resistance at the probe tip

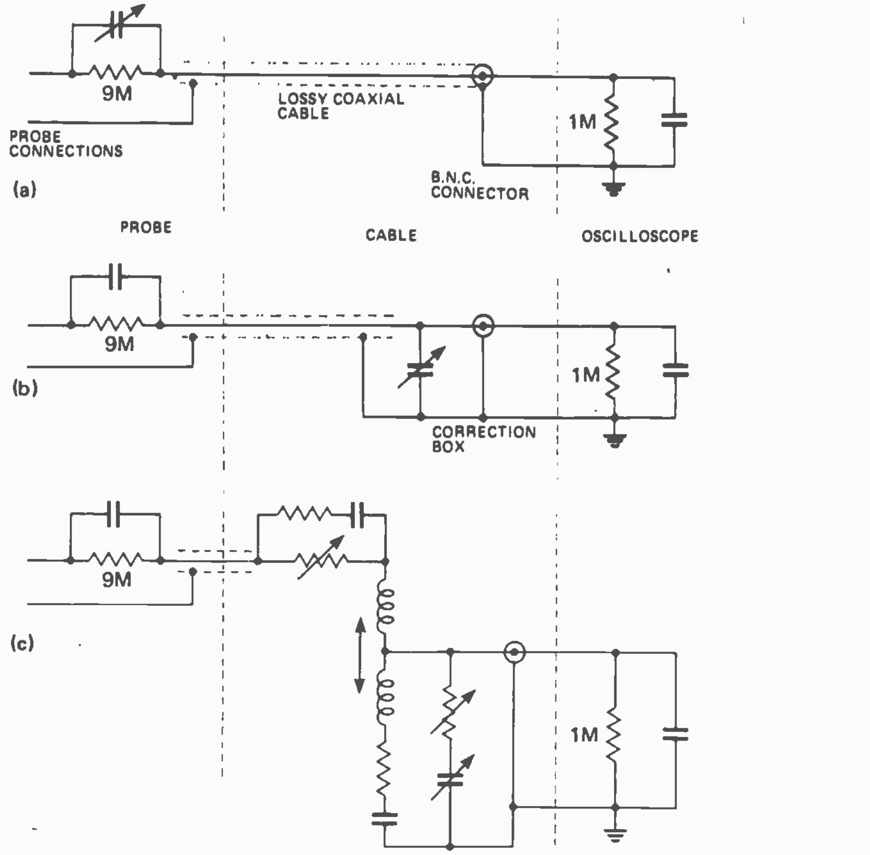
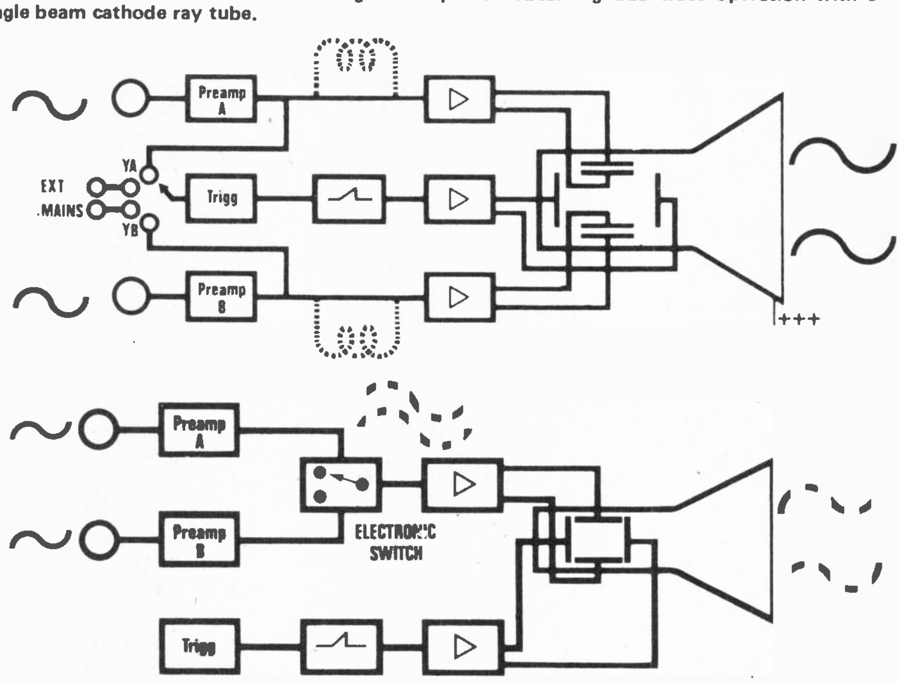


Fig. 4. Schematic of attenuator probes (a) simplest concept (b) capacitive loading to extend bandwidth (c) inductive.

Dual trace oscilloscopes can be implemented in two ways: using a *dual beam* cathode ray tube or using a single beam tube and *electronic switching* of the trace. The block diagram at the top is of a Philips model 3232 and is typical of dual-beam types. The block diagram at the bottom shows the electronic switching technique of obtaining dual-trace operation with a single beam cathode ray tube.



plus a capacitance which is in parallel with the 'scope input capacitance (usually around 20-30pF).

For higher input resistance, x10 probes are available which include a 9M ohm resistor, thus raising the input resistance to 10M ohm.

Probes require compensation for capacitive effects which limit their bandwidth. For very wide bandwidth operation, complex compensation network may be used. Typical probe circuits are illustrated in Fig. 4.

Sensitivity and Accuracy

The sensitivity of an oscilloscope is usually expressed in mV/cm or mV/div, and in general, a higher sensitivity 'scope is more useful than an insensitive one.

Accuracy, in the absolute sense, is probably less important than with other pieces of test equipment, as an oscilloscope is generally used for qualitative analysis. Most oscilloscopes have an accuracy of ±5%, but as one moves into laboratory, as opposed to service/general purpose machines, ±3% accuracy is more common. It is tempting to suppose that by buying a more accurate oscilloscope, one could save money on other test equipment but, this is not the case. Modern digital test equipment is now quite cheap, while accurate oscilloscopes are not, even leaving aside the inconvenience of making measurements by counting divisions on the graticule.

Other Facilities

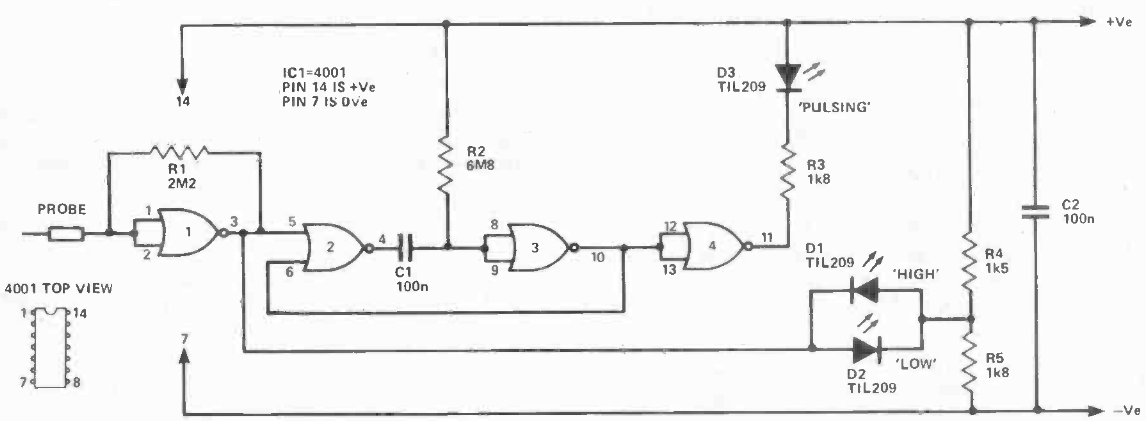
In deciding on an oscilloscope, several other factors ought to be taken into consideration. The obivious question is: will I need a dual-trace 'scope? There is very little to be said about this choice; you pays your money (as much as you can afford) and you takes your choice. Single-trace 'scopes are becoming quite rare beasties, in fact, as dual-trace types are considerably more versatile.

The triggering facilities of a prospective purchase should also be carefully examined. It's probably true to say that poor triggering on a 'scope can render it the greatest bugbear of the user's life – virtually useless, in fact.

Unfortunately, there is no universal way to specify the triggering performance of an oscilloscope. It is best to arrange a demonstration, either by the dealer or by an associate or friend who already has the oscilloscope in question. In any case, it is generally wise to ask around for other user's impressions when considering such a major purchase.

A useful facility on some oscillopes is the provision of two timebases with delayed sweep facility. In this mode of operation, for the first timebase, the delaying sweep is triggered by the trigger circuitry and continues for selected delay time. When this time is reached, the second timebase takes over (usually at higher speed), providing accurate resolution of an event which can occur some time after the trigger event. ●

Designer Circuits



CMOS LOGIC PROBE

A logic probe is a device which is used when testing digital circuits, and it shows the logic state at the selected test point. In common with most designs this one can indicate four input states, as follows:

1. Input high (logic 1).
2. Input low (logic 0).
3. Input pulsing.
4. Input floating.

The circuit uses the four 2 input NOR gates contained within the 4001 CMOS device, and is primarily intended for testing CMOS circuits. The probe derives its power from the supply of the circuit being tested. The first gate has its inputs tied together so that it operates as an inverter, and it is biased by R1 so that roughly half the supply potential appears at its output. A similar voltage appears at the junction of R4 and R4, and so no significant voltage will be developed across D1 and D2 which are connected between this junction and gate 1 output. Thus under quiescent conditions, or if the probe is connected to a floating test point, neither D1 or D2 will light up. If the input is taken to a high logic point, gate 1 output will go low and switched on D1, giving a "high" indication. If the output is taken to a low test point, gate 1 output will go high and D2 will be switched on to indicate the "low" input state.

A pulsed input will contain both logic states, causing both D1 and D2 to switch on alternately. However, if the mark space ratio of the input signal is very high this may result in one indicator lighting up very brightly while the other does not visibly glow at all. In order to give a more reliable indication of a pulsed input gates 2 to 4 are connected as buffered output monostable multivibrator. The purpose of this circuit is to produce an output pulse of predetermined length (about half a second in this case) whenever it receives a positive going input pulse. The length of the input pulse has no significant effect on the output pulse. D3 is connected at the output of the monostable, and is switched on for about half a second whenever the monostable is triggered, regardless of how brief the triggering input pulse happens to be. Therefore a pulsing input will be clearly indicated by D3 switching on.

The various outputs will be:
Floating input—all L.E.D.s off.
Logic 0 input—D2 switched on (D3 will briefly flash on).
Logic 1 input—D1 switched on.
Pulsing input—D3 switched on, or pulsing in the case of a low frequency input signal (one or both of the other indicators will switch on, showing if one input state predominates).

VFET APPLICATIONS

Is the VMOS power FET a really important device, or a mere flash-in-the-pan? In the next few pages Ray Marston appraises the device.

IMAGINE A POWER transistor that has virtually infinite input impedance, 'beta', and power gain which has a bandwidth extending from DC to 600 MHz and which can switch 1 A on or off in a mere four nanoseconds. Imagine also that this device is immune to secondary breakdown and has a negative temperature coefficient that minimises thermal runaway problems and enables devices to be directly parallelled for increased power handling capability.

The above 'miracle' device already exists, and is readly available at fairly low cost. It is known as a VMOS Power FET. VMOS Power FETs were first introduced by Siliconix in 1976. At that time they were hailed as "the most revolutionary semiconductor in decades — likely to eliminate bipolars within five years". Now, four years on, VMOS still hasn't made a great impact on the industrial or consumer market.

What Is It?

The term 'VMOS power FET' stands for 'Vertical structured Metal-Oxide Silicon power Field-Effect Transistor'. Conventional MOSFETs use the form of construction shown in Figure 1, in which current flows *Horizontally* from source to drain through the channel, which is induced on the top surface of the silicon substrate. This form of structure results in low current densities, poor heat dissipation capabilities, very limited power handling capacity and relatively large chip capacitance.

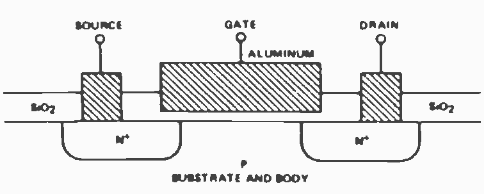


Fig. 1. Cross Section of a conventional FET.

VMOS power FETs, on the other hand, use the form of structure shown in Figure 2, in which current flows *vertically* from source to drain. This structure results in high current densities, low saturation resistance, excellent heat dissipation and power handling capabilities, low chip capacitance and excellent wide band performance.

VMOS power FET technology has been pioneered by Siliconix, who currently produce a variety of such devices

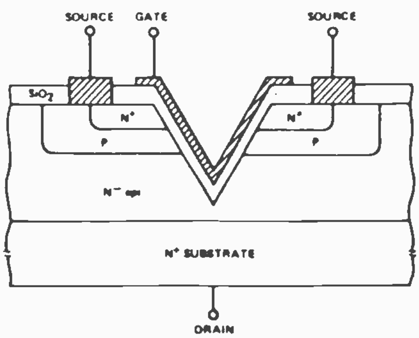


Fig. 2. Cross Section of a VMOS power FET.

with maximum continuous drain current ratings ranging from a modest 500 mA up to a hefty 12A5, and with maximum drain-to-source voltage ratings ranging from 35 to 90V. All the products in their present VMOS range are n-channel enhancement-mode devices, in which the source-to-drain path is normally closed but can be opened by applying a positive gate voltage. The gate has a near-infinite input impedance.

A major defect of the existing VMOS technology is that it is not readily compatible with the production of p-channel devices. This factor greatly reduces the devices' attractions in audio power amplifier applications, where class-AB output stages are currently in vogue.

A more detailed account of VMOS construction and operation theory is given in the Nov-Dec '77 edition of ETI.

Characteristics

Figure 3 shows typical output and saturation characteristics of the type VN67AF VMOS power FET. Note the following points:

1 The device passes negligible drain current until the gate voltage reaches a threshold value of approximately 1 volt The drain current then increases non-linearly as the gate is varied up to approximately 4 volts, at which point the drain current has a value of about 400 mA. The device, in fact, has square law transfer characteritics below 400mA.

2 The device has a highly linear transfer characteristic above 400mA (4V on the gate) and thus offers great potential as a low-distortion class-A power amplifier.

3 The drain current is controlled almost entirely by the gate voltage and is almost independent of the drain voltage so long as the device is not saturated. A point not shown in the diagram is that, for a given value of gate voltage, the

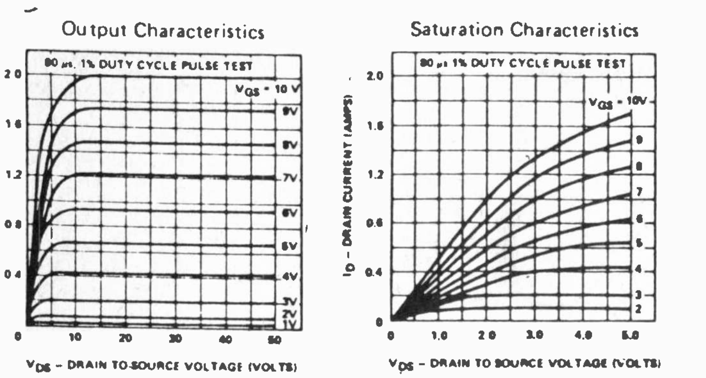


Fig. 3. Output and saturation characteristics of the VN67AF VMOS power FET.

drain current has a negative temperature coefficient of about 0.7% per °C so that the drain current decreases as temperature rises. This characteristic gives a fair degree of protection against thermal runaway.

4 When the device is saturated (switched fully on) the drain-to-source path acts as an almost pure resistance with a value controlled by the gate voltage. The resistance value is typically 2R0 when 10 volts are on the gate, and 10R when 2 volts are on the gate. The off resistance of the device is in the order of megohms. These characteristics make the device highly suitable for use as a low-distortion high-speed analogue power switch.

Figure 4 shows the circuit symbol and the case outline of the VN67AF, which incorporates a 15V input-protection

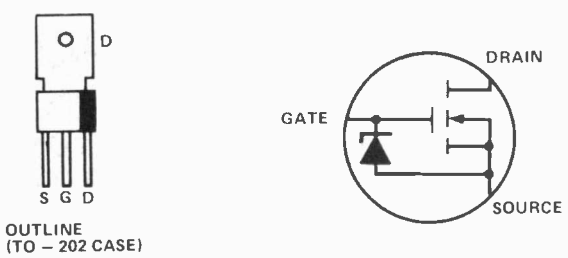


Fig. 4. Symbol and outline of the VN67AF.

Zener and Fig. 5 summarises the static and dynamic characteristics of the device. Points to note here are that the input (gate-to-source) signal must not be allowed to exceed the 15V Zenerating of the device and that the device has a typical dynamic input capacitance of only 50p: this capacitance dictates the dynamic input impedance of the device. The static input impedace is of the order of a million megohms.

Digital Circuits

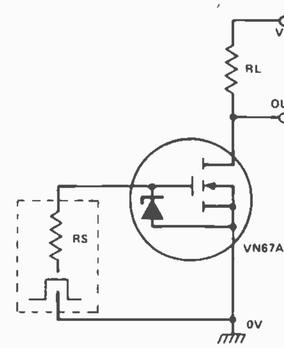
VMOS is delightfully easy to use in digital switching and amplifier applications. Figure 6 shows the basic connections. The load is wired between the drain and the positive supply rail and the digital input signal is fed directly to the gate. Switch-off occurs when the input goes below the gate threshold value (typically 1V2). The drain on current is determined by the peak amplitutde of the gate signal, as shown in Figure 3, unless saturation occurs. In most digital applications the on current should be chosen to ensure saturation.

STATIC	Maximum Drain-Source Voltage	60V
	Maximum Drain-Gate Voltage	60V
	Maximum Continuous Drain Current	2.0 A
	Maximum Pulsed Drain Current	3.0 A
	Maximum Continuous Forward Gate Current	2 mA
	Maximum Pulsed Forward Gate Current	100 mA
	Maximum Continuous Reverse Gate Current	100 mA
	Maximum Forward Gate-Source (Zener) Voltage	15V
	Maximum Reverse Gate-Source Voltage	–0.3V
	Maximum Dissipation at 25°C Case Temperature	15W
	Temperature Operating and Storage Range	–40 to +150°C
	Gate Threshold Voltage	0.8V min, 1.2V typical
	Zero Gate Voltage Drain Current	10uA Max at 25°C
	ON-state Drain Current at V_{GS}=10V	1.0A min, 2.0A typical
DYNAMIC	Forward Transconductance	250 millimhos typical
	Input Capacitance	50pF typical
	Reverse Transfer Capacitance	10pF typical
	Common-Source Output Capacitance	50pF typical
	Typical switching times, 25 volt supply 23R load, 0–10V gate drive from a 50R source	Turn-ON Delay 2 nS
		Rise Time 2 nS
		Turn-OFF Delay 2 nS
		Fall Time 2 nS

Fig. 5. Summary of the static and dynamic characteristics of the VN67AF.

The static input impedance of VMOS is virtually infinite, so zero drive power is required to maintain the VN67AF in the on or off state. Drive power is, however, required to switch the device from one state to the other. This power is absorbed in charging or discharging the 50p input capacitance of the VN67AF.

Fig. 6. Basic VMOS digital switch or amplifier.



The rise and fall times of the output of the circuit are determined by the source impedance of the input signal, the input capacitance and forward transconductance of the VMOS device and the value of R_L. If R_L is large compared to R_S the VN67AF gives rise and fall times of roughly 0.11 nS per ohm of R_S resistance. Thus, a 100R source impedance gives an 11 nS rise or fall time.

If R_L is not large compared to R_S these times may be considerably changed. A point to note when driving the VN67Af is that it's input Zener forward and reverse ratings must never be exceeded. Also, because of the very high frequency response of VMOS, the device is prone to unwanted oscillations if circuitry is improerly designed. Gate leads should be kept short, or be protected with a ferrite bead or small resistor in series with the gate.

VMOS can be interfaced directly with the output of CMOS, as shown in Figure 7. Rise and fall times of about 60 nS can be expected, due to the limited output currents available from a single CMOS gate. Rise and fall times can be reduced by driving the VMOS from a number of CMOS gates in parallel, as shown in Figure 8, or by using a special high-current driver.

VMOS can be interfaced with TTL (either standard or LS type) by using a pull-up resistor on the TTL output, as shown in Figure 9. The 5 volt TTL output of this circuit is sufficient to drive 600 mA through a single VN67AF. Higher currents can be obtained either by wiring a level shifter between the TTL output and the VN67AF input, or by wiring a number of VN67AFs in parallel as shown in Figure 10.

Analogue Circuits

VMOS power FETs can be used with relative ease in either the common source or common drain (voltage follower) modes. The voltage gain in the common source mode is equal to the product of RL and the devices gm or forward transductance. In the case of the VN67AF, the device gives a voltage gain of 0.25 per ohm of R_L value, i.e., a gain of 4.0 with 16R load, or a gain of 25 with a 100R load. The voltage gain in the common drain mode is slightly less than unity.

Fig. 11 shows three alternative basic ways of biasing the VMOS power FET for common source operation. In most practical applications, the device will be biased into the linear mode, with the drain at a quiescent value of approximately $V_{supply}/2$, so that maximal signal swings can be accommodated between the cut-off and saturation clipping levels.

In Fig 11a the gate is biased at a supposedly fixed level by potential divider R1-R2. The input impedance of the circuit is (at low frequencies) equal to the parallel values of R1 and R2. Defects of this simple biasing arrangement are that the voltage biasing level varies with the supply voltage, and the drain current biasing level depends on the characteristics of the individual VN67AF that is used in the circuit. An advantage of the circuit is that the quiescent drain voltage can be biased below that of the gate.

The alternative circuits of Figs. 11b and 11c can be used in cases where the quiescent drain voltage is greater than that of the gate. In Fig 11b, potential divider R1-R2 is fed from the drain of the VN67AF, and DC negative feedback makes the quiescent drain current substantially independent of variations in supply voltage and device characteristics. AC negative feedback also occurs, and reduces the effective input impedance to a value approximating the parallel values of R1 and R2 divided by the voltage gain (gm x R_L) of the circuit.

Figure 11c is a simple modification of the Fig 11b circuit, and results in increased input impedance. R3 is wired between the gate of the VN67AF and the junction of R1-R2. R3 does not effect the biasing of the circuit, but if its value is large relative to that of R1 and R2 it raises the input relative to that of R1 and R2 it raises the input impedance to a value approximating that of R3. If the source impedance of the input signal is low relative to R3, the AC negative feedback effects of the circuit are virtually eliminated and the input impedance is further increased. If. in the Fig 11c circuit, the drain is likely to swing below the desired gate bias level under active conditions, a capacitor can be wired across R2 to preserve stable biasing conditions.

Fig.12 shows methods of biasing VMOS power FETs for common drain operation. In Fig. 12a the circuit is biased by a simple potential divider (R1-R2), and the source takes up a value a few volts below that of the gate. Because of the inherently high level of negative feedback of this configuration, the resulting bias (quiescent) source/drain current of the circuit is substantially independent of the characteristics of the individual VN67AF that is used. The input impedance of this circuit is equal to the parallel values of R1 and R2.

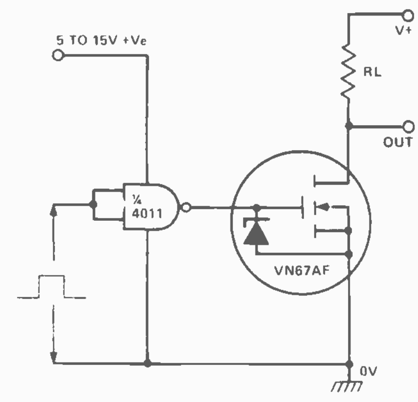


Fig. 7. Method of interfacing VMOS with CMOS!

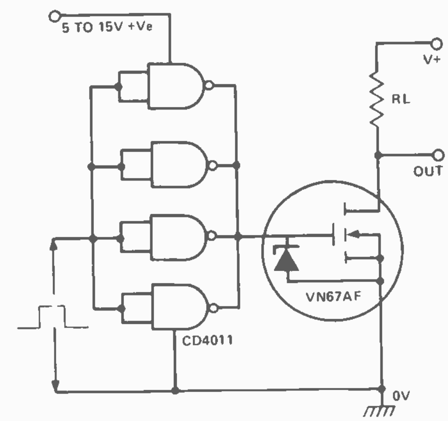
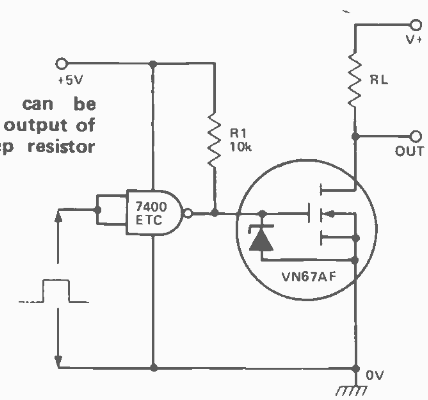


Fig. 8. VMOS switching times can be reduced by driving with a number of gates in parallel. Typical Rt = 25nS.

Fig. 9. VMOS can be driven from the output of TTL if a pullup resistor (R1) is used.



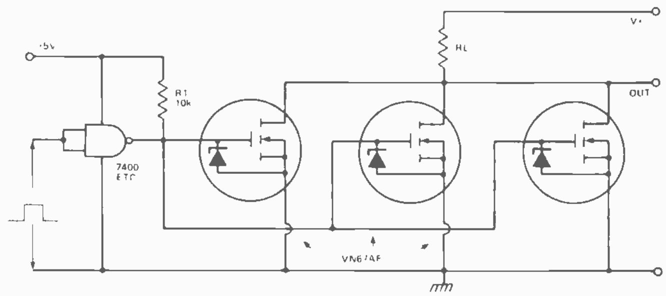
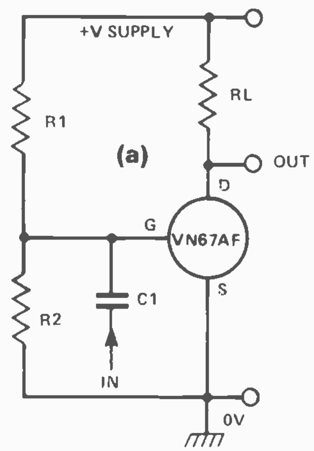
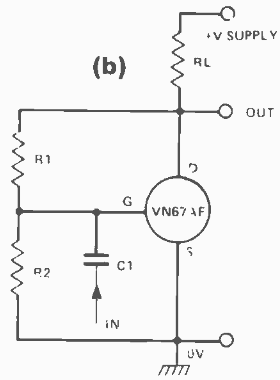


Fig. 10. Boosting the output of Fig. 9 by driving three VN67AF in parallel.





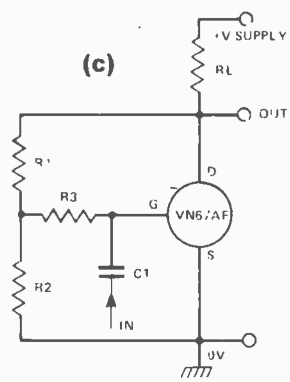
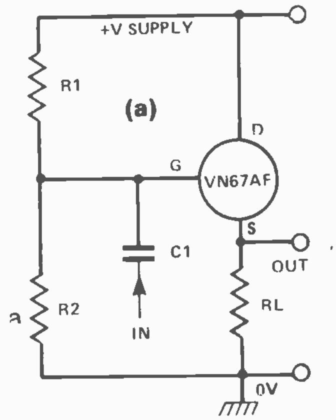
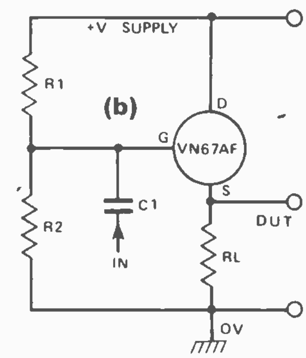


Fig. 11. Methods of bias for common source VMOS operation.





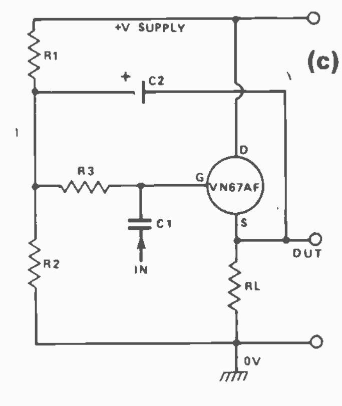


Fig. 12. Bias for common drain VMOS operation methods.

Figures 12b and 12c show how the input impedance of the basic Fig 12a circuit can be increased. In Fig 12b, R3 is given a value that is large relative to R1 and R2, thereby raising the input impedance to a value approximating that of R3 without effecting the biasing of the circuit. In Fig 12c the value of R3, and thus the input impedance, is effectively increased by a factor of 1/(1 — Av) via bootstrap capacitor C2. Thus, if R3 is 10M and Av is 0.95, the input impedance is raised to 20M. If R3 is 1MO and Av is 0.99, the input impedance is raised to 100M. C2 must have the impedance that is low relative to R1 and R2 over the required bandwidth of the amplifier.

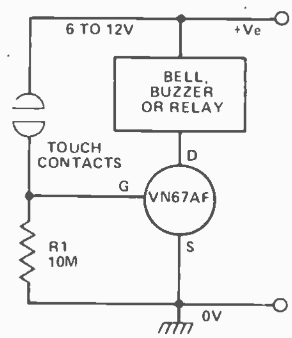


Fig. 13. Touch switch

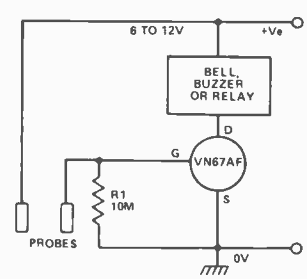


Fig. 14. Water Switch

Practical Circuits

The best way to get to know VMOS power FETs is to experiment with them in a few practical circuits. With this in mind, Figs. 13 to 22 show a few simple designs that you can play with. All of these circuits are based on the VN67AF, which typically costs less than $3.00 single quantities.

Figs, 13 and 14 couldn't be simpler. When the contacts/probes are open, zero volts are on the gate of the VN67AF and the device passes zero current. When a resistance (zero to tens of megohms) is placed across the contact/probes (by contrast with skin resistance, water, etc), a substantial gate voltage is developed by potential divider action and the VN67AF passes a high drain current.

In the Fig. 15 circuit, C1 charges rapidly via R1 when S1 is closed and discharges slowly via R2 when S1 is open Thus, the load activates as soon as S1 is closed, but does not deactivate until some tens of seconds after S1 is released.

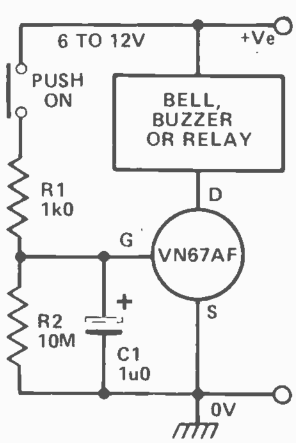


Fig. 15. Delay turn off switch

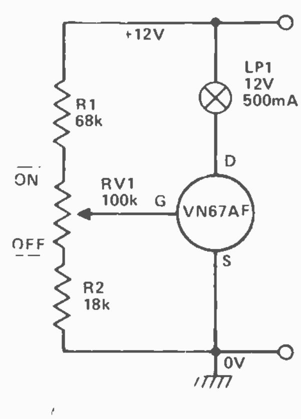


Fig. 16. DC lamp dimmer

Figs. 16 to 18 are lamp control circuits. In Fig. 16 the drain current and lamp brightness is controlled via RV1. In Fig. 17 the lamp turns on slowly when the switch is closed as C1 charges up via R3, and turns off slowly when the switch is opened as C1 discharges via R3.

The Fig. 18 circuit is a highly efficient 'digital' lamp dimmer. The two 4011 gates are connected as an astable multivibrator that has a mark/space ratio that is variable from 10:1 to 1:10 via RV1, and has it's output fed to the gate of the VN67AF, thereby enabling the 'mean' lamp brightness to be varied from virtually full-off to full-on.

Fig. 19 is an inexpensive but very impressive alarm-cell generator circuit that produces a police-like 'dee-dah' sound. The alarm can be turned on by closing PB1 or by feeding a 'high' voltage to the R1-R2 junction. The circuit is used with an 8RO speaker, and generates roughly 6 watts of output power.

The Fig. 20 class-A power amplifier gives an incredibly impressive performance, but is very inefficient. The VN67AF must be mounted on a decent heat sink. Since the amplifier is used in the class-A mode, it produces a 'tube' sound output. Because of the excellent linearity of the VN67AF, the apparent distortion of the amplifier is remarkably low. When used with 8RO resistive load, the amplifier has a bandwidth that extends up to 10 MHz.

The Appraisal

VMOS is undoubtedly a remarkable technology with many great advantages over conventional bipolar technology. Latest reports indicate that at least five major semiconductor companies other than Siliconix are now actively researching into or actually manufacturing VMOS power FETs, so that technology is clearly not just a 'flash in the pan'. Each of these companies is apparently developing it's own particular version of the technology and preliminary reports indicate that the Siliconix technology is still way ahead of the competition in most areas (switching speeds, device linearity, high voltage rating, etc.).

Siliconix are expected to announce a 400 volt 8 amp device, which can switch 8 amps in less than 100 nanoseconds, within the next few months. They already have a 65 volt 8 amp 100 watt device on the stocks that can give a 10 dB gain at 175 MHz.

The simple circuit of Fig. 21 makes an excellent radio control or CW transmitter output stage. The L1-C2 and L2-C3 values must be chosen to suit the required operating frequency.

Finally, Fig. 22 shows the basic circuit of a 20-watt class-D audio power amplifer using a pair of VN67AF's. We hope to publish a practical version of this circuit in ETI in the near future, so keep your eyes open.

The only criticism that we've been able to make against the Siliconix VMOS power FET technology concerns the present total lack of p-channel devices. Our spies tell us, however, that Siliconix are already working on that problem, and will have it beaten within a year. If that is so, we

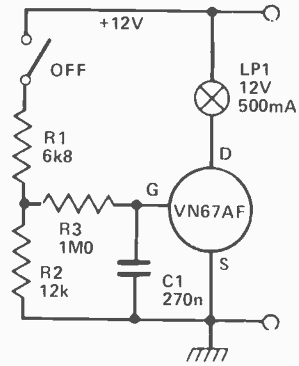


Fig. 17. Soft-start analogue lamp switch

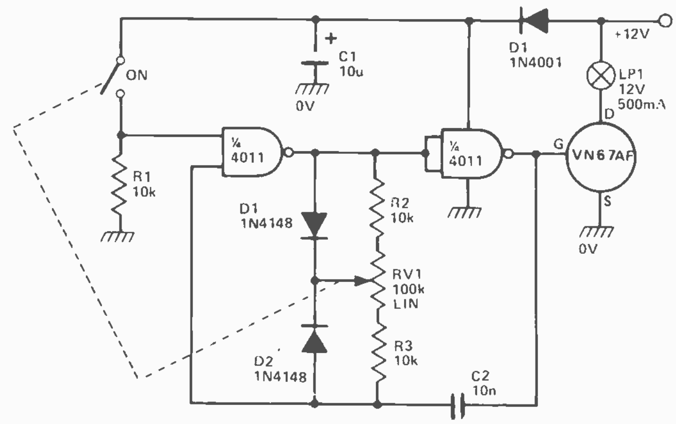


Fig. 18. Digital DC dimmer.

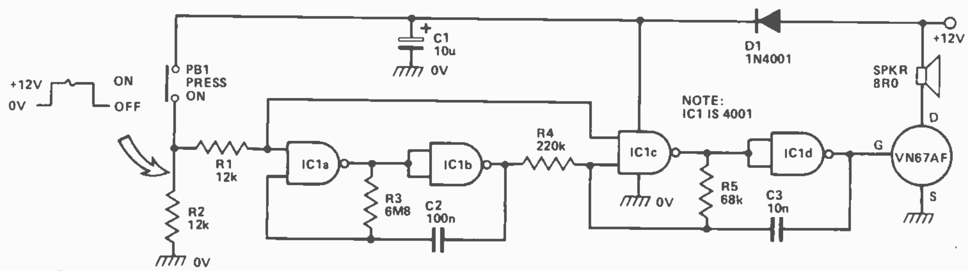


Fig. 19. Warble-tone alarm (2 tone output).

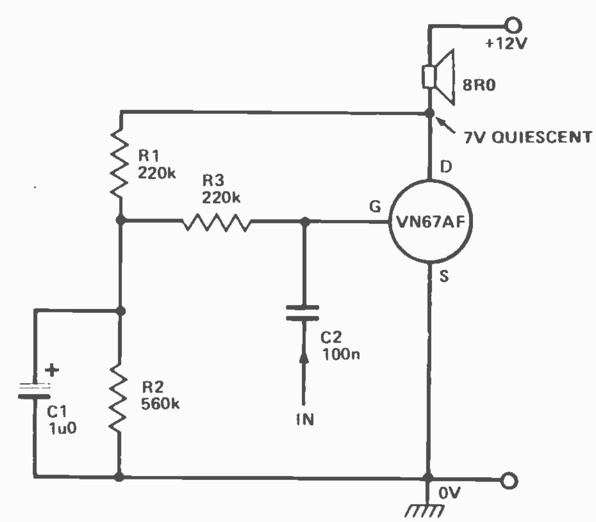


Fig. 20. Super simple class-A amplifier.

reckon that the 1976 prediction that "VMOS may eliminate bipolars within five years" could still come true. ●

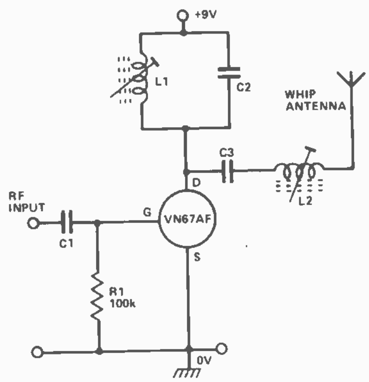


Fig. 21. 60mW R/C or CW transmitter L1-C2 is tank circuit, C3-L2 is the antenna circuit.

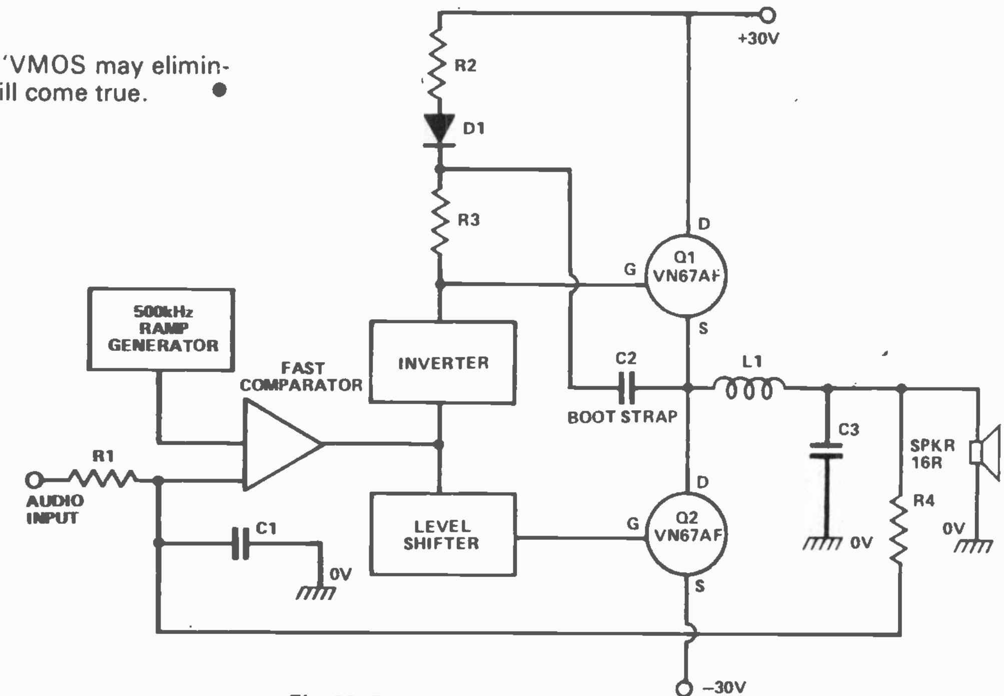


Fig. 22. Basic circuit of a 20W class-D switched-mode audio power amplifier. An ideal application for VMOS.

HUM FILTER

There are a few things more annoying in life than attempting to track down and remove all sources of hum from a hi-fi set up only to be partially sucessful, no matter how hard you try. This project should remove the last vestige of that 60Hz pest from your system. Go 'notch' that nasty!

SO YOU'VE just spent most of your spare money, unpacked everything from the boxes, connected it up and turned it on. What on earth is that awful noise?

Maybe this is a bit of an exaggeration, but it does illustrate the problems some of us have with line induced hum. Often it's necessary to position the various components of a hi-fi system close together and this can cause problems.

The magnetic field around the transformer in the power amplifier can couple to the preamp or tape deck. Also, the location of a nearby 120V power wiring can cause problems that can be very difficult to overcome. In theory, if the equipment and leads have been properly shielded and grounded this problem shouldn't exist. In practice it's a very different story.

This project aims at overcoming some of the problems of line induced hum by using a notch filter at the hum frequency of 60Hz. At this frequency any signal present will be attenuated. At frequencies either side of the notch the response should return to the unattenuated input level.

The 'Q', or Quality Factor, of a tuned circuit — which the RC network in this circuit forms, determines the bandwidth, or narrowness, of the amplitude response of the circuit (see the diagram). As this circuit forms a notch filter, the Q of the circuit determines the narrowness of the notch.

With a high-Q notch the frequency response of the circuit will dip suddenly around the notch frequency. Frequencies a little on either side of the notch centre frequency will be little affected. If the Q is low, frequencies some way either side of the notch frequency will be attenuated. The actual attenuation at the notch frequency is greater with a high-Q circuit than with a low-Q circuit.

High-Q circuits have the disadvantage that slight changes in component values, due to temperature changes etc, will affect the centre frequency. Tuning of the circuit to frequency is also quite critical. Lower-Q circuits do not suffer so much from this disadvantage.

The design Q chosen for this project was a compromise between the constraints of critical tuning and drift effect and good attenuation at the notch with little affect on nearby frequencies. Peak attenuation at the notch centre frequency of 60Hz is around 80dB while attenuation of only 3dB is obtained at 48Hz and 70Hz. There is some audible effect on the bass response of a system, but this is minimal.

