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May 1984

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Computer Review:
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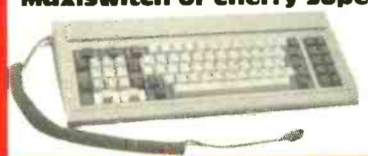

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4164-150nS (1x64K single +5V) Motorola	$9.95
T.I.	$7.95
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4116-150ns (1x16k)	$1.99
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2102L-200 ns (1kx1 static)	$1.94
5101-CMOS RAM	$3.84
2708-(1kx8 EPROM)	$6.74
2716-(2kx8 EPROM single +5V)	$5.50
2732-(4kx8 EPROM single +5V)	$8.95
2532-(4kx8 EPROM single 5V)	$8.74
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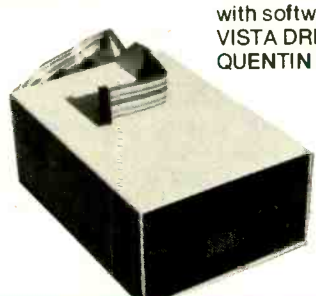

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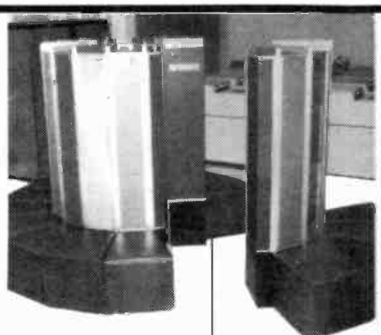
28



47

33

Features

Projects

Columns, News and Information

Our Cover

The Coleco Adam was reviewed by Bill Markwick. Photos by Steve Liard.

Electronics Today is Published by:

Moorshead Publications
Editorial and Advertising Offices
Suite 601, 25 Overlea Boulevard,
Toronto, Ontario, M4H 1B1
Telephone (416) 423-3262

Editor: **William Markwick**
Editorial Assistant: **Edward Zapletal**
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Production: **Douglas Goddard**, **Neville Williams**, **Naznin Sunderji**, **Deedee Whitehead**
Circulation Manager: **Lisa Salvatori**
Advertising: **Omar Vogt**, **Rick May**
Advertising (Que.): **John McGowan & Associates (514) 735-5191**

Publisher: H.W. Moorshead; **Executive Vice-President:** V.K. Marskell; **General Manager:** S. Harrison; **Controller:** B. Shankman; **Accounts:** P. Dunphy; **Reader Services:** C. Wyatt, S. Halladay, H. Brooks, K. Adams; **Advertising Services:** C. Zyvitski, **Dealer Services:** A. Nagels.

Newsstand Distribution:
Master Media, Oakville, Ontario

Subscriptions
$19.95 (one year), $34.95 (two years). For US add $3.00 per year, other countries add $5.00 per year. Please specify if subscription is new or a renewal.

Postal Information
Second Class Mail Registration No. 3955. Mailing address for subscription orders, undeliverable copies and change of address notice is:
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Editorial Queries
Written queries can only be answered when accompanied by a self-addressed, stamped envelope. These must relate to recent articles and not involve the staff in any research. Mark such letter ETI Query. *We cannot answer telephone queries.*

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Previous issues of ETI Canada are available direct from our office for $4.00 each; please specify by month, not by feature you require. See order card for issue available.

We can supply photocopies of any article published in ETI Canada; the charge is $2.00 per article, regardless of length. Please specify both issue and article.

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 0.1 uF is 100nF, 5600pF is 5n6. Other examples are 5.6pF = 5p6 and 0.5pF = 0p5.

Resistors are treated similarly: 1.8Mohms is 1M8, 56kohms is the same, 4.7kohms is 4k7, 100ohms is 100R and 5.6ohms is 5R6.

PCB Suppliers
ETI 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 when ordering boards.

Please note we do not keep track of what is available from who so please don't contact us for information on PCBs and kits. Similary do not ask PCB suppliers for help with projects.