Construction

Mount the resistors and capacitors on the board first. Be sure the orientation of the tantalum capacitors is correct. These are polarized and can only be installed one way round. Next, install the preset pot. If you elect to use the same mounting we did, the preset must lie flat on the board. This is best done by

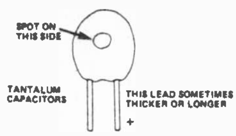
bending the pins 90° first and then soldering onto the printed circuit board. Finally, solder the transistor in place.

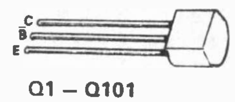
The input and output connections are best made by mounting the four RCA sockets directly above the input and output pads on the pc board. Strong wires can be soldered onto the RCA sockets and the entire board slid onto the four wires. This serves the purpose of holding the board in place as well as forming the input-output connections. A short insulated wire should be connected to the ground point provided on the pc board (see overlay diagram) and to the chassis. The RCA sockets are grounded by their mounting nuts, so be sure to use a metal case.

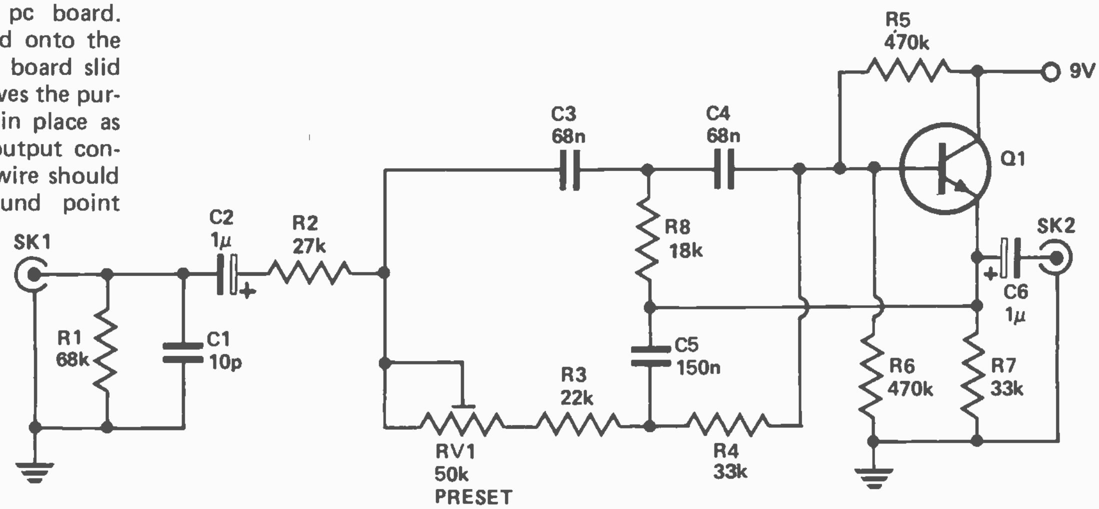
The circuit is run from a single # 216 nine-volt battery. The current consumption of the prototype was 200uA so the battery life should be good for several months. If it is found that battery life is not long enough a power switch could be fitted.

The filter can be used almost anywhere in the amplification chain since its overload margin is very high (typically 8V p-p). It should obviously be placed after the point where the hum is being picked up. If the hum is in the turntable it can even be placed between the turntable and the magnetic phono input of the amplifier since the input, impedance is 47k shunted by 10pF, which should suit most magnetic cartridges.

Once the filter is in place, the presets are adjusted so that the hum is brought to a minimum by adjusting each channel independently.





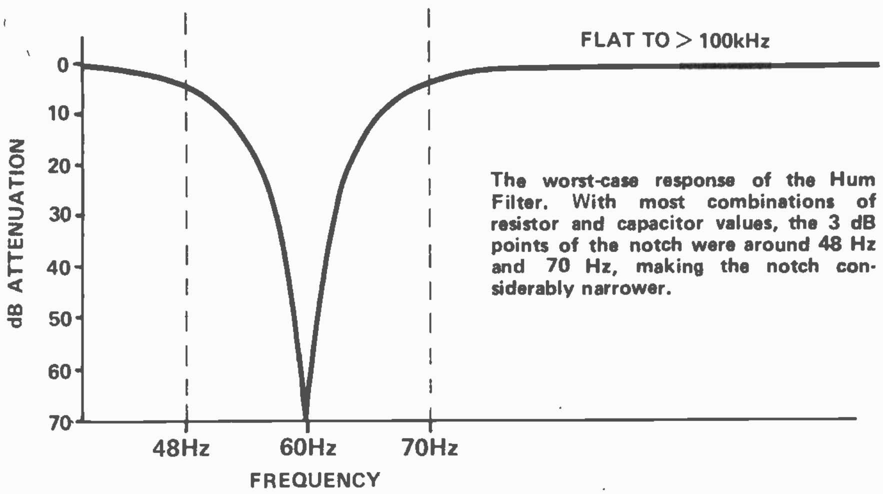


NOTE
ONLY ONE CHANNEL HAS BEEN SHOWN FOR CLARITY. THE COMPONENT NUMBERING OF THE OTHER CHANNEL BEGINS at 101 i.e. R101 R102 etc.

Installation

Before connecting the battery, check the pc board thoroughly. Check the orientations of the tantalum capacitors and the transistor. If all is right, plug in the battery and seal the base.

In the unit we built, holes were drilled in the chassis immediately above the preset pots. This allows the filter to be fine-tuned after it has been connected into the circuit. The presets themselves are connected to the base of the transistors via some resistance, so the transistor bias voltage is present on the preset. If the pot is to be adjusted through a hole in the chassis this voltage will probably be shorted out by the screwdriver touching the grounded chassis. Although this won't damage the circuit, it could damage the loudspeakers if the filter is being used in the magnetic phono line.



The worst-case response of the Hum Filter. With most combinations of resistor and capacitor values, the 3 dB points of the notch were around 48 Hz and 70 Hz, making the notch considerably narrower.

PARTS LIST

Resistors all ¼W, 5%

R1, R101	68k
R2, R102	27k
R3, R103	18k
R4, R104	33k
R5, R6, R105, R106	470k
R7, R107	33k
R8, R108	18k

Capacitors

C1, C101	10pf ceramic
C2, C102	1u tant
C3, C4, C103, C104	68n polyester
C5, C105	150n polyester
C6, C106	1u tant

Potentiometers

RV1, RV101 — 50k min preset

Semiconductors

Q1, Q101 — MPS6515

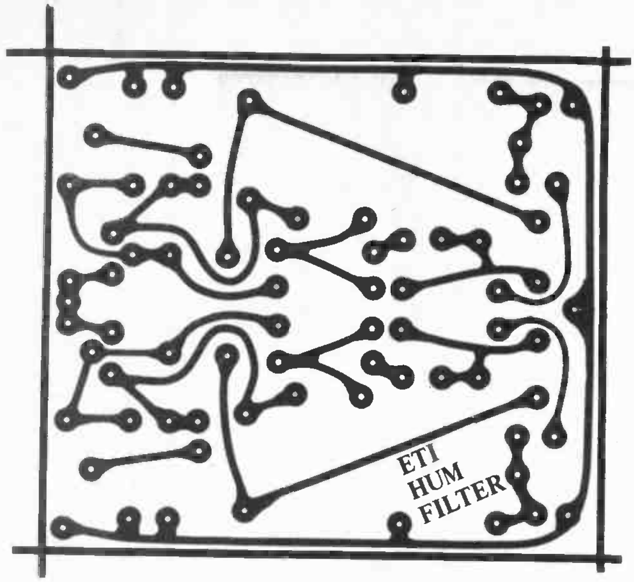
Miscellaneous

PCB box to suit, 4 panel mounting, RCA sockets.

Components for 120Hz operation

R4, R104	16k
R8, R108	9k1

Replace R3 with wire link.



HOW IT WORKS

The circuit consists of a "Twin-T" notch filter formed by capacitors C3, C4 and C5 and resistors R3, R4 R8 and preset PR1.

The operation of the Twin-T requires that

$$C_3 = C_4 = \frac{C_5}{2}$$

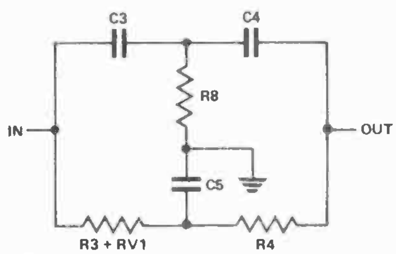
and $R_3 + PR1 = R_4 = 2R_8$

These conditions must be met with reasonable accuracy if a good, deep notch is to be obtained. The preset corrects to a certain extent for errors due to component mis-match and assumes that the notch can be adjusted to the exact frequency of the hum to be rejected.

The frequency of the notch is then given by

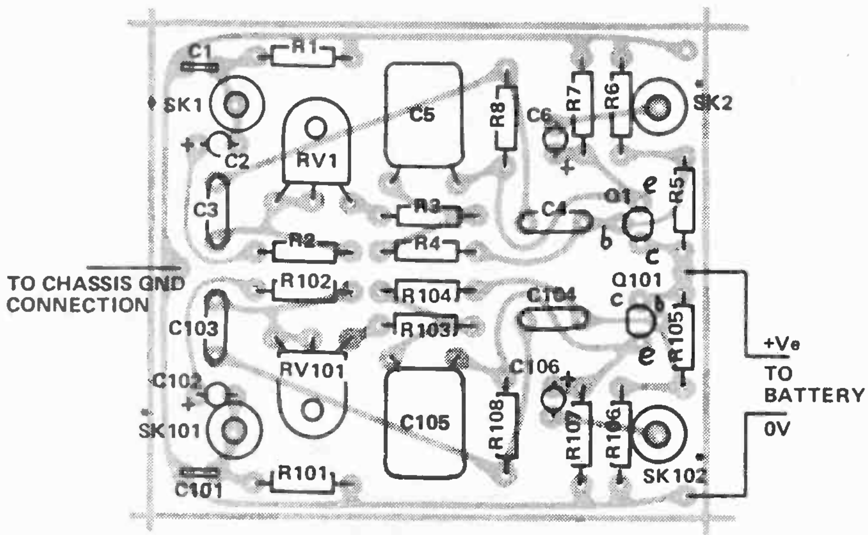
$$f = \frac{1}{2\pi R_4 C_4}$$

The transistor is operating as an emitter follower, giving zero voltage gain, but providing feedback into the notch to increase the Q to acceptable limits.



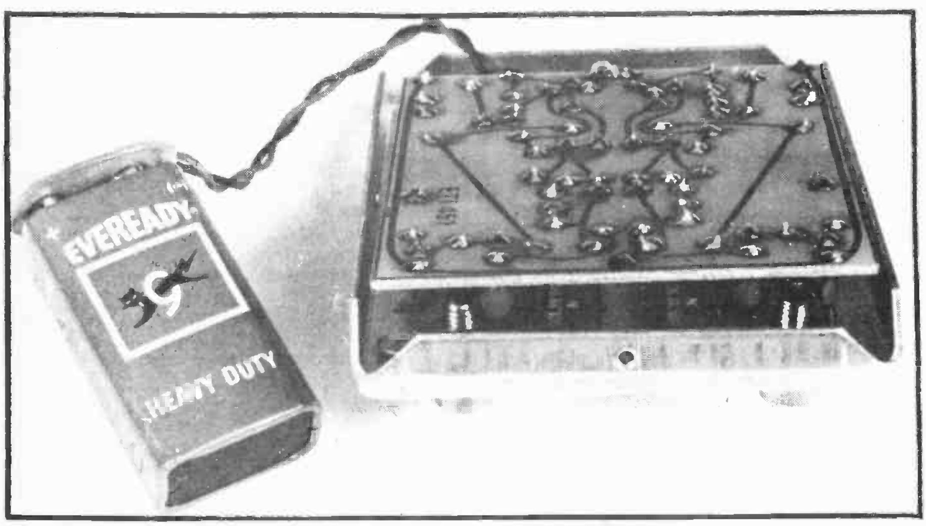
It certainly makes the adjustment meaningless, so either use a non-metal adjustment tool or use LED mounting grommets to insulate the holes.

If the hum problem you are experiencing is 120Hz instead of 60Hz the filter is easily adapted. Simply replace resistor R3 (18k) in each channel with a wire link. Remove R4 (33k) and replace with a 16k resistor. Remove R8 (18k) and replace with a 9k1 resistor. ●



*RCA SOCKETS POSITIONED HERE ON FRONT PANEL OF CHASSIS

PROBLEMS? NEED PCBs? Before you write to us, please refer to 'Component Notations' and 'PCB Suppliers' in the Table Of Contents. If you still have problems, please address your letters to 'ETI Query', care of this magazine. A stamped, self addressed envelope will ensure fastest reply. Sorry, we cannot answer queries by telephone.



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"By jove professor — you're right it is a recording!"

CATALOGUE SURVEY

By John Van Lierde

A PERSISTENT problem that hobbyists face is where does one buy parts. Those of us who are fortunate enough to live in large metropolitan areas like Montreal, Toronto, and Vancouver, this is no problem. On the other hand, if you live out in the sticks, you're going to have to resort to mail order.

Even if you're not into mail order, having a good selection of catalogues is very useful for reference purposes, as many contain technical data as well as IC and transistor pinouts.

R-A-E Industrial Electronics Ltd.

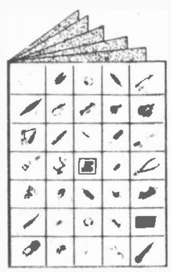
AT THE TIME OF THIS WRITING R-A-E's 1981-82 catalogue had not been printed and all we got was a copy of the cover. We understand, however, that the finished product will be 1200 pages thick. Like all industrial sources, they have a vast array of linear, digital and microprocessor IC's, passive components, tools cabinets and more. Telephone, mail and charge (Visa or Mastercharge) orders are welcomed.

The catalogue is $10 for individuals or free to industrial customers. R-A-E has two locations: 3455 Gardner Court, Burnaby, B.C. V5G 4J7, telephone (604) 291-8866; and 11680-170th street, Edmonton, Alberta T5S 1J7, telephone (403) 451-4001.

Distribution JMC distribution Inc.

JMC's effort consists of some 70 pages of products such as CB & audio accessories, test equipment, cables & connectors and so on. Representation on the component side is a bit thin, no resistors, capacitors or semiconductors, however, they do have a good selection of switches, cases and similar items. In all, a useful catalogue to have.

Incidentally the catalogue is bilingual , sort of. Some of the blurbs don't have French equivalents, but this probably won't be too much of a problem. $1.00 gets you the catalogue and a current price list. Write to Distribution JMC Distribution Inc., C.P. 142 88Ave., Laval Mont-Joli, P.Q. G5H 3K9



IUS Electronics Ltd.

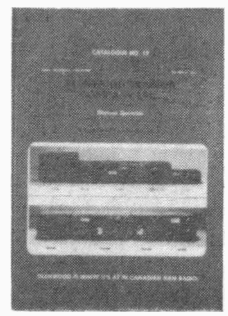
A small (10 pages) but neatly produced leaflet is how IUS features their line of speakers. Individual drivers and cross-overs are featured as well as several speaker kits (which are also available assembled).

The catalogue comes with a separate price list. Students get a 10% discount. We also noted that they listed a branch of the Toronto-Dominion Bank as a reference, something regular users of mail order would find very reassuring. Write to IUS Electronics Ltd. P.O. Box 81, Trail, B.C. V1R 4L3.

Glenwood Trading Company Ltd.

Glenwood's catalogue No. 19 consists of 48 pages of amateur radio and SWL gear. Brands include Kenwood, Ten-Tec, Hansen, Dentron, KLM, Delhi, Swan, etc. A broad range of shack and antenna accessories are offered.

Write to Glenwood Trading Company Ltd., 278 East 1st Street, North Vancouver, B.C. V7L 1B3. Telephone (604) 984-0405.



Exceltronix Components and Computing Inc.

"The catalogue that keeps on coming" is how we would describe Exceltronix's 1980-81 catalogue. Initially, the prospective customer gets approximately 30 pages of products in a "Duo-Tang" type cover. Once on the mailing list, he'll receive monthly (?) updates on new products, prices or any special deals, all pre-punched for insertion in the cover.

Products include 7400 (regular and 'LS'), TTL, 4000 CMOS, Linear (get yer LM10s here) and microprocessor ICs. Also passive components, Jana and Exceltronix Kits, A P Products and more. It's all yours for $2.00. Write to Exceltronix Components and Computing Ltd., 319 College St., Toronto, Onatrio M5T 1S2. Telephone (416) 921-5295.

Heathkit

This little number is easily the electronic wishbook for people who are into building but hate looking for parts. A wide variety of audio, computer, test-equipment, amateur, and educational kits are featured.

Heath has six stores in Montreal, Winnipeg, Edmonton, Ottawa and Vancouver. Their head office is in Mississauga. Write to Heath Co., 1478 Dundas St. E., Mississauga, Ontario L4X 2R7 or telephone (416) 277-3191.

Surplus Electro Quebec

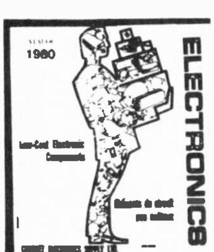
Not so much a catalogue but a flyer detailing various kits of switches, components, relays etc. Lots of neat things here, we would recommend this for anyone who has a parts box that's getting low.

You can get it by writing to Surplus Electro Quebec, 2264 Montee Gagnon, Blainville, P.Q. J7E 4H5.

Coronet Electronics Supply Ltd.

Coronets' 1981 catalogue isn't ready yet (we've heard that somewhere before) but judging from the 1980 edition it should be good. Coronet has a diverse range of components and a surprisingly complete selection of semi's including 4195 voltage regulators, 571 compounders and so on The usual order form is provided as well as an addressed envelope; nice touch!

Coronet Electronic Supply Ltd., 649A Notre Dame W., Montreal, P.Q. H3C 1H8. Telephone 288-6731.



J & J Electronics Ltd.

J & J catalogue hadn't hit the presses at the time of this writing, however, we understand that it follows the format of their earlier catalogue. The new book will be 64 pages thick. Aside from the usual range of semi's, resistors, capacitors etc., J & J also stocks Vero products.

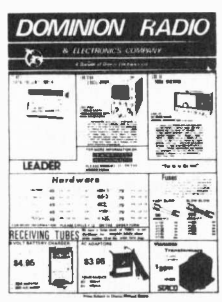
J & J also sends out a flyer every month or so to advertise surplus and new components.

To get in on all this write to J & J Electronics, P.O. Box 1437, Winnipeg, Manitoba R3C 2Z4.

Dominion Radio & Electronics Co.,

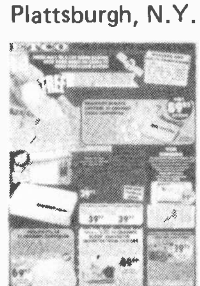
The latest Dominion catalogue was printed in the December 1980 issue of ETI. Good representation of all components as well as leader test equipment, Philips speakers and more. Also featured are Dominion's line of Edukits.

You can get it for free by writing to Dominion Radio & Electronics Co., 535 Yonge St., Toronto, Ontario M4Y 1Y5.



Etco

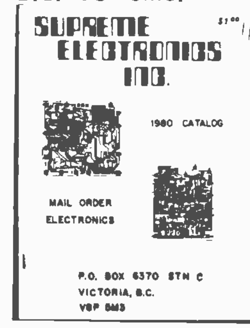
There are, of course, many of us who dearly love to sort through electronic surplus on the off chance we'll get something fantastic for almost nothing. Etco's catalogue No. K is 96 pages of everything that can be remotely associated with electronics. If you're looking for specific parts, this won't be of much use. On the other hand, there are lots of component kits suitable for collecting. Write to Etco Electronics, Dept 280, Box 796, Plattsburgh, N.Y. 12901.



Supreme Electronics Inc.

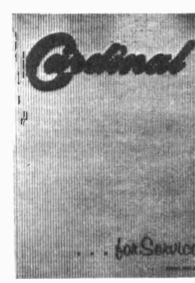
32 pages handles Supreme's selection of products. These include 4000 series CMOS, transistors, Exar ICs, lotsa Armaco products (switches, battery holders, and so on) and some test equipment. Supreme also stocks Yaesu Musen receivers and Beckman DMMs.

Cover price on this catalogue is $1.00. Write to supreme Electronics Inc., P.O. Box 6370, Stn. C, Victoria, B.C. V8P 5M3.



Cardinal Industrial Electronics

One of the Fat Cats, Cardinal's book is 1120 pages thick. What else can we say? Just about anything you want can be found here: Intersil, B & K, Amphenol, Mallory, Hammond and more. The whole thing will set you back $10.00 + $1.35 postage and handling. Write Cardinal Industrial Electronics at P.O. Box 12000, Edmonton, Alberta T5J 2P4.

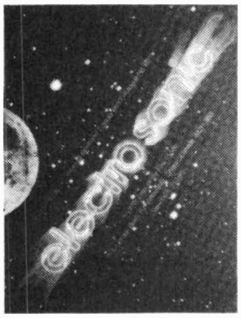


Active Component Sales

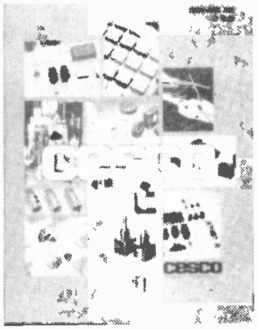
Active hasn't come up with a new catalogue since our last survey. Apparently it is felt that prices fluctuate far too much to make it worthwhile. Active stocks TI, Siliconix, Siemens, Zilog and many more. You can get a good idea of what their into by checking their ads which have appeared on the backs of ETI since May, 1980. If you can't find what you want, write to Active Component Sales Corp, 5647 Ferrier Street, Montreal, Quebec H4P 2K5.

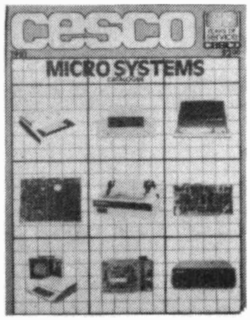
Electro Sonic Inc.

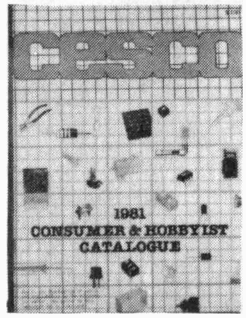
Another industrial source, Electro Sonic's catalogue No. 801 is one of the best produced and printed books we've seen. Electro Sonic are distributors for a wide range of products and manufactures ranging from Motorola, National and RCA ICs to Hammond cases, Philips resistors and capacitors and so on. The catalogue is available for $15.00 postpaid from Electro Sonic Inc., 1100 Gordon Baker Rd., Willowdale, Ontario M2H 3B3.



CESCO Electronics Ltd.







CESCO has not one, but three catalogues to offer. The largest is their 1981 Industrial catalogue. $2.00 will get you 276 pages of a wide array of transformers, cases, switches, passive components and more. The only thing missing is any sort of listing of semiconductors. They do have them, but you'll have to phone or write for prices and availability.

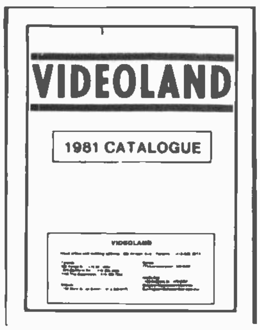
Catalogue number 2 isn't ready yet so we don't know anything about it other than it will be on microprocessors and will cost $1.00.

Catalogue number 3 we know alot about it because we had it printed up along with the rest of our February 1981 issue. Altogether there are 54 pages of tools, components, books, meters etc. The catalogue is available free from CESCO or you can get a back issue of February '81 from us for $3.00.

Write to CESCO Electronics Ltd. 4050 Jean Talon St. W., Montreal, Quebec H4P 1W1. ●

Videoland

Another non-component catalogue. Videoland's 32 page catalogue features pre-recorded video cassettes, Video cassette recorders and cameras, a satellite down-link, projection TV and other good video things. Write to Videoland, 780 Wilson Avenue, Toronto, Ont, M3K 1E2.

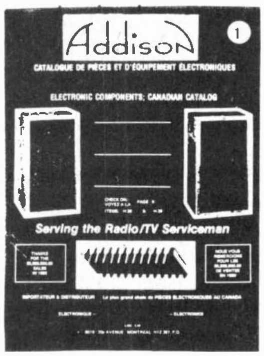


A-1 Electronics

While you can't really classify it as a catalogue, A-1 did manage to pack alot into their 4 page flyer. Lots of semis resistors, pots, capacitors as well as Ohio Scientific products and some surplus deals. Write A-1 Electronics, 5062 Dundas St. West, Islington, Ontario M9A 1B9.

Electronique — Addison — Electronics Ltd.

Nice little item this 180 *bilingual* pages of both hobby and radio/TV servicing items. Great selection of ICs, transformers, etc. Also some 'consumer' stuff like Sanyo radios and cassette recorders, Audio Sphere speakers and so on. Over all a very good and diverse mail order source. Electronique — Addison — Electronics Ltd., 8018 — 20e Avenue, Montreal, P.Q. H1Z 3S7.



Electronics Today INTERNATIONAL

NEXT MONTH

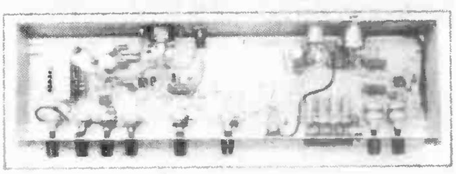
At the time of going to press, the articles mentioned are in an advanced stage of preparation. However, circumstances may result in changes to the final contents of the magazine.

APRIL

Ultrasonic Switch

This project uses a 40kHz ultrasonic frequency to switch a relay at distances up to 20 feet. Modern circuitry keeps the component count low. The relay can of course control any equipment including a 110V socket.

Stereo Image Coordinator

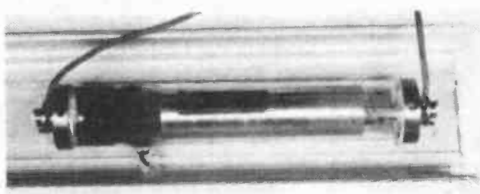


This box of tricks gives you the opportunity to try out what has up to now been predominantly a studio technique. The stereo sound image may be controlled automatically or manually; you can position the image in one place and keep it there or continually sweep the images between channels - and more.

Current Affairs

We seem to take for granted that semiconductors work. 10-15 years ago magazines continually carried features on the internal workings, holes and current carriers but its a long time since we've explained the internal workings. Next month we put that right.

Lasers

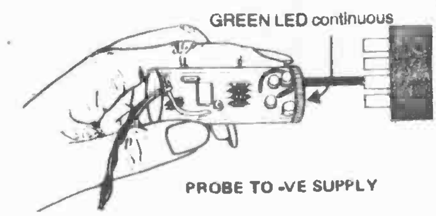


The first laser was built just 21 years ago by Theodore Maiman for the Hughes Aircraft Corporation. Once labelled the 'solution without a problem', the laser is now used in dozens of applications. In our feature David Tilbrook gives us a rundown on these fascinating devices and the physics of their operation.

Audio Supplement

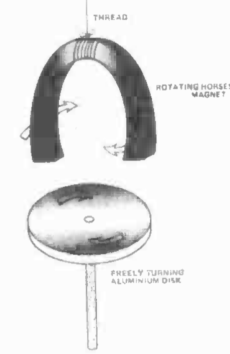
In the April issue we are carrying the third of our special supplements, this time on the technical aspects of Hi-Fi planned. Features include: Recording tape and Tape Recording, Ugrading your Hi-Fi, a feature on Room Acoustics, Flat Speaker Drives and more.

Autoprobe



When it comes to finding faults-or confirm correct operation in a vehicle's electrical system, a multimeter has disadvantages. This convenient project is very useful in those awkward places: it's also easy to build and inexpensive.

Eddy Currents



Eddy currents present peculiar problems-especially in the design of transformers yet the heating effects produced by them are used in the manufacture of semiconductors. A.S. Lipson explains.

DRUM SYNTHESISER

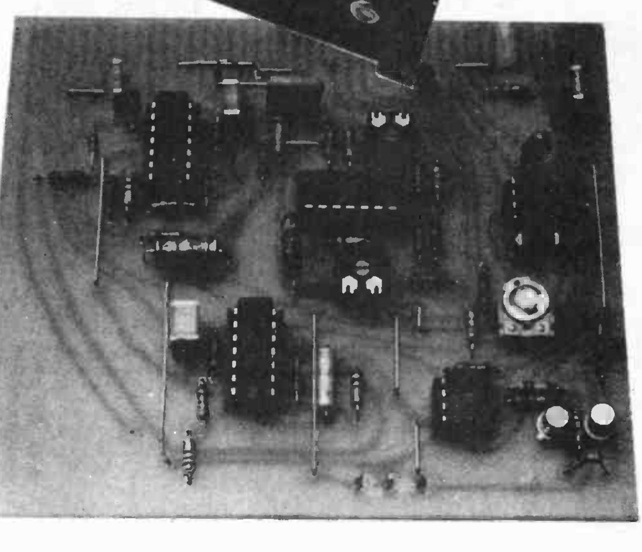
At last ETI's own machine which peeoom-peeoom, bim-bams, whizeees or boo-ooms in all its onomatopoeic glory.

Designed by Roger Shore

YOU'VE ALL HEARD the effect on disco or pop records. It was first heard some years ago and since then, it seems, has grown in popularity so much that no decent, self respecting drummer would let it be known that he hasn't got one. Mind you, they are only obtainable commercially at a price—$400 or so can buy you one. A fair price, the enquiring musician might muse in perspective, in order to keep up with the times and the modern music trends. A fair price indeed, until the even more enquiring technical musician takes the lid off the studies the electronic circuitry involved. That's exactly what we did! We decided that this new sound was one to be investigated with a future project in mind and so we took a good look at a major proportion of the available commercial units.

Our first conclusion was that somewhere along the line of manufacturer, middle-man and musician, somebody was ripping off somebody else-and, as usual, it is the end link in the chain having to pay more than the odds.

A fairly conservative costing of all components and hardware for the project, which is a two channel synthesiser,



All 42 ways of the control board (above) are used, Cut a slot at pin 37 for identification.

forming a stereo output with the added facility of a monitor amplifier circuit to power a pair of stereo headphones (allowing setting up of the synth without being overheard) comes to around $150–200.

The modular construction means that any number of channels can be built as required and perhaps the most enterprising of you out there can envisage a complete electronic drum kit of bass, snare, tom-toms, high hat and cymbals for about half the price of a standard kit. Of course the extra drum sounds of the synthesiser are also there as required.

The ETI Staccato is a line powered device, none of those nasty batteries running out on you half way through a gig. A simple microphone or miniature loudspeaker acts as the trigger sensor and can be positioned inside an existing drum, on the underside of a simple wooden block or, as in the prototype, inside or underneath a practice drum pad. The drum pad is probably the ultimate as it means a permanent and compact method of holding the sensor whilst maintaining a good-looking and functional appearance.

Also featured is a sensitivity control which adjusts for a very wide range of trigger sensors and levels which means that virtually any combination of microphone, or speaker and holder will trigger the synthesiser.

Our aim was to incorporate a systematic approach to interwiring connections, therefore providing a unit that could easily be expanded. The most favoured compromise combined three PCBs; a power supply unit and monitor board, control-circuit and a function board which holds all PC mounting potentiometers, switches and LEDs for a single channel synth.

Begin construction by building the power supply unit and monitor PCB, insert all pins and wire links followed by IC sockets, resistors, diodes, capacitors and semiconductors. Next in line is the control circuit; follow the same procedure as above. Take care when you come to wire the edge connector as all of the 42 ways have been used right down to the last pin! A slot will need to be made at pin 37 of the circuit board to polarise the edge connector.

Before assembling the function board, it is wise to use it as a template for marking out the front panel. This will give a physical representation of the layout and will enable easy alignment of the potentiometers, etc after drilling. Mount all right angled, inter-PCB sockets (3 ways or 5 ways) around the edge of this board. Be sure to mount all potentiometers from the copper side of the PCB with their tags bent at right-angles.

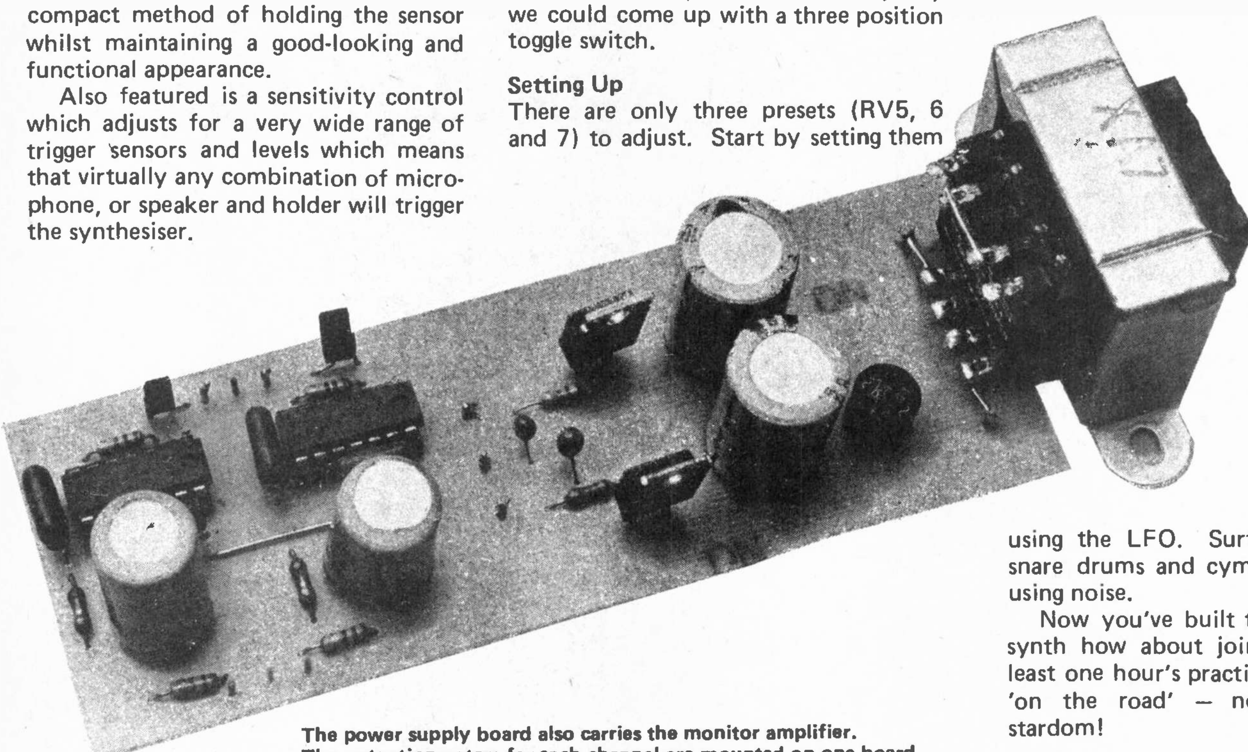
It is highly recommended that the specified switches are used, especially in the case of SW1, that was the only way we could come up with a three position toggle switch.

Setting Up

There are only three presets (RV5, 6 and 7) to adjust. Start by setting them all to mid-position then turn the noise control to minimum and switch the noise on. This effectively disconnects the sine filter from the circuit. Now switch the VCO to sine output. Switch the device on and adjust RV7 preset until a continuous signal is heard at the output. If an oscilloscope is available, adjust RV5 and 6 for minimum sine-wave distortion. If no oscilloscope is available, simply adjust the presets for minimum audible distortion. This may seem somewhat haphazard, but the human ear is very discerning where sine distortion is concerned! Once the minimum distortion position has been established, it only remains to adjust and that's it!

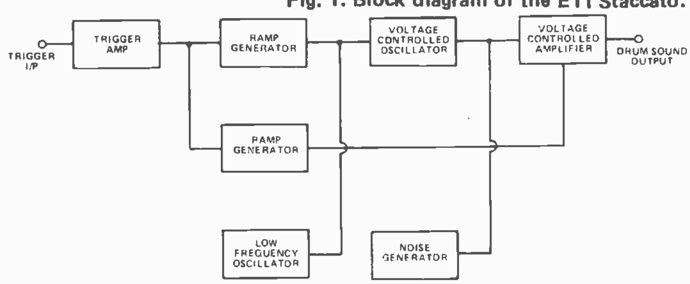
Now, the the golden rule is to experiment. Apart from the sounds for which the drum synth is well known, a whole range of strange and wonderful sounds is possible, particularly if the LFO and noise generator are used. Vibratos, warbles, chimes and gongs are obtained using the LFO. Surf, wind, applause, snare drums and cymbals are obtained using noise.

Now you've built the staccato drum synth how about joining a band? At least one hour's practice should put you 'on the road' — not necessarily to stardom! ●



The power supply board also carries the monitor amplifier. The potentionmeters for each channel are mounted on one board.

Fig. 1. Block diagram of the ETI Staccato.



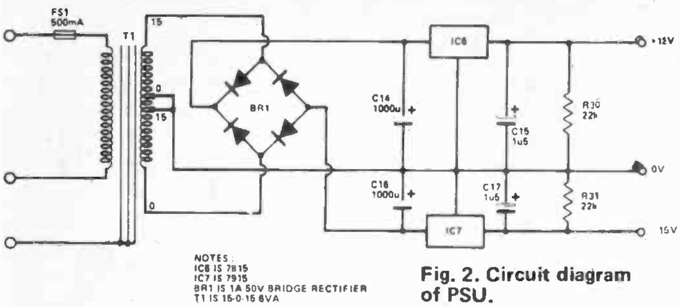


Fig. 2. Circuit diagram of PSU.

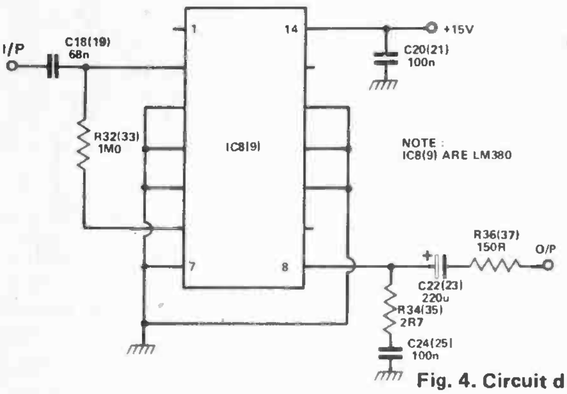


Fig. 4. Circuit diagram of monitor amplifier.

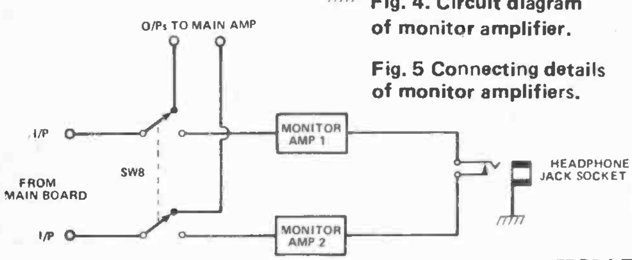
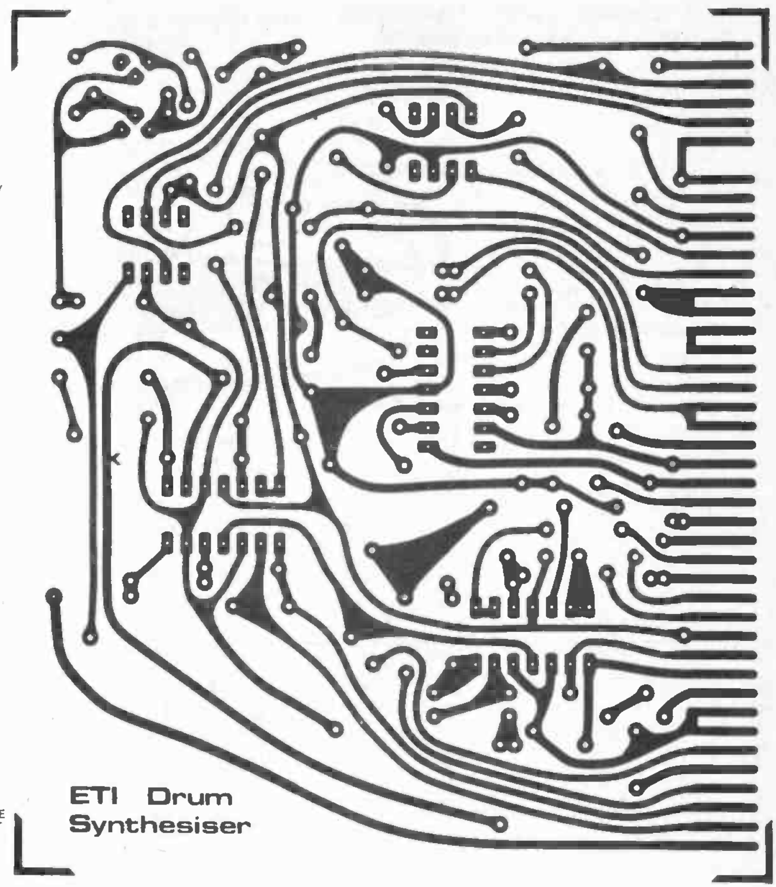


Fig. 5 Connecting details of monitor amplifiers.



HOW IT WORKS

The block diagram (Fig. 1) shows the main principle of operation of the synthesiser. It can be seen very simply as a voltage controlled oscillator followed by a voltage controlled amplifier. This means that the frequency of the final signal and its amplitude ie its pitch and envelope, are controlled by DC voltages derived from the original trigger. Two separate ramp generator circuits provide these DC voltages and all necessary parameters of these ramps are externally controllable. A low frequency oscillator can be applied to modulate the VCO if desired and a generator produces noise for cymbal or snare sound, etc.

The voltage controlled oscillator is based on the 8038 waveform generator chip, IC2. Its frequency is varied by adjustment of the pitch control RV4, allowing the initial frequency to be set to the required level. Alternatively, the frequency can be controlled by a varying DC voltage applied via D3, from the VCO ramp to be described later. The oscillator works over the frequency range between about 10 Hz and 1k5 Hz. All three output waveforms available from the 8038, sine, triangle and square waves, are used.

The trigger for the synthesiser is provided by a microphone (virtually any microphone will do) fitted inside a suitable drum or holder, even a tin can will do! The signal from the microphone is differentiated by C1, R1, so that surrounding sounds do not cause false triggering. The pulse generated when the drum is struck is then amplified by IC1a, the gain being varied by RV1. The output of this amplifier is then rectified by D1 to provide a positive going pulse which is fed to further amplifiers to provide negative going pulses to drive the VCO and VCA ramp generators.

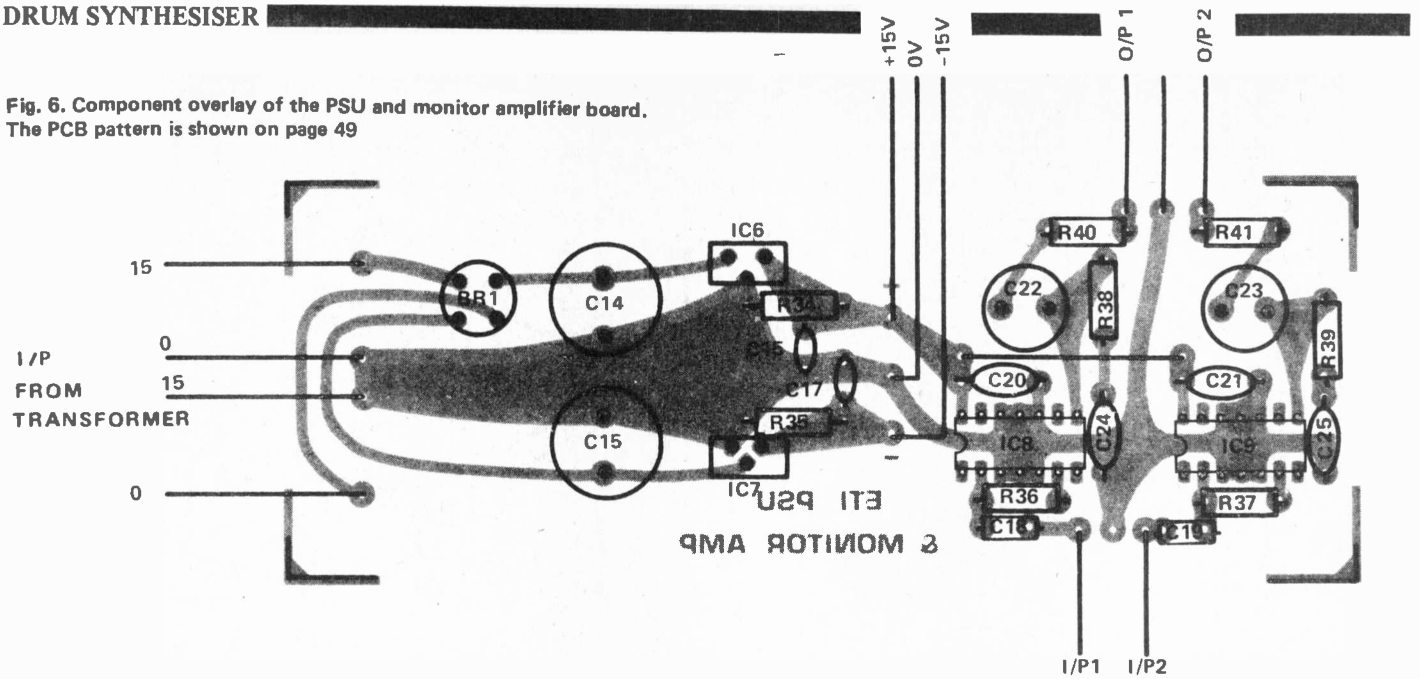
The anode of ZD1 is normally at zero volts and the cathode at +15 volts. When the output of IC1b is driven negative by a trigger pulse the cathode of D2 approaches zero. This negative-going pulse is rectified by D2 and charges C2 rapidly. C2 discharges through RV2 and R4, the value of RV2 varying the rate between a few milliseconds and several seconds. This DC ramp is buffered by IC1c connected as a voltage follower, to prevent RV3 affecting the C2, RV2 discharge time. As both ends of RV3 are normally at +15 volts, D3 is biased off. When the output of IC1c swings negative on receipt of the trigger, D3 is turned on and allows the ramp waveform to control the sweep input of the VCO. RV4 sets the lower frequency of the oscillator and as pin 8 goes more negative, the frequency rises. The range of this frequency sweep is determined by RV3 whose setting limits the negative swing of D3 cathode. However, C2 charges quickly and discharges more slowly. The characteristic falling sine sound of the drum systh is created at the output of the VCO. By use of RV4 pitch, RV3 pitch bend and RV2 slope a whole range of sweeps are possible.

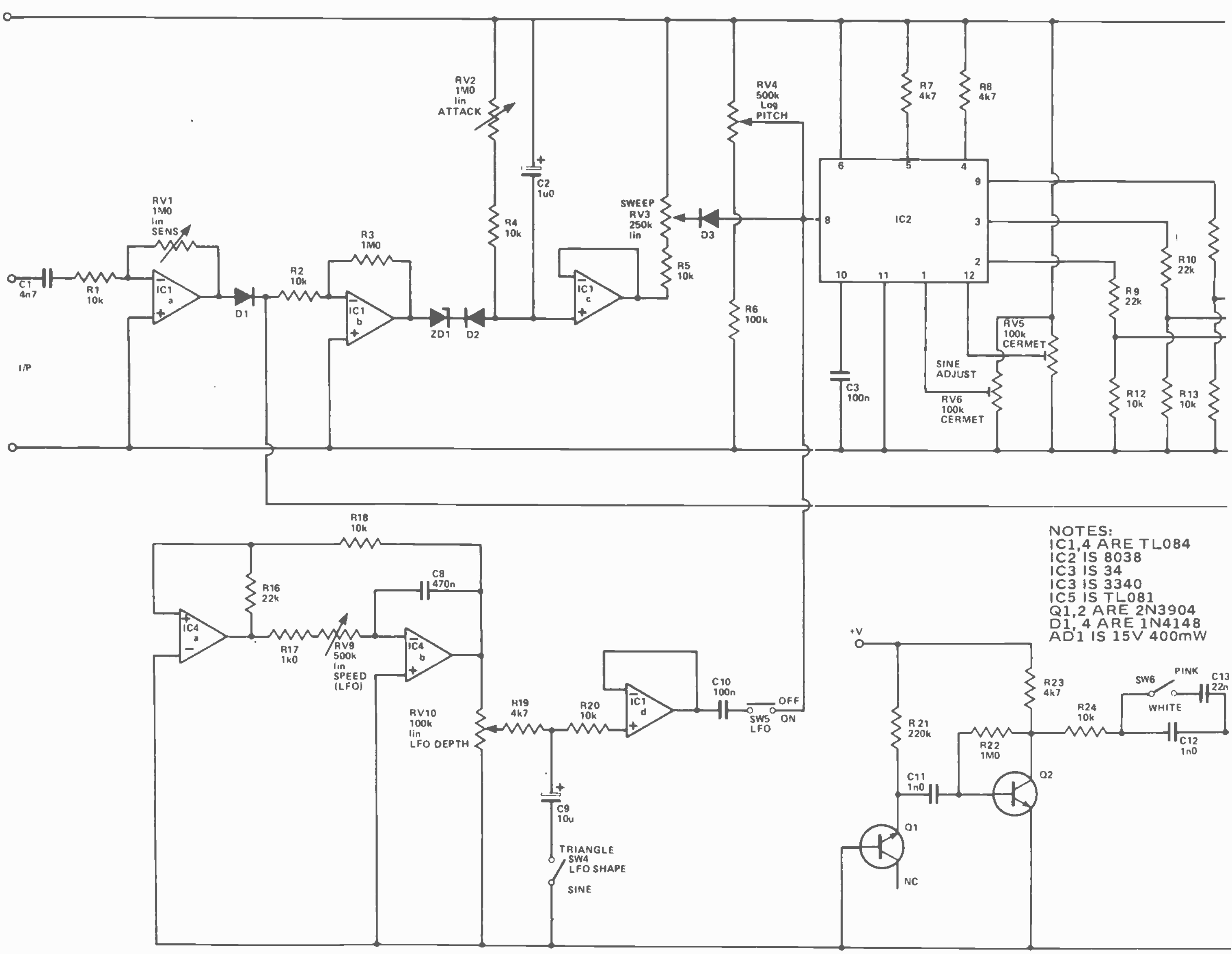
The voltage controlled amplifier is based on the Motorola 3340 voltage controlled attenuator IC. The selected output from the VCO is fed to the IC and the output is fed to the volume control, RV8. The voltage controlling input is fed to pin 2 via RV7, which is preset so that with no trigger present there is no output. The VCA ramp generator functions in a similar manner to the VCO ramp generator. The base-emitter junction of Q1 is reverse biased to provide the noise source. This noise is amplified by Q2 and further amplified by IC5 whose gain is variable via RV11, determining the noise level to be fed to the VCA input.

Notice that when the noise is switched in, the sine filter, C4, is switched out. This is to ensure that when noise and sine are used together, this filter does not attenuate the useful part of the noise spectrum required. Although this marginally increases the sinewave distortion this is not noticeable above the deliberately introduced noise.

The low frequency oscillator uses IC4b as an integrator and IC4a as a Schmitt trigger, together making a triangle wave oscillator. The speed is varied by RV9 between about 0.5 Hz and 1 kHz, and the amplitude is varied by RV10. C9 can be switched in to integrate the triangle wave to provide a sinewave approximation for vibrato effects.

Fig. 6. Component overlay of the PSU and monitor amplifier board. The PCB pattern is shown on page 49





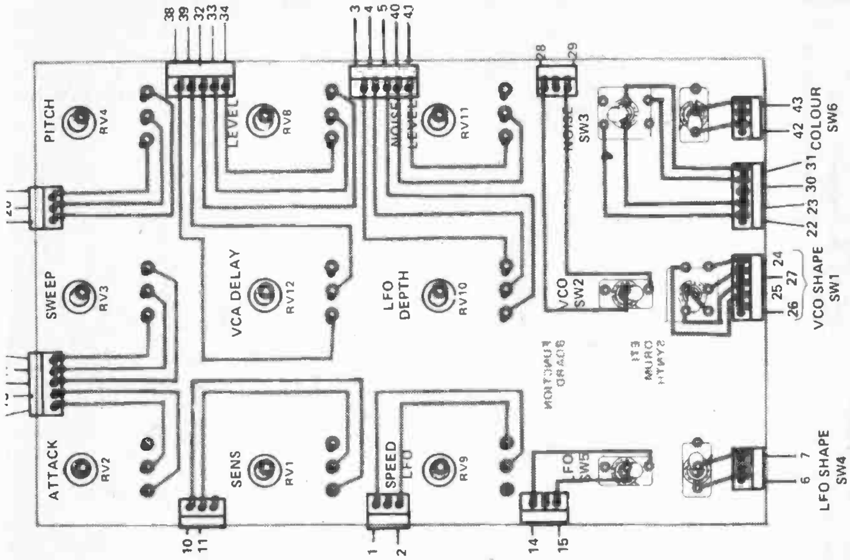
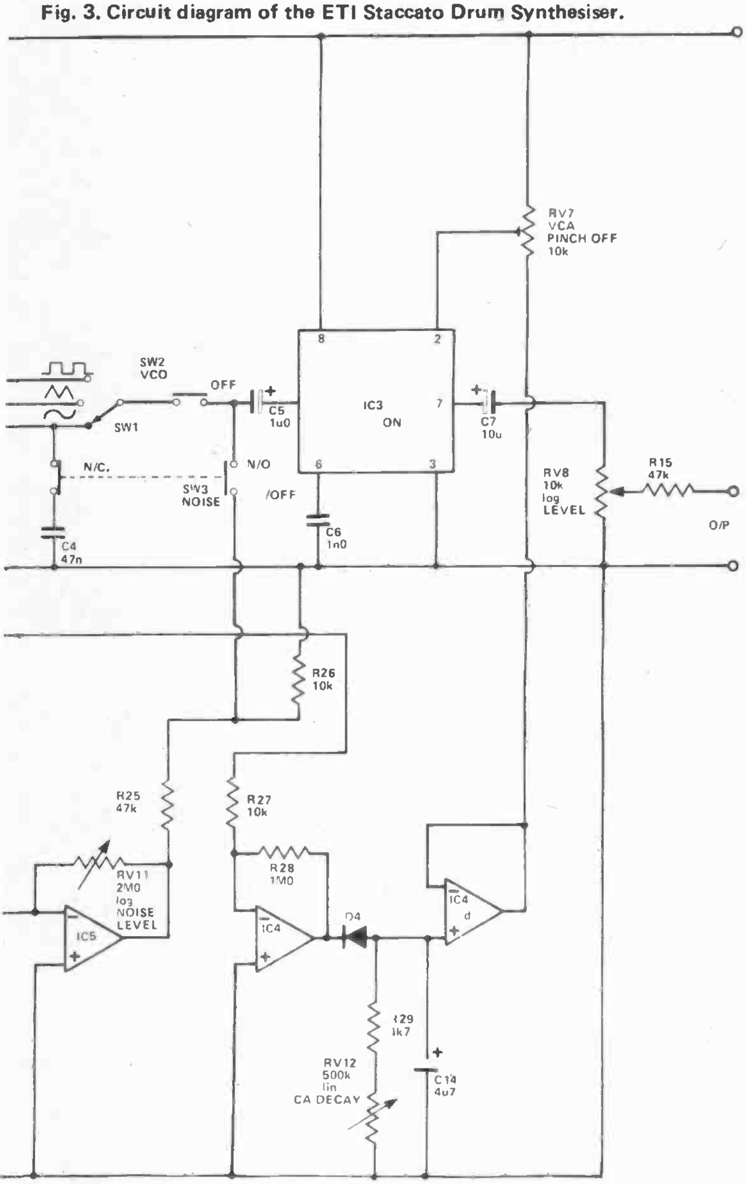


Fig. 8. Component overlay of the function boards.

Fig. 3. Circuit diagram of the ETI Staccato Drum Synthesiser.



PARTS LIST

Components For One Channel

Resistors

R1,2,4,5,12, 13, 14,18, 20, 24,26, 27	10k
R3,22,28,	IM0
R6	270k
R7,8,19,23, 25,29,	4k7
R9,10,16	22k
R11,21	220k
R15	47k
R17	1k0
R38	2k2 1W

Potentiometers

RV1,2	1M0 lin PCB mounting
RV3	250k lin PCB mounting
RV4	500k log PCB mounting
RV5,6	100k miniature horizontal preset
RV7	10k miniature horizontal preset
RV8	10k log PCB mounting
RV9,12	500k lin PCB mounting
RV10	100k lin PCB mounting
RV11	2M0 log PCB mounting

Capacitors

C1	4n7 polycarbonate
C2,5	1u0 tantalum 35V
C3	100n polyester
C4	47n polyester
C6,11,12	1n0 polycarbonate
C7	10u tantalum 35V
C8	470n polycarbonate
C9	10u 25V electrolytic
C10	100n polycarbonate
C13	22n polycarbonate
C14	4u7 16V electrolytic

Semiconductors

IC1,4	TL084
IC2	8038
IC3	MC3340P
IC5	TL081
D1–D4	1N4148
ZD1	15V 400 mW
Q1,2	2N3904

Switches

SW1	1P3T PC mount toggle switch, C&K Model 7211
SW2,4,5,6	SPST PC mount toggle switch, C&K model 7101
SW3	DPDT PC mount toggle switch, C&K model 7201

Miscellaneous

43 - way edge connector (Edac, Amphenol, or Vero), 30VCT/1A transformer, 500 mA fuse, line cord, knobs, hardware, etc.

Additional Components For Two Channels

Resistors

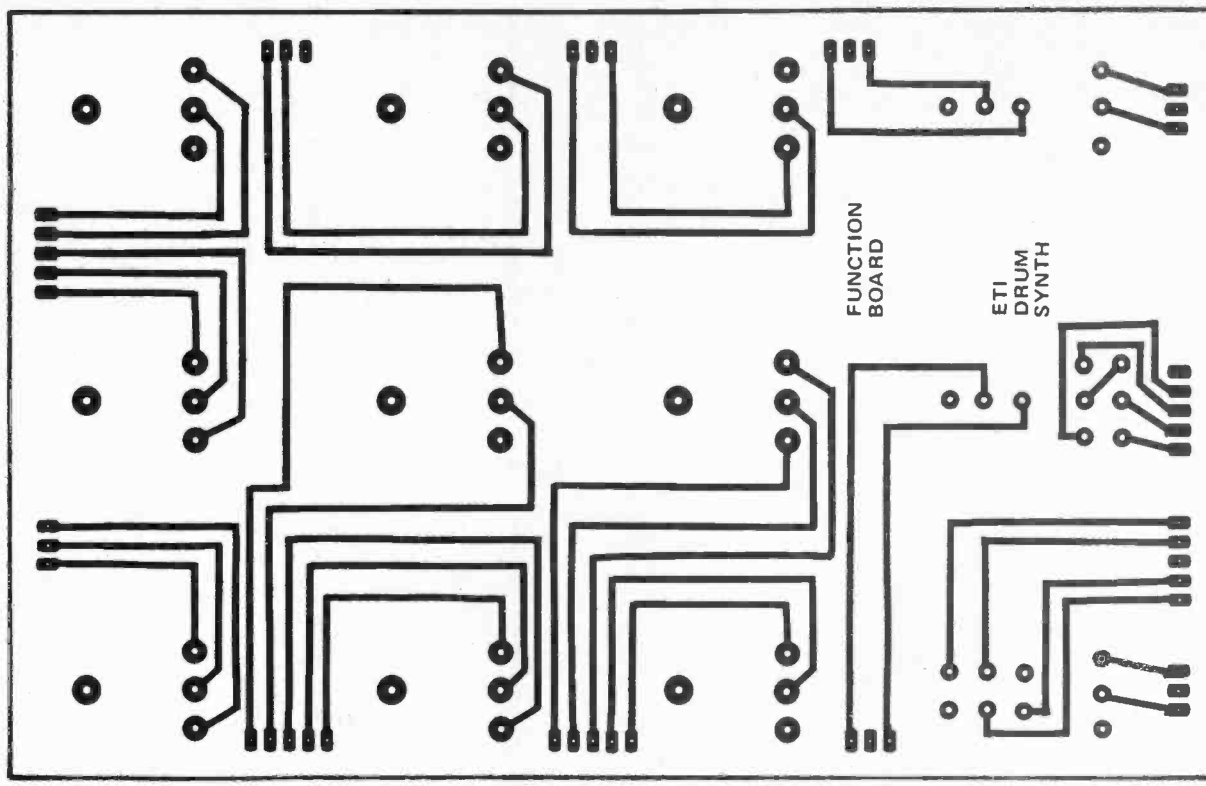
R30,31	22k
R32,33	1M0
R34,35	2R7
R36, 37	150R

Capacitors

C14,16	1000u 25V PCB electrolytic
C15,17	1u0 16V tantalum
C18,19	68n ceramic
C20,21,24,25	100n polyester
C22,23	220u PCB electrolytic

Semiconductors

IC6	7815
IC7	7915
IC8,9	LM380
BR1	1A 50V bridge rectifier



PCB foil pattern.

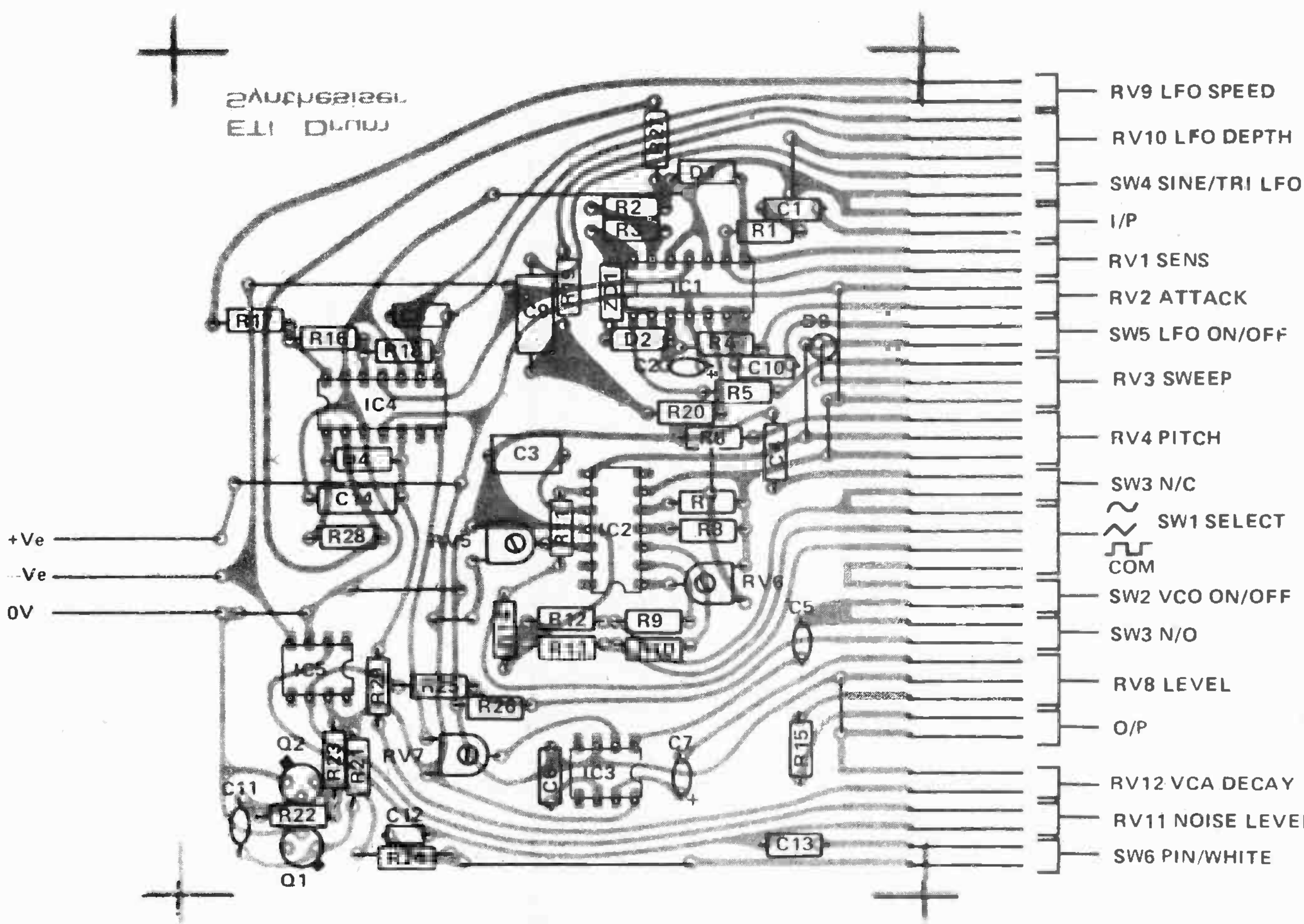
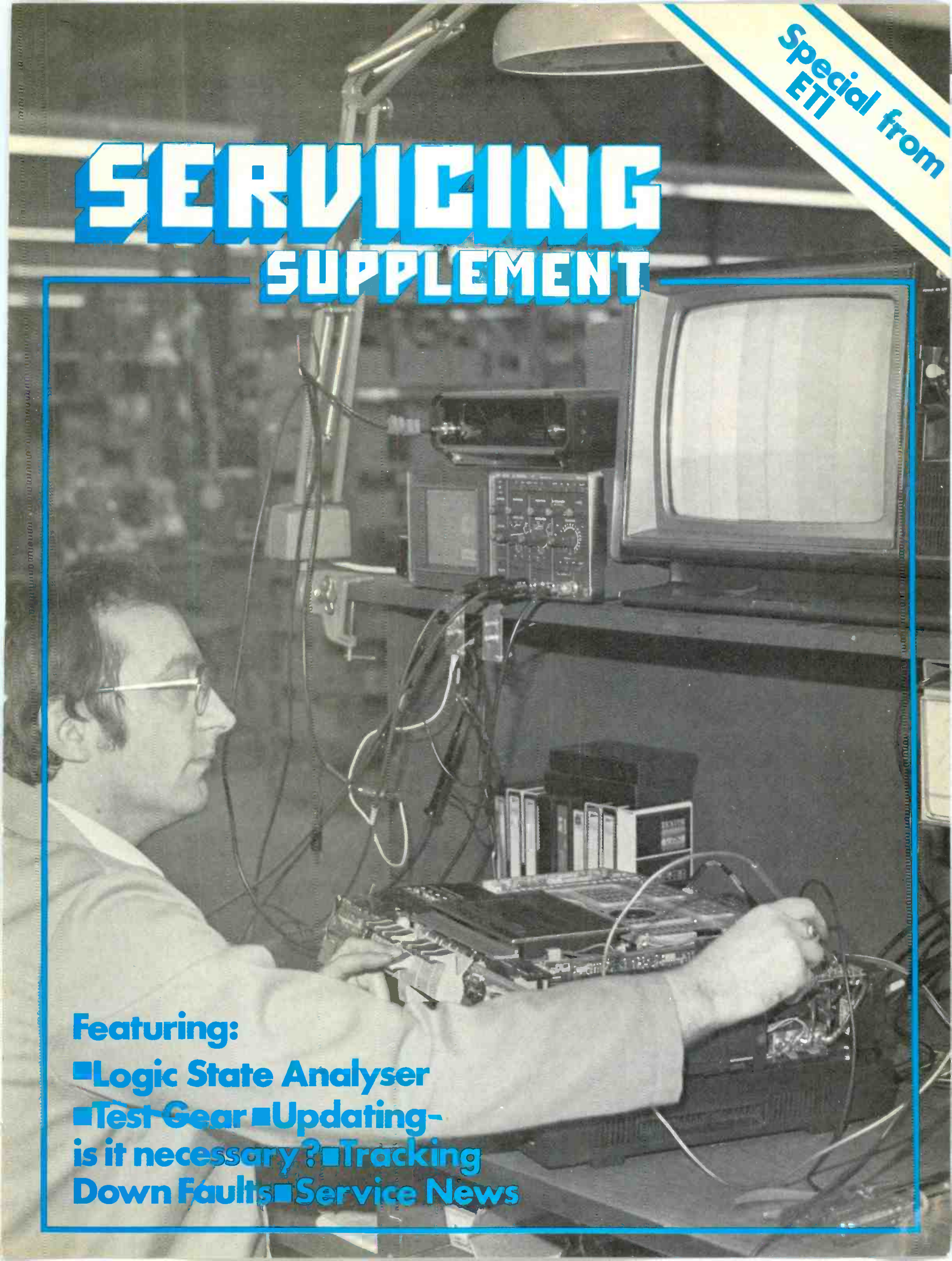


Fig. 7. Component overlay of the control circuit board. Take care when wiring the edge connector.



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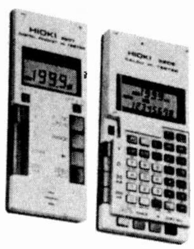
- Logic State Analyser
- Test Gear Updating- is it necessary?
- Tracking Down Faults
- Service News

HIOKI

3207 DIGITAL POCKET Hi TESTER



Display: 3½ digits LCD (1999), auto-polarity, unit symbol
Ranging: Automatic & Manual
Overrange Indication: The "1" in the maximum figure blinks. (Buzzer On:Alarm)
Battery Indication: BATT on display lights.
Sample Rate: 2 samples per second
Battery Life: Approx. 70 hours continuous
Temperature: 0°C. 40°C, operating; —10°C 50°C, storage.
Power Source: Silver Oxide Cell (S15,S76E, MS-76H, SR44) or Alkaline Cell (LR44) 2pcs.
Maximum Input: Voltage DC MAX. 1000V, AC MAX. 750V
Ω·mA →Fuse (0.3A) & Diode protected
Dimensions: 150H × 60W × 12.5D mm
Weight: Approx. 120g
Accessories: Test Leads, Soft Case, Fuse (0.3A)

PRICE — $175.00

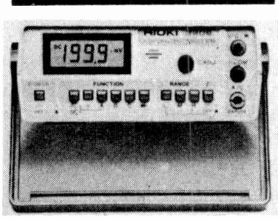
3208 CALCU Hi TESTER

• Measuring Range (DMM)
Same as model 3207

Battery Life: Approx. 100 hours continuous
Calculator: Separate Entry/Function keys
Display: 8 digit sign or 5 mantissa and 2 exponet with sign
Power Source: SUM-3 (Size AA) 2pcs.

PRICE — $315.00

3209 DIGITAL Hi TESTER



• Measuring Range (DMM)
Same as model 3207

Display: 3½ digits LCD (1999), auto-polarity, unit symbol
Ranging: Automatic & Manual
Overrange Indication: The "1" in the maximum figure blinks and buzzer alarm.
Battery Indication: BATT on display lights.
Sample Rate: 2 samples per second
Battery Life: Approx. 100 hours continuous
Temperature: 0°C ~40°C, operating; —10°C~ 50°C, storage
Maximum Input: Voltage DC MAX. 1000V, AC MAX. 750V
Ω·mA →Fuse (0.3A)& Diode protected
Calculator: Separate Entry/ Function keys
Diplay: 8 digit sign or 5 mantissa and 2 exponet with sign
Power Source: SUM-3 (Size AA) 2pcs.

Model 3209 — $535.00

KEITHLEY

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- Tough polycarbonate plastic window and front panel

Performance Plus

- Convenient size and weight—only 282 grams (10 oz.)
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- Low battery annunciator
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- 20,000-hour MTBF
- Externally accessible battery and fuse
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- Only one calibration adjustment, only once per year
- 25 ranges and five functions: DC volts, AC volts, DC amps, AC amps, ohms
- 100 V, 1 A, 0.1 sensitivity
- 1000V DC, 750V AC, 10 A and 20M upper range limits
- Full range of accessories

PRICE — $175.00

UNI-VOLT

• DT-810

Display: LCD, max. indication 1999
Over Input Indication: "1" or "—1"
Polarity: "—" indication automatically
Input Impedance: 10 meg.Ω
Operating Temperature: 0°—40°C 80% R.H.
Power Supply: 006P DC9V battery
Power Consumption: 14mW max (45mW for buzzer)
Size: 172(D) × 90(W) × 36(H)mm
Weight: 280g including battery 159.00

• DT-815

Same specifications as DT-810 but without transistor checker & quick conductance checker
149.00

• DT-820

Display: LED, max. indication 1999
Over Input Indication: "1" or "—1"
Polarity: "—" indication automatically
Input Impedance: 10 meg. Ω
Operating Temperature: 0°—40°C, 80% R.H.
Power Supply: UM-3 (AA size) battery × 4pcs.
or AC adaptor (option)
Power Consumption: 420mW max
Size: 174(D) × 90(W) × 40(H)mm
Weight: 350g, including batteries 119.00

HITACHI

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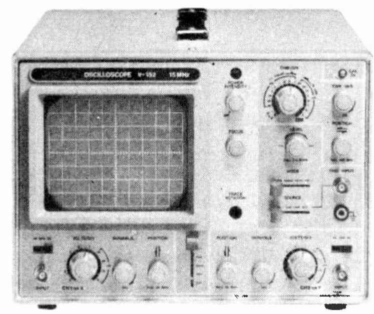
Hitachi Oscilloscope V-152 DC-15MHz dual-trace



1. TV sync-separator circuit
2. High-sensitivity 1mV/div.
3. X-Y operation
4. Sweep-time magnifier (10 times)
5. Trace rotation
6. Additional Z-axis input for use as CRT display

Hitachi Oscilloscope V-151 DC-15MHz single-trace

1. TV sync-separator circuit
2. High-sensitivity 1mV/div.
3. X-Y operation
4. Sweep-time magnifier (10 times)
5. Trace rotation
6. Additional Z-axis input for use as CRT display

Hitachi Oscilloscope V-302 DC-30MHz dual-trace

1. TV sync-separator circuit
2. High-sensitivity 1mV/div.
3. Signal delay line
4. X-Y operation
5. Sweep-time magnifier (10 times)
6. Trace rotation

Hitachi Oscilloscope V-301 DC-30MHz single-trace

1. TV sync-separator circuit
2. High-sensitivity 1mV/div.
3. Signal delay line
4. X-Y operation
5. Sweep-time magnifier (10 times)
6. Trace rotation

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Logic State Analyzer

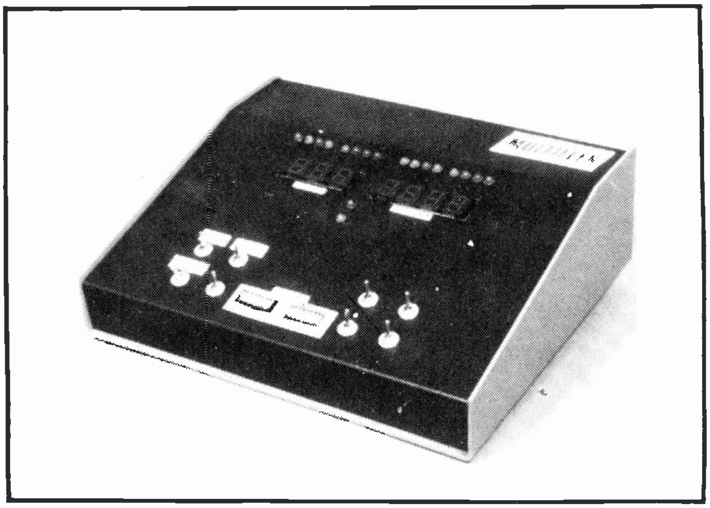
Rapid improvements in diaital technology are creating a demand for sophisticated digital test equipment. Shane Dunne of Multiflex Technology, Inc, explains one of the most useful of the new breed of digital instruments.

UNTIL THE development of the microprocessor in the early 1970s, electronics engineers needed only to be concerned with signal flow from one point in a circuit to the next. Linear circuits could easily be analyzed with an oscilloscope, looking at the waveform at the input and output of each active device. Digital logic wasn't much different because of functions of each chip were fairly simple and a dual—or four—trace scopes sufficed to compare levels and timing between inputs and outputs.

Microprocessors created a whole new breed of problems. Firstly, the microprocessor represented a system rather than a function, on a single chip, and was therefore much more complex logically than its predecessors. Second, there were new long-term timing considerations because a microprocessor performed totally different logical functions at different times when executing a program. These two difficulties combined to seriously limit the value of the oscilloscope as a troubleshooting aid. Even if enough traces were available to handle all the signals involved. It would still not be possible to represent a long enough time interval on the screen. The oscilloscope provided a "snapshot" when what was needed was a "movie".

Enter the Logic State Analyzer. This device uses a memory to store sequences of bit patterns at high speed, so that they may be examined step by step, conquering the problems of multiple inputs and long-term timing. A good example is the Multiflex logic analyzer featured in the contest in the December 1980 issue of ETI. It has all the essential features of much more expensive machines, without their "frills", so it is quite easy to understand.

The Multiflex analyzer has 16 input channels, which may be used to monitor any 16 points in a digital system such as the data bus and half of the address bus of a microcomputer. There is also a clock input which, when it undergoes a transition, can load the 16 input bits into an internal 16 by 1024-bit memory. The analyzer is thus capable of storing 1024 consecutive 16-bit words for later examination.



The Multiflex Logic State Analyzer allows a technician to quickly track down faults in the microprocessor system.

Inside

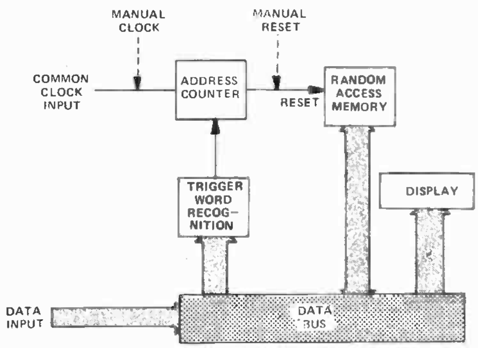
The block diagram in figure 1 is representative of all state analyzers, including the Multiflex type. Note the RAM memory used to store input bit patterns, and its address counter; which may be incremented either by the clock input or manually for step-by-step examination of the memory's contents on the display. The last block in figure 1, the trigger word recognition circuits is what makes the analyzer really useful. The device will not trigger (start storing input bit patterns) until a user-specified trigger word is received at the inputs. For example, if a computer was known to fail when a certain memory location was addressed, that address could be used as the trigger word with the analyzer monitoring the address bus to see where the program goes during the failure.

Why Use a Logic Analyzer?

For most hobbyist computer users, a logic analyzer is not an essential investment, because most computer systems presently on the market have some kind of monitor or debugging software to assist in troubleshooting. However, if it is necessary to modify an existing system or develop a new one for a specific requirement, the logic analyzer becomes invaluable.

An analyser is very convenient to have when debugging any digital circuits. The operation of simple counters or shift registers can be checked with great ease by connecting an analyzer to the outputs. A surplus keyboard with an unknown encoding scheme can be deciphered in a few minutes. In fact, any device which outputs data sequentially can be tested, either to find an unknown code or to verify a known one.

Dedicated microprocessor projects, in which there are no fancy video displays, monitor or assembler programs, or high-level languages, are the type of systems with which a logic analyzer is almost essential. Imagine that you have designed



Block diagram logic state analyser.

The Hewlett Packard Model 10264A represents the other end of the LSA spectrum.

a microprocessor-based alarm system containing nothing but a Z80, a 2716 EPROM, and some logic for input/output control. If it didn't work perfectly the first time, which is very likely, you would have no way of telling what was really going on. The processor would be running wild at 2 MHz or more, with no way to slow it down to a speed a mere human could keep up with. An analyzer, however, could easily follow the action and store it so that you could get an "instant replay" in slow motion. By being able to see what happens on the address and data buses and the control lines, you might find that an error in the programming is causing the processor to jump to an incorrect address, or that one bit is consistently lost from the memory due to a burned-out buffer chip. Even such simple errors would be nearly impossible to find with an oscilloscope or a logic probe.

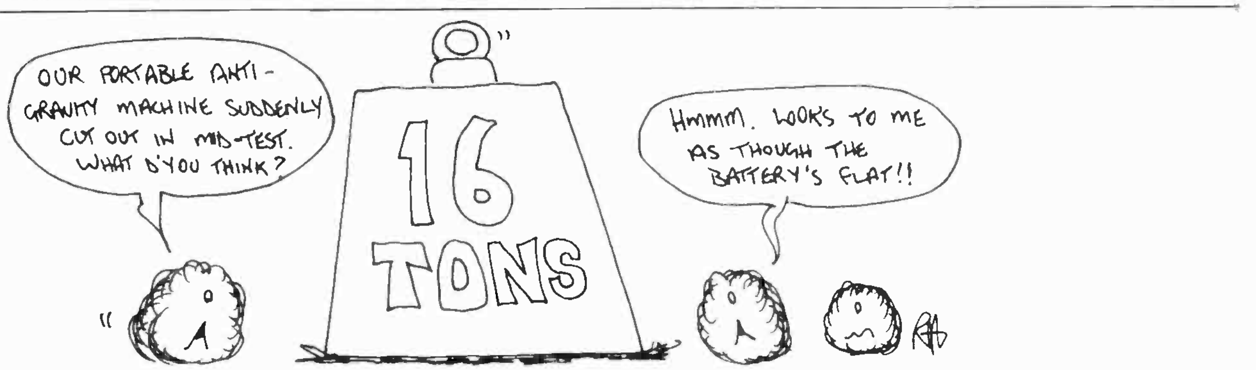
How Much?

All right, you say, but these logic state analyzers must be pretty expensive. Well, most of them are, but an inexpensive version has recently become available. The Multiflex analyzer sells for just $400 in kit form, which compares very nicely with the industry standard Hewlett-Packard 1602A at $2500. This may still seem like a lot of money, but it would be a wise investment for a serious hobbyist as the microprocessor revolution really gets into gear. One important point to note: The price reductions in the Multiflex design have been achieved by eliminating unnecessary features of higher-priced devices and using readily available parts. Equipment of this type won't be getting any cheaper.

Further information on the Multiflex logic state analyzer can be obtained from Exceltronix Components and Computing, Inc., the main distributor for Multiflex. You can find their address and telephone number elsewhere in this magazine. ●

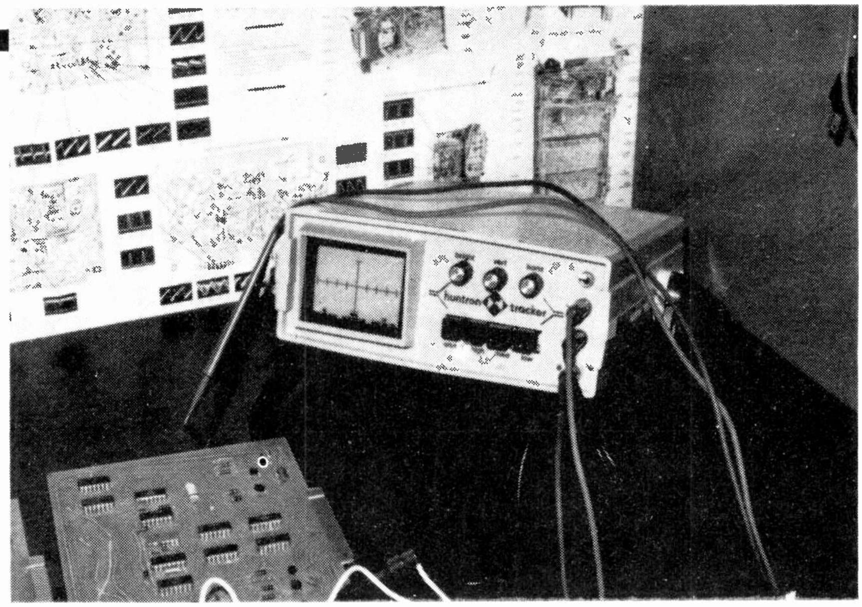
Some technical specifications of the Multiflex Analyzer are included here for reader reference.