K.S.K. Associates, P.O. Box 266, Milton, Ont. L9T 4N9.
B—C—D Electronics, P.O. Box 6326, Stn. F, Hamilton, Ont. L9C 6L9.
Wentworth Electronics, R.R. No. 1 Waterdown, Ont. L0R 2H0.
Danocinths Inc., P.O. Box 261, Westland MI 48185, USA.
Arkon Electronics Ltd., 409 Queen Street W., Toronto, Ont., M5V 2A5.
Beyer & Martin Electronic Ltd., 2 Jodi Ave., Unit C, Downsview, Ontario M3N 1H1.
Spectrum Electronics, 14 Knightswood Crescent, Brantford, Ontario N3R 7E6.

Tachometer

The widest speed measuring range of any portable non-contact tachometer and a simultaneous maximum hold capability are two of the unique features which make the Monarch Instrument Model TACH IV Digital Optical Tachometer the most versatile laboratory instrument ever available. TACH IV's ability to measure speeds from 5 RPM to 500,000 RPM make it suitable for every application throughout the laboratory, from measuring very slow stirring speeds to extremely high speed centrifuges. TACH IV's simultaneous maximum capability makes it the only instrument also capable of measuring peak speeds, a feature particularly useful in adjusting speed governors or setting overspeed trip switches. Contact the metermaster Division of R.H. Nichols Co. Ltd., 214 Dolomite Drive, Downsview, Ont. M3J 2P8 (416) 661-3190.

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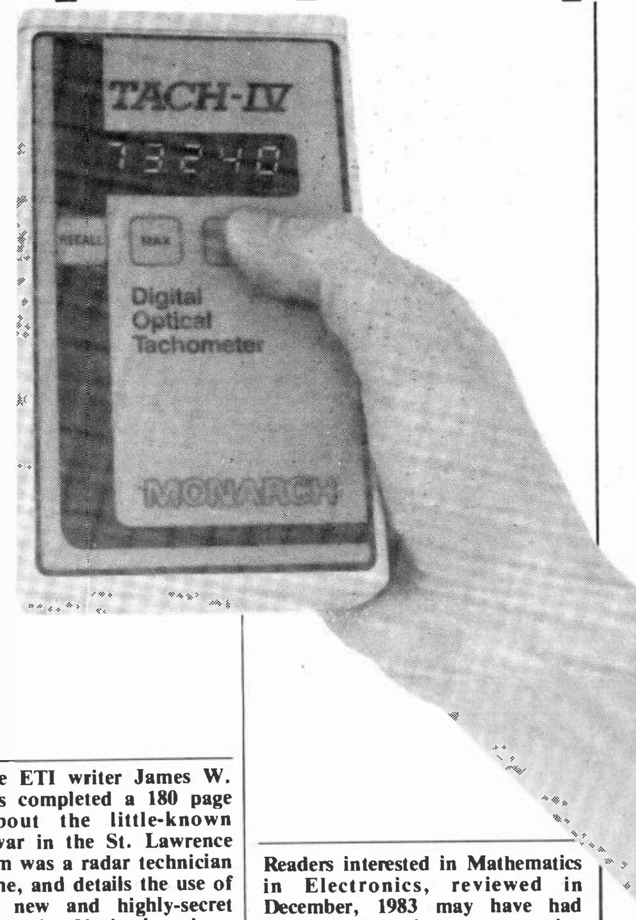

Howard W. Sams & Co., Inc. now offers a comprehensive introduction to machine-language programming based on standard assembly-language mnemonics. Don Lancaster's Micro Cookbook, Volume 2 (ISBN 0-672-21829-1) is available at participating Sams dealers and bookstores nationwide. Second of a series on microprocessors and microcomputers, Lancaster's newest book uses a group of "discovery modules" to explain machine-language programming fundamentals the reader can use with any microcomputer or microprocessor family. Virtually all available opcodes are explored, as are the details of flowcharting, using a stack, testing individual bits, creating text messages, using files, subroutines, interrupts, and more.

Circle No. 34 on Reader Service Card

Long-time ETI writer James W. Essex has completed a 180 page book about the little-known U-boat war in the St. Lawrence River. Jim was a radar technician at the time, and details the use of the very new and highly-secret radar in locating Nazi submarines. Despite the loss of 700 lives and 23 ships in the St. Lawrence, the government has so far declined to publicly acknowledge the heroism of the sailors and civilians involved. Victory in the St. Lawrence – Canada's Unknown War will be published this spring by Boston Mills Press of Erin.