- 16 input channels. One bit per channel.
- clock input latches data into internal memory.
- 1024 by 16-bit memory. Addressing is internal to the machine.
- 16 display LEDs for individual bit testing, plus 4 hex 7-segment displays for numeric interpretation of 16-bit words.
- 3 hex 7-segment displays to indicate "entry number" for each stored word. The entry number is the machine's own memory address and indicates where the word is located in the 1024-word trace.
- clocking switch selects either rising or falling edge of clock signal to latch data.
- data polarity switch selects active high or active low inputs.
- triggering (commencement of "trace" or data storage) is in 3 modes: Manual triggering allows words to be latched into memory whenever the clock changes state. Automatic Start triggering allows storage of 1024 words after the receipt of a user-specified trigger word on the inputs. Automatic End triggering allows words to be latched into memory whenever the clock changes state. Until the receipt of the trigger word ends the trace.
- trigger word selection is by 16 minature DIP switches. But this can be easily modified to a hex keyboard configuration.
- increment pushbutton allows forward stepping through internal memory contents either one location at a time or at high speed.
- decrement pushbutton allows backward stepping through memory contents either one location at a time or at high speed.
- several analyzers may be linked with a minimum of connections, to increase the number of input channels.
- two versions are now available with maximum clock rates of 5 MHz and 6.6 MHz. 10 MHz version will be available soon.
- all inputs are buffered with maximum input loading currents of 20 uA (input low)
- inputs are TTL compatible.
- requires +5 V at 1.6 A.
- available in kit form with case (space allowed in case for power supply) or fully assembled tested and guaranteed.
- data and clock inputs are by a separate probe pod (included) with a 1 meter ribbon cable to the main unit. Input buffers are within the pob to minimize the length of wires carrying low-power signals.



Circle No. 30 on Reader Service Card.

Tracking Down Faults



A major problem in electronic equipment servicing is finding intermittent or faulty components. Gerry Cyprus of Cyprus Products Inc. describes how the Huntron Tracker can help.

THE HUNTRON TRACKER is a special-purpose oscilloscope and test processing instrument which adds a new dimension to electronic servicing. It gives the technician a new way to troubleshoot, adding ammunition to his arsenal in the battle to keep electronic equipment functioning properly. The Tracker has been designed for rapid troubleshooting of solid state circuits and components with no circuit power applied and has intentionally been kept free of complex controls to simplify operation. The CRT display can be adjusted for brightness, vertical and horizontal centering with the three rotary controls at the top of the front panel. An on-off switch and three impedance range switches for testing various devices and circuits are the only other front panel controls on the single input model. The dual input model also has a triple-throw toggle switch which selects input channel A, B or A-B alternately.

Theory of Operation

The Huntron Tracker applies a test signal across two terminals of the device being tested. This test signal causes a current to flow through the device and a voltage drop across its terminals. The current flow is processed in such a way as to cause vertical deflection of the scope trace while the voltage drop across the test component causes horizontal deflection of the scope trace. This internally generated test signal is an 80Hz. modified sine wave which applies alternately positive and negative voltages across the component being tested. Figure 1 shows a simplified equivalent of the generator section and how the voltage across the terminals affects the horizontal and vertical deflection plates of the scope. Shown is the symbolic representation of a current generator with a series internal impedance Zgen and a current sensing point I. Across these network elements are two test points, A and B. In figure 1, test points A and B are open circuit, therefore, only a horizontal voltage vector would appear on the scope. Zero current would be flowing as sensed at point I and the resultant equivalent voltage at the vertical scope plates would be zero. On the high and medium ranges this is represented by a straight horizontal trace from the maximum left to maximum right of the screen. The low range open circuit condition is a diagonal line from the lower left hand corner to the upper right. The test points shorted out will cause maximum current to flow and with zero voltage across them would, therefore, be indicated by a vertical trace from top to bottom, as shown in figure 2. This is true in all ranges. Pure resistance, in figure 3, across the test points would create both current flow and voltage drop and would show up as a clockwise deflected straight trace. Since pure resistance is always a linear electrical element, the resulting trace will always be a straight line. Non-linear electrical elements never give a straight line over the entire trace length. A non-linear component such as a semi-conductor junction would allow a large current to flow during the half-cycle when it is forward biased and very little current to flow during the reverse bias half-cycle. Also, the voltage drop across the junction in the forward biased condition would be small, i.e., .7v for a silicon junction. This would appear as a near short during the time of forward bias and would cause a vertical trace to appear during that portion of the cycle. The reverse bias condition would cause very little current to flow with a large voltage drop and would look like a horizontal trace on the scope (see figure 4). A basic circuit representation of the signal section of the Tracker is shown in figure 5 with a diode across the test terminals. During the half-cycle when the horizontal end of the transformer secondary is negative, the diode is reverse biased with very little current flowing through the transformer secondary and the resistor. The vertical end of the secondary is close to ground potential because of the resistor and a very small voltage appears at the vertical plate of the CRT. Since the impedance across the horizontal end of the secondary is very high relative to that appearing across the vertical end, most of the secondary voltage will appear at the horizontal end. During the next half-cycle the horizontal end will go positive and the diode will clamp at approximately .7v for a silicon diode. Current will flow through the resistor creating a large voltage at the vertical end of the secondary. The voltage which appears across the resistor is a direct representation of the current that flows through the diode. Actual circuit design is such that the test signal is voltage and current limited in all ranges to prevent damage to the component under test.

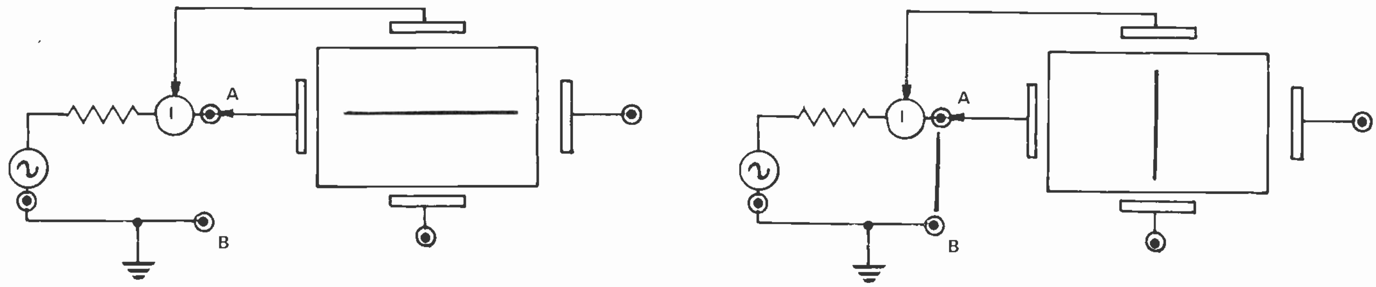


Fig. 1,2. How the Tracker works. See text for explanation

Trace Interpretation

As a general rule, traces should be straight with sharp angles. Curved traces or rounded angles where they should be straight are indications of leakage. Trace flagging, jitter, glitches and offsets are also signs of junction breakdown.

Troubleshooting With The Huntron Tracker

Both analog and digital devices may be tested with equal ease in or out of circuit. When testing in circuit no circuit power is applied, thus making it possible to test printed circuit boards without the use of a test fixture, extender cards or cables, etc.

The "MEDIUM" position is most commonly used to check ICs, transistors e-c, zeners, etc. The test voltage in this range is sufficient to turn on most devices. What appears to be a short in medium may in fact just be an impedance below 1000 ohms and too low for this range. A check in low should be made before assuming a short exists.

The "HIGH" position may display extra junctions in some ICs that cannot be seen in medium due to the higher test voltage applied in high. For the same reason, high should be used to test high voltage devices and zeners which will not reverse fire in medium.

circuit under test, measure voltages or trace signals using an oscilloscope, by all means do so. When a suspected defective component has been found it can be tested quickly with the Tracker, in most cases without removal from the circuit.

In some cases it is not possible to power the circuit under test for a variety of reasons. When power is applied a fuse may blow or a circuit breaker will open. Components may overheat and smoke and power should not be applied under these circumstances. The technician may have little or no idea where the defect is located. Something there is no circuit

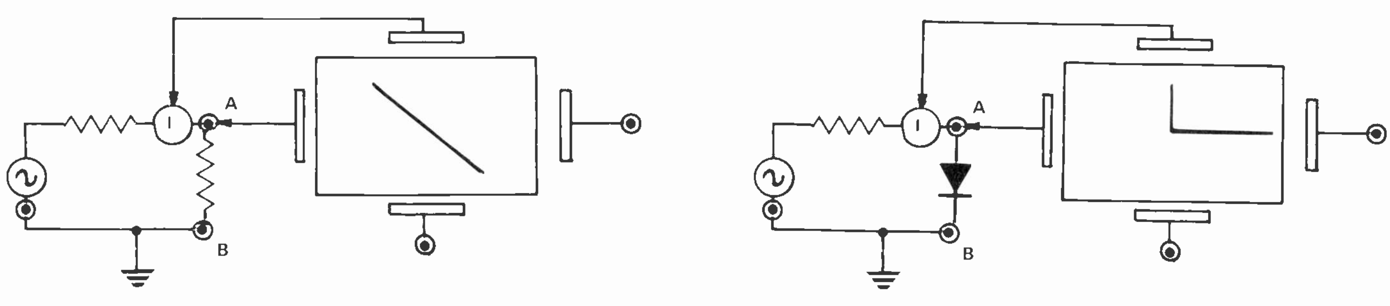


Fig. 3,4. How the Traker works. See text for explanation.

Selecting The Proper Range

In the "LOW" position, a low impedance device may be tested in or out of circuit. Even with parallel resistance of 10 ohms a useful signature may be obtained. This range does not supply a high enough test voltage to forward bias more than one PN junction and will therefore NOT give a valid signature when testing several junctions in series or testing analog and digital chips. Transistors from emitter to collector are also too high impedance for the low range. It will, however, show shorts from IC pins to substrate and pin to pin. Base punch-through and e-c shorts in transistors may also be seen in low.

Obviously, if the test voltage required by the device under test is beyond the range of the Tracker even in high, no useful information will be learned. An example would be a 100 volt zener. It is impossible to cause it to zener. Any impedance below 1500 ohms will look like a short in this range.

Testing Procedure

The Tracker is very useful when used in conjunction with other troubleshooting methods. Since the name of the game is to efficiently isolate the defective component (s) in a circuit, any method, or combination of methods, which accomplishes this end should be used. If it is possible to power the

information and he does not know how the circuit is constructed or how it works. The Tracker can be invaluable in these cases because it does not rely on circuit operation to test components. A number of methods of attack exist using the Tracker alone.

(1) On PC boards, start by running the edge connector with reference to a common point such as ground. Look for any unusual signature in "LOW", then "MEDIUM", then "HIGH". This could quickly lead you to the fault if it shows up at the edge connector.

(2) All discrete components like transistors, diodes, etc., can quickly be checked in "LOW" because other components in the circuit will have

little or no effect on your readings

(3) All chips can be checked by referencing to Vcc or ground and running the pins of each chip. If reference to ground fails to show a fault, change to Vcc and run the pins again. A fault will occasionally show up with one reference and not the other. If running the pins referencing ground or Vcc does not show a fault, try testing between pins, i.e., between inputs, or inputs to outputs, etc.

(4) Comparator testing of identical boards or circuits often locates the fault quickly. It should be kept in mind, however, that chips from different "batches" or from different manufacturers MAY have different signatures.

Digital Circuits

Testing common bus circuits can be difficult since the faulty signature will show up on every chip tied to the bus. The defective chip can somtimes be located by carefully looking at all pins of the chips concerned. Often one chip will show more faulty signatures than the others. If this examination does not locate the faulty chip, desolder each pin on the bus one at a time to isolate it, then retest.

Remember that digital circuits use either "saturated" logic or "near saturated" high speed logic. One may well find curvature indicating "leaky" devices which, when replaced, do not correct the fault. Since we are turning things "off" and "on" very hard in digital circuits, a little leakage may not cause a circuit to fail.

Leaky devices should be replaced because they will not get better with age, only worse, and are likely to cause a failure in the future. Leaky devices may be involved if you are "dropping bits" or have a timing problem.

Testing MOS and CMOS chips may be done by referencing to Vcc or ground but the horizontal portion of the signature is usually quite small and it is difficult to see faults. It has been found that faults can be located more quickly by using the following method:

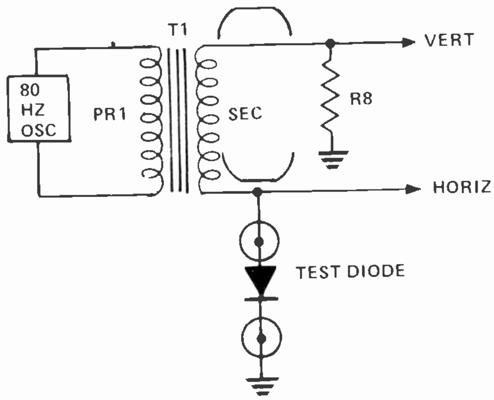


Fig. 5. Simplified diagram of the Huntron Tracker.

i) Short out Vcc to ground by placing a clip lead across Vcc to ground. Do not use this point as the reference. Use an input or output pin on the chip being checked as the reference and check between inputs or input to output, etc.

ii) MOS and CMOS chips can be tested out of circuit since the Tracker will not damage them, however, there is always the danger of static discharge damaging the chip. Here again, the best method is to short out Vcc to ground and check between inputs, input to output, etc.

iii) LSI and VLSI chips such as CPU's can be checked the same as any other chip. All addresses should look identical and all data ports should look identical. Tests should first be made using Vcc as a reference and if nothing unusual is found, use V_{DD}, then Vss (ground). Keep in mind these chips are so complex that a closed-loop fault may exist which does not reflect itself to the outside world. In this case the Tracker would fail to indicate the chip to be faulty. It has been our experience most chips will generally suffer a catastrophic failure that does reflect to the outside world.

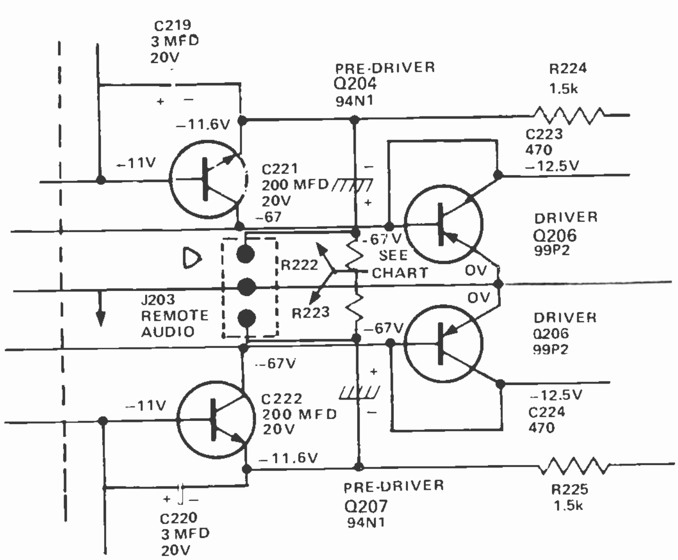
Analog Circuits

In testing analog circuits the same general procedure should be followed as with digital. Usually low is the best range because of the large number of low impedance devices used. In many instances a comparator circuit is not necessary because a duplicate is available in the unit under test. A good example of this would be a stereo amplifier such as shown in figure 6. The pre-drivers, drivers, output transistors and other components can be compared one channel to the other, i.e., Q203 and Q204, Q205 and Q206, D201, C227 and C228, etc.

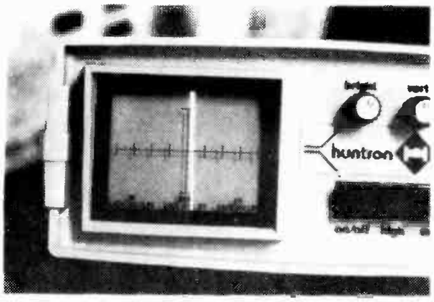
The Tracker should be used to screen new components before insertion in the circuit. How many times have new, but defective, parts been used as replacements? Many hours can be spent trying to resolve these situations.

Both "novice" and "old hand" technicians will find this instrument extremely useful. The novice will produce results even though his experience is limited. The old hand will be able to combine his long experience and technical knowledge to quickly solve problems. As was stated earlier, the Tracker gives the technician a new way of doing things. ●

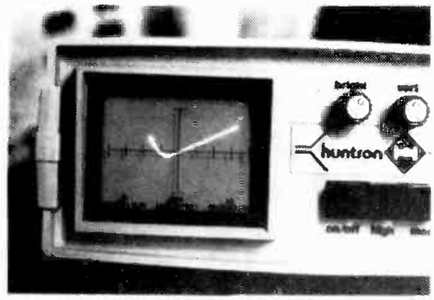
Fig. 6. Testing stereo amplifiers is easy, since the technician usually has an identical circuit to make comparisons with!



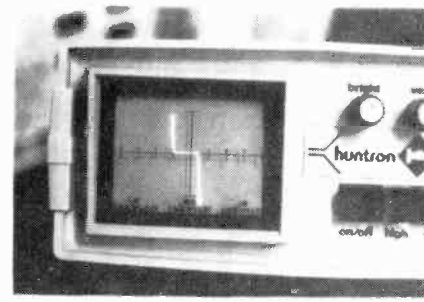
WHAT YOU SEE



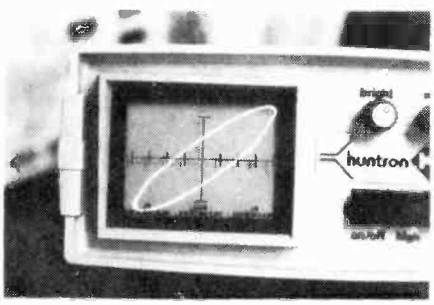
"LOW" range, transistor emitter to base, bad trace, shorted.



"LOW" range, transistor emitter to base, bad trace, leakage.

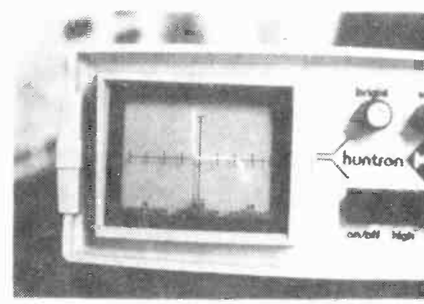


"MEDIUM" range, 7400 quad NAND gate, pin 14-1 (VCC to input) good trace.



"LOW" range, 50mfd capacitor, good trace.

"LOW" range, 50 mfd capacitor with power diode in parallel, good trace.

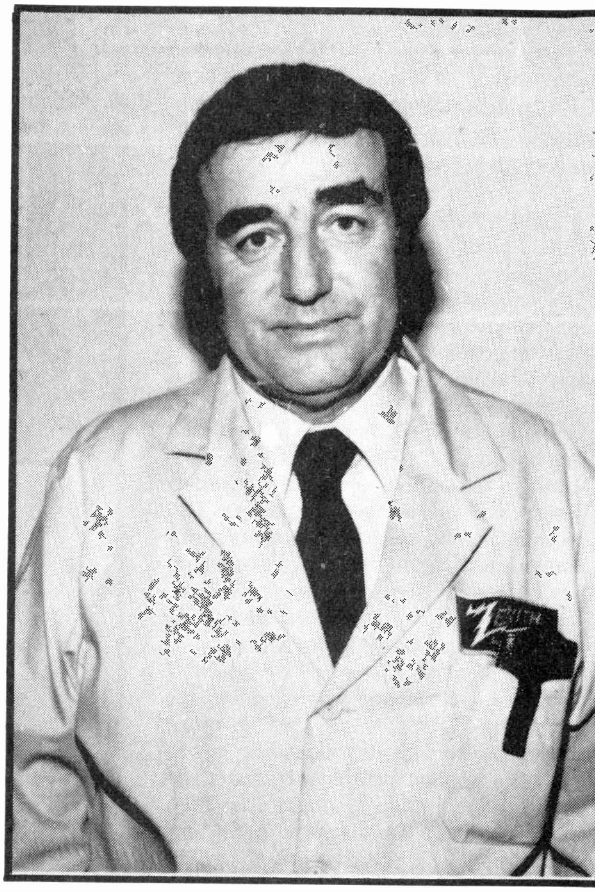


"MEDIUM" range, 7400 quad NAND gate, pin 14-3 (VCC to output), bad trace, leakage.

Circle No. 14 on Reader Service Card.

Updating–is it Necessary?

Today's technician faces changes in state of the art and even changing products. Should one try to keep up? George Hess, Technical Training Manager of Zenith Radio Canada Ltd. thinks so.



George Hess of Zenith.

AS I SIT here planning the training program for the coming year, the full impact of the rate of technological change as it applies to our industry becomes increasingly evident. Unlike the change from radios to black and white and finally colour T.V., or the component utilization from tubes to solid state, the change to digital technology will totally revolutionize our industry. Both from the standpoint of reliability and service methodology, this new state of the art will prove very challenging.

The transition to both black and white and colour T.V. did not require a basic change in diagnostic procedures. A television added a visual image to the existing audio, but the circuitry utilized was very similar to that used in radio, i. e. electron tubes either diodes, triodes or pentodes etc. Therefore a D.C. voltage analysis would determine if a particular stage was inoperative or not. Secondly, since these units were basically hand wired component substitution would work when all else failed. This same situation applied when we got into discrete solid state components.

Our Changing Times

With the advent of IC's, printed circuitry, and finally digital technology, new diagnostic procedures will be required. There are several reasons for this. First of all component replacement has virtually reached the point of redundancy with printed circuit boards, and I.C.'s. Secondly a D.C. voltage analysis of a digital circuit proves of little value to a technician who has little or no understanding of the circuit function under test. Therefore the days of the parts changer are numbered.

The reliability of electronic equipment has been greatly enhanced and so the amount of service required per unit will decrease in the future. There are two main reasons for this. First of all solid state circuitry removed both the heat factor, and failure due to lack of thermionic emission. Secondly the use of digital circuitry removed the need for mechanical switching in all its various forms. This decrease in the per unit serviceability needs in the electronic home entertainment industry will require the technician to diversify. For example a service centre specializing in colour T.V. service only may find it difficult to remain a viable operation in the future. Therefore, new areas of service within the home intertainment field will be required to fill the gap such as the new video equipment and various other forms of T.V. accessories.

New Fields

A very lucrative new servicing field is now appearing on the horizon, that of the mini-computer. The need for servicing these units on location down to at least the board replacement level will be very real. This will require a general knowledge of computer technology sufficient to allow the technician to catagorize failures as hardware, software, program or operator. In short the industry is changing. The choice the technician must make is whether he wants to stay current or be left behind.

The cost of up-dating in terms of lost wages, and or profits should be considered a normal business expense much the same as the telephone, heat, or cost of new equipment. Moreover the lack of understanding of all the new technology being introduced into the industry will result in inefficiency, which in turn will result in higher prices to the consumer and lower profits to the repair industry as a whole. Perhaps dusting off the old text books and spending hours trying to understand new concepts does not strike a pleasing note, but such are the prospects for the coming decade. ●

Digital Test Gear

Norman Furness of Atlas Electronics describes some of the latest equipment designed to make servicing easier.

The Hewlett-Packard 5004A Signature Analyser.

Signature Analysers

THIS HAS NOTHING to do with the John Henry on your cheque! The largest single factor that looms in the minds of most servicemen is the mystery of the microprocessor. Where and when will the application of these devices end? We have seen them applied to T.V. tuners, Microwave ovens, Washing machines, Dryers, consumer telephone products, video games and in Home Computers. The servicing of these items becomes more and more difficult with the continuing rise of products based upon the microprocessor and the increasing inventory investment in "floating" modules.

The "floating" module or board – swapping concept of servicing is becoming more and more uneconomical as product is made available to the public. In fact, the central repair depots report that 60% of all returned boards were in perfect working order! This means that 60% of the repair "float" is unnecessary investment. Quite a large sum of money to be wasting away!

The problem of field servicing equipment that is microprocessor based, has been in having instrumentation that is economical to purchase and uncomplicated to use as well as providing the user with a speedy way of locating the problem component.

A microprocessor, or any digital system, consists of a series of inputs, or address terminals, and a series of output terminals. For a particular input, or address, function, the outputs will follow a logical course of events and give a final result dependant upon (a) the input function and (b) an internal clock function (if used). An instrument has been developed which injects a known digital signal (algorithm) into the inputs of the microprocessor. VCC, GROUND, STOP and START functions are provided as well as a CLOCK function.

The algorithm is injected repetitively so that the output will always produce the same digital "signature". By using a probe to detect this signature, a hexadecimal number (a 4 digit number comprising letters and numbers) appears on the LED display of the SIGNATURE ANALYSER which may be compared with the "signature" of a "good" microprocessor. The hexadecimal signatures may be introduced on to the schematic diagram of the microprocessor at the time of manufacturing and production of the service manual.

There are presently two signature analysers on the market – the H - P 5004A and the B & K Dynascan model SA–1010. Since both of these instruments are designed to produce the same algorithm and to detect the

Signature Analyser Model SA-1010 from B & K. Service engineers will have to become familiar with this type of test equipment in order to cope with circuitry in many of the latest consumer electronics products.

signatures by the same decoding techniques, some form of standardisation in signature analysers does exist. Thus if a manufacturer has designed the hexadecimal signature system based upon the H-P 5004A, it will be identically formed on the B & K SA and vice-versa.

The signature analyser has been designed so that a bad component may be quickly and easily traced, even by servicemen with a limited knowledge of digital techniques. After all, if the numbers aren't right, the component must be wrong!

On existing equipment, where no signatures have been recorded on the circuit diagram, the "good" boards may be quickly examined and signatures allotted to the various node points of the digital signals. If the microprocessor should fail, the signatures may then be compared with the previous "good" results and the faulty component quickly located.

The purpose of producing the signature analyser has been to supply the service technician with a low cost fault finder for today's low cost microprocessor based equipment.

Logic Analysers

Strictly speaking, these instruments are intended for the testing of logic systems during development and production and production of new devices.

Using a concept of storage oscilloscopes, the logic inputs are displayed on a CRT or oscilloscope. A comparative logic pattern may be chosen in a '1' '0' or 'DON'T CARE' configuration from a bank of switches. The switched logic pattern is then compared with the device under test. The number of Logic Analysers on the market are many, some with included CRT displays, companion CRT units or for use with a dual trace oscilloscope.

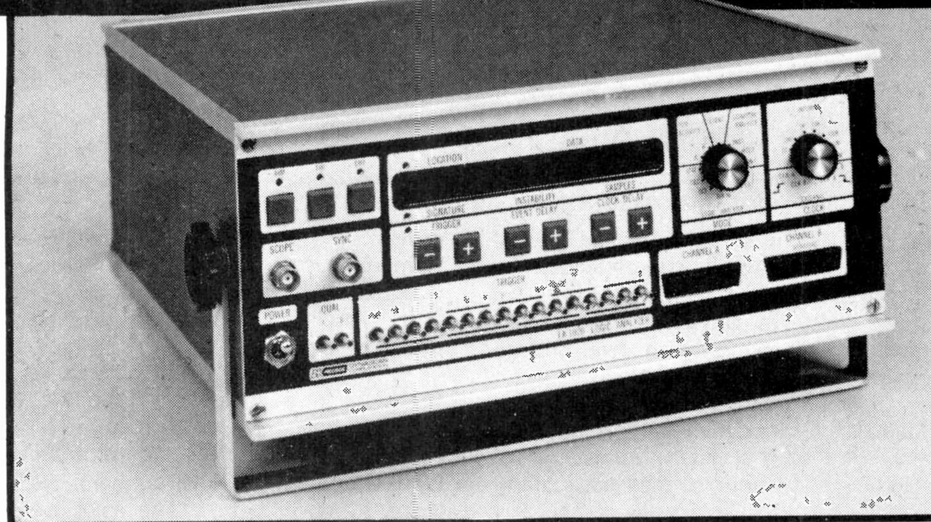
The versatility of these instruments make them capable of developing language in HEX, OCTAL, ASCII, whilst some analyser even disassemble machine code captured from a data bus into machine language mnemonics. The interpretation of logic analyser requires considerable skill and they are not recommended for field service work.

Oscilloscopes

Obviously, with the increase in digital equipment and microprocessor based devices, the service oscilloscope has undergone some drastic changes.

The dual trace oscilloscope has proved to be the best kind of instrument for a wide range of applications and the new digital equipment has demanded that the frequency range (or band width) of oscilloscopes be pushed further up the scale. For ease of comparison in digital circuitry the four trace, dual time base 100 MHz oscilloscope is now making an appearance at the service level. The B & K Dynascan Model 1500 has a rise time of 3.5n Secs. with selectable 1 Mohm or 50 ohm input impedances. Together with selectable sensitivity of 1 mV per div at 30 MHz to 5 mV per div at 100 MHz, this low cost oscilloscope is well within the reach of the computer serviceman with a performance to equal the top of the pile scopes.

Summing up then, the new developments in test equipment is geared toward the increasing demand for a simpler method of repairing digital equipment. Innovations and increasing accuracy of tried and trusted instruments will make their appearance throughout the coming year but new developments will be in the digital service market place. ●



The B & K Precision Dynascan LA-1020 Logic Analyser is basically intended for development work. The interpretation of tests requires considerable skill.

Service News

Dick Cartwright returns as a guest columnist.

WHEN GEORGE HESS called to say that his article was complete (elsewhere in this issue) I was delighted to have the opportunity to go to Zenith Radio's head office on Islington Ave. and to renew old friendships.

Glen Andrews, the National Service Manager, George and I sat and discussed the state of the service industry as a whole. They both seemed particularly concerned with the apathy on the part of many of the practising electronic service technicians of this Province regarding the necessity to upgrade their technical knowledge, and as George stated so clearly in his article, the days of tube jockeys and/or parts changers have just about come to an end. These two gentlemen think that not only upgrading but diversification into new fields of electronic servicing are absolutely essential if the technicians or their employers are to survive with today's new scientific advances.

It was an extremely enjoyable chat and all the more satisfying to me as I had expressed this same opinion in an article written some 18 months ago for ETI.

Before I left, George gave me details of a home study course prepared by their relatively new subsidiary, Heathkit. The information contained in the first part, entitled "Digital Techniques", is essential for today's practicing technician. The second part entitled "Microprocessor" will be equally essential in the very near future. Particulars, including costs, etc., are as follows:

Digital Techniques.

EES–3201 Program with Kit Trainer	$229.95
EE–3201 Program, Text Only	$114.95
ET–3200 Trainer Kit only	$129.95

Microprocessor

ETS–3400 Course and Trainer	$459.95
EE–3401 Course without Trainer	$149.95
ET– 3400 Trainer Kit Only	$349.95

I had the opportunity of examining some of the materials, including the trainer kits, and I personally am most impressed.

Quick Change

On January 12 and 13 Zenith held their annual New Year Open House. As usual their products were most tastefully displayed, with adequate staff there to answer queries (and of course take orders). The catering by the noted Chinese restaurant, Lichee Gardens, was, as one would expect, absolutely first class. (The barmaid was very pretty.)

From the serviceman's point of view the highlight of the whole thing had to be the finals of their picture tube changing competition. Approximately 20 technicians (regional winners) were there to participate. The rules were extremely rigid. The receivers used were identical 20" portables. The only tools allowed were supplied by Zenith, and again each set was identical. Time was to be the deciding factor, but the quality of the picture produced by the receiver on the completion of the picture tube change had to be completely satisfactory as regards purity, focus, convergence, etc.

When all competitors had finished, the technician was then asked to remove the back of the receiver again (the judges noting that all screws were in place). The judges then examined the mounting hardware to ascertain that all mounting screws, brackets, clips, etc. were in place. Disqualification would follow if they were not.

I unfortunately was only able to watch the first day's competition but I must admit to being most impressed at the speed with which these tubes were changed, and also the overall quality of the end result.

My heart bled just a little for the technician who inadvertently dropped a screw into the guts of his particular receiver - he looked, he probed, and finally in desperation picked up the set and shook it - eventually the screw popped out and he was able to complete. Also, for the serviceman who was far ahead of his nearest rival, replaced the back, all screws in place, and suddenly realized that he had done what all of us have done at sometime or another - he had forgotten to hook the tuner to the antenna terminals on the back of the set. All in all, it was a great show and a credit to this wonderful company.

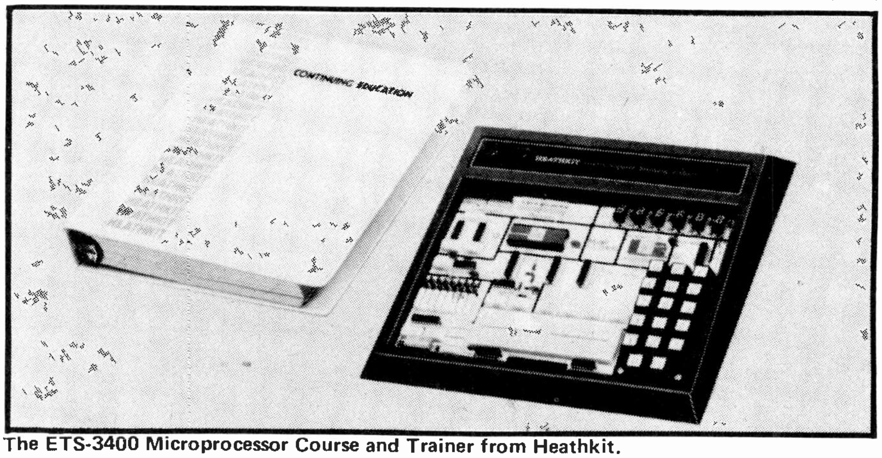
The first prize was a trip for two to the Bahamas. It was won by Rick Jones of Jones Electronics, Norwich, Ontario. His time was an incredible 8 mins. 50 secs.

Congratulations, Rick!

Warranties.

Considerable controversy has been stirred up in the latter part of 1980 by Zenith's introduction of their 3-year Stay-at-Home Protection Plan, and the powers-that-be have asked me to investigate. The warranty is self-explanatory. Herewith a faithful copy: *"Under this Protection Plan, if during the first three years of ownership your Zenith System 3 - 20" or 26" television receiver should fail to operate properly and cannot be repaired in your home, Zenith Radio Canada Ltd. will replace it with a comparable new Zenith System 3 television receiver at no additional cost to you. (The 20" and 26" screen sizes are those sizes serviced in-home under existing warranty programs, which remain unchanged.) If such replacement is necessary, Zenith Radio Canada Ltd. will make every effort to supply a comparable Zenith System 3 - 20" or 26" television receiver. However, Zenith Radio Canada Ltd. reserves the right to substitute a substantially similar Zenith System 3 television receiver. Final decision as to comparability or substantial similarity will rest solely with Zenith Radio Canada Ltd. Replaced television receivers become the property of Zenith Radio Canada Ltd.*

"This Protection Plan extends to all repairs or service of Zenith System 3 - 20" and 26" television receivers



The ETS-3400 Microprocessor Course and Trainer from Heathkit.

purchased on or after June 9, 1980 and on or before May 31, 1981 except cabinet repairs or cosmetic repairs. Neither 14" or 18" portables (carry-in-service models) are covered by this plan."

I discussed this new warranty with a number of independent service companies, both big and small, and many seemed to be completely unconcerned, but a few felt that it could in the long run cause them a not inconsiderable loss of income. In order to understand fully Zenith's thinking one has only to pay attention to that part of the warranty which states that only sets which *cannot* be repaired in the home will be replaced. Remember that Zenith have advertised that the Triple-Plus Chassis in every System 3 is 100% modular. This design is more costly to manufacture than competitive singleboard chassis, but they feel that the benefits to the consumer make the added cost a worthwhile investment. Furthermore, any servicing that may be required, can, with only *rare* exceptions, be accomplished readily in the home.

A few years ago such a warranty would have been incomprehensible, but now with the new technology such warranties may soon be commonplace.

From the consumers' point of view this Protection Plan is bound to influence their choice of set, as it shows an incredible faith in their product on the part of Zenith Radio Canada Ltd., and I don't doubt that other manufacturers will be forced to follow.

How fast can you change a color TV picture tube, including purity and coverage, Would you believe under nine minutes?

From CEASA (Canadian Electronic and Appliance Service Association).

Thanks to CEASA for permission to reprint the following editorial from Service Contacts, the Association's quarterly publication:

"Over the past year we have heard it said that the small independent service shop is doomed - finished - because the large service companies are selling service contracts that syphon away 'demand service' business. There is also the complaint that "manufacturers are making their products more complicated with an endless variety of peculiar parts. Although products fail less frequently, they are more difficult and expensive to repair. Models and features are changing so rapidly that technicians are hard pressed to keep up with the changes. As a result, the small independent service business is 'under the gun'." Today we also hear a lot about inflation, the high cost of energy and the economic squeeze, but this situation isn't peculiar to today's business climate. In business there is always an economic squeeze going on. It appears there is always something 'fouling up the works'.

"In business it is essential that you compete to stay alive and healthy. In order to compete, you must change with the times. Conditions are changing so rapidly in the service business that we hardly get a handle on one situation before we are faced with another. Look at the technical changes that have occurred in the last decade. Electronics have gone from tube circuits to transistors to integrated circuits and now to computers. Major appliances have 'frost free' and two temperature refrigerators, microwave ovens and microprocessor controls. All these changes have placed a burden upon the service technician to deep up to date with the technology.

"At the same time the economy has been changing right before our eyes. You may not have noticed but the economics of a service business is different today than it was just a year ago. But you can't find your cost of doing business by simply adding up the expenses. Although figuring out your costs isn't complicated it isn't that simple either. It requires some thought and constant monitoring. It required 'feedback' in order to make it function. The feedback comes in the form of 'Profit and Loss', budget and inventory statements.

"If you haven't made out a budget forecast for the coming year, do so now. Set up a Monthly Profit and Loss Statement that shows all of the costs and revenues so that the *real* direction of your business can be seen and the necessary adjustments made quickly before costly losses occur."

Bill White,
General Manager.

Murphy's Laws (from Service Contacts).

* Nothing is as simple as it seems.
* Everything takes longer than it should.
* All warranty and guarantee clauses become void upon payment of invoice.
* Firmness of delivery date is inversely proportional to the tightness of the schedule.
* An important service manual or operating manual will have been discarded by the receiving department.
* Any wire cut to length will be too short.
* Identical units tested under identical conditions will not be identical in the field.
* The availability of a component is inversely proportional to the need for that component.
* If a project requires N components, there will be N-1 units in stock.
* A dropped tool will land where it can do the most damage.
* Probability of failure of a component, assembly, subsystem or system is inversely proportional to ease of repair or replacement.
* A transistor protected by a fast-acting fuse will protect the fuse by blowing first.
* Nature always sides with the hidden flaw.
* If everything seems to be going well, you have obviously overlooked something.

Sony of Canada Service Department.

On this somewhat humorous note, I would like to take this opportunity to wish you all a belated but Happy and Prosperous New Year. ●

Best of luck.

Richard H. Cartwright.

SHARK!!

Shark game brings you the sun, surf and sand. All electronic; add absolutely no water! This project originally appeared in Hobby Projects.

OVERTIRED, TENSE, NERVOUS HEADACHE? Then this is the game to really send you over the edge. Featuring fingertip control, it is the ideal toy for the squeamish, hydrophobics and non-swimmers. It takes the shark out of water and the mess out of being devoured.

The top panel has two columns of ten LEDs leading to a tropical island. One LED lights in each column to indicate the swimmers' progress towards the safety of the island. Two push buttons are mounted, one either side of a central LED which represents the shark's fin. The power switch, reset button and 'lose' alarm are mounted on the small front panel while a PCB accommodates most of the other components.

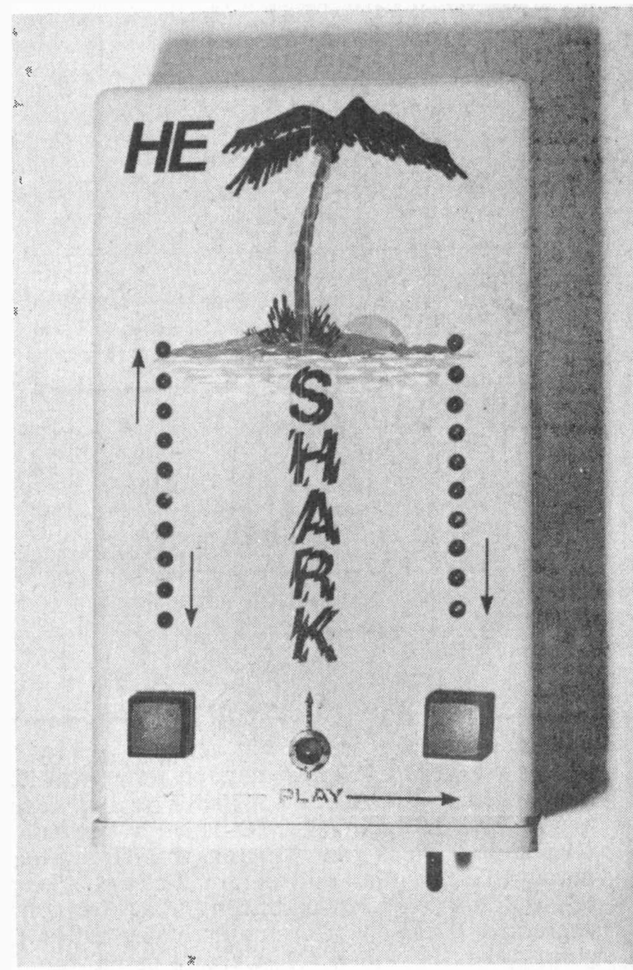
A Bigger Splash

To play, after pressing reset, each player must depress his pushbutton switch for as long as possible while the single 'shark's fin' LED remains lit. This causes his swimmer to appear and begin moving towards the island. Short depressions or failure to play at all will result in that swimmer moving only slowly or not at all. A depression while the LED is extinguished causes the swimmer to slip back towards the shark.

The winner of the game is the player whose swimmer first reaches the safety of the island when the 'lose' buzzer will sound for his opponent and both columns of LEDs will light, the highest indicating the winner.

What! No Chips?

It has often been remarked that most electronic games can be reduced to one; find the 4017. It is true that this chip has been overused and we are pleased to say that this game is an outstanding exception. Featuring a hybrid mixture of analogue and digital circuit techniques it is based on the LM3914. This little known chip from National is an LED dot/bar bargraph display driver and comes in an eighteen pin DIP package. It is very simple to set up and use. LED display current and full scale range are programmable by selection of a couple of resistors and individual constant current outputs remove the need for limiting resistors and tedious LED selection which was necessary with previous devices of this type. CMOS analogue transmission gates are used to multiplex the two signals to the bargraph chip input. This keeps the unit's cost down without sacrificing performance or increasing circuit complexity too much. Any size and colour of LEDs may be used. We used miniature green for one column and red for the other with a yellow standard 0.2" LED for the shark fin. The driver chip sinks about ten milliamps through each LED.



The case for Shark was made from a Vero box, the artwork on the case makes it look very attractive.