Circle No. 35 on Reader Service Card

Readers interested in Mathematics in Electronics, reviewed in December, 1983 may have had trouble locating at regular bookstores. It can be ordered by sending a cheque or money order to Collier Macmillan Canada Inc., Order Department, 539 Collier Macmillan Drive, Cambridge, Ontario N1R 5W9. Mathematics in Electronics (02-818220-0) is $9.94, and the accompanying Instructor's Manual (02-818230-8) is $7.50.

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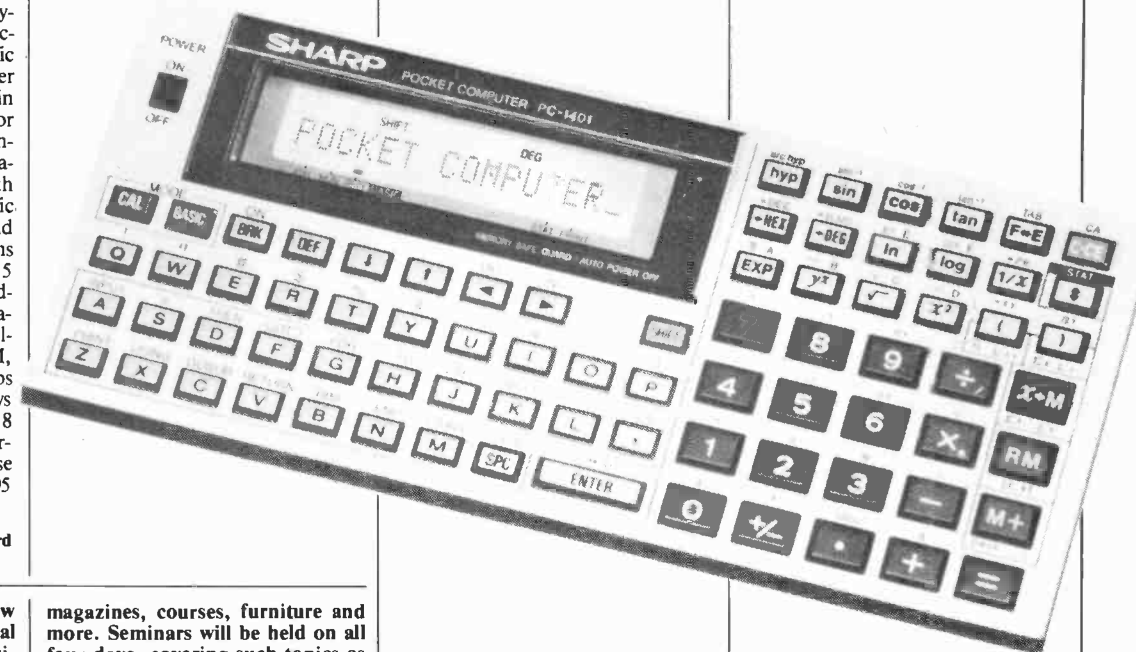
Two powerful machines are contained in one in the new PC-1401 pocket computer from Sharp Electronics of Canada Ltd. The unique dual keyboard permits the PC-1401 to function both as an advanced scientific calculator and also as a computer programmable in BASIC. A built-in LCD display serves both calculator and computer functions. As a scientific pocket computer, the unit features: Basic calculator functions with single-key access to 59 scientific operations; 16-digit dot-matrix liquid crystal display; fingertip conversions for hexadecimal calculations; 15 levels of parenthesis with eight pending operations, and standard calculator logic. For BASIC programmability: There are 4 Kilobytes of RAM, equivalent to 3,486 program steps and instant BASIC command keys for easy programming. There are 18 user-definable program slots, permitting the user to call up only those programs that are required. $159.95 at Sharp dealers.

Circle No. 38 on Reader Service Card



Canada's largest computer show will be held at the International Centre, Airport Road, Mississauga, Ontario. The show dates are: Thursday and Friday, May 10 and 11, from 10:00 AM to 9:00 PM, Saturday and Sunday, May 12 and 13, from 10:00 AM to 6:00 PM. Tickets are $6.00 each at the door: $5.00 each for seniors and students.

Over 100 exhibitors will display the latest in computers, disk drives, monitors, modems, buffers, circuit boards, business and educational software, games, magazines, courses, furniture and more. Seminars will be held on all four days, covering such topics as portable computers, business applications, kids and the computer, future trends in software, etc.