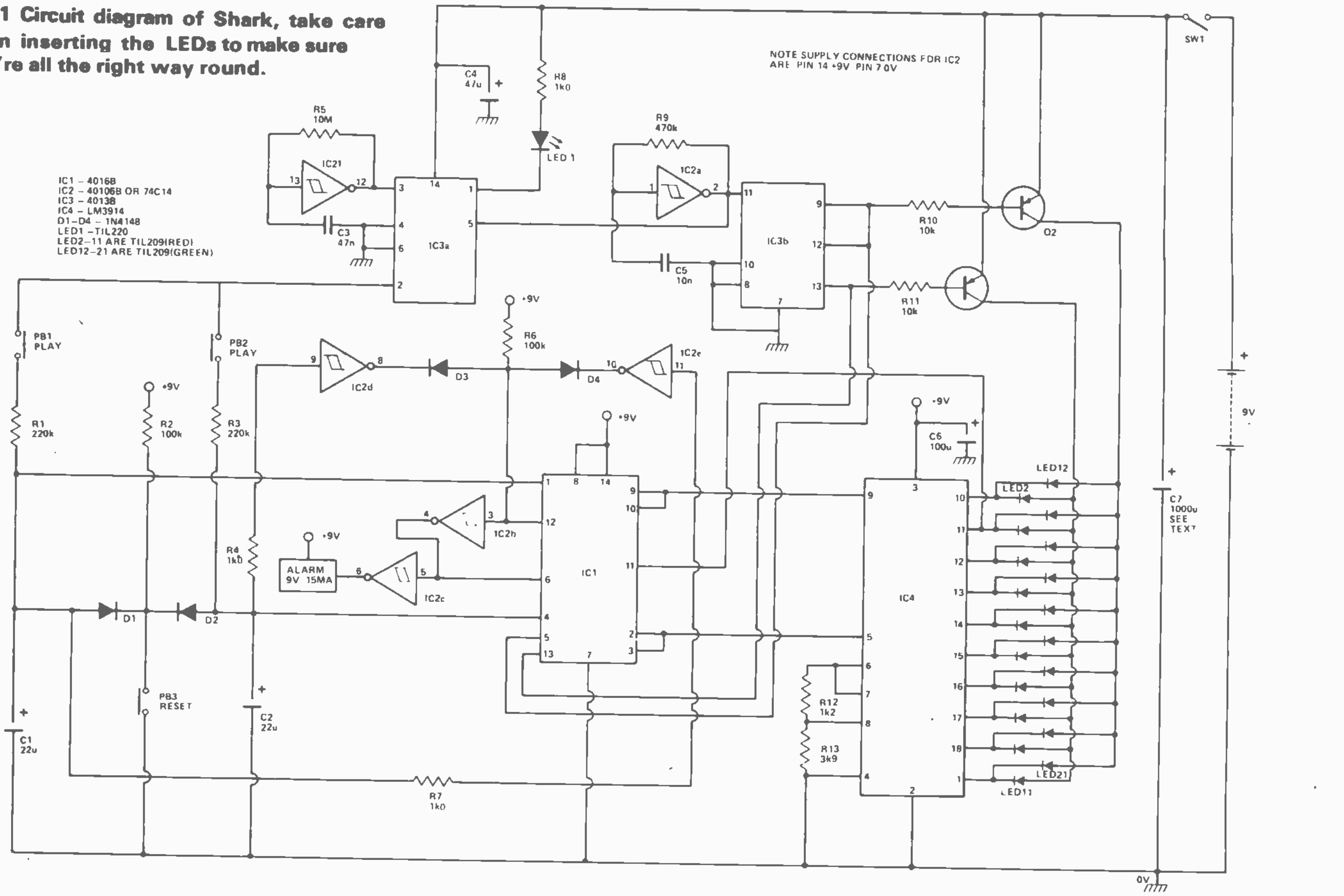
Construction

Construction of the game is greatly simplified if our PCB is used. As the components are closely packed on the board, the PCB tracks have to be made quite thin, so take care when soldering that no excessive heat is applied to any section of the board.

Begin construction by inserting all vero-pins and links followed by IC holders, resistors, capacitors and semiconductors paying attention to the orientation of all polarised components. To allow more space on the PCB, C7 has been mounted off board beside the battery and is held in place by a sticky pad as shown in the internal photograph of the game. The solid state buzzer was glued into position against the front panel of the case.

To complete construction, mount the switches in

Fig. 1 Circuit diagram of Shark, take care when inserting the LEDs to make sure they're all the right way round.

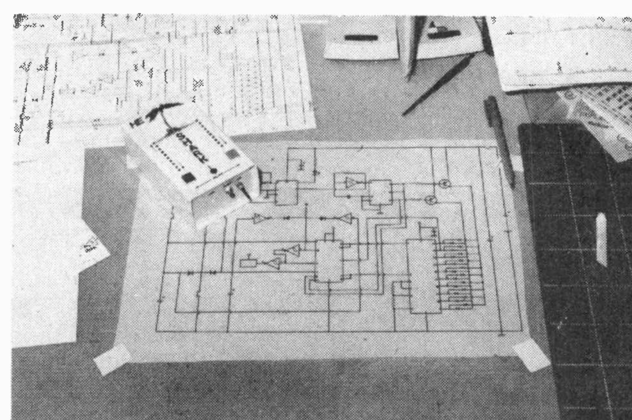


HOW IT WORKS

Each competitor's progress is represented by the charge on C1 or C2. These capacitors are initially discharged at the start of a game by depressing 'reset'. The 'shark's fin' LED is on when the Q output of IC3a is low. During this time the Q̄ output (pin 2) is high and C1 or C2 can charge via R1 or R3 if the corresponding play button is depressed. If the switch remains closed when the output goes low then C1, C2 will discharge. To introduce a degree of chance into the game, the state of IC3a and the 'shark's fin' LED depends on the logic level from fast clock IC2a which is present at the data input (pin 5) during the rising edge of the slow clock signal from IC2f.

IC4 drives the LED displays in dot or bar format according to the state of two of the transmission gates in IC1. These are in turn controlled by the 'OR ed' outputs from IC2d and IC2e and the inverted signal from IC2b. When the voltage on C1 or C2 rises above the transition level of IC2d or IC2e, the display changes from dot to bar mode, one column of LEDs lights and the 'lose' alarm sounds indicating a completed game.

To conserve power and keep construction costs down, the input signals to IC4 from C1, C2 are multiplexed by transmission gates in IC1. These are controlled by the antiphase Q and Q signals from IC3b which also control the LED driver transistors Q1 and Q2. C6 helps to prevent possible oscillations at the output of IC4 while C7 smooths the whole supply and prevents false triggering of IC3.



position and insert all LEDs. It is wise at this point to confirm their polarity. For the Texas TIL 209 series the flat on the body denotes the cathode. Most of the interwiring is concentrated between the LEDs and the PCB so extreme care and attention should be exercised. Flying leads should be taken from the PCB to the case mounted components and the battery fitted. There are no adjustments to make and the circuit should work first time so switch on and swim for your life! ●

PARTS LIST

RESISTORS:

R1, R3	220k
R2, R6	100k
R4, R7, R8	1k0
R5	10m
R9,	470k
R10, R11	10k
R12	1k2
R13	3k9

CAPACITORS:

C1, C2	22μ 10V Tantalum
C3	47n polyester
C4	47μ 10V Tantalum
C5	10n polycarbonate
C6	100μ 10V Tantalum
C7	1000μ 10V Electrolytic, (PCB mounting — see text)

SEMICONDUCTORS:
(All CMOS ICs are 'B' series)

IC1	4016
IC2	40106 (74C14)
IC3	4013
IC4	LM3914
Q1, Q2	MPS6523
D1—D4	IN4148

LED 1 — Standard yellow (0.2" dia.)
LEDs 2-11 are TIL 209 red (0.125" dia.)
LEDs 12-21 are TIL 211 green (0.125" dia.)

MISCELLANEOUS:
SW1 — SPST Min. Toggle.
PB1—PB3, push buttons momentary action
Audible alarm, 9V @ 15mA.
Vero case — Series 2 casebox No. 65-2066A.
9V battery

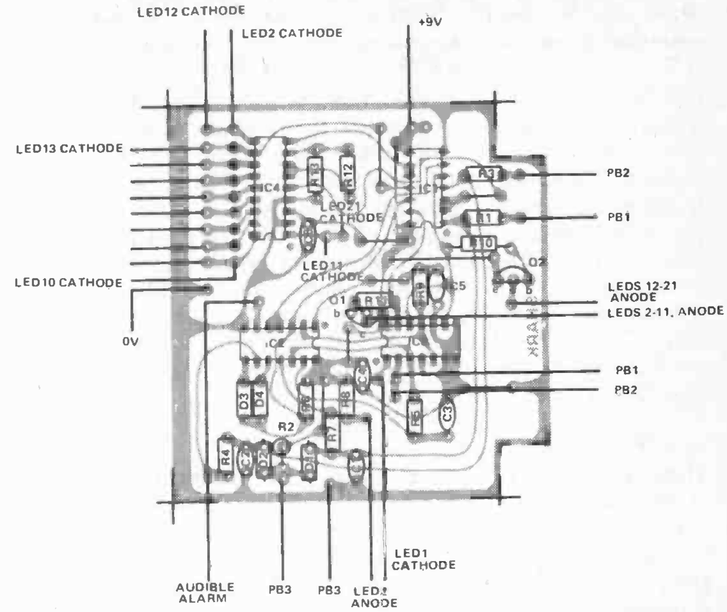
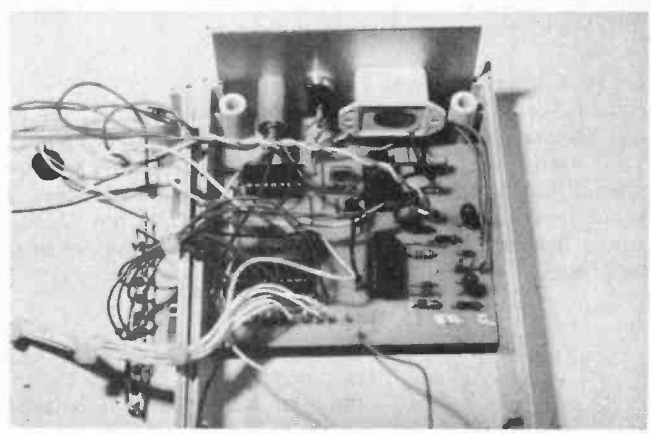
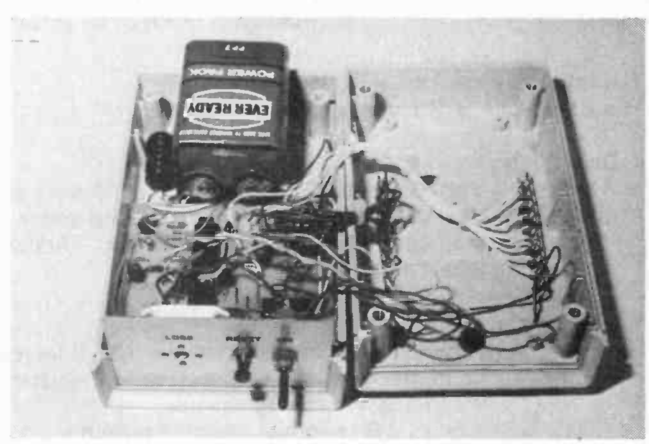


Fig. 2. PCB overlay for Shark. It's a good idea to use IC sockets.



Inside Shark, you can see the buzzer that operates when the Shark. catches the luckless swimmer.



The case of Shark opened for inspection, using a large battery ensures the game will not suddenly die on you. Note C7 mounted next to the battery, using a PCB type makes the wiring easier.

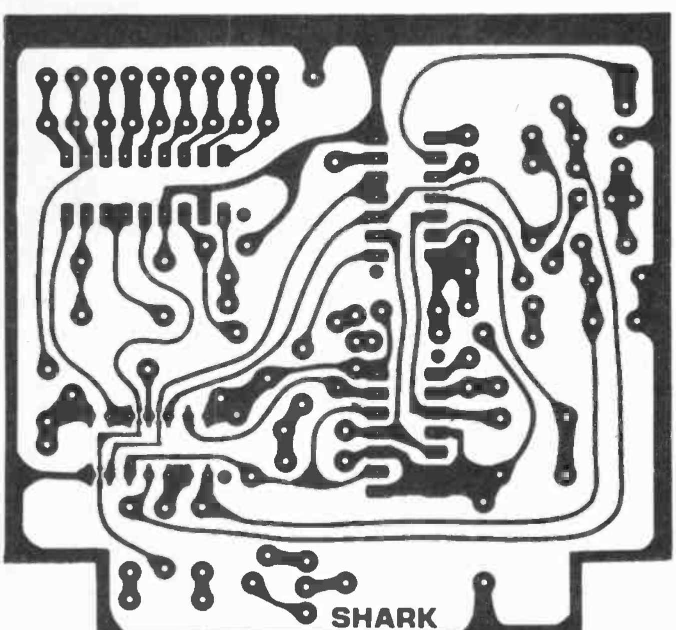


Fig. 3. PCB foil pattern for Shark, using a PCB will lessen the amount of interwiring that has to be made.

INTERFACING MADE EASY

A. P. Stephenson explains the operation of the Motorola MC6821 PIA.

AN INPUT/OUTPUT PORT must provide a versatile programmable interface between the microprocessor and the external system devices (peripherals). Since the "devices" can vary from simple lamps, switches or keyboards to paper-tape readers, punches, visual displays, XY recorders etc. it is understandable that a price must be paid for such versatility. The MC6821 Peripheral Interface Adapter (PIA) is certainly versatile but its architecture and personality reflects the data sheets supplied with it–––cold, logical and aloof. Once this data is deciphered and confidence is gained, the PIA will be accepted as a well designed little box and surprisingly easy to program.

Relationship Between PIA And MPU

There are no special instructions for the PIA because, as far as the 6800 MPU is concerned, it appears as a block of four "memory addresses" which can be read from or written into like any other RAM. These addresses can be chosen arbitrarily when wiring up the system providing they occupy four consecutive addresses. In Figure 1, these addresses have been chosen as 8004, 8005, 8006 and 8007 in order to correspond with the Evaluation Kit (D2) supplied from the makers. The eight data lines of the PIA are simply connected to the MPU data bus as normal and it will be noticed that several control lines are also connected between the two.

External Interface Lines

Except for subtle differences to be explained later, the PIA can be considered as two identical halves, side "A" and side "B", each half having eight data I/O input lines and two special lines used for control or "handshake" purposes. To avoid repetition, discussion will be limited to the "A" side and it can be assumed that the "B" side will behave in the same way.

PA0 to PA7 –– are the data I/O lines any of which can be used as either an Input or an Output depending on how the programmer writes the initialisation routine. Thus we can have say three behaving as Inputs and five as Outputs, a most useful property.

CA1 and CA2 – are the peripheral control lines. CA1 is always an Input but CA2 can be initialised as an Input or an Output.

The Internal Registers

There are three registers in each half:

a. Data Register

This is the buffer between the I/O lines and the MPU data bus and after initialisation is available to the programmer as "Address 8004" (8006 for B side).

b. The Direction Register

It was stated earlier that the I/O lines can be inputs or outputs. The direction register is used to decide this by the rule,

"0" = input ; "1" = output

Thus if this register is initialised with the pattern 00001111 (OF hex) then PA0, PA1, PA2 and PA3 would behave as outputs and the rest as inputs. It is available to the programmer as "Address 8004" (8006 for B side). This is rather surprising because it is the SAME address as the data register!

c. The Control Register

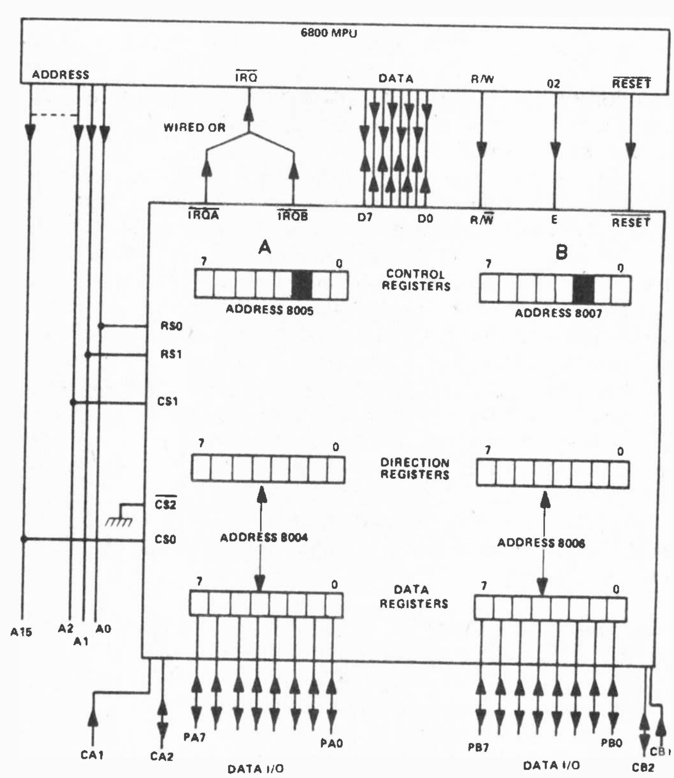
This is the register which causes some anxiety to the newcomer because it is a hotch potch of various bits, each having a separate functional identity. (If it is any consolation, it caused the writer more than anxiety–– apoplexy in fact).

Although full details will be attempted later, only bit "2" is important at this stage (shown dotted in figure 1), because it is this bit which dissolves the discrepancy of two registers having to share the same address.

When bit "2" is 0, the address 8004 belongs to the direction reg. When bit "2" is 1, the address 8004 belongs to the data reg. The control register is available to the programmer as address 8005 (8007 for B side). The remaining bits are all concerned with the behaviour of the control lines CA1 and CA2, a torture to come later.

The allocation of the addresses are cunningly thought out. Under system reset conditions, all registers in the PIA are reset to zeros––which includes the bit "2" in the control register. So the first time address 8004 is used, it will address

Figure 1 The PIA and its relation to the MPU.



the direction register. After this the programmer will ensure that bit "2" is set to 1, so subsequent reference to 8004 will address the data register. It would be most unlikely to have to change the direction register contents in the same program, but if so, it would be necessary to clear bit "2" first and reset it again afterwards.

Connections To The Address Bus

The PIA behaves as four memory locations, so it must be similar in some respects to conventional memory chips in the manner of connection to the main address bus of the MPU. Thus we must expect to find address lines to pick out which location within the chip and other lines which select the chip itself.

There are five lines from the PIA to the MPU address bus, two Register Select lines (RS0 and RS1) and three Chip Select lines (CS0, CS1 and CS2). Note from Figure 1 that RS0 and RS1 are driven by the two lowest order address lines A0 and A1 which ensures that the four internal locations have consecutive address codes.

The chip select lines must ALL be enabled in order to bring the PIA on-line. Thus CS0 and CS1 must both be HIGH and CS2 must be LOW. The arrangement shown in figure 1 is deliberately naive to simplify the appearance for the purpose of understanding the basic ideas behind "chip select". Thus CS2 is shown connected to ground ensuring this line is enabled. CS0 will only be enabled when address line A15 is HIGH and A2 must be HIGH to enable CS1. Taking the four perms of A0 and A1 as 00, 01, 10 and 11, it may be seen (with a bit of mental effort) that the four hexadecimal codes 8004, 8005, 8006 and 8007 are established as active addresses for the PIA registers. Unfortunately, there will be thousands of other address combinations which will also activate the PIA because the twelve wires unused out of the sixteen can be 1s or 0s; thus the address code FFF4 will have the same effect as 8004, so will C004, ABC4 etc etc. Now if the PIA was the only other chip apart from the MPU itself, this wouldn't matter much but of course there would be RAM and ROM chips each competing for a unique band of addresses. However, it is easy to modify Figure 1 to increase the "exclusivity factor" of the PIA addresses. For example, the ground return of CS2 could be replaced by say an OR gate as shown in figure 2.

Only when every input to the OR is a "0" will CS2 be enabled so the range of addresses is severely limited (apart from A12, A13 and A14 which are still don't-care lines). Of course if you have bought a complete Evaluation or Development kit, the foregoing details have all been taken care of but there is always the possibility that an extra or perhaps several extra PIAs are required for a particular project so it is as well to have some familiarity with address decoding principles. Although unlikely, it would be possible to connect say, 1000 PIAs to the address bus which would allow a total of 20,000 peripheral lines to play around with. These would still only occupy 4,000 addresses out of the total of 65,536 possible. One word of warning, if such grandiose schemes are to be considered the poor old address and data buses will require some additional "Bus Driver ICs" to handle the accumulated leakage currents.

Control Lines To The MPU

Enable (E) is the timing control, usually connected to the 02 clock line of the MPU. Even with the correct address lines enabled, the PIA is not viable until the E pulse goes HIGH. (When we later discuss the Control register bits the E pulse level will be found important).

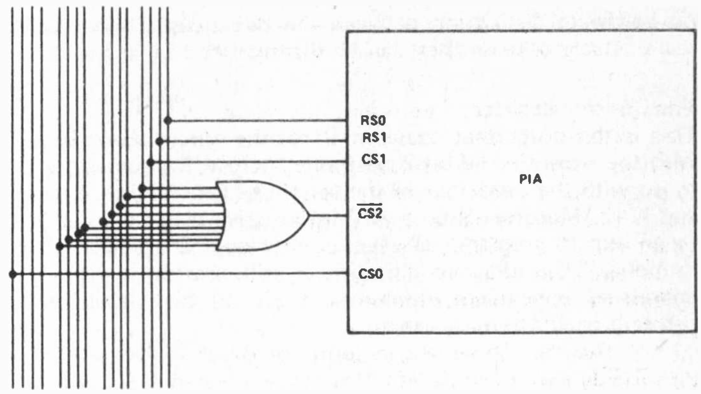


Figure 2 Alternative chip select arrangement.

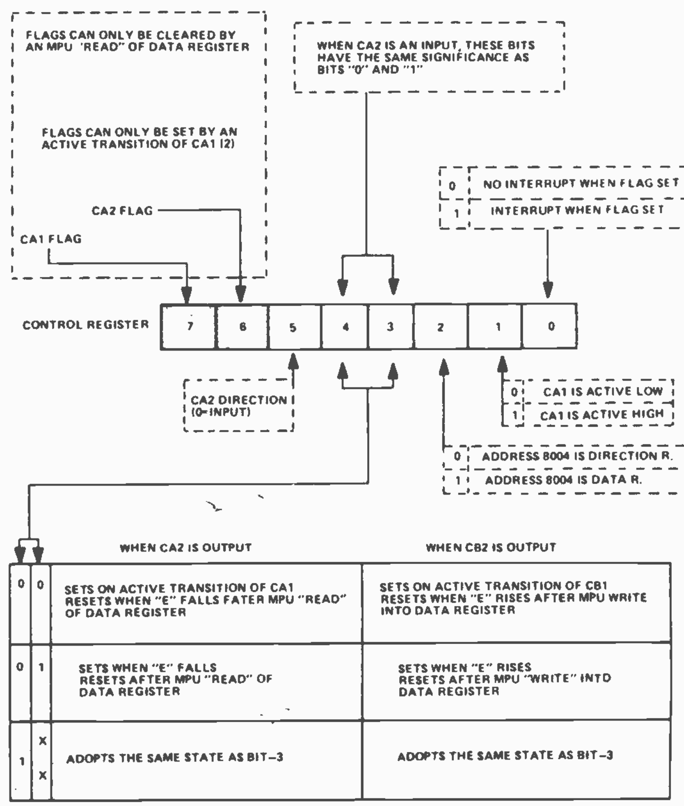


Figure 3 Programming the PIA control registers.

RESET When this is driven LOW, by say a momentary pulse from a push-button, the six registers of the PIA are cleared to zero.

Read/write (R/W) The state of this line decides whether the MPU is reading from or writing to the PIA registers. The "normal" state is HIGH (read) and LOW (write).

INTERRUPT REQUEST (IRQA and IRQB) inform the MPU that a peripheral line is asking to interrupt the present program and cause a jump to another program called the "interrupt routine". Unfortunately, there is only one IRQ input on the MPU which means that the A and B side interrupt requests must be wire-ORed, implying that there is no hardware distinction between the two sides. This is no real obstacle because they can be distinguished by software.

The Control Register
This is the brute that causes most of the misery. Each bit, with the exception of bit-2 mentioned before, has something to do with the behaviour of the peripheral control lines CA1 and CA2. Motorola issue a very informative diagram which, to an expert programmer, reveals all. Figure 3 attempts to "simplify" this diagram although it still presents a rather depressing appearance, requiring a bit by bit discussion before it begins to make sense.

The definitions are in terms of the PIA A-Side but the B-Side behaviour is identical except when CB2 is an output.

a. The two FLAG bits
These are best got out of the way first because these are the only two which cannot be set by instructions in the program. Bit 7 can only be set by a signal from the outside world arriving via CA1; bit 6 can only be set via CA2 (when it is defined as an INPUT).

Once set, they can only be cleared by the next MPU read of the DATA REGISTER Example: if either of the two flags are set, the instruction LDA A 8004 will clear them.

b. CA2 DIRECTION (bit 5)
Bit 5 determines whether CA2 behaves as an input or an output according to the same rule previously encountered with the direction register:

If bit 5 is a 1, CA2 is an output
If bit 5 is a 0, CA2 is an input

c. Interrupt bit (bit 0)
If this bit is 1, when CA1 flag is set the interrupt request signal is activated.

d. CA1 Active-level (bit 1)
This bit decides which EDGE of the CA1 signal sets the flag, according to the rule:

If bit 1 is 0, CA1 is ACTIVE LOW
(flag sets when CA1 goes LOW)
If bit 1 is 1, CA1 is ACTIVE HIGH
(flag sets when CA1 goes HIGH)

This is very useful because some peripheral devices are normally HIGH and go LOW when active, others are opposite in behaviour.

e. Bits 3 and 4 when CA2 is an input
These two bits are very nasty because their function is different according to whether CA2 is defined as an input or an output. When CA2 is an input, they behave exactly the same as bits 0 and 1 except the flag is the CA2 flag. Thus bit 3 will be the interrupt bit for the CA2 flag and bit 4 will determine the CA2 active level.

f. Bits 3 and 4 when CA2 is an output
Figure 3 shows the possibilities. Perhaps the strangest perm is when bit 4 is a 1 because we can imagine that bit 3 is physically connected to CA2. Thus if bit 3 is 1, CA2 is HIGH; if bit 3 is 0, CA2 is LOW. Thus we can say that when bit 4 is held at 1, CA2 will "follow bit 3".

In this mode, CA2 behaves as a 9th I/O output line which can be made HIGH or LOW by programming bit 3 accordingly.

Initialisation Examples
"Initialising the PIA" refers to the few instructions, normally at the head of the program which loads the correct bit patterns in the direction and control registers. The patterns must first be set into a register (accumulator or index register) using immediate addressing and then storing in the appropriate PIA locations. Because the direction and control registers always occupy consecutive addresses it is both convenient and economical to utilise the double length Index Register to kill two birds with one stone.

For example, supposing the pattern 00001111 (OF hex) is to be placed in the A side direction register and the pattern 00000100 (04 hex) in the control register. Assuming the address allocations as shown in Figure 1, the initialisation would proceed as follows:

```
CE 0F 04    LDX #0F 04   (# means immediate address)
FF 80 04    STX  80 04
```

This is easily understood when remembered that when storing the Index Register the higher order byte (0F) goes in the address quoted and the lower order byte (04) in the next higher address. The following examples should be studied:

Example 1
PA0, PA1 and PA3 to be inputs and the remaining five to be outputs. CA1 and CA2 not required.
All eight lines PB0 to PB7 to be outputs. CB1 and CB2 not required.

The initialisation is as follows: 11111000 in 8004, 00000100 in 8005, 11111111 in 8006 and 00000100 in 8007.

```
CE F8 04    LDX #F8 04    A side
FF 80 04    STX  80 04

CE FF 04    LDX #FF 04    B side
FF 80 06    STX  80 06
```

Note: only bit 2 is important in the control registers, the remaining bits are "don't care" so, for reasons of simplicity, are made 0s.

Example 2
PA0 to PA7 to be outputs. CA1 to be active LOW input without interrupt request. CA2 to be active HIGH input with interrupt request.
PB0 to PB7 to be inputs. CB1 to be active HIGH input with interrupt request. CB2 to be active LOW input with interrupt request.

Initialisation: 11111111 in 8004, 00011100 in 8005, 00000000 in 8006 and 00001111 in 8007.

```
CE FF 1C    LDX #FF 1C    A side
FF 80 04    STX  80 04

CE 00 0F    LDX #00 0F    B side
FF 80 06    STX  80 06
```

Example 3
PA0, PA1 and PA2 to be inputs, the rest outputs. CA1 to be active LOW input without interrupt request. CA2 to be

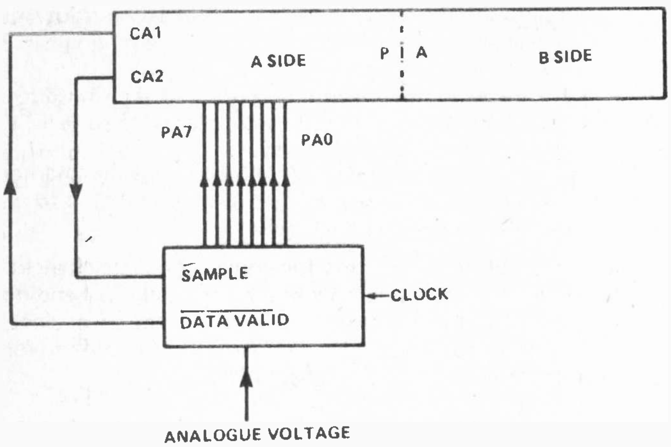


Figure 4 Interface to A/D converter.

output which adopts the same state as bit 3 in the control register.
PB0 to PB7 to be outputs. CB1 to be active HIGH input with interrupt request. CB2 to be output which is set HIGH when the CB1 flag sets HIGH and is cleared after the next STA 8006 instruction.

Initialisation: 11111000 in 8004, 00110100 in 8005, 11111111 in 8006 and 00001111 in 8007.

```
CE F8 34     LDX #F8 34     A side
FF 80 04     STX   80 04

CE FF 27     LDX #FF 27     B side
FF 80 06     STX   80 06
```

Example 4
As example 3 above but assuming it applies to a second PIA with new addresses as follows: A side Direction Register at 6000, Control Register at 6001; B side Direction Register at 6002, Control Register at 6003.

```
CE F8 34     LDX #F8 34
FF 60 00     STX   60 00

CE FF 27     LDX #FF 27
FF 60 02     STX   60 02
```

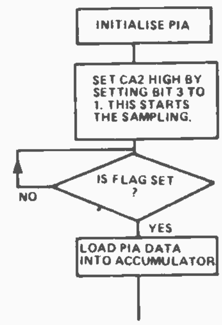
Example 5
To introduce a more practical bias, we shall assume an 8 bit resolution Analogue to Digital Converter IC is to be connected to the A side PIA with interface lines as shown in Figure 4.

Action: On receipt of a pulse to "SAMPLE" (a HIGH), the A/D conversion count commences. When the correct count is reached, DATA VALID goes LOW indicating the digital outputs are truly representing the analogue input voltage.
Assuming interrupt is not to be employed, then it is clear that PA0 to PA7 must be inputs, CA1 must be active LOW and CA2 can be made to follow bit 3 (although the latter is only one of the possible solutions).

A suitable initialisation could proceed as follows:

```
CE 00 34     LDX 00 34
FF 80 04     STX 80 04
```

Note that the initialisation will leave CA2 LOW (inactive). The rest of the program must monitor CA1 flag bit and set bit 3 HIGH again after the valid data has been read from 8004 into one of the accumulators. The following flow chart may be useful in appreciating the overall scheme:



How can we tell if the flag is set? By loading the control register into an accumulator and testing if it is a negative value (CA1 flag is at bit 7 so it is interpreted as the sign bit when in the accumulator).

Input And Output Drive Requirements
Full details are given in the PIA data sheets and should be consulted when contemplating any serious design. However, the "detail" can be a little frightening at first sight so the following broad outline may help to break the ice:

A SIDE I/O DATA LINES

When inputs: behave as one standard TTL load. CA1 similar

When outputs: can drive one standard TTL load

B SIDE I/O DATA LINES

When inputs: behave as high impedance tristate inputs drawing only 2 uA typical when driven HIGH or LOW.

When outputs: can drive one standard TTL load, but can deliver 2mA5(typical) 1 mA(minimum) at 1V5 in the HIGH state. CB2 also has this power when output.

Note the B side has greater possibilities than the A side. For example it can easily supply the minimum 1V2 necessary to drive a Darlington pair at a comfortable 1 mA or more.

Making Effective Use Of The PIA
Although there are twenty external interface lines on the PIA, it is easy to run out of wires unless a stern frugal attitude is adopted. Every one of them must be made to pull its weight to the full; the alternative could be the purchase of a second (or third) PIA which apart from the cost, places an extra load on the address bus and wiring time. It is easy to develop a kind of mania for software . For example, there is little point in writing twenty or more bytes of code to "save" the use of a 7490 counter (costing about 70¢) simply to satisfy the ego of a microprocessor purist. A well designed system should render unto Caesar the things that are Caesar's and to the ROM the things that are ROM's! The distribution of hardware and software should be a common sense exercise free from predetermined bias.

There is of course a danger in the other direction; if there is too much hardware and too little software the obvious conclusion is that a microprocessor was not required and the system could have been implemented by a completely hard wired black box. It is a good plan to reject out of hand the first solution that comes to mind (even if you eventually return to it in the end). Letting the problem simmer in the mind for a while can often lead to a flash of divine inspiration—called "lateral thinking" by the Mid Atlantic fraternity—which could save you ½K of ROM in return for a couple of TTL chips.

The word "system" has been mentioned above and to those readers who use microcomputers only for number crunching or games or filing systems, requires some explanation. Any computing system can be considered as a closed loop "servo mechanism" in which the computer input and output is "closed" by the external peripherals. For example, a computer connected to a conventional teletype receives input from the keyboard and outputs a "correction" to the print mechanism. A simple VDU with keyboard behaves in a similar fashion. There is however a wide range of activities which can be controlled by a microcomputer in addition to the conventional data processing role. Model Railway enthusiasts for example can increase the sophistication of the operating system by using a microprocessor as the controller, keen gardeners with a scientific bias can arrange a perfect green house environment throughout the year, the family car can have its instrument panel transformed into a futuristic (and impressive) panorama of winking warning lights and LED digits vomiting out data on gallons per mile, engine noise level, gradient of road etc etc.

These may appear to be grandiose schemes but in reality, providing some electrical background knowledge is assumed, will be found well within the capabilities of an enthusiastic amateur. Returning to earth, the design of games for children (or adults) embodying external MOVING devices can have more appeal than the present crop of VDU oriented pastimes.

Transducer Interfacing
The Motorola PIA, like the majority of microprocessor I/O ports and home computers, is TTL compatible which means that the inputs must be within the range zero to 5 volts, a LOW being any voltage less than 0V4 and HIGH any voltage higher than 2V4. Unfortunately, the outside world doesn't conform to this copy two-state environment so it is necessary to convert all input "signals", whatever their origin, into the above acceptable form. The conversion, will in general, consist of two distinct operations:

a) Converting a non-electrical (physical) change into an electrical change by some form of TRANSDUCER.

b) Converting the electrical output of the transducer into the right amplitude and polarity to suite TTL.

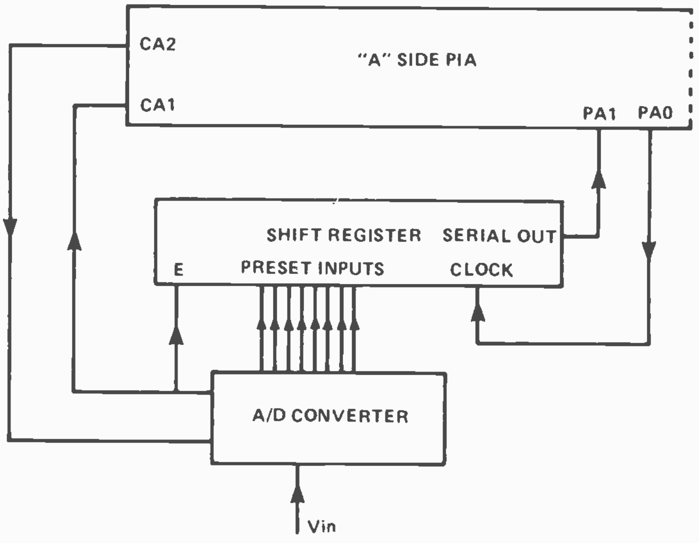
There are a host of suitable transducers on the market capable of converting almost any physical quantity into an electrical output, some examples follow:-

Photocells or photo transistors for converting light changes. Strain gauges for detecting how much something is bending (usually by stretching a resistance in the form of a tape). Thermo couples for converting temperature. Ph probes for converting degree of acidity (or alkalinity).

The electrical output of most transducers is low, probably in the millivolt or even microvolt order so the first step is to amplify (normally by an OP AMP) to bring it up to a suitable level. There is still another step however because the voltage is still an analogue of the physical quantity, ie, it is a smoothly varying voltage instead of the two-state nature acceptable to the PIA. The final component in the change is therefore some form of analogue to digital converter to change a voltage level into a binary number proportional to the level. A/D converters are in most cases "eight-bit" resolution which implies that an analogue voltage can be digitised into 2^8 (256) increments, (See Figure 4 previously).

Returning to the subject of economical use of the PIA, it is clear that we must "waste" ten of the available twenty wires if we insist on the minimum amount of extra hardware to convert. Suppose we are prepared to relax a little and allow a TTL shift register between the A/D and the PIA as shown in figure 5.

Figure 5 Using a shift register to economise on PIA wires.



The shift register has parallel inputs which are enabled-in on a pulse from the A/D data valid signal to the E pin on the register. Eight pulses from PA0 can now shift out the parallel word bit by bit into PA1. The programming of the system may take a few more bytes than the straightforward method shown earlier in Figure 4 but six PIA wires (PA2 to PA7) have been freed.

Examples Of Interfacing

The following outline systems may be found useful, if only to stimulate thought on possible projects. The flow charts indicate the software required.

Action is quite straightforward: Timer output rests LOW and turns HIGH on the receipt of a trigger pulse. Depending on the value of R, the output eventually turns LOW again. Thus CA1 must be initialised to be ACTIVE LOW to detect this fall. The flow chart shows how the count in accumulator A will gradually increase and the final count (depending on the setting of R) will be in A when the loop exits. To allow for the restriction that R must not be allowed to fall too near zero, (by adding a fixed padder resistor) the accumulator can start with some fixed offset value instead of being cleared. Note that only two of the PIA wires have been used.

This is an example of "lateral thinking". The solution which might have immediately come to mind would probably be a tachometer geared to the shaft with the output feeding an analogue to digital converter. Apart from the expense, this solution would utilise eight I/O lines on the PIA. The method shown only uses one input (CA1) line of the PIA and although superficially crude, would be equally (if not more) accurate.

The fundamental idea is to count how many revs (how many times the flag is set) in a given time period. The actual time period depends on the number initiallised in the Index register(X); this doesn't have to be one second because scaling can be arranged after Exit. The timing accuracy is good because of the crystal controlled clock in the microprocessor. The block marked "compensating delay" is a few NOPs to balance the extra time when the flow is via Clear Flag.

Figure 6 Digitising a resistance valve.

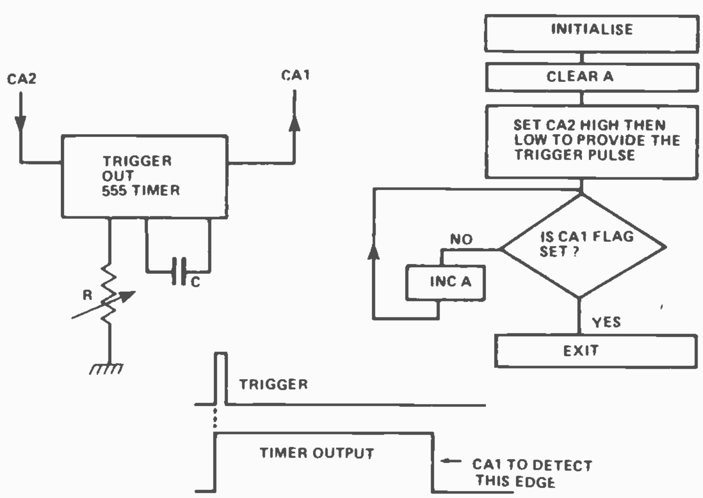
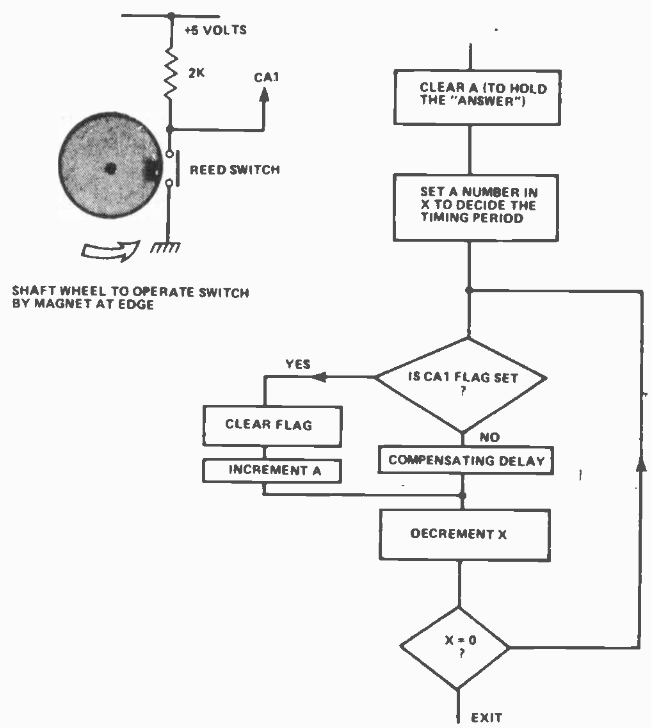
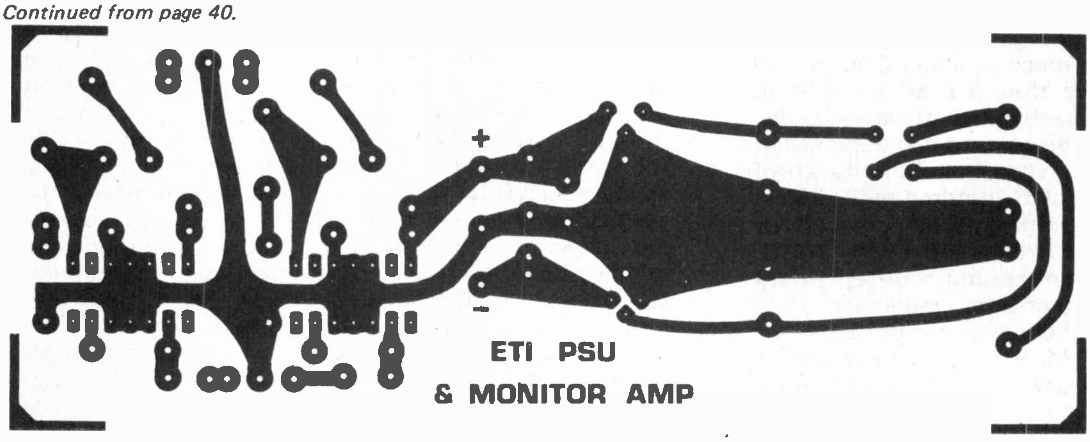


Figure 7 Digitising the velocity of a shaft.



DRUM SYNTHESIZER

Continued from page 40.



The PCB pattern for the PSU and monitor board for the Drum Synthesizer.

PHOTOCELLS

Photocells are the devices we use to detect light by making use of the energy that is carried by the light to generate an electrical signal. There's a remarkable number of different varieties of photocells, due to the fact that there's an equally remarkable number of substances which are affected by light. K.T.Wilson explains. .

LET'S START with any solid-looking chunk of material. All these materials are made up of atoms which, in a solid material, are packed tightly together. These atoms, though, are hollow, mainly empty space, containing a positively-charged core called the nucleus and a lot of incredibly small negatively-charged particles called electrons. These electrons are involved in everything electrical or electronic (and a lot more besides).

Now we can get hold of electrons in comparatively small numbers, just a few millions at a time, and make measurements on them. We're pretty sure, as a result, that all electrons are identical. The electrons inside an atom don't behave as if they are identical, though, because some can be removed much more easily than others. We explain this by saying that the electrons have different energy levels, meaning that some are much more tightly held by the attraction of the nucleus than others. This idea of energy levels is probably one of the most important ideas of modern physics, and it's practically impossible to discuss why electronic components behave as they do without bringing in energy levels somewhere.

Light Reading

What about the light, then? Light, like radio, is an electromagnetic wave. That, translated a bit, means that where you have a light ray there's a voltage oscillation and a magnetic oscillation as well. It's the voltage oscillation that we're interested in — that's the one we pick up in an aerial when we receive a radio broadcast. What happens in an aerial is that the electrons in the metal follow the oscillations of the voltage wave, so that an alternating voltage is created in the wire. That's the radio signal that we detect and amplify.

Now we come across one of these horses-for-courses choices. We find electromagnetic waves at all sorts of frequencies, from a few hundred kHz (long waves), through the UHF band of several hundred MHz, past the much higher frequencies of light waves and beyond. These waves all have two things in common — they travel at the same speed in space — about 300 million metres per second — and they are all emitted in bunches, not continuously. Each bunch of waves carries a definite amount of energy, an amount that depends on the frequency of the waves in the bunch. A bunch of light waves at a frequency of 6 hundred-million-MHz therefore carries a lot more energy than a bunch of medium-wave radio waves at 1 MHz, and it's this bunch energy called the quantum energy (the word quantum just means bunch) that has an effect on materials.

Measured in this way, radio waves are rather feeble things, just about able to carry out the easy job of moving electrons in wires. Light waves carry a lot more quantum energy, and the energy of one of these bunches of light waves *can* be enough to shift an electron from its own energy level to the next higher one. Can? Yes, because the gap between energy levels is not the same for all substances and only some of the millions of substances we know have just the right arrangement of electrons for packets of light waves to shift one.

The first substance discovered behaving in this way was the element selenium. Selenium is photovoltaic, meaning that the effect of light is to free electrons completely from their atoms. If a piece of selenium is part of a circuit, then the action of light on the selenium is to make it behave like a battery, causing current to flow in the circuit. Selenium is still used for light-measuring meters, but more modern photovoltaic cells, based on another semiconductor, silicon, have been developed. It's these silicon cells which are our main hope for generating electricity direct from sunlight, incidentally, so that there's a lot of research going on at the moment.

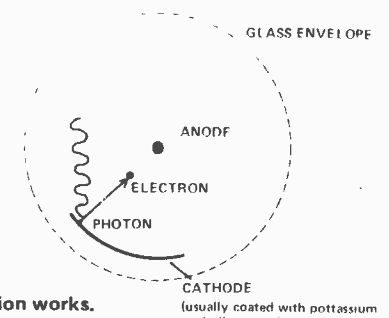


Fig. 1. How photo emission works.

Photo Emission

A few substances have electrons with such low energy levels that electrons can be shot out at high speeds when a light beam strikes the material. Materials like this are called photoemissive, but they can be used only in a vacuum. There are two reasons for this. One is that the materials themselves are chemically attacked (oxidised) by air; the other is that the electrons that are released can't get very far if the material is surrounded by air. A vacuum photocell contains a photocathode — a nickel plate coated with the electron-releasing material such as the metal caesium — and an uncoated anode, both inside a bulb from which the air has been removed. To use the cell, a voltage of 90 to 200 V is connected across the terminals (anode positive). When light strikes the photocathode, electrons are released and are attracted to the anode by the positive voltage. The current that flows in the circuit can be detected by a microammeter; it's small but it's there. This type of vacuum photocell was once the main method of detecting light, particu-

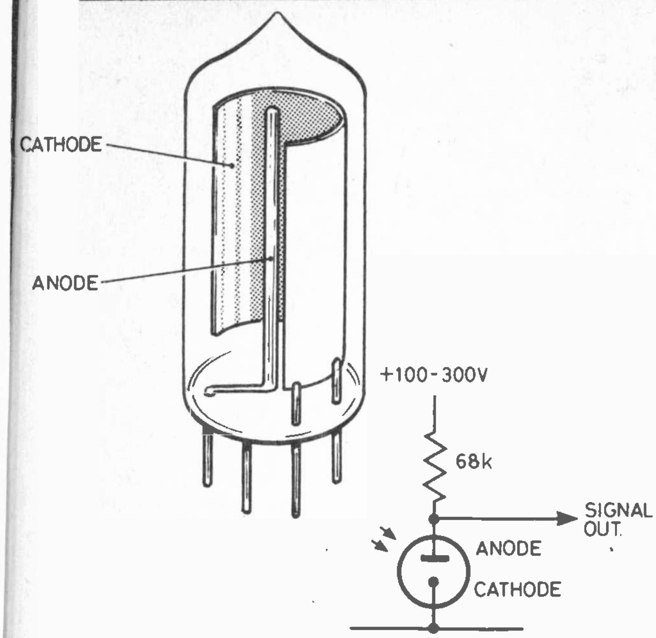
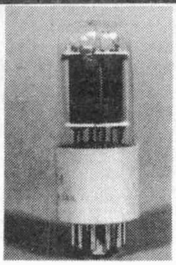


Fig. 2. A vacuum photocell, and typical circuit.


A photo multiplier tube is essentially a super vacuum photocell. This is an RCA 931-A which can have a gain of up to 5000. The light enters through the gridded space.

larly of rapidly-changing pulses of light such as those from the sound track of a movie film. What made the vacuum photocell particularly suitable was its quick response — there was very little time between starting or stopping the light and starting or stopping the current. Very little time means less than a microsecond, in contrast to the selenium cell which takes about a quarter of a second to respond either way.

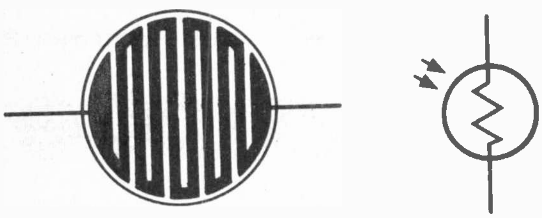


Fig. 3. The Cadmium Sulphide LDR, and symbol.

For many years, the selenium cell and various forms of vacuum photocell were the only types of photocells we knew — then the semiconductor age began. We've learned so much about energy levels and how to play with them that a whole new set of photosensitive materials has been invented. Semiconductor materials have their energy levels arranged so that only a small amount of energy is needed to release an electron, allowing the material to conduct better. This process is called electron-hole pair production, because each electron that is released leaves a space, called a hole, in the crystal structure of the semiconductor. The holes behave like conducting particles, assisting the material to conduct. Let's see how this process is used in modern semiconductor materials.

Hard Cell

One of the most familiar cells is the cadmium sulphide photoconductive cell. Cadmium sulphide is a material that can be evaporated onto any smooth surface, so that it's easy to make into a thin film; cadmium sulphide photocells (often called LDRs — light dependent resistors) use tracks of film of the shape shown in Fig. 3. We can make electrical connections to each end of such a track, so that the cell can be wired into a circuit as if it were a resistor. In darkness, the cadmium sulphide is practically an insulator, and a cell will have a resistance of 1M or more. Light falling on the material causes electrons and holes to separate, so that the material conducts, and the resistance falls very greatly, to 1k or less depending on the width and length of the track.

Cadmium sulphide cells have some peculiar advantages and disadvantages compared to other types of cells. They can be used in circuits where quite high voltages exist, 300 V for some types of cells, so that these cells can be connected directly across the mains supply. They can also pass quite large currents, so that relays can often be driven directly with no need for transistors.

Photodiodes and phototransistors are the other important classes of modern photocells. Unlike the cadmium sulphide photocell, which consists of a single material, a photodiode has a PN junction. P-type semiconductor material conducts mainly by hole movement, N-type mainly by electron movement, and we can form thin films which are P-type on one side and N-type on the other, with an electrical contact to each. This is, of course, the familiar junction diode, and a diode like this which is reverse biased does not normally conduct because the voltages that are applied have the effect of pulling the holes and electrons away from the place where the two types meet, the junction.

If light hits the junction, though, electron-hole pairs are generated and the junction becomes conducting. With a steady voltage across the junction, a current will flow when the junction is illuminated. The current is small, only a few microamps, but the response speed is very fast, measured in nanoseconds. ($1\ ns = 10^{-9}s$). Photodiodes of this type, plus fast pulse amplifiers are the natural choice for detecting very short flashes of light.

Phototransistors

The phototransistor is the type of light detector which is chosen for most applications that don't need ultra-high speed or very large currents. A phototransistor is constructed in the same way as any other transistor, with the sandwich of PNP and NPN semiconductor materials. In the dark, it'll work away like any other transistor, with

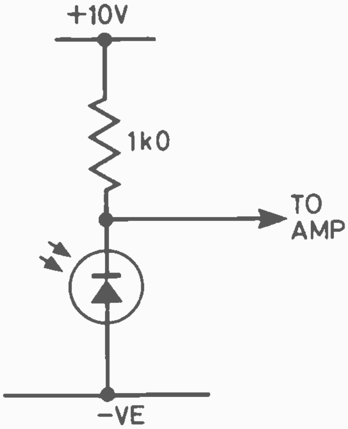
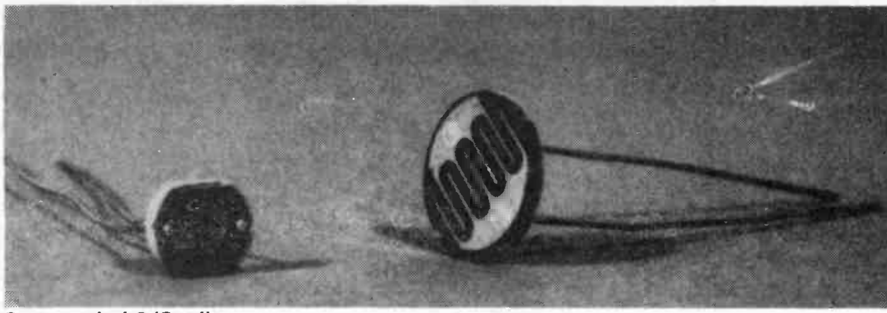
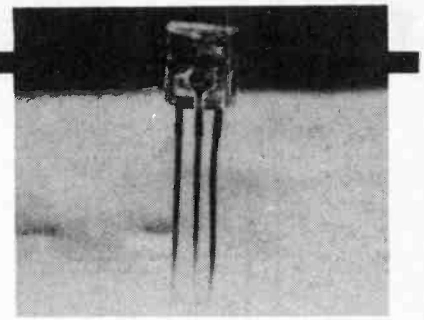


Fig. 4. The photodiode symbol and typical circuit. Though the action of the cell is fast, the maximum frequency of operation is limited by the capacitance of the diode, typically 1 nf (1 000pF).



Some typical CdS cells.



Looking in on a photo transistor

the current between the base and emitter layers controlling much larger currents between the collector and emitter layers. In the light, though, interesting-things happen—(well relatively). A phototransistor is operated with no connection made to the base — some phototransistor types have no base connection terminal. Now if you operate an ordinary transistor in this way, nothing happens, because it's the current into the base terminal which fills up the base-to-emitter junction with electrons or holes and so makes the lot conduct. A phototransistor is constructed so that light can reach this base-emitter junction, and the light will have the usual action of separating electrons from holes at the junction. Now neither of these can flow to the base contact, because it's disconnected, so that the only possible direction is towards the emitter or the collector.

Suppose the phototransistor is an NPN type, with the collector voltage positive and the emitter voltage negative. When an electron is separated from a hole at the base-emitter junction, the electron will head towards the collector, but the hole isn't so lucky. At the start, there's practically no voltage between the base and the emitter, so there's no reason for the hole to move. The result is that the base gets more and more positive as it loses electrons and hoards holes. Pretty soon, this positive voltage does exactly what positive bias does to an ordinary transistor — it attracts electrons from the emitter. Most of these electrons go straight to the collector, though, because the base layer is so thin, and the phototransistor then passes several milliamps of current between collector and emitter just to make sure that a few microamps flow to the base. The result is a photocell which can pass much higher currents than a photodiode, though with a slower switching speed. ●

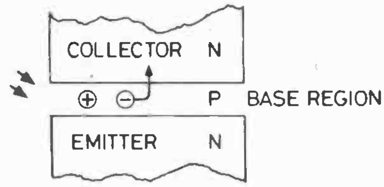


Fig. 5. The junction in a phototransistor.

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INTO ELECTRONICS (Part 6)

Last month Ian Sinclair introduced the practical aspects of transistor circuits. This month he looks at two transistors and switching circuits.

WE'VE HINTED often enough that we usually need more than one transistor in a complete amplifier, so now we need to look more closely at how we can make an amplifier with more than one transistor. Obviously we need to be able to transfer the amplified signal from the first transistor into the base of the second transistor, but there's more to a two-stage amplifier than that.

One of the big problems of a two-stage amplifier is to make sure that each transistor has the correct bias. If we just connected the collector of one transistor to the base of the next, it's unlikely, to say the least, that the bias would be correct. Direct coupling, as this sort of system is called, is not quite so simple. We'll look at some direct coupled arrangements later.

One obvious method is to use a capacitor for coupling. DC can't flow through a capacitor, so that we can have the collector voltage, say +6 V, on one terminal of a capacitor and a base voltage of, perhaps, 0.5 V on the other. This is the normal method of coupling signal between stages; it's usually called capacitor (or RC) coupling. Like anything that looks simple, there's a penalty to pay. The capacitor will happily pass high-frequency signals, but its reactance for low-frequency signals will cause the gain of the complete amplifier to be lower at low frequencies. The coupling capacitor behaves as if it were part of the source resistance of the first stage of the amplifier, so that it forms part of that potential divider for signals. Since the reactance of a capacitor is very large for low-frequency signals, the total gain for these low frequency signals is smaller. Another effect is that the phase of signals is shifted when the signal frequency is low. At low frequencies, the capacitor has time to charge and discharge, and the current through the capacitor in the coupling circuit of Fig. 2. is phase advanced by 90°, meaning that a sinewave current peak appears a quarter of a cycle earlier than the voltage peak when a steady sinewave signal is passing through. This causes a form of distortion, phase distortion, which alters the shape of signals such as square waves, though the effect on a sine wave is not so easy to detect since the shape is not changed.

The big advantage of using capacitor coupling is that the bias of each transistor stage is unaffected by the coupling. The use of a transformer to couple signal from one stage to another is another way of ensuring that the bias is not upset. Transformers are seldom used nowadays on grounds of cost, size and weight, and also because of the odd effects that a transformer can have on the gain at various frequencies. Each winding of a transformer is an inductor, so that there will be resonance with any capacitor (including stray capacitances in the wiring and also between the turns of wire in the transformer). If these resonances are at frequencies in the range being amplified, the gain/frequency graph will have some very noticeable peaks or dips.

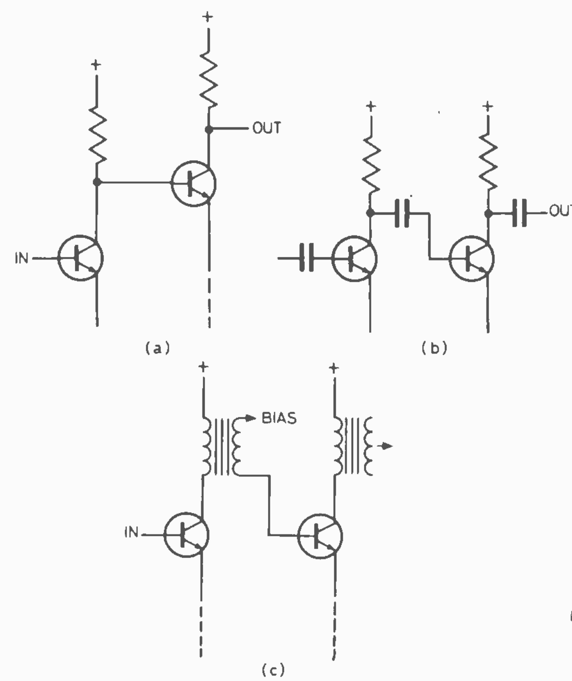


Fig. 1. Coupling methods (bias components omitted) (a) Direct (b) Capacitor, (c) Transformer.

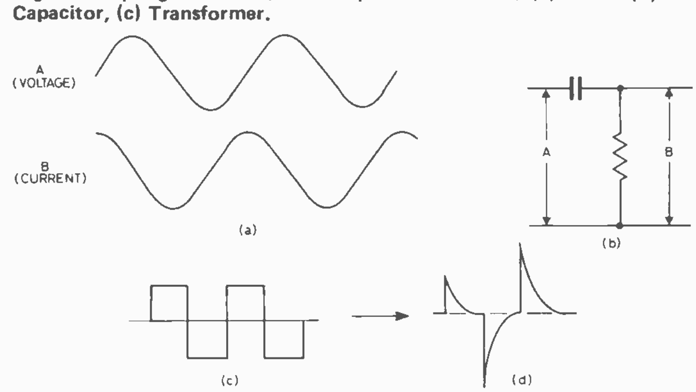


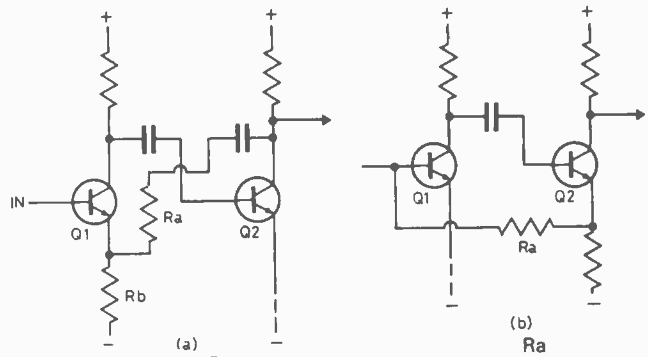
Fig. 2. The effects of capacitor coupling on low-frequency signals. (a) Phase shift of voltage relative to current, (b) in the coupling circuit, the output voltage (A) is not in phase with the input voltage (B) to the next stage. A low frequency square wave (c) becomes distorted to the spiked shape (d) unless very large capacitance values are used.

Negative Feedback Over Two Stages

Earlier in this series we used some rule-of-thumb methods for finding the voltage gain of single stage transistor amplifiers with negative feedback. These rule-of-thumb approximations become pretty exact if the gain of the amplifier before feedback is connected (**the open-loop gain**) is large. It's an advantage, then to have negative feedback applied to an amplifier of more than one stage, because the large amount of open-loop gain ensures that our calculations work out better. If, for example, the open-loop gain is very high, and 1/n of the output signal is fed back (so as to be negative feedback), then the factor n is called **loop gain (NOT** open-loop gain), and it also happens to be the value of voltage gain of the whole amplifier. For example, if 1 / 20 of the output voltage is fed back as a negative feedback loop, then the loop gain is 20, and the voltage gain of the complete amplifier is 20.

Now, as it happens, picking a fraction of the output signal is simple, we need only a potential divider, a pair of resistors. Using an amplifier with a high open-loop gain (before using feedback) therefore enables us to set the value of gain that we want by using only a pair of resistors. This makes circuit design a lot easier, because we do not now have to bother about calculating the gain of each stage of the amplifier with any accuracy, providing that the open-loop gain is high compared to the final figure of gain that we want. It's easier, in fact, to make a two-stage amplifier with a gain of exactly 20 times, using negative feedback, than to make a single transistor stage with a gain of exactly 20 without using feedback. We have, in addition, all the usual advantages of negative feedback, ensuring low distortion, low noise, and very little change of gain when transistors are replaced or when resistors age (apart from the two which set the loop gain). The reduction of distortion and noise, incidentally should be by the same factor as the gain is reduced, so that if the open-loop gain was 500, and the loop gain is 25, then the reduction factor is 25/500, which is 1/20, and the distortion should be only 1/20 as much as that of the open-loop amplifier, and so on.

How do we go about it? Well, connection from the second collector back to the first base certainly doesn't do it! That's **positive feedback** (try it!) because the signal at the collector of the second transistor has a signal that is *in phase* with the signal to the base of the first transistor. There are two possible connections that give negative feedback over a two-stage amplifier. One is to take signal from the output collector back to the input emitter, the other is to take signal from the output emitter back to the input base. The first method causes the input resistance of the amplifier to rise, the second method reduces the input resistance. Approximate figures for the loop gain (which will be the gain of the complete amplifier) are shown in Fig. 3.



(a) Gain = $\frac{Ra}{Rb}$ (if Rb is small)

(b) Gain = $\frac{Ra}{Rie}$ (where Rie is input resistance of Q1)

Fig. 3. Methods of connecting negative feedback over two stages. (a) Collector-to-emitter, (b) emitter-to-base.

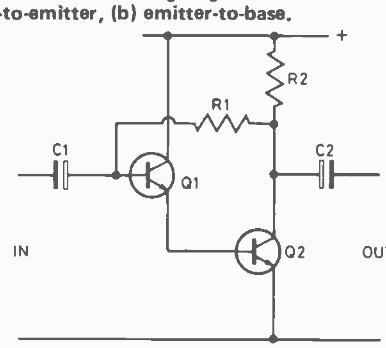


Fig. 4. Direct-coupling two stages together, using an emitter-follower and a common-emitter pair.

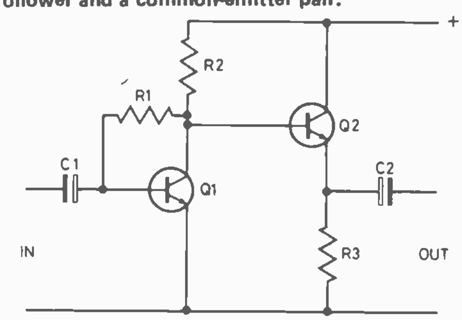


Fig. 5. Direct-coupling two stages together, using a shunt-feedback amplifier and an emitter-follower.

Direct Coupling

Two transistors can be direct coupled provided that some arrangement is made to keep the bias correct on each transistor. Fig. 4. shows one arrangement, with an emitter-follower feeding a common-emitter stage. Because the emitter-follower output signal is in phase with its input signal, bias and negative feedback can be applied by the resistance R1. If we want this to act for bias only, the total resistance can be divided into two sections with a capacitor to remove (or 'decouple') signals.

Another two-transistor arrangement is shown in Fig. 5. This uses a shunt feedback stage action of the emitter-follower. The negative feedback action of the emitter resistor ensures that the biasing of the emitter follower is correct, and the biasing of the first stage is set by the shunt feedback resistor R1.

A very popular arrangement of two transistors which has a very large open-loop gain is shown in Fig. 6. Q1 is a common-emitter amplifier whose collector is directly coupled to the base of Q2. Q2 uses an emitter resistor, R3 which is decoupled by C2 to ensure that

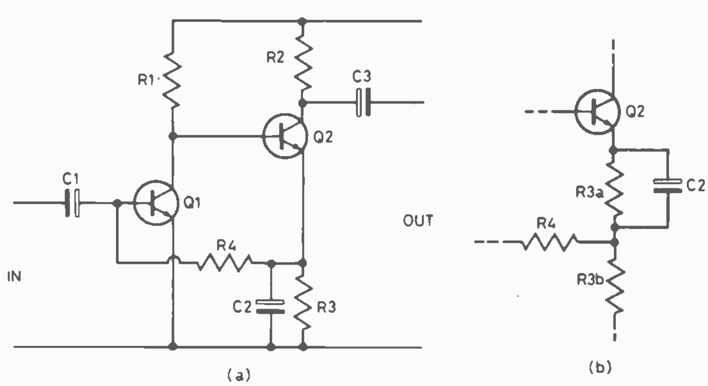


Fig. 6. A high gain two transistor circuit (a) with direct coupling negative feedback of signal can be achieved by removing C2, or by using the circuit in (b) where only part of R3 is bypassed.

there is no negative feedback of signal, but bias is fed back through R4. Because the bias is obtained by DC feedback over two stages, the bias is very stable, and a surprisingly small number of components is needed compared to a two-stage amplifier using capacitor coupling.

Switching Action

So far in this Part, we've assumed that we want linear amplification, with an output signal that is a near-perfect copy of an input signal. This isn't always so, and some of the most important applications of transistors are in circuits where there is no linear action to speak of, just a rapid change between the cut-off and the bottomed states. To see why a transistor should be useful for this type of action we need to know two (transistor) vital statistics.

1. The transistor does not conduct until the base-emitter voltage is about 0.5 V.
2. Once the transistor *is* conducting, each 60 mV increase in the base-emitter voltage causes the collector current to increase by ten times.

The second point needs illustrating. Suppose that a transistor has 1 mA of collector current flowing when the base-emitter voltage is 0.55 V. Then a change to a base-emitter voltage of 0.61 V (another 60 mV) will make the collector current 10 mA, and a change to 0.67 V (another 60 mV) will make the collector current 100 mA. This sensitivity to base-emitter voltage is why the transistor can be used for switching. Suppose, for example, that the collector load of a transistor is a relay which switches over at a current between 5 and 10 mA. If the transistor is set with 1 mA flowing, then a voltage change of only 60 mV will operate the relay with complete certainty.

Figure 7. shows a transistor circuit that will operate a relay when the light falling on a photoresistive cell LDR1 is cut off or reduced below a set value. The preset variable RV1, the fixed resistor R1 and the photoresistive cell LDR1 form a potential divider circuit across the supply voltage. The action of the photoresistive cell is that its resistance is low when light falls on the element, but removing or dimming the light causes the resistance to rise considerably. The variable resistor RV1 can be set so that with normal illumination on the photoresistor, the voltage at the base of the transistor is below the 0.5 V or so that is needed to start current flowing in the transistor. When the light dims, the resistance of the photocell rises, so that the voltage at the base rises. The transistor now switches on, and current will flow, switching the relay. The diode D1 prevents damage to the transistor when the current shuts off.

The sensitivity of this circuit can be increased by adding a current-amplifying stage (emitter-follower). This ensures that the current that is needed by the base of the switching transistor is supplied by the emitter-follower rather than by RV1 and R1. Another way of using transistors is shown in Fig. 8. in which the sensitivity is increased by using the first transistor as a voltage amplifier. Note that the potential-divider circuit needs to be connected the other way round, because the first transistor must be switched *on* when the illumination is bright. The same basic circuit can be used along with a thermistor to make the switchover occur on a change of temperature.

Circuits like these have one flaw, though. Because

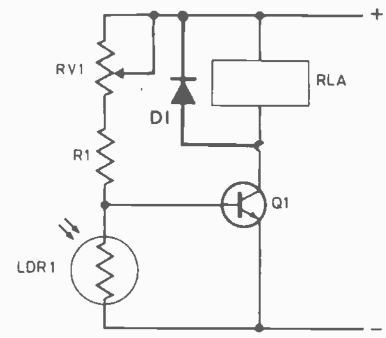


Fig. 7. Circuit for operating a relay when the light level drops.

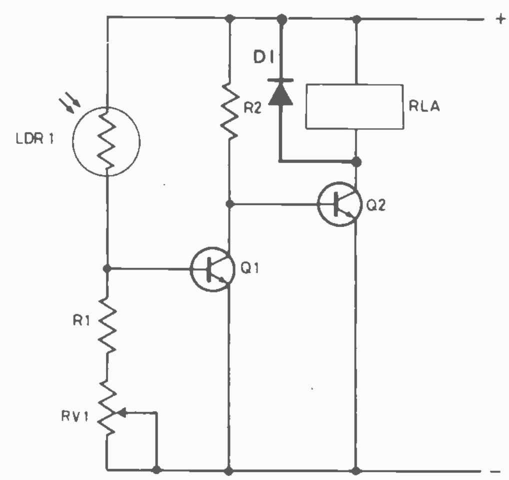


Fig. 8. More sensitive light-relay circuit.

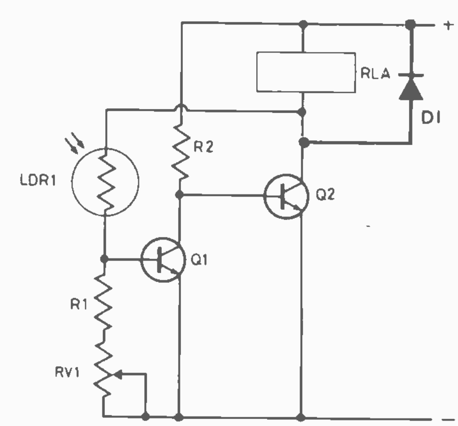
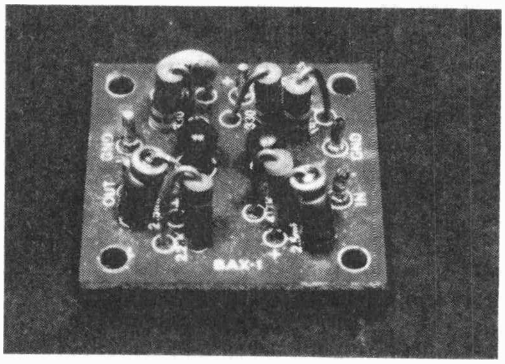


Fig. 9. A light-relay circuit with hysteresis (see text).



they are so sensitive, the circuit can switch to and fro when the conditions (light or temperature or whatever we are detecting) are steady around the changeover point. If the input is at the critical value at which the circuit switches, then the relay 'chatters' as the transistors switch on and then off again with each tiny fluctuation of light or temperature as the case may be.

A small change in the circuit can correct this. In Fig. 9. the photoresistor is returned to the collector of Q2 rather than to the supply voltage. While the light is bright, Q1 is fully on and its collector voltage is bottomed, so low in voltage that Q2 is off; the collector voltage of Q2 is high. When the light level falls, however, the resistance of LDR1 increases, Q1 switches off, Q2 switches on, and the voltage at the collector of Q2 falls, ensuring that Q1 is now cut off *even* if the light becomes slightly brighter again and the resistance of LDR1 increases. This is positive feedback, and it acts to make a switchover much more definite. In the circuit shown, it is quite difficult to make the transistor switch back at all, and a more controllable circuit is that of Fig. 10 in which the amount of positive feedback is controlled between zero and maximum by the setting of RV2.

RV2 can be adjusted so that there is enough difference between the inputs needed for switchover and for switchback to ensure that the circuit does not 'chatter'. This difference between switchover and switchback is called **hysteresis**, and is an important factor in switching systems. In an ordinary light-switch, for example, hysteresis is obtained mechanically by the use of a spring so that the switch always snaps over.

Positive Feedback

Positive feedback is the process of taking some of the signal at the output of an amplifier and connecting it back, in phase, to the input. How much effect this has depends on how much of the signal is fed back. Small amounts of positive feedback (as we call this) can increase the gain of an amplifier and also increase the input impedance. A simple example of this use of positive feedback is the circuit of Fig. 11. This is an emitter-follower (see earlier parts) with a capacitor feeding signals back from the emitter to the base. Because the voltage gain of an emitter-follower is always less than unity this has no effect on the gain of the whole circuit, but it does make the input impedance for signals very much higher than that of the unaltered emitter follower. This use of positive feedback is called **bootstrapping.** The name comes from the (US) inventor of the circuit who remarked that *"it looks a bit like pulling yourself up with your own bootstraps."* A two-stage bootstrap circuit with a very high input resistance is shown in Fig. 12.

The bootstrap circuit is stable because there is unity (or slightly less than unity) gain in the amplifier that is bootstrapped. If we attempt to use positive feedback in an amplifier which has voltage gain, then we run into difficulties because the amount of feedback has to be very carefully controlled. Any change in the gain of the amplifier or in component values may be enough to make the circuit unstable so that the amplifier oscillates. For this reason, positive feedback, other than bootstrapping, is seldom used in amplifier circuits.

The main use of positive feedback, then, is to make amplifier circuits into oscillators. There are two kinds of oscillators, the sine-wave type, in which the amount of positive feedback is controlled so as to give a sinewave with a good wave-shape; the other sort is the aperiodic

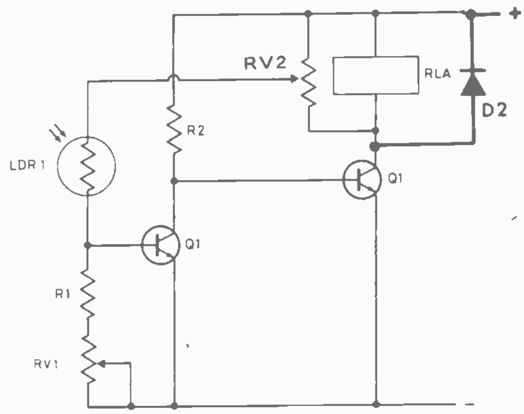


Fig. 10. A more controllable circuit with variable hysteresis.

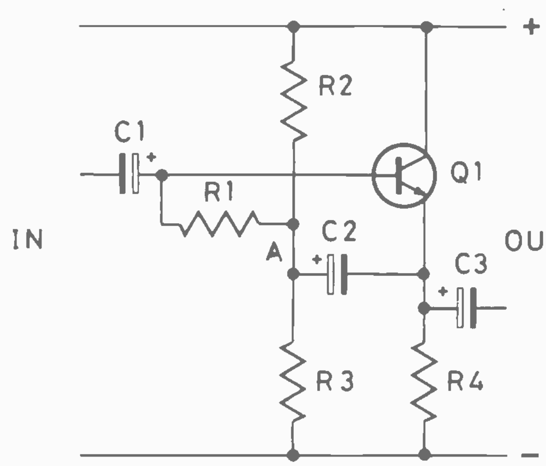


Fig. 11. A bootstrapped emitter-follower. The voltage at point A changes in phase with the input voltage, so that practically no signal cirrent flows through R1. The effect is similar to that of having a very large value of R1 for signals only.

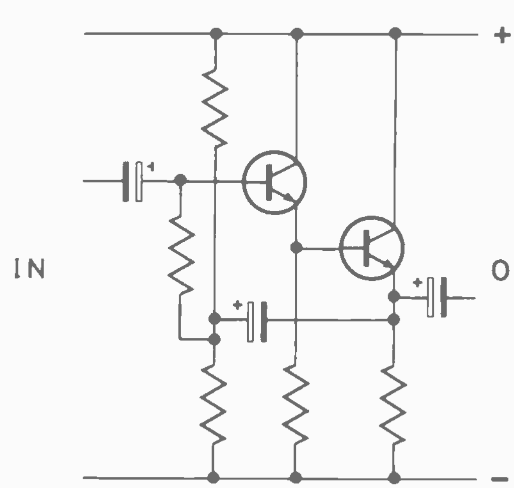


Fig. 12. A two-stage bootstrapped circuit with a very high input resistance of several megohms.

type in which the positive feedback is allowed to run wild. This second type of oscillator uses so much positive feedback that it spends most of its working life with the transistors either bottomed or cut-off. Because it's simpler, we'll look at this type first.

The Wild Ones

Take a look at the circuit in Fig. 13. It's a simple two-transistor amplifier, and the output signal will be in phase with the input signal but greatly amplified. Now make the dotted connection and there is a positive feedback loop. This is 100% positive feedback; all the signal at the output is connected back to the input and it converts a simple two stage amplifier into an oscillator of a type called the **astable multivibrator.** The word astable means 'not stable', and that's a good description. The positive feedback is so effective that the circuit cannot exist for more than a few nanoseconds with both transistors conducting. It's an important circuit, so let's go over the action carefully.

When the circuit is switched on, the voltages at the collectors and also at the bases of the two transistors will start to rise. Because of the inevitable slight differences between transistors, one will conduct before the other, so that its collector voltage will start to fall again. Let's say that it's Q1 that is conducting — then the voltage at the collector of Q1 is falling and the capacitor coupling through C1 will cause the voltage at the base of Q2 to drop as well. A drop of voltage at the base of Q2 will cause the collector voltage of Q2 to rise and this rise of voltage is coupled by C2 to the base of Q1, completing the positive feedback loop and making the voltages change very, very quickly. The whole process is over in a matter of nanoseconds, and it ends with Q1 conducting fully, its collector voltage bottomed at about 0.2 V, and Q2 cut off with its base voltage at about —5.3 V. Why —5.3 V, you ask, very reasonably? Well, it's like this: suppose that the base of Q2 was about to conduct, at around 0.5 V when all this happened. The collector voltage of Q1 changes from 6 V (not conducting) down to about 0.2 V (bottomed). That's a drop of 5.8 V. Now a capacitor will couple a voltage change like this, so that the voltage at the base of Q2 also drops by 5.8 V, from 0.5 V to —5.3 V, making pretty sure that Q2 is shut off. Meantime, the connection of R2 to the +6 V line makes equally sure that Q1 stays fully conducting. Once it gets into this condition, there's no more positive feedback, because there's no more amplification when one transistor is bottomed and the other cut-off. It would stick like this for good if it were not for one important point: the base of Q2 is connected to the +6 V line through R2.

Since there's a voltage difference across R2 (+ 6V at one end, and –5.3 V at the other), current flows. Where? Into the capacitor C1, that's where, so that C1 charges up. The voltage of one plate of this capacitor is held at about 0.2 V by the collector voltage of Q1; the voltage of the other plate now rises in the shape of an exponential curve (Fig. 14c. from – 5.3V. Left alone, it would eventually get to +6 V in the usual time of about four time constants (4 ×R2 ×C1). It's not left alone, though. When the voltage at the base of Q2 reaches about 0.5V, Q2 starts to conduct and once again the positive feedback loop takes control.

Once the positive feedback loop takes control, the

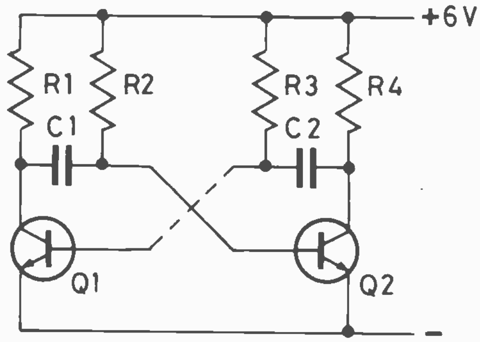


Fig. 13. The astable circuit. Try this out with the following values: R1, R4=3k3, R2, R3=33k, C1 C2=0.02 iF. Use an oscilloscope to examine the output waveform.

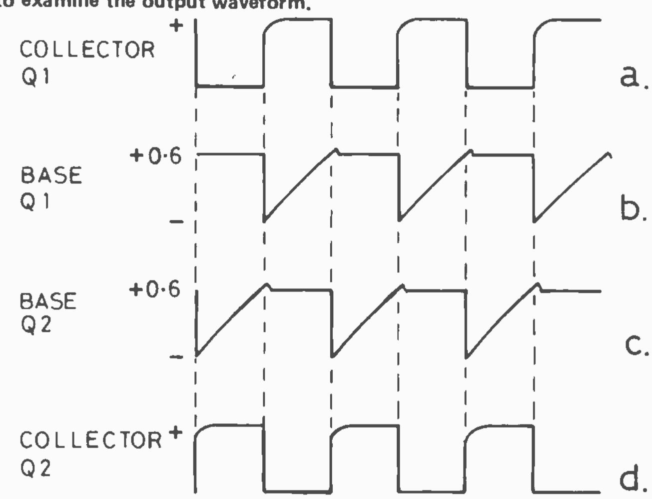


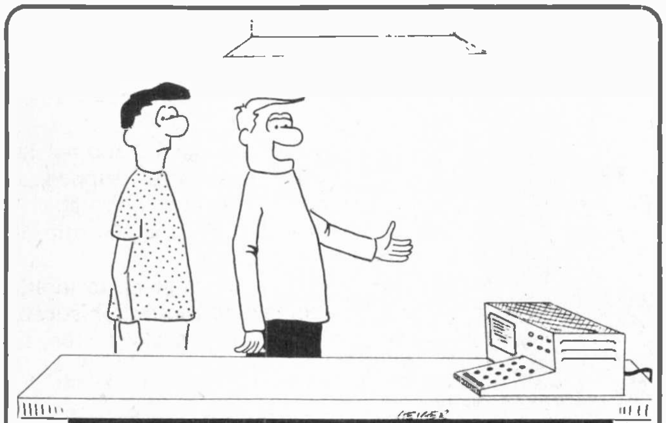
Fig. 14. Astable waveforms — these have been drawn to the same time-scale, with the vertical dotted lines linking changes which take place at the same time.

circuit goes wild again. Q2 is forced into full conduction, Q1 is shut off within a few nanoseconds. The same performance as before now happens as C2 charges, allowing the voltage at the base of Q1 to rise from about –5.3V until Q1 can start to conduct again. . .and there we go again. Fig. 14. shows the waveforms, comparing the graphs so that you can see what is happening at each electrode at the same time. Notice, by the way, that when one base is being driven negative, the other is being driven positive. The base voltage cannot, however, greatly exceed around 0.6 V because of the current that can flow between the base and the emitter of the transistor. The base-emitter junction effectively acts as a short circuit, preventing the base voltage from rising above about 0.6 V.