You can even meet some of the staff of Moorshead Publications at the Computing Now! booth.

For further information, contact Hunter Nichols Inc., 721 Progress Rd., Scarborough, Ontario M1H 2W7 (416) 439-4140.

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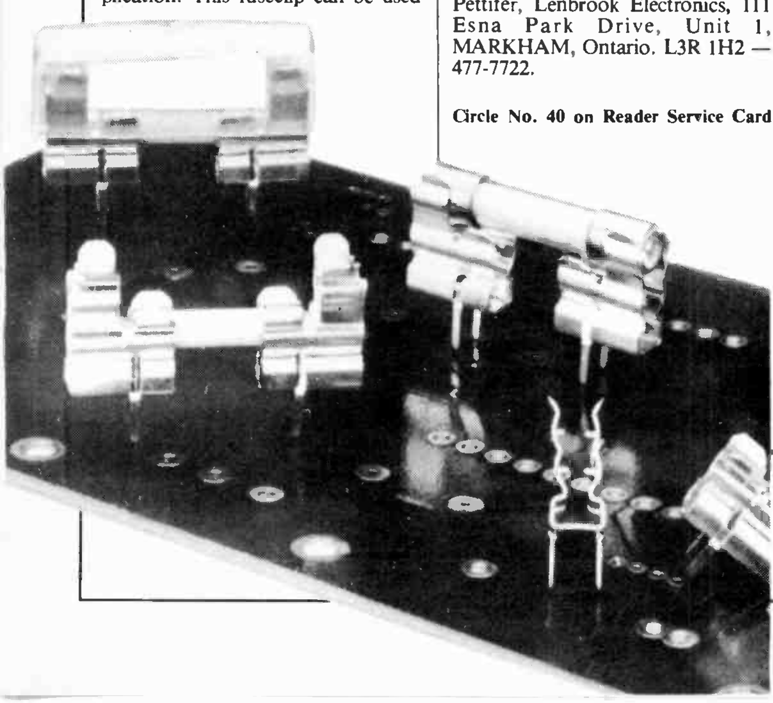
Fuseclip

SCHURTER introduces a new International Fuseclip for ¼ x ¼ and 5 x 20 mm Fuses. This fuseclip satisfies the requirements of both domestic and foreign use. It eliminates the need to use two separate fuse clips for a domestic and international application. This fuseclip can be used with standard American ¼ x ¼" fuses in the upper portion, and 5 x 20 mm in the lower portion of the clip. Thus fuses can always be replaced with the common size fuse types in the various countries. This new clip can be specified in bronze, tin plated or brass, tin plated. For further information please contact Doug Pettifer, Lenbrook Electronics, 111 Esna Park Drive, Unit 1, MARKHAM, Ontario. L3R 1H2 — 477-7722.

Circle No. 40 on Reader Service Card



Test Equipment

It's time to retire that old scope with the vacuum tubes; check out some of the bells and whistles available these days.

IN THIS mini-survey, you'll find some of the test equipment available from a number of Canadian sources. If it's time to upgrade the old testbench, or you're just interested in seeing what's around, you'll find a sampling of what high-tech has done for testing and measuring.

The most obvious change in today's equipment is the widespread use of large-scale integration. LSI circuits mean lower costs for low-end equipment and greatly expanded flexibility in the more expensive gear. Features that were once available only in the most expensive of laboratories are now turning up in units as small and inexpensive as hand-held multimeters.

There's such a wealth of test equipment available that we weren't able to cover all of it; many of the products shown are only a tiny sampling of the dealer's range. Any prices given are the list prices as we went to press and may not be valid by the time you read this.

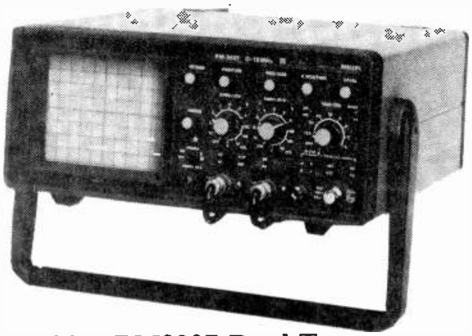
A list of dealer addresses follows the article.

Oscilloscopes

The main unit of any testbench, the workhorse oscilloscope is indispensable for actually seeing electrical signals, and the quality of the signal display has been greatly improved by recent solid-state circuitry. Displays are rock-steady and drift-free (scopes in the past tended to roll and quaver as they warmed up), and some scopes can display three or more waveforms.

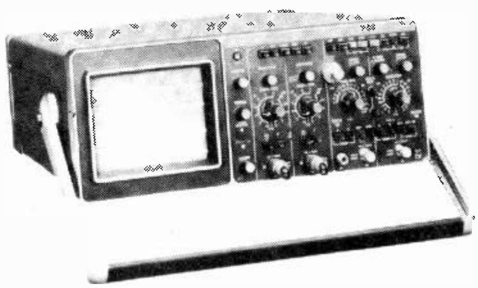
Triggering circuits are generally far more comprehensive than described in the limited space, and many of the small but convenient extra features had to be omitted.

The scopes shown are only a small sampling of the ranges available from the dealers listed.



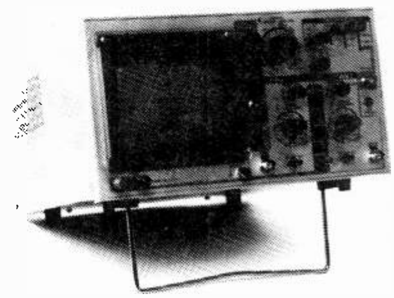
Philips PM3207 Dual Trace

Screen size: 8 x 10 cm
Vertical Response: DC-10 MHz
Risetime: 23 nS
Sensitivity: 5 mV to 10 V per div., 1-2-5 sequence
Accuracy: 5%
Horizontal Response: DC to 2 MHz
Sensitivity: same as vertical
Sweep: .2 V per div. to 5 uV per div.
Triggering: internal or external
Other: calibrator, X-Y operation, range of options.
Price: $790



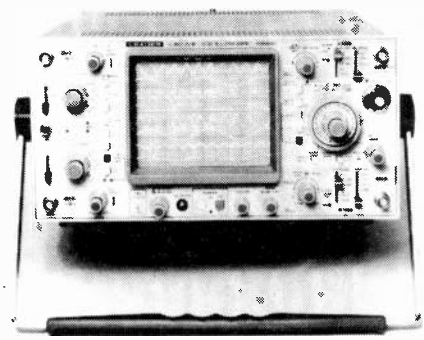
Philips PM 3215 Dual Trace

Screen Size: 8 x 10 cm
Vertical Response: DC-50 MHz
Risetime: 7 nS
Sensitivity: 2 mV to 10 V per div., 1-2-5 sequence
Accuracy: 3%
Horizontal Response: DC to 1 MHz
Sensitivity: 200 mV per div.
Sweep: .5 S/div. to 100 nS/div.
Triggering: internal or external
Other: calibrator, X-Y operation, range of options
Price: $1750



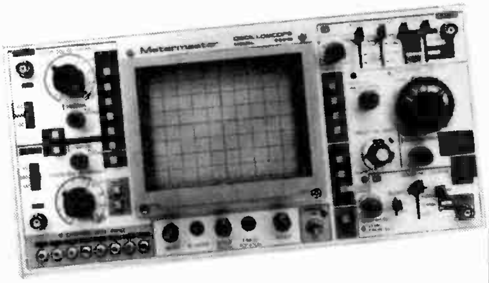
Brunelle 2988 Dual Trace

Screen Size: 8 x 10 cm
Vertical Response: DC-20 MHz
Risetime: 17 nS or less
Sensitivity: 5 mV to 20 V per div., 1-2-5 sequence
Accuracy: 3%
Horizontal Response: DC to 1 MHz
Sensitivity: uses CH-B vertical amp
Sweep: .2 uS to .5 S per div.
Triggering: internal or external
Other: Z-axis mod., component tester
Price:N/A