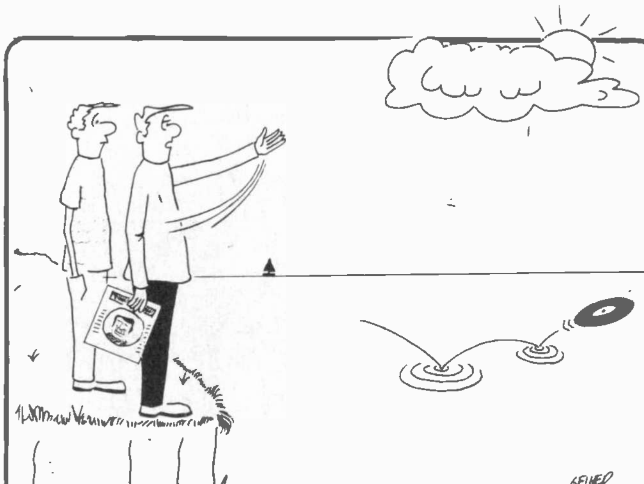
In a circuit of this type, the positive feedback is just a way of ensuring that the circuit flips over from one stage to the other very quickly. The real control is exercised by the time constants R2.C1 and R3.C2. If these are identical, both parts of the wave take equal times. The total wave-time for a complete cycle is given by 0.7 (R2.C1 + R3.C2). If the two time constants are not equal, then the wave is not symmetrical, but there's a limit to the mark-space ratio (on/off ratio) that we can get by altering the time constants. ●

I'm just trying to figure out how to work this new machine — you're supposed to be able to use it to locate shorts

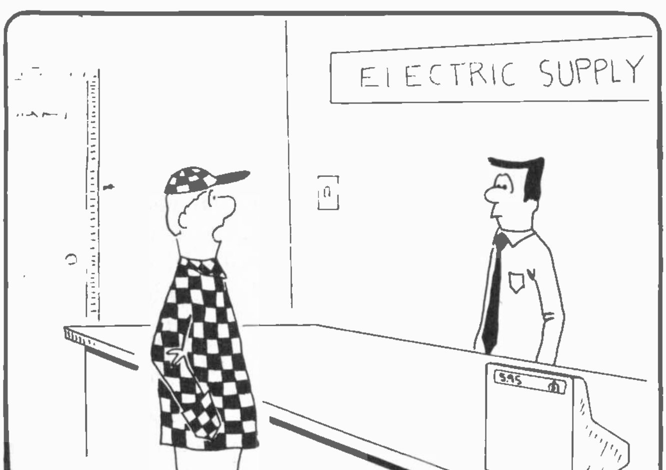
Well, your new water alarm is all hooked up, now to test it we're going to have to pour about 10,000 gallons of water into your basement.



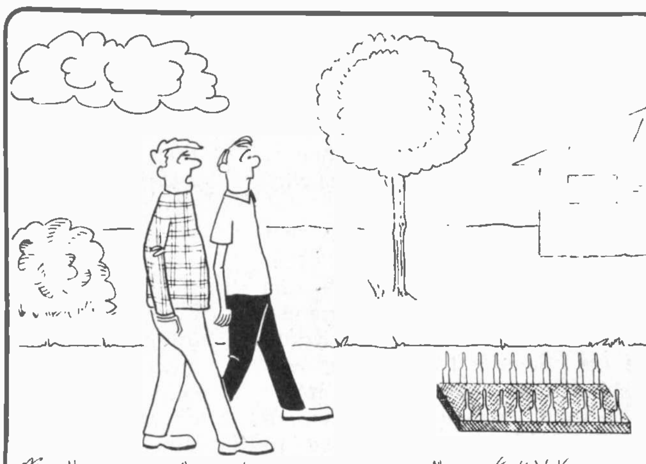
It's a computer built entirely with coils and chokes. That makes it the first computer that uses inductive logic.



The guy at the record store said I couldn't return it unless I was sure that it skips.



My boss told me to pick up a matching transformer. Got any in black and white checks?



Yeah, we've been trying for a long time to get the city to do something about that dip in the road.

WHAT'S NEW

By Steve Rimmer

Captain's Log: Star Date 3047.6.

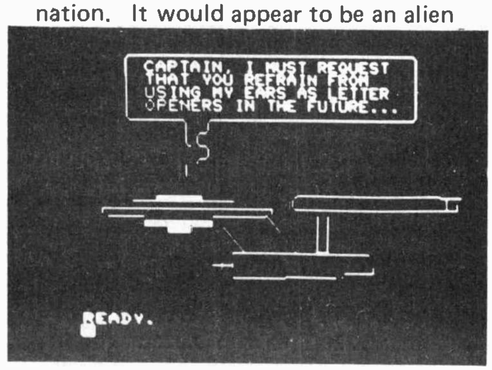
WE HAVE BEEN on patrol for six months, now, without leave. The crew is on edge. There is an underlying tension, almost a madness about the ship. An example of this took place several hours ago when my science officer, Mr. Spock, and my communications officer, Lt. Uhura left the bridge unexpectedly, arm in arm. When I asked Spock where he was headed, he replied "to boldly go where no man has gone before." He cast an evil leer at the lieutenant, and shut the doors of the turbolift.

We are experiencing some difficulty with the ship's controls. The helm is slow to respond, and, on several occasions, our phasers have fired at non-existent targets, apparently without anybody in the phaser control room knowing about it. I have been unable to locate Mr. Scott to ask him about these goings on. When last seen, he was headed for the engineering section with an armload of so called technical journals. A crewman has reported that these were somewhat unusual engineering publications, as many seemed to contain centrefolds.

"Bones" McCoy, ship's surgeon, has apparently contracted some rare form of space sickness, for which, he maintains, the only cure is to drink all the Saurian brandy on board. The computer estimates that he was roughly half way to recovery when he passed out in recreation hall three with a lampshade on his head.

The computer also estimates that we have entered the fringes of another dimension, and this is what is affecting the crew. Indeed, I have observed things in the last half hour that would make me concur. I have never seen stars like these. We have just left a solar system consisting of a square white dwarf sun which seemed to bounce between two other, almost rectangular looking stars, which somehow seemed to be moving as if to intercept it. Our communications equipment picks up a raucous beep every time two of these unusual bodies collide. Our long range scan indicates that we are rapidly approaching another equally unusual sun, which has two planets which race around it at lightning like speeds, darting in and out of each others' orbits. From time to time, one will apparently slip out of orbit,at which point it almost seems to disappear, only to reappear back in place several minutes later, at which point the chase seems to start all over again.

Shortly after beginning this entry, we encountered an apparition for which the computer has no explannation. It would appear to be an alien



ship, but it is entirely unlike anything previously experienced. It does not appear to be solid, but rather, formed of glowing lines. It appeared suddenly, as if it was simply switched on. All attempts to hail it have failed; there is some interference on all hailing frequencies, resembling pops, whistles, gunshots, phaser blasts, and a strange, electronic voice repeating over and over again "Targon kill... we'll be back... lucky." A few moments ago these noises were interupted by what sounded very much like a giant quarter landing in a coin box. The alien has begun firing on us. We have lost all control of the ship, and the phasers are operating as if they had a mind of their own. Periodically strange, glowing words have materialized in space, such as "HIT!", "RED ALERT" ...there are also two sets of huge BABY BLUE block digits a few parsecs away, which seem to change whenever one or the other of us manages to effect a direct STRIKE. We are... totally powerless. I am preparing to jettison this recording. There is only one explanation for what we have seen and experienced, and, though I can hardly bring myself to say it, I believe now that it must be true. If so, we will surely never leave this place alive. We would appear to have trespassed into...

Pong Space.

This is Captain James T. Kirk, . U.S.S. Enterprise, signing off.

And with that, a giant hand reached across the stars, and flipped an intergallactic selector switch to "Submarine Battle", and the ship dissolved for good.

This month, we're going to look at another, somewhat more sophisticated computer graphics package for the APPLE II.

New And Disproved

The SubLogics graphics package we had a peer at a couple of months back was heavily nifty for what it was into, but it had, as well, a few hassles. Manifest and rampant among these was that it did everything quite nicely, but nothing supremely well. It had reasonable resolution, reasonable speed and fairly good animation possibilities, but it was kind of slow for real time complex movement and too coarse for the ol' electronic drafting board trip. It also had some practical limitations in terms of entering the data base by which images were defined on the tube; the process was glacially slow.

Bill Budge's 3-D Graphics System and Game Tool (fanfare in G, if you would), marketed by Top of the Orchard Software, offers several potential improvements over some of the things the SubLogics approach was into. This may seem to be a bit qualified. In essence, the SubLogics package was predominately a line drawing device, that is, given a list of points and commands, it would set up lines on the screen. Once drawn, it couldn't actually do anything with the stuff without lengthy manipulations in software. At best, it could shift the observer's viewpoint in space, which allowed it to simulate transformations of the contents of said universe. The Budge package is somewhat more manipulatable in these respects. It is capable of rendering any graphics concept that can be reduced to being a game or simulation. It has fast animation capacity, a slightly easier time with outside world interfaces, and a much less demanding data base structure.

In all, the support software for the Budge trip is an order of magnitude less complex, and using the system to produce working, practical game sub-software would seem to be within the realm of practicality. Oh ho...this could be fun, you know.

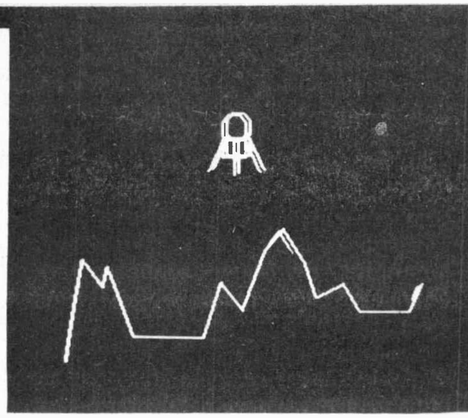
The software will only run on an Apple having the full, snobby, upper-middle class 48K of RAM. All attempts to use it on an 8K PET will probably fail. The software menu for the program disc is:

ENTER A COMMAND:
E EDIT A GRAPHICS DATA BASE
M BUILD A GAME MODULE
D RUN THE DEMO PROGRAM

The software is fairly expensive, so, upon ushering it into the house and first introducing it to the machine, it is not advisable to start telling the family about two page, high resolution three dimensional cartesian co-ordinate plotting, modules or system poking...no, this is the moment to limber up that trusty index finger and strike it firmly and decisively upon the "D" key. This will cause the system demo to run... this being an animation of some little Star Wars ships. This impresses the bejeezes out of people, who will frequently sit and watch them come whipping across the screen for long periods of time. Gives you a good idea as to just how far commercial TV has sunk.

Shooting for the Moon

The thing to do with the system demo, when you think you've really seen quite enough of it, is to accidentally hit a key on the keyboard, which will dispense with it. Apologize to your audience, explaining that the demo cannot be rebooted without a sixty four kilobyte bootstrap loading ROM interface card which costs twenty five hundred dollars. Most people will believe this, for some reason. You can now proceed to the first step in



actually loading a data base and getting something on the screen... (besides the Star Wars ships).

All the data bases I've set up to date have been pretty weird. My latest, and, I think, my finest, is part of a game called "A Night in a Harem". It's designed for two or more wholly unclad players, and, needless to say, they'd never let me run it in this magazine. We are, therefore, going to use an example provided by Bill Budge, that of a lunar lander against the background of a moonscape, in the familiar computer-video game. The object of this is to steer the lander to a safe and comfortable touch down, whereupon a little astronaut usually emerges, plants a flag, shoots a few golf balls, greets his fellow spacefarer on the surface, and is subsequently devoured by a ninety-foot high canal worm from Mars.

The initial problem is to tell the software where there are to be points on the screen, and which of these are to be joined to which others. This is accomplished with the "E", or Editor function. It is first necessary to devise a sketch of the thing we'd like to animate, as in figure1.

Since the sketch consists entirely of straight lines, it can be reduced down into a series of lines on a X-Y plot, which is what's about to happen, hence, figure 2. The terminations of these lines become points in space, figure 3. Gotten pretty abstract, hasn't it? This, in turn, can be reduced to raw data.

All these numbers specify the shape of the lunar surface and the LEM. It's either that, or my bank statement. You can never be too sure when this stuff comes at you through the post office.

Up until this point, the computer itself is quite superfluous, as the whole thing can be done up with a doodle pen and that Wizard of Id notepaper you got for Christmas. Now we get into the difficult part, that is, the one that involves typing.

The editor gets told what to do via commands. In essence, it is a language within a language, although one having far fewer instructions than does its host Applesoft Basic. The program is essentially a loop that INPUTs these commands and digests them, eventually winding up with the relevant information scattered around the memory. It checks out what it gets, and, if it doesn't decide it's holding onto text, it figures it has a command specification. After gobbling this, it comes back after another. It will do this until the cows come home if it isn't interupted.

The data base is loaded under the auspices of the mighty Append function, as summoned forth by the command "A". At this stage, it becomes apparent why this trip is so much easier to load than the SubLogics package was. Whereas, previously it was necessary to specify several lines of data about each point at the time of loading, the Game Tool requires only the co-ordinates. It even uses the point reference number as a prompt, eliminating a few more key-strokes. Entering the lunar lander, then, one would see the machine point "O:", to which one would reply, from figure 4, –4, 14, 0. This "O" is the "Z" position...Yes, I know, it's a two dimensional model, but the system is hot for 3D. It gets put off if it isn't given at least a taste of it every so often. It also likes to have a "(cr)" after each line.

After getting the first line, the machine will store the data somewhere and return, wagging its tail, and want more. You'll know this, as it will say "1:". You should reply "4, 14, 0". This will appease it, but not for any measurable length of time. You can shut it up for indefinite periods by entering "(esc)", which breaks it out of the "A" command loop, and prepares it to receive another instruction.

A "c" instruction can be employed with the further passing of time to add or change points in the data base. This is handy, as the present base makes no provision for the Martian canal worm...without which the game will have no jollies at all.

Next, there is the "L" instruction. This stands for "LIST". It only has one prompt: "RANGE: "X" "X,Y" (cr) (esc)". It's a bit confusing, because the "X" and "Y" are not cartesian co-ordinates, but, rather, point reference numbers. It will list the first point, designated by whatever is entered for "X", and all points thereafter until it encounters that one having the number held in "Y". "(cr)" dumps the whole data base in one shot.

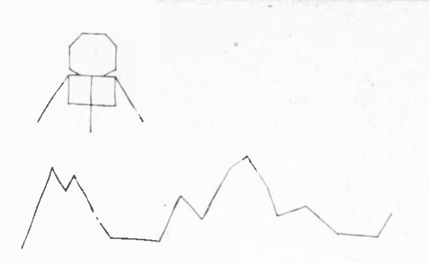


Fig.1 The first step in creating a data base is to draw the picture.

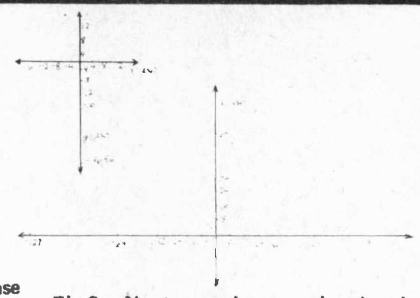


Fig.2 Next superimpose the drawing on a suitable axis.

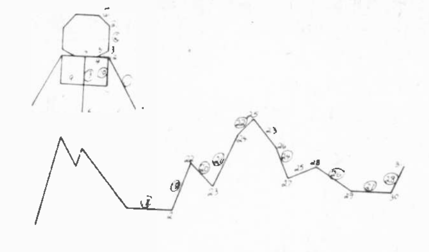


Fig.3 From this you can assign values to points and lines. These values are entered into Table 1.

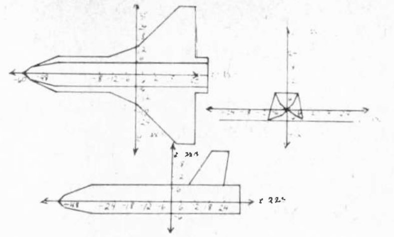


Fig.4 Drawing 3D figures require three views.

```
Object 0 contains points 0-15, .ines 0-13.
Object 1 contains points 16-31, lines 14-28.

Point  0 is at   -4, 14        Line. 0 connects points  0 and  1
Point  1 is at    4, 14        Line  1 connects points  1 and  2
Point  2 is at    8, 10        Line  2 connects points  2 and  3
Point  3 is at    8, 10        Line  3 connects points  3 and  4
Point  4 is at    4,  0        Line  4 connects points  5 and  6
Point  5 is at   -4,  0        Line  5 connects points  6 and  7
Point  6 is at   -8,  2        Line  6 connects points  7 and  0
Point  7 is at   -8, 10        Line  7 connects points  8 and  9
Point  8 is at   -8,  0        Line  8 connects points  8 and 10
Point  9 is at  -18,-18        Line  9 connects points 10 and 11
Point 10 is at   -8,-10        Line 10 connects points 11 and 12
Point 11 is at    8, 10        Line 11 cohnects points 12 and 13
Point 12 is at    8,  0        Line 12 connects points  8 and 12
Point 13 is at   18,-18        Line 13 connects points 14 and 15
Point 14 is at    0,  0
Point 15 is at    0,-20


Point 16 is at -127,  0        Line 14 connects points 16 and 17
Point 17 is at -112, 60        Line 15 connects points 17 and 18
Point 18 is at -100, 44        Line 16 connects points 18 and 19
Point 19 is at  -96, 56        Line 17 connects points 19 and 20
Point 20 is at  -64, 16        Line 18 connects points 20 and 21
Point 21 is at  -32, 16        Line 19 connects points 21 and 22
Point 22 is at  -20, 48        Line 20 connects points 22 and 23
Point 23 is at   -4, 32        Line 21 connects points 23 and 24
Point 24 is at   12, 68        Line 22 connects points 24 and 25
Point 25 is at   24, 80        Line 23 connects points 25 and 26
Point 26 is at   40, 60        Line 24 connects points 26 and 27
Point 27 is at   48, 40        Line 25 connects points 27 and 28
Point 28 is at   58, 48        Line 26 connects points 28 and 29
Point 29 is at   92, 32        Line 27 connects points 29 and 30
Point 30 is at  120, 32        Line 28 connects points 30 and 31
Point 31 is at  127, 48
```

Exciting little numbers, these are, but sooner or later one is bound to weary of them. Thus, the software is also equipped with that little extra, a command to make it possible to actually see the shapes on the tube. Hoo-hah...This instruction is called "S", which means "SHOW". In this mode, the images are displayed as they will be when the software is actually running, and it is possible to alter their relative positions. Herein we encounter one of the limitations of the Budge software...one not, incidentally, found in the SubLogics approach. The system does not clip the lines that extend beyond the boundaries of the screen. This can produce some rather peculiar pictures.

Transformations of the shapes are initiated by the "T" instruction, which, no, does not stand for toxiphobia. The paddles do X and Y movements,...weird in 2D. "Z" gets things happening as they should. At this point, it's also possible to shift the whole scale to increments of an overall factor of sixteen, using the cursor keys. Ve zoom in, ve zoom out, ve make sur-realistic zinima, ya?

"W" writes the data to a disc, and "Y" gets you out of the whole program, so you can go back to running "Devil's Dungeon" in peace.

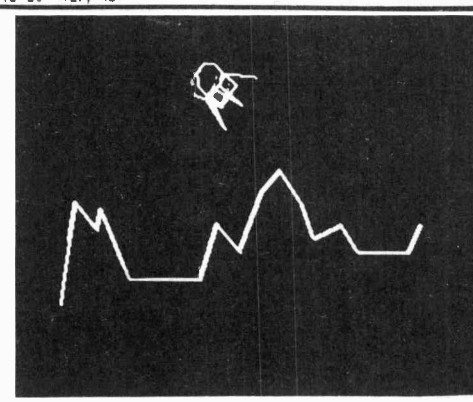
Module Airplane & Likewise Puns

The sole function of the editor was to get the database scurrying around inside the machine. The same thing could very well have been handled with a bucketful of pokes, although the tedium would have veged the senses. Once the editor has been shrugged off, the machine is, essentially, no more capable of doing any drawing than it was previously, although it might have a swarm of angry points buzzing around inside it. It is therefore necessary to summon forth the Mighty Magical Module Maker, the command for which is... well, it would seem to be "M" now, wouldn't it.

A module is a sort of a thing...of sorts. What it's about is to interface this great ball of data just entered with the machine's programming language. It's actually very simple to set up. In the M mode the machine requests, first of all, a choice of drawing methods, the ones being offered being "OR" and "XOR". "OR" is faster, but, once an "OR" line has been run over by another "OR" line, as in the case of the LEM passing in front of the lunar backdrop, it stays erased. This would necessitate redrawing the background with each change of frame. A hassle, this, and slow. Therefore, in situations where in this sort of thing is likely to occur, "XOR" is used. It's slower than straight "OR", but not so slow as "OR" that has to keep being redone.

Next, since the module is to associate itself with a language, it has to know which one. You have a choice of Integer or Applesoft Basic. I don't know if you'll be able to buy this thing in Quebec...it gives you an error message if you ask for French.

You can also have high resolution text and missiles in the module. Missiles, aye? We'll get to these in the unfolding of time. Chances are that unless the LEM game has a "Battle for control of the moon" feature built in, these won't be necessary at this stage.



The data base can be added to the completed module from the disc.

Writing the Program

Thought we were about done, didn't you. Oh ho ho (ho ho). Ho! We have yet to begin. That's not entirely correct, I know, but it has a great ring to it.

Having come this far, we now need a program to tell the machine when and how to dump the data base into the module so it will draw pictures on the screen. Naturally, this is pretty simple, as all it is really required to get into is feeding data to the module, and giving it cues. The program contains any manipulations required by the game proper. For instance, it we want the LEM to go down, the program has to understand this, and translate it into a module code. The module will draw the pictures needed to have it descend.

The program begins with a header, which initializes things and gets the module underway. It is presented here to make the whole works appear intimidating. From this point on, you're free to write a regular basic program to make things move. The module deigns to be addressed via a series of codes, which are actually arrays that are dimensioned in the header. There are quite a few of these. For example X%(i) and Y%(i) indicate where you want the object indicated by "i" to be on the tube. SCALE%(i) determines how large it is to loom. There are also matrixes like SX%(i) and YX(i) by which the module informs you of the position of the final point of the object on the screen.

Other arrays are used to define the animation functions. These include HIRES%, which switches on the high resolution graphics, and the eternally fabulous heart of the matter CRNCH% array, which writes on one page while displaying the other. This means that the actual drawing of an image always occurs on an invisible page.

The actual software is fairly simple to get together with all these bits. The documentation for the Game Tool provides the program to complete the simple Lunar Lander game; it runs for less than two pages. In contrast, to get together the same trip from scratch, above five or six times the number of lines would be required.

Good trip, man. Keeps the digits from becoming all worn down to a frazzle.

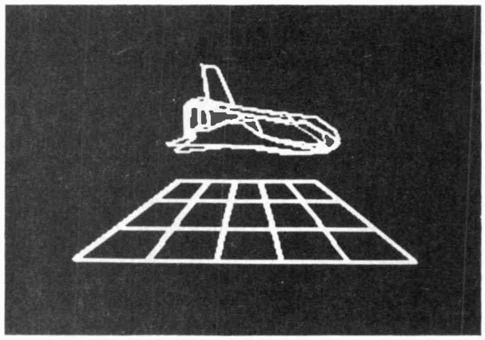
Far out and super delux options

As mentioned earlier, the system can deal with three dimensions. A data base is therefore given for a solid object, a representation of the space shuttle "Enterprise". With a three dimensional object in its head, the editor can do a few new tricks. In the show mode, typing "S" again will cause it to revolve. Depressing the X,Y, and/or Z keys will determine the axis about which it does so. What's really heavy is that it can do all of these simultaneous. This will get you really woozy if you're already three sheets to the wind before you start.

There are, of course, also arrays to access these functions when the module is running in a program, these being XROT% and YROT%.

The only hassle in three dimensional animation is that the thing doesn't have any notion of perspective or hidden lines. As a result, everything drawn on the screen looks, in a 3D sense, like it is only a skeleton formed out of wire. This can get a little confusing to the eye, which will often choose to see objects as being inside-out.

Now we get into the realy trippy features of the software. The oddest of these is the missile generator. It's just what it appears to be. Missiles are a rather important feature of most games, which usually take the form of blasting your opponent vicariously to smithereens. The missiles provided are of the generic photon torpedo/cosmic energy plasma bolt type, that is, one



glowing point with trajectory and ballistics. The missile generator is actually just a small bit of subroutine that can be called at will to move the missile, and deal with it when it has exceeded the boundaries of the screen. Once initialized and fired, it specifies the resulting path of the missile until it is no longer active. It accepts four parameters which determine the trajectory; the horizontal and vertical position of the missile's origin, and the horizontal and vertical components of its path.

There can be as many as sixteen missiles on the screen at any one time, which should result in quite a bit of electronic carnage. There is an array for them to determine whether they wrap or clip at the edges of the screen ...clipping is usually the case. This array will also return the result of the missile's flight. If it reaches the edge of the screen without hitting anything, and thus requires wrapping or clipping, the array will thereafter contain a number 128 in excess of the original entry.

The other nifty option is TXTGEN, which allows one to include high resolution text on the screen. This is actually pretty good stuff for the APPLE II, as it does lower case letters, something the machine isn't really into in its regular day to day running.

One important point is that the software is pretty huge, and, because of the additional size of things, the nifty neeto options aren't useable if the game program is written in Applesoft.

Tripping Out

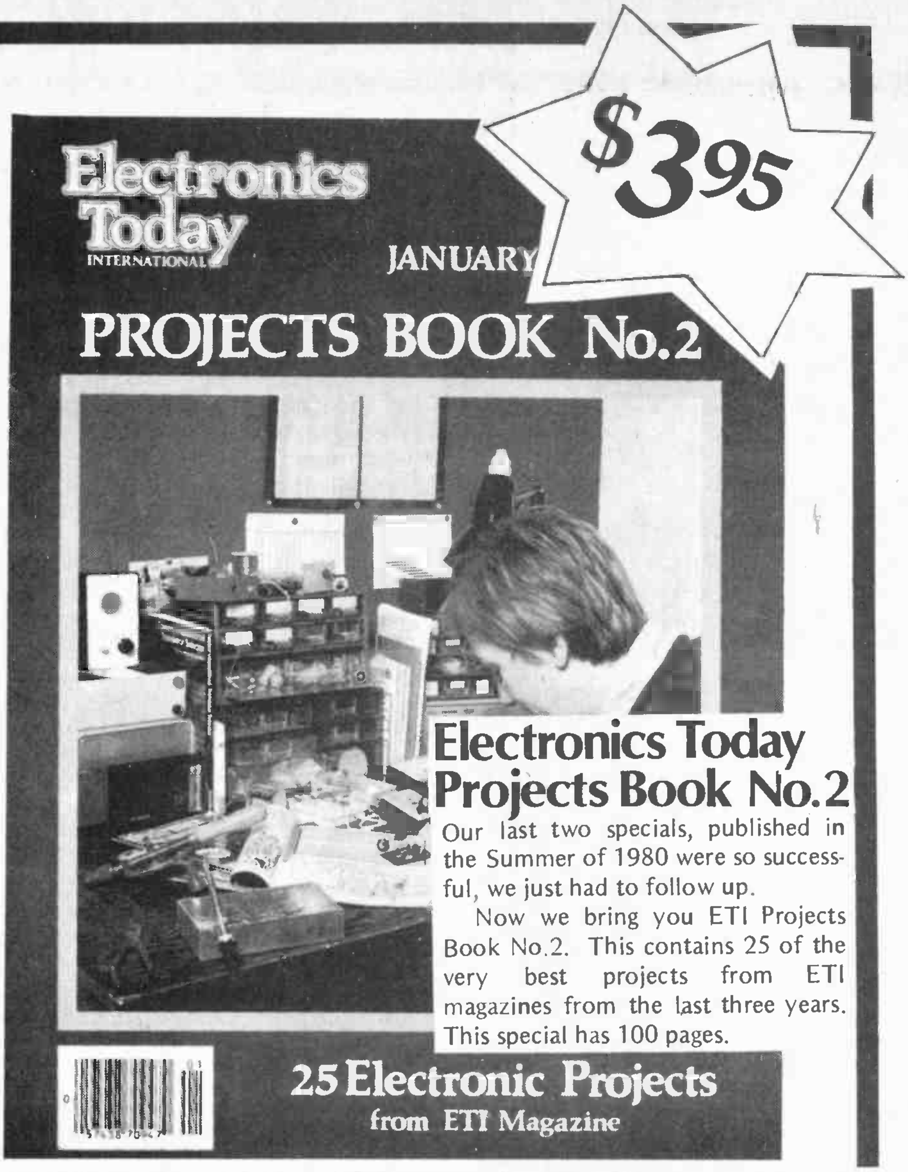
A graphics package is always a compromise between being able to do a wide enough range of stuff to make it useful, and being easy enough to use to make it workable. The Budge package achieves a good balance by being strictly a game writer. It enhances it with a high degree of human engineering. Unlike the Sub-Logics approach, there are no unrelated mnemonic codes to learn, and the words involved lend something to their own explanations. The notion of having a separate data handling module is also an improvement, as it eliminates the need for the programmer to have to keep poking into the machine to modify the graphics.

The software package is probably the best way to get into doing really complex games and simulations. It saves vast amounts of fiddling with the screen, and allows one to concentrate on the niceties of...ze game! Gadzooks...Andorrians to the left of us, Klingons to the right, Romulans materializing in the female crew's showers, the Organians on acid, a giant, one celled baked bean devouring solar system after solar system, our dylithium crystals exhausted, Mr. Spock gone with the seven year itch and Lt. Uhura pregnant...Captain, vat are ve going to do.

Relax, Mr. Checkhov. I've got a call in to Star Fleet for script changes.

Stay tuned.

In his feature on Studio Techniques, by Steve Rimmer, in the January 1981 issue some references to John Lennon were made. These were not meant unkindly and this issue was printed and distributed before his death. ●



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The only book giving all data for building every type of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential horn, folded horn, tuned port, klipschorn labyrinth, tuned column, loaded port and multi speaker panoramic. Many clear diagrams are provided showing all dimensions necessary.

BP37: 50 Projects Using Relays, SCR's & Triacs $5.50

Relays, silicon controlled rectifiers (SCR's) and bi directional triodes (TRIACs) have a wide range of application in electronics today. These may extend over the whole field of motor control, dimming and heating control, delayed, timing and light sensitive circuits and include warning devices, various novelties, light modulators, priority indicators, excess voltage breakers, etc.

The enthusiast should be able to construct the tried and practical working circuits in this book with a minimum of difficulty. There is a wide latitude in component values and types, allowing easy modification of circuits or ready adaptation of them to individual needs.

BP39: 50 (FET) Field Effect Transistor Projects $5.50

The projects described in this book include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various miscellaneous devices which are useful in the home. This book contains something of particular interest for every class of enthusiast – short wave listener, radio amateur, experimenter or audio devotee.

BP42: 50 Simple L.E.D. Circuits $3.55

50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most expensive and freely available components – the Light Emitting Diode (L.E.D.). Also includes circuits for the 707 Common Anode Display. A useful book for the library of both beginner and more advanced enthusiast alike.

BP44: IC 555 Projects $7.55

Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. It is manufactured by almost every semiconductor manufacturer and is inexpensive and very easily obtainable.

Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP46: Radio Circuits Using ICs $5.90

This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. Chapters on amplitude modulated (a.m.) receivers and frequency modulation (f.m.) receivers. Discussion on the subjects of stereo decoder circuits, the devices available at present for quadrophonic circuits and the convenience and versatility of voltage regulator devices. An extremely valuable addition to the library of all electronics enthusiasts.

BP47: Mobile Discotheque Handbook $5.90

The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco gear". The approach adopted is to assume the reader has no knowledge and starts with the fundamentals. The explanations given are simplified enough for almost anyone to understand.

BP48: Electronic Projects For Beginners $5.90

The newcomer to electronics, will find a wide range of easily made projects and a considerable number of actual component and wiring layouts. Many projects are constructed so as to eliminate the need for soldering. The book is divided into four sections. "No Soldering" Projects, Miscellaneous Devices, Radio and Audio Frequency Projects and Power Supplies.

BP49: Popular Electronic Projects $6.25

A collection of the most popular types of circuits and projects which will provide a number of designs to interest the electronics constructor. The projects selected cover a very wide range. The four basic types covered are Radio Projects, Audio Projects, Household Projects and Test Equipment.

BP50: IC LM3900 Projects $5.90

The purpose of this book is to introduce the LM3900, one of the most versatile, freely obtainable and inexpensive devices available to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses.

Simple basic working circuits are used to introduce this IC. The reader should set up each of these for himself. Familiarity with these simple circuits is essential in order to understand many more complicated circuits and advanced uses.

BP51: Electronic Music and Creative Tape Recording $5.50

This book sets out to show how electronic music can be made at home with the simplest and most inexpensive of equipment. It then describes how the sounds are generated and how these may be recorded to build up the final composition.

For the constructor, several ideas are given to enable him to build up a small studio including a mixer and various sound effects units. All the circuits shown in full have been built by the author. Most of the projects can be built by the beginner.

BP62: BOOK 1. The Simple Electronic Circuit & Components $8.95
BP63: BOOK 2. Alternating Current Theory $8.95
BP64: BOOK 3. Semiconductor Technology $8.95
BP77: BOOK 4. Microprocessing Systems & Circuits $12.30

Simply stated the aim of these books is to provide an inexpensive introduction to modern electronics. The reader will start on the right road by thoroughly understanding the fundamental principles involved.

Although written especially for readers with no more than ordinary mathematical skills, the use of mathematics is not avoided, and all the mathematics required is taught as the reader progresses.

The course concentrates on the understanding of the important concepts central to electronics. Each book is a complete treatise of a particular branch of the subject and, therefore, can be used on its own. However, latter books assume a working knowledge of the subjects covered in earlier books.

BOOK 1 This book contains fundamental theory necessary to a develop a full understanding of the simple electronic circuit and its main components.
BOOK 2 This book continues with alternating current theory.
BOOK 3 Follows on semiconductor technology, leading up to transistors and integrated circuits.
BOOK 4 A complete description of the internal workings of microprocessors.

BP65: Single IC Projects $6.55

All the projects contained in this book are simple to construct and are based on a single IC. A strip board layout is provided for each project, together with any special constructional points and setting up information, making this book suitable for beginners as well as more advanced constructors.

BP66: Beginners Guide To Microprocessors & Computing $7.55

This book is intended as an introduction to the basic theory and concepts of binary arithmetic, microprocessor operation and machine language programming. The only prior knowledge which has been assumed is very basic arithmetic and an understanding of indicies. A helpful Glossary is included. A most useful book for students of electronics, technicians, engineers and hobbyists.

BP67: Counter Driver & Numeral Display Projects $7.55

The author discusses and features many applications and projects using various types of numeral displays, popular counter and driver IC's, etc.

BP68: Choosing & Using Your HI-FI $7.25

The reader is provided with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of stereo equipment currently on the market. This should aid him in understanding the technical specifications of the equipment he is interested in buying. Full of helpful advice on how to use your stereo system properly so as to realise its potential to the fullest and also on buying your equipment. A Glossary of terms is included.

BP69: Electronic Games $7.55

The author has designed and developed a number of interesting electronic game projects using modern integrated circuits. The book is divided into two sections, one dealing with simple games and the latter dealing with more complex circuits. Ideal for both beginner and enthusiast.

BP70: Transistor Radio Fault-Finding Chart $2.40

Author Mr. Chas Miller has drawn on extensive experience in repairing transistor radios to design this book. The reader should be able to trace most of the common faults quickly using the concise chart.

BP71: Electronic Household Projects $7.70

Some of the most useful and popular electronic construction projects are those that can be used in or around the home. These circuits range from such things as '2 Tone Door Buzzer' and Intercom through Smoke or Gas Detectors to Baby and Freezer Alarms.

BP72: A Microprocessor Primer $7.70

A newcomer tends to be overwhelmed when first confronted with articles or books on microprocessors. In an attempt to give a painless approach to computing, this small book will start by designing a simple computer that is easy to learn and understand. Such ideas as Relative Addressing, Index Registers, etc will be developed and will be seen as logical progressions rather than arbitrary things to be accepted but not understood.

BP 73: Remote Control Projects $8.58

This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control and many of the designs are suitable for adaptation to the control of other circuits published elsewhere. Full explanations have been given so that the reader can fully understand how the circuits work and see how to modify them. Not only are Radio control systems considered but also Infra red, Visible light and Ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

BP74: Electronic Music Projects $7.70

Although one of the more recent branches or amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category, ranging in complexity from a simple guitar effects unit to a sophisticated organ or synthesiser.

The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser-Units, Tremelo Generator etc.

BP75: Electronic Test Equipment Construction $7.30

This book covers in detail the construction of a wide range of test equipment for both the hobbyist and radio amateurs. Included are projects ranging from a FET Amplified Voltmeter and Resistance Bridge to a Field Strength Meter and Heterodyne Frequency Meter.

Not only can the home constructor enjoy building the equipment but the finished project can also be usefully utilised in the furtherance of his hobby.

An ideal book for both beginner and advanced enthusiast alike.

BP76: Power Supply Projects $7.30

Power supplies are an essential part of any electronic project.

The purpose of this book is to give a number of power supply designs, including simple unstabilised types, fixed voltage regulated types, and variable voltage stabilised types, the latter being primarily intended for use as bench supplies for the electronic workshop. The designs are all low voltage types for use with semiconductor circuits.

There are other types of power supplies and a number are dealt with in the final chapter, including a cassette supply, Nicad battery charger, voltage step up circuit and a simple inverter.

BP78: PRACTICAL COMPUTER EXPERIMENTS $7.30

This book aims to fill in the background to microprocessors by describing typical computer circuits in discreet logic and it is hoped that this will form a useful introduction to devices such as adders, memories, etc. as well as a general source book of logic circuits.

An essential edition to the library of any computer and electronic enthusiast.

BP79: Radio Control For Beginners $7.30

The aim of this book is to act as an introduction to Radio Control for beginners to the hobby. The book will commence by dealing with the conditions that are allowable for such things as frequency and power of transmission. This is followed by a "block" explanation of how control device and transmitter operate and receiver and actuator(s) produce motion in a model.

Details are then given of actual solid state transmitting equipment that the reader can build. Plain and loaded aerials are then discussed and so is the field strength meter to help with proper setting up.

The radio receiving equipment is then dealt with, this includes a simple receiver and a crystal controlled superhet. The book ends with electro mechanical means of obtaining movement of the controls of the model.

BP80: POPULAR ELECTRONIC CIRCUITS–BOOK 1 $8.25

Another book by the very popular author, R. A. Penfold, who has designed and developed a large number of circuits which are accompanied by a short text giving a brief introduction, circuit description and any special notes on construction and setting up that may be necessary.

The circuits are grouped under the following headings, Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Projects, and Miscellaneous Circuits.

An extremely useful book for all electronic hobbyists, offering remarkable value for the number of designs it contains.

NO.213: Electronic Circuits For Model Railways $4.50

The reader is given constructional details of how to build a simple model train controller controller with simulated inertia and a high power controller. A signal system and lighting for model trains is discussed as is the suppression of RF interference from model railways. The construction of an electronic steam whistle and a model train chuffer is also covered.

NO.215: Shortwave Circuits & Gear For Experimenters & Radio Hams $3.70

Covers constructional details of a number of projects for the shortwave enthusiast and radio "Ham". Included are an add in crystal filter, adding an "S" meter in your receiver, crystal locked H.F. Receiver, AM tuner using phase locked loop, converter for 2MHz to 6MHz, 40 to 800MHz RF amplifier, Aerials for the 52, 144MHz bands, Solid State Crystal Frequency Calibrator, etc.

NO.221: Tested Transistor Projects $5.50

Author Mr. Richard Torrens has used his experience as an electronics development engineer to design, develop, build and test the many useful and interesting circuits in this book. Contains new and innovative circuits as well as some which may bear resemblance to familiar designs.

NO. 223: 50 Projects Using IC CA3130 $5.50

In this book, the author has designed and developed a number of interesting and useful projects using the CA3130, one of the more advanced operational amplifiers that is available to the home constructor. Five general categories are covered: Audio Projects, R.F. Projects, Test Equipment, Household Projects and Miscellaneous Projects.

NO.224: 50 CMOS IC Projects $4.25

CMOS IC's are suitable for an extraordinary wide range of applications and are now also some of the most inexpensive and easily available types of ICs. The author has designed and developed a number of interesting and useful projects. The four general categories discussed in the book are: Multivibrators, Amplifiers and Oscillators, Trigger Devices and Special Devices.

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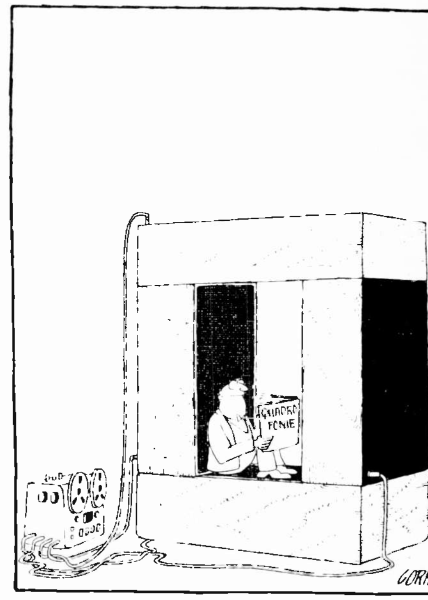
Audio Today



Setting up a listening room? Wally Parsons has some useful design considerations.

ONE OF THE oldest cliches in audio purports that the man of the family is concerned exclusively with hardware and its performance, while wives are a bunch of clods who would have equipment designed by Ladies' Home Journal.

According to this convention, wives are totally pre-occupied with interior decor, dust removal, and the elimination of clutter. And heaven forbid that a living room might have its decor desecrated by even a hint of technology, other than something which can be hidden inside some sort of furniture box. And speakers, out of sight or disguised as something else.

Husbands, of course, are really a bunch of overgrown kids, who delight in playing with their fancy toys, and revel in the sight of all that hardware strewn about the room, wires festooned from every corner, big speakers all over the place, sans grilles, of course.

Wherefore Lies The Truth

Actually, there is probably a grain of truth to this stereotype, enough to keep it alive over the years. My mother, for example, came from that generation which regarded the "parlour" as sacrosanct, a room dominated by a large piano, which gave me ready access to it, and whose only concession to modernity was a large console radio of the sort which today would be regarded as a desireable antique had I not cannibalized it during my early high school years.

This console radio was suitable for use on Sundays only, which is probably the reason I remember the Sunday evening mystery stories so fondly.

I also knew a woman, once, who was so decor conscious as to be compulsive. She once bought an absolutely horrible sounding stereo modular system, chosen because it could be hidden in her office, and the speakers (all speakers were regarded as ugly) brought out only on those occasions when she was actually using them, to be hidden away whenever anyone called.

My wife, on the other hand, is extremely tolerant in this respect. I do have a certain tendency towards wired sound, which is inevitable with someone who does a great deal of experimenting, but this is countered by installing all equipment except speakers either in a separate room, or a partitioned section of a room. Except when experimenting or modifying a large speaker, cables are generally routed to the listening room via channels under the house, and brought out against the speaker wall from under the rug. I happen to like this approach myself, as it contributes to the sense of realism by eliminating visual distractions to a large extent, and plans for my present listening room include developing a decor which is not only accoustically correct, but visually directs attention to the sound emanating from the big fellas.

FOR ANY RESONABLE RUN OF SPEAKER CABLE, NEVER USE ANYTHING LESS THAN 16 GAUGE.

Cable Dressing

But it is surprising how often one encounters the kind of audiophile who carefully selects the most suitable equipment for his system, or builds it up with painstaking care either from his own designs or from magazine projects, yet gives little thought to the layout of interconnecting cables.

Then there is the person who pays so much attention to getting wires out of the way that they are either selected solely on the basis of hideability, or exposed to constant hazards, such as being stepped on.

From The Output Backwards

The most obvious problem area lies in speaker connection. This is the only component consistently located remote from the rest of the gear.

In order to facilitate draping cables behind furniture, under rugs, etc, many people buy stuff which is sold at electronics stores as "speaker wire". Offhand, I can't imagine using this stuff for anything more demanding than connecting a small extension speaker in the bathroom. Generally this stuff consists of 20 to 22 Gauge twisted pair in a thin insulator. People who make and market this stuff think of "heavy duty" cable as 18 Gauge wire in a transparent jacket. You might as well use electrical zip cord.

For any reasonable run, you shouldn't be using anything smaller than 16 Gauge, and this is available in the form of portable power cordage which is flexible enough to dress around furniture, and has a tough enough jacket to withstand a fair amount of abuse.

Many people, the professor here included, regard even this as inadequate, preferring something in the order of 12 Gauge. Although it can be handled in a similar manner, there are other alternatives available.

My own system requires a 50 foot run, and since both the equipment and listening room are both on the main floor, the solution is to run it through the basement. This is complicated, however, by the fact that I'm using a set of high definition cables which I built from some off-the-self assemblies intended for a different application (yes, this will be the subject of a later column), and requiring laying out four 50 foot lengths, each spaced the same distance apart, and each conductor having a diameter of ¼ inch.

One very practical way of laying cable right down the middle of a room is to lay, first, a layer of underpad, and over this lay the cable. Cut another layer of underpad into as many pieces as needed to cover the first layer, with a cut-out channel for the cable. This layer should be slightly thicker than the height of the laid out cable, even if it means multiple layers. Over this place another layer, covering the cables. This is topped by the carpet. The cable is now protected by a cushioned channel. The cables might enter and exit at the carpet perimeter, or if you're prepared to cut into the carpet, anywhere along the channel. If you're carpeting with several pieces butted together, including "carpet tile", which are square pieces of carpeting each about 1 foot or 1 yard square, cable can enter or exit at any of the junctions.

If cabling must be exposed, you might consider using plastic or metal floor channel, normally used in open-planned offices for telephone and power lines, and available from electrical supply houses. Another similar choice would be plastic duct such as Panduit or Dek, available from Electrosonic.

It's a bit of work, but sure beats an all-in-one equipment stand.

The method of installation consisted of drilling four holes each slightly larger than ¼ inch through each floor joist and through suitable locations in the floors. It also meant dressing around heating ducts, and avoiding close proximity to power cables.

To The Input Sections

Dressing of signal cables is greatly facilitated if the equipment is housed in some kind of cabinetry, or even an equipment stand or rack. The important thing here is mainly keeping input and output cables separated, and keeping all cables away from power lines. However, at times you may wish to run cables from one sub-installation to another. such as one section which contains RF equipment such as FM and AM tuners, Television sound tuners, or, in my case, a broadband line amplifier feeding FM and TV.

Unfortunately, too many prepared cables do not offer adequate shielding, and if placed in close proximity to each other may cause cross-talk or even instability.

The solution here is to make your own cables, using fully shielded cable, such as the Belden products with the foil shield, or an RF cable such as RG58R, or, if small diameter is called for, RG174U. Both are available with a stranded centre conductor for flexibility, both have capacitance of 30 pF/ft and are inexpensive.

Such assemblies can be bundled together and dressed in a manner similar to the one described for speaker cables, only using one hole large enough to accept the whole bundle.

Surface Dressing

Some people live in apartments. Some apartment dwellers also have stereo systems. In fact, one system often suffices for the whole building, whether the neighbours like it or not. Obviously, it isn't practical to drill holes in the floor and through steel beams. Or there may be many other reasons why you would not wish to go under the floors, yet draping behind furniture is undesireable, perhaps because of an open floor/wall junction, or perhaps it would necessitate unreasonably long runs.

Anyone with an audio system who is reading this has a rug on the floor, or is planning to lay one. Ideally, it will cover the entire floor surface. In addition, as any carpet salesman will tell you, it should have an underpad, both for comfort, and to preserve the life of the carpet. For acoustical reasons, it would be a thick pad, perhaps a closed-cell foam, neoprene, or something similar. Most pads are about ¼ inch thick, but it is often desireable to use something thicker, even if it means multiple layers, perhaps three or four. And it feels marvellous underfoot. ●

AUDIO TODAY LETTERS

I have decided to build an amplifier and preamplifier and I have made my choice on Siliconix 40 Watt designed by Lee Shaeffer (ETI Nov '77). My problem is the choice of a tone control as well as a series of questions I would like you to answer:

1) What I want is bass, midrange and treble. I want to calculate the frequency cutoff of bass, treble, and I want to introduce a midrange. I am sending you two circuits. Could you show me your calculations.

2) What is the difference between Baxendall and Constant Turnover type tone control?

3) We talk about amplifier and preamplifier distortion. What about the tone control distortion, is it important?

4) Sony introduced on the market the pulse power supply. What does this mean? Do you have an idea.

5) The double power supply (one for each channel), do you think it is a great deal or simply a gadget?

6) Harmonic distortion preamp, + harmonic distortion, tone control + harmonic distortion amplifier = Harmonic Distortion Total. Is it true or false?

7) What is the difference between these two schematic circuits? Which one is the best? (Fig. 1) These circuits came from two different magazines, one from Electronic Experimenters Handbook (Winter, 1968) and the other from ETI (October, 1980).

All answers, suggestions, books,

references would be appreciated.

L. J., Montreal P.Q.

This letter was selected for publication because it represents, better than any hypothetical example I could dream up, what I call the cook-book approach to amplifier design. (There is also a cook—book approach to speaker design which parallels it). "Take 2 healthy fresh transistors, connect to the input of one standard integrated circuit, add feedback to taste, modify as needed, and solder to board".

Since all my 1977 magazines are still packed away I cannot comment on the suitability of the preamp for use with the power amplifier you've chosen, but it should be noted that if tone controls are incorporated in the circuit you have no problem. If you wish to *modify* the circuit I would suggest you write to the editor of "Audio" magazine for advice. Building any component from a magazine project, whether it be ETI, Audio, or any other publication, has much in common with purchasing a manufactured unit. To a very large extent you are accepting not only the benefits of the designers' expertise and knowledge, but also their judgements as to what features are suitable, and the manner in which each feature and performance characteristic is achieved. If these are not acceptable to you, then you should either design the unit from scratch yourself, if you have the ability, or select another project, from either the same source or elsewhere.

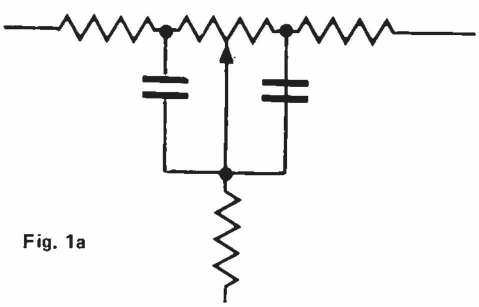


Fig. 1a

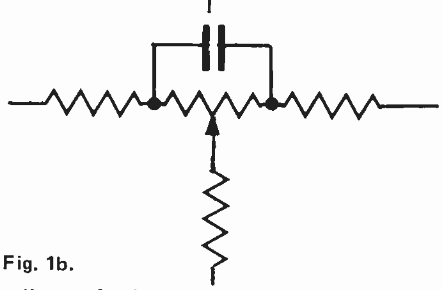


Fig. 1b.

Now, to answer your specific questions:

1) I cannot give you any calculations for your tone controls. You do not provide sufficient data, such as corner frequencies, centre frequency, variable parameter, and the rest of the circuit details. In any case, this would be beyond the scope of a letter section.

2) The Baxendall tone control is a specific circuit designed by Peter Baxendall, and was first used in North America by David Bogen in the DB20 tube amplifier. It is still one of the standard circuits, "as standard as a half-inch bolt" to quote one reader. It is a feedback design whose slopes do not quite approach 6 dB/Octave, and although it is theoretically a constant turnover circuit with variable slope, practical circuits normally result in the turnover point moving toward the midband as the slope is increased. In effect, it produces a happy combination of variable slope and variable turnover response with reasonable simplicity of design and use. Thus, its popularity.

3) It is not meaningful to talk about preamplifier, amplifier and tone control distortion in this manner, as these are not distortion mechanisms. If we acknowledge that any given distortion mechanism results in unacceptable performance, then it is important no matter in what part of the circuit it is generated. In any case, "tone control" is just shorthand for a particular sub-circuits or complete components.

4) A pulsed power supply, as its name implies, supplies a series of high amplitude short duration pulses to the rectifier of the power supply, much in the way the flyback transformer in a television set supplies pulses at the horizontal scanning rate to the high voltage rectifier.

5) Separate power supplies for stereo power amplifiers are used to isolate both channels from each other and reduce interaction, especially during high power demands. Because the power supply is part of the feedback circuit, any signal component from one channel which appears in the supply will be transferred to the other channel via it's feedback loop. In fact, you actually have two independent amplifiers on one chassis. It's usefulness depends entirely on amplifier design objectives. Since isolation is much easier to achieve in preamplifiers, it is seldom used there.

6) Not necessarily. Harmonic distortion is expressed in terms of the number and/or order of harmonics of the fundamental present at the output of a circuit. Consequently, a distorting amplifier driven by a signal which contains distortion components will distort not only the fundamental, but also the aforementioned distortion components, resulting in distortion components which were not in the originally distorted signal. This is one reason why low distortion in low level stages is so important even when it would appear that later stages would mask it. It is also one of the reasons why some components go well together while other combinations don't work.

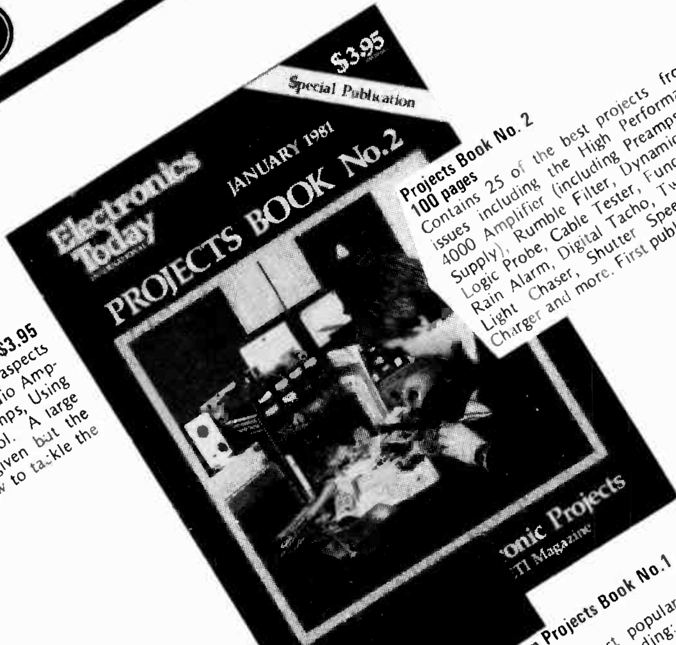
7) Fig 1a provides the same corner frequencies at each extreme setting, while Fig 1b provides a more remote corner frequency, that is, a lower break point, in the maximum cut position, but with a smaller parts count. In actual practice, boost is usually more useful than cut, so this is seldom as significant as it would appear at first glance.

As for the other two circuits referred to in question (1), I would use the IC version rather than the discrete circuit. The latter is more complex to build, and the devices are old enough and their performance sufficiently limited to negate any advantages which might be achievable with a discrete circuit.

I would suggest you get hold of National Semiconductor's Audio Handbook, as well as the Linear Applications book, available from any National Semiconductor distributor, and many Radio Shack stores.

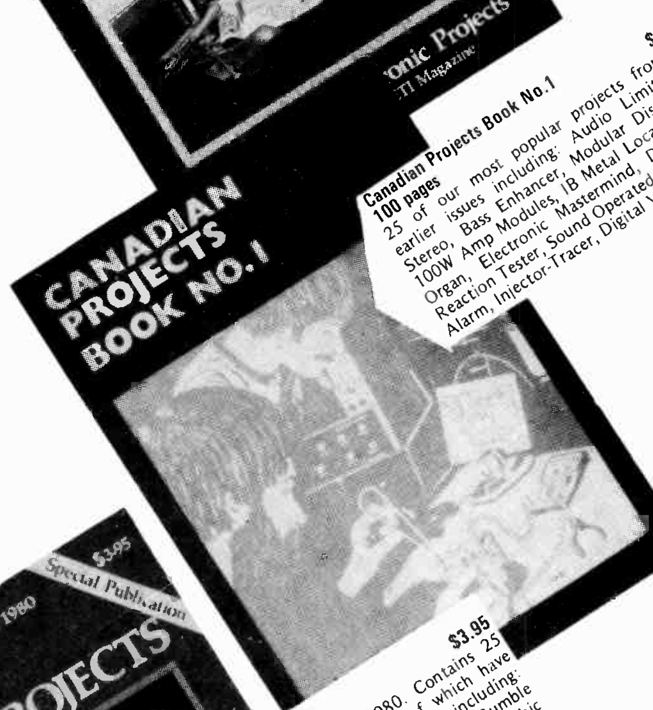
For your information, letters like this one often form the basis for future columns. Therefore, they are most welcome. ●

ETI SPECIALS



Projects Book No. 2 $3.95
100 pages
Contains 25 of the best projects from recent issues including the High Performance Series 4000 Amplifier (including Preamps and Power Supply), Rumble Filter, Dynamic Noise Filter, Logic Probe, Cable Tester, Function Generator, Rain Alarm, Digital Tacho, Two Octave Organ, Light Chaser, Shutter Speed Timer, Ni-Cad Charger and more. First published January 1981.

Electronic Circuit Design $3.95
92 pages
A collection of major articles on various aspects of circuit design including CMOS, Audio Amplifiers, Power Supplies, SCR's, Op-Amps, Using the 3080 and Temperature Control. A large number of useful circuits are given but the emphasis is on guidance and how to tackle the design for yourself.



Canadian Projects Book No.1 $3.00
100 pages
25 of our most popular projects from our earlier issues including: Audio Limiter, 5W Stereo, Bass Enhancer, Modular Disco, 50W/100W Amp Modules, IB Metal Locator, Touch Organ, Electronic Mastermind, Double Dice, Reaction Tester, Sound Operated Flash, Burglar Alarm, Injector-Tracer, Digital Voltmeter.

More Circuits $4.50
108 pages
Over 150 circuits plus articles on Circuit Construction, Test Gear, a project on a Digital Panel Meter, Design notes on Speaker Crossovers, TTL pin-outs, Design notes on Crystal Oscillators.

Hobby Projects $3.95
100 pages
First published Summer 1980. Contains 25 straight-forward projects most of which have never appeared in the magazine including: Stereo Amp, Audio Mixer, Scratch and Rumble Filter, Constant Volume Amp, Graphic Equaliser, Envelope Generator, White Noise Effects Unit, Linear Scale Ohmmeter, Intercom, Drill Speed Controller, LED Tacho, Parking Meter Timer, Electronic Organ, Touch Switch, Electronic Dice, Siren, Simple Receivers.

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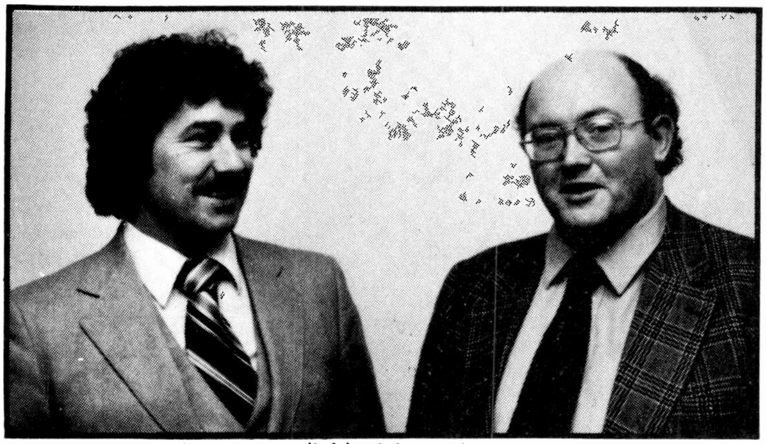
DOMINION RADIO PLAN NATIONWIDE DISTRIBUTION

A major new distribution network for electronics parts is being planned by Dominion Radio and Electronics. ETI has been talking to one of their Directors, Chris Comeau.



Chris Comeau (left) talking to ETI's Editor Halvor Moorshead.

Dominion Radio and Electronics is one of the best known parts suppliers in Canada. Apart from being established for 31 years, ETI readers will be familiar with their catalogues which have been included in the magazine on several occasions.

It is only a year since DR & E entered the kit business with their range of Edukits but the expansion is continuing by offering franchised distributorships throughout Canada and the US.

We talked to Chris Comeau, one of the Directors of Dominion:

ETI: Why are you going into the franchise business?

DR & E: Although were very strong in the Toronto area and have been supplying other wholesalers for a number of years, we feel there's a much bigger market in other areas. We're in an excellant position to expand our operation as we carry a very high level of inventory—in fact this is estimated at 100 million parts!

ETI: Briefly, how will this work?

DR & E: We shall be appointing one company or one person in a given geographical area who will have the exclusive distribution rights for our products. We'll supply them with the stock, leaflets, catalogues and our know-how of the parts business.

ETI: How big will these areas be?

DR & E: This isn't fixed. If someone asks for a large territory—say the whole of British Columbia—we would first have to satisfy ourselves that they could cover this properly but also they would have to commit themselves to an investment in stock in keeping with the size of the territory.

Inside the Dominion Radio store.

ETI: Who will these people sell to?

DR & E: They'll sell to other distributors, industrial accounts and hobby shops. They can also sell to schools either directly or indirectly.

ETI: Are you asking for these people to handle your line of products exclusively?

DR & E: No. In the case of an existing distributor it's almost certain they'll have many lines and we're not asking them to drop anything. In fact the experience gained through dealing with other lines would have advantages. This doesn't mean that we wouldn't consider someone who is not in business as an electronics distributor at the moment.

ETI: Will they be expected to carry stock held locally?

DR & E: Yes, but the level and mix is up to them.

ETI: What sort of investment are you asking for?

DR & E: For a territory with 250,000 population they'll need only $5000; this is also the minimum. Large territories would need a proportionately higher investment.

ETI: What will they get for this money?

DR & E: Except for a $100 licence fee, all the money is for stock.

ETI: We assume they'll have to undertake to buy so much a year?

DR & E: Yes and No. They are not obliged to buy any particular level but we would expect someone with a 250,000 population area to take $15,000 of stock a year—that's an average of $1250 a month. If they don't maintain this they run the risk of losing their franchise.

ETI: What if they get their stock balance wrong?

DR & E: No problem. We have a programme by which they can exchange inventory easily—we feel this is important. Remember that we have a very strong interest in our distributor-agents being successful.

ETI: What sort of products will be available?

DR & E: All kinds of parts, passive and active components—we have a very good range in this area. There'll also be the Edukits (which we manufacture ourselves); there are 25 kits at the moment but several more are on the drawing board. We're pretty big in loudspeakers, we even have our own brand name of Ultraflex. There is also a good range of industrial parts.

ETI: What sort of companies or people are you looking for?

DR & E: Whoever we choose must know something about electronics parts. We'll give preference to an existing parts outlet but we'll consider a hobbyist or technician as a suitable candidate.

ETI: Will this operate only in Canada?

DR & E: No, we have a similar programme for the US and even for other countries. Outside of North America we will only appoint one agent in each country.

ETI: The licence fee of $100 seems

The outside view of the Dominion Radio's Yonge Street store.

very little, why is this so?

DR & E: Let's face it, this is a new side of our operation and we want to get it off the ground: it's a bit like McDonalds on day one. When it gains momentum the licence fees for the remaining territories will rise considerably. At this point however we want to get quick coverage of North America more than anything else.

ETI: What sort of support will you be giving to your distributor-agents?

DR & E: In many areas they will inherit existing customers; any business that we get from our national advertising will be passed on and they'll all be supplied with a list of potential customers in their area.

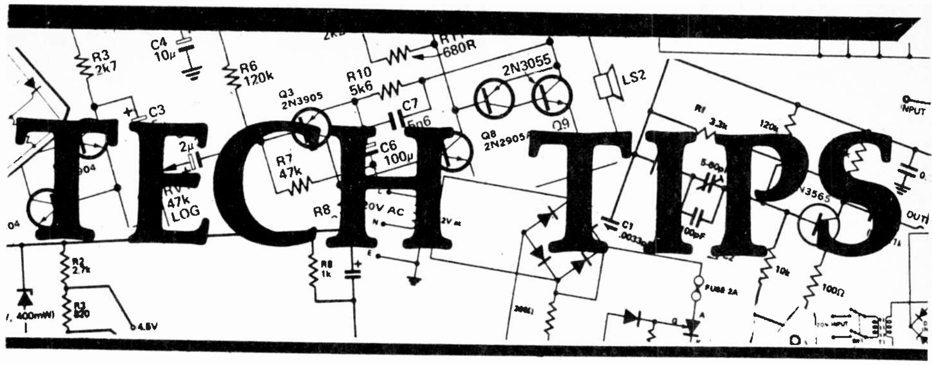
We'll also be supplying good back-up literature as well as a specially prepared catalogue on which they can put their own name.

We have a lot of experience in selling electronic kits to schools and will train people in this field. In addition we'd pass on our experience as to who is likely to buy what.

ETI: How are you going to select these distributor-agents?

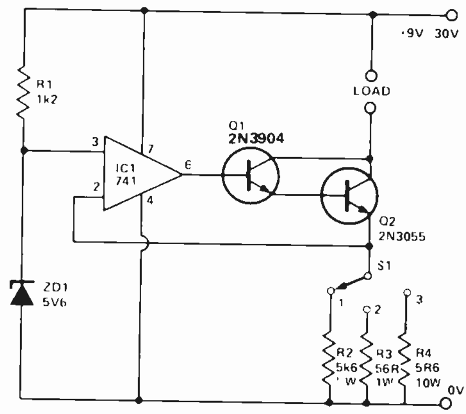
DR & E: We shall be visiting various cities to hold interviews beginning in March. Anyone interested in being considered should call me, Chris Comeau at Dominion Radio at (416) 495 - 2524.

ETI: Thanks Chris. Good luck with this venture. ●



Constant Current Source

J Macaulay



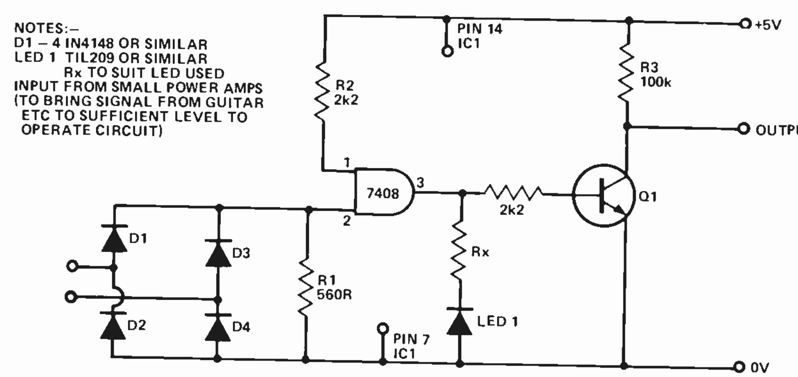
The circuit shown will provide 3 pre-set currents which will remain constant despite variations of ambient temperature or line voltage.

ZD1 produces a temperature stable reference voltage which is applied to the non inverting input of IC1.

100% DC feedback is applied from the output to the inverting input holding the voltage at Q2s emitter at the same potential as the non inverting input.

The current flowing into the load therefore is defined solely by the resistor selected by S1. With the values employed here, a preset current of 10mA, 100mA or 1A can be selected.

Q2 should be mounted on a suitable heatsink.



Extension Trigger Device for Synthesizers

J. Trinder

The following device is intended to provide a trigger pulse for a synthesizer when using an external input source, e.g. a guitar.

The output from the guitar must first be amplified by a small power amplifier in order to bring the signal to a sufficient level to operate the device.

The AC input to the device is converted to DC by the bridge rectifier. When the DC level reaches a sufficient level the input of the AND gate is taken high. As the other input is already high its output becomes high.

When this happens the transistor is turned on, thus taking the output voltage to nearly zero. When the DC level at Pin 2 falls below the required level its output goes low thus turning the transistor off.

The output from the device is approx 3V5 (off) and approx 0V (on). The LED is on when the unit is triggered.

The synthesizer intended for use with the circuit has an extension trigger input which requires less than —3V on, thus the common and output connections of the external trigger device have to be reversed so that the external trigger input usually sees —3V5 (off) instead of +3V5.

The circuit can be easily modified to suit individual needs. An example of its use is to trigger a filter sweep when the input of, e.g. a guitar, reaches a certain level.

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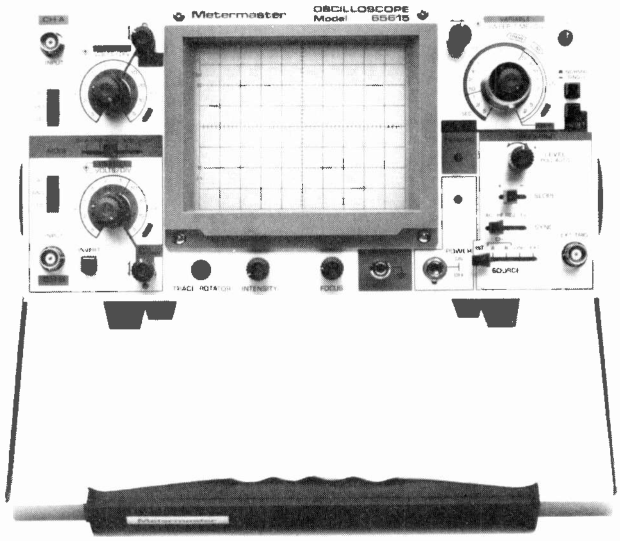

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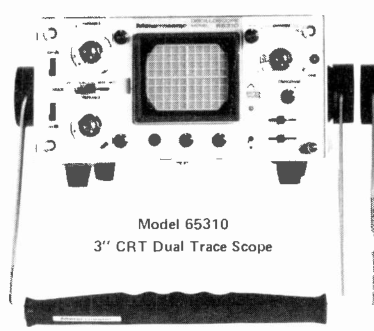

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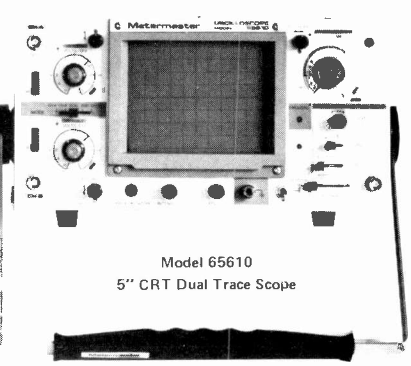

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- Fully Automatic Triggering.
- Bandwidth DC – 15MHz (–3dB).
- Trace Rotator.
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Accessories: Probes (extra).

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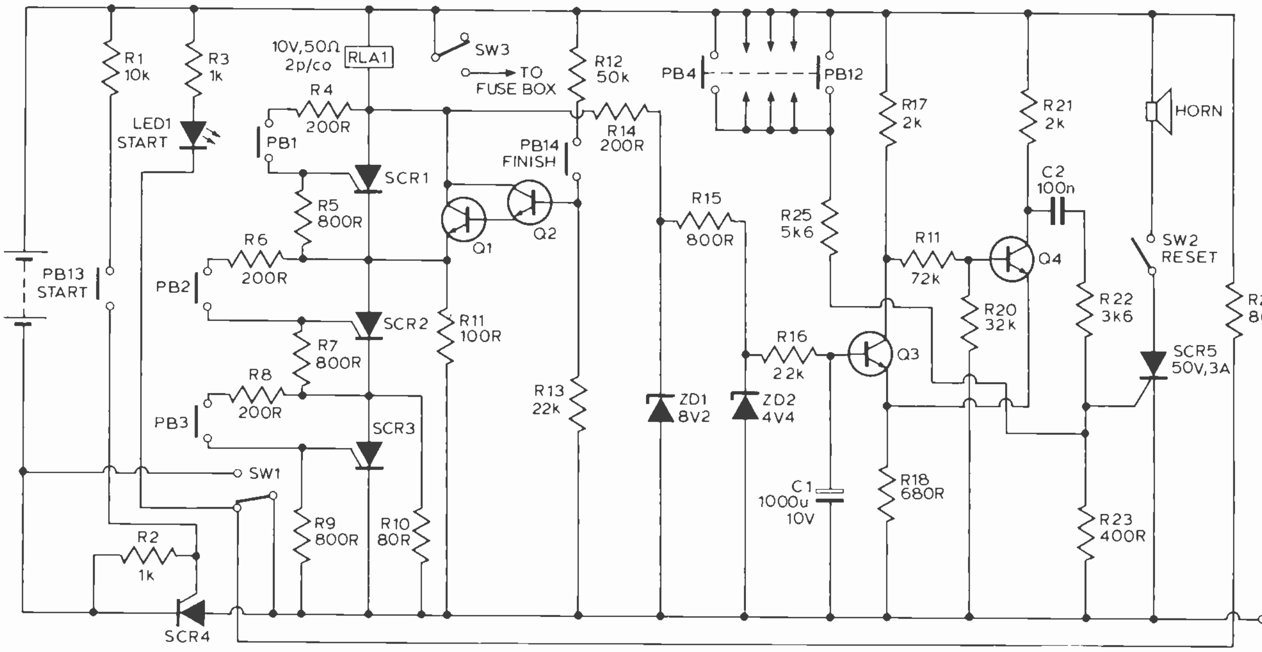

Electronic Ignition Switch

K. A. Last

When used with a calculator type keyboard, this circuit provides a 'combination lock' ignition switch which only activates if the correct sequence of three numbers is keyed in. The keyboard has 14 keys numbered 1 to 12, 'START' and 'FINISH'. To start the car, the 'start' key is pressed and the start LED will light. The correct sequence of 3 numbers is then keyed in. If the sequence is wrong, the cars horn will be sounded. If the right sequence is entered, the 'START' LED will extinguish and the ignition will be energised. The correct sequence will be PB1, PB2, PB3, but these can be arranged amongst the other keys in the keyboard, and given any numbers.

NOTE
Q1 is 2N4401
Q2,3,4, are 2N3904
SCR1—4 50V, 1A TYPES
SCR5 50V, 3A
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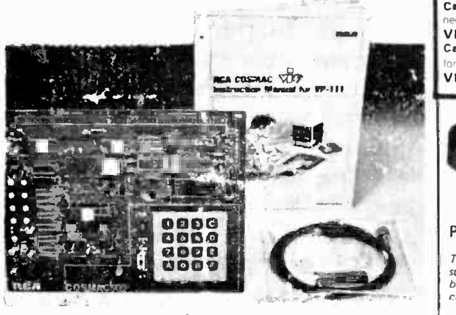

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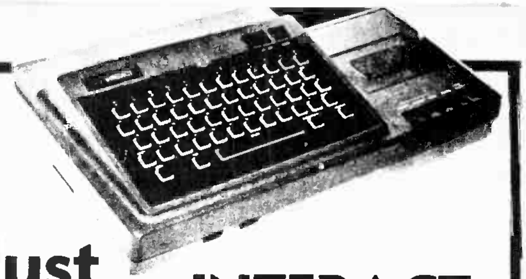

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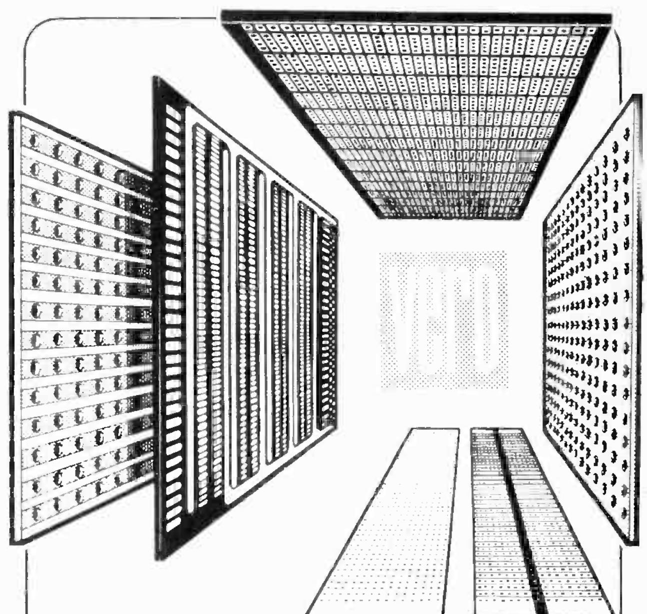

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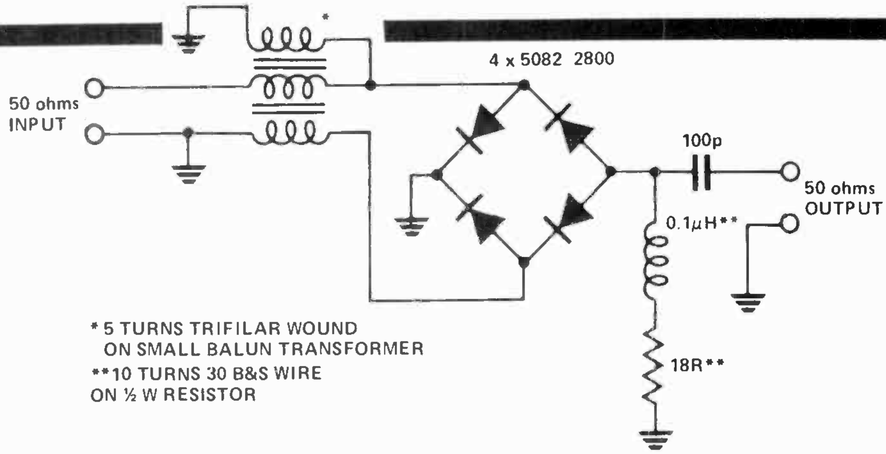
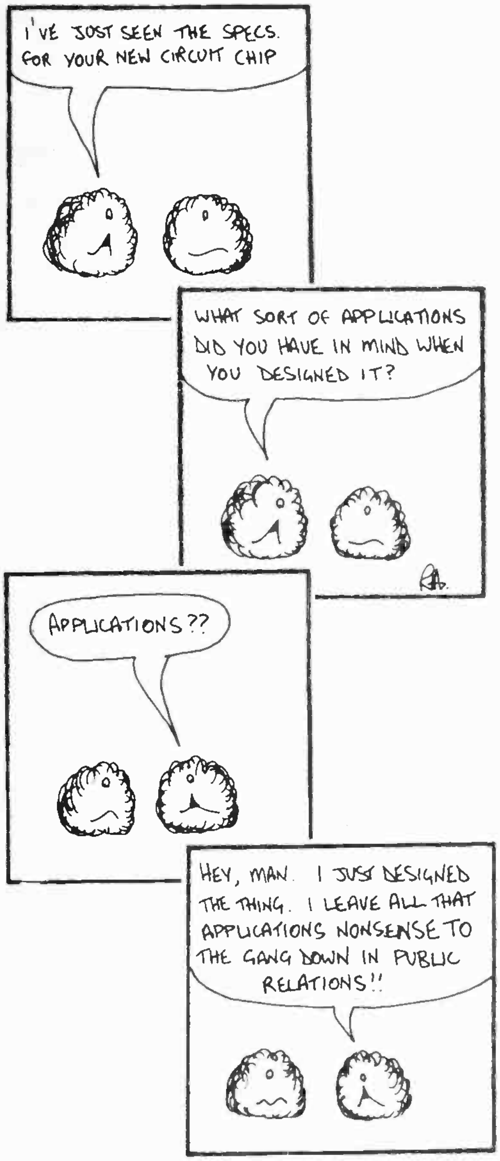


This circuit from staff files can be used to double the frequency of an RF signal generator. A generator with a top range of say, 100MHz, can be used to provide signals of up to 200MHz. Fundamental, third and fourth harmonic are about 20dB or more below the second harmonic (desired) content provided the diodes are all well matched.

Input and output impedances are around 50ohms. All wiring should be as short and direct as possible. The whole circuit may be mounted in a short piece of tube with a BNC connector on each end.

This could also be used in an oscillator/multiplier chain and for VHF/UHF converters or transverters and would most likely be followed by some sort of tuned amplifier.



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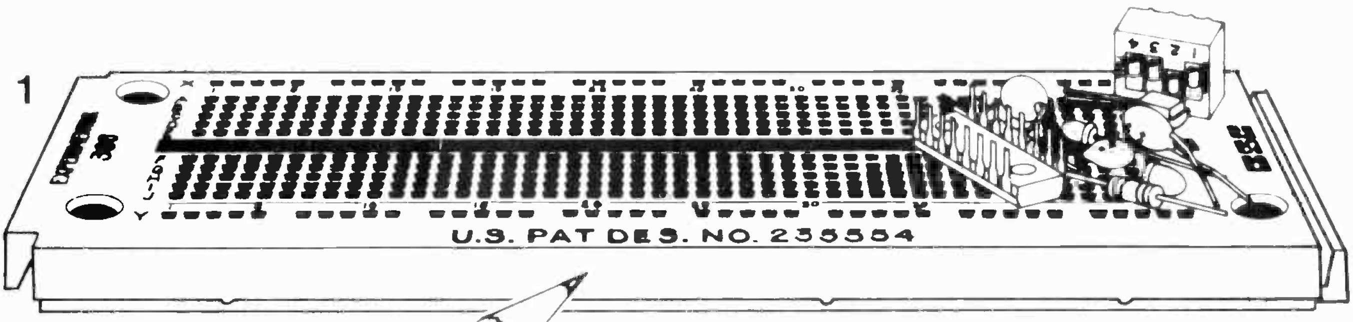
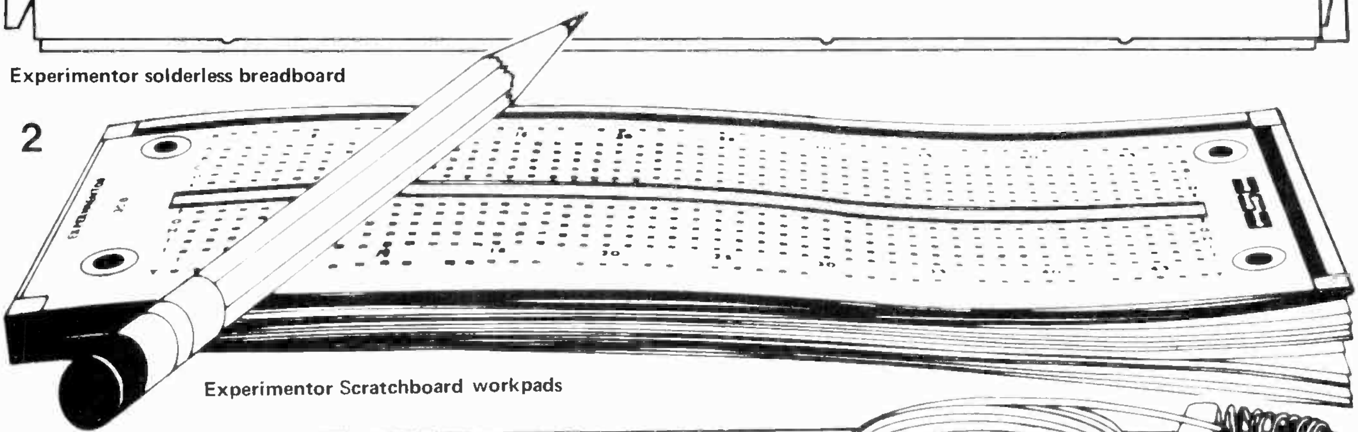


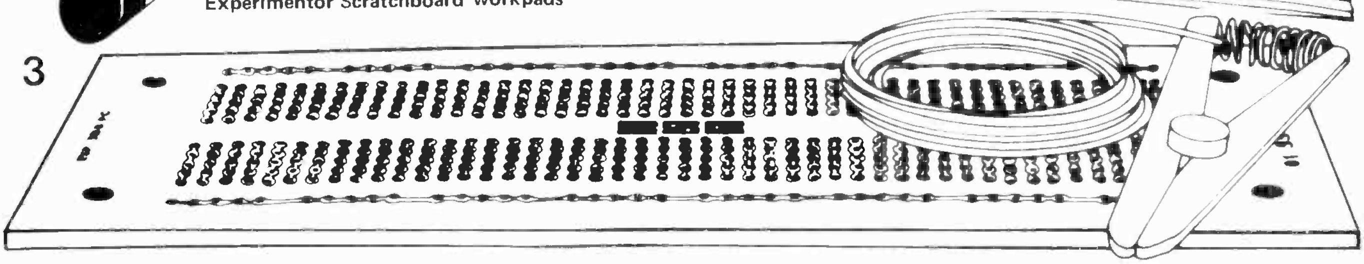
Experimentor solderless breadboard

2



Experimentor Scratchboard workpads

3



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