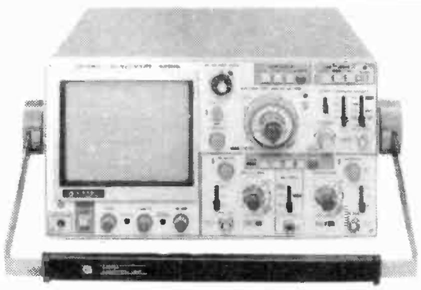
Leader LBO-518 8-trace

Screen Size: 8 x 10 cm
Vertical Response: DC-100 MHz
Risetime: 3.5 nS
Sensitivity: 5 mV to 5 V per div.
Accuracy: 3%
Horizontal Response: DC-3 MHz
Sensitivity: same as vertical
Sweep: 20 nS to .5 S per div.
Triggering: internal or external
Other: 50 ohm CH-1 output, calibrator
Price: $2995, distributed by Omnitronix



Metermaster 65810 8-trace

Screen Size: 8 x 10 cm
Vertical Response: DC-100 MHz
Sensitivity: 5 mV to 5 V per div.
Risetime: 3.5 nS per div.
Sweep: 100 nS to .5 S per div.
Triggering: internal or external, adjustable delay
Other: two sweep generators, XY operation
Price: $2595



Kikusui COS5060 3-Channel

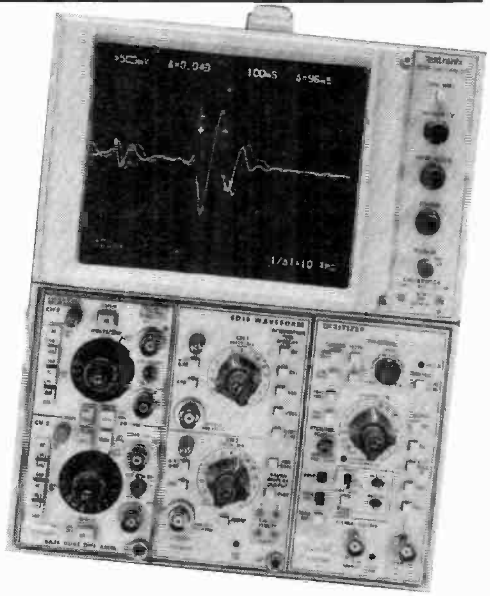
Screen Size: 6' rectangular
Vertical Response: DC-60 MHz
Sensitivity: 5 mV to 5 V per div.
Horizontal Response: DC-2 MHz
Sensitivity: uses vertical channel
Sweep: 50 nS to .5 S per div.
Triggering: internal or external, adjustable delay
Other: TV sync separator, camera mount
Price: $1748, distributed by Interfax

Hameg HM103 Single Trace

Screen Size: 6 x 7 cm
Vertical Response: DC-10 MHz
Sensitivity: 5 mV to 20 V per div.
Sweep: .2 uS to .2 S per div.
Triggering: internal or external to 30 MHz
Other: built-in component tester
Price: $550, distributed by BCS

Tektronix 5116 Dual Trace Colour

Screen Size: 10 x 12 cm
Vertical Response: DC to 100 KHz
Sensitivity: 1 mV to 20 V per div.
Sweep: .1 mS to 50 S per div.
Other: specs depend on plug-ins; uses all 5100 series modules. Colour is LCD switched rather than shadowmask. Digital info display.
Price: $3900 from Tektronix

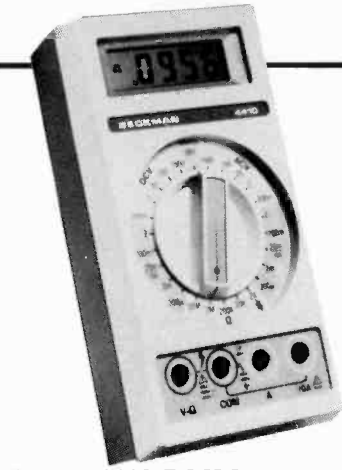


Meters

This section covers different types of meters, from some of the usual handheld DMMs to earth resistance testers.

Brunelle 4060 DMM

Display: 3 1/2 digit LCD
DC volts: 200 mV to 1000 at .25%
AC volts: 200 mV to 750 V at .5%
DC current: 200 uA to 10 A at .5%
AC current: 200 uA to 10 A at .75%
Resistance: 200 ohms to 20 megohms
Other: diode and HFE tester, total of 35 ranges, fuse protected.
Price: $99.00 from Brunelle Instruments



Beckman 4410 DMM

Display: 4 1/2 digit LCD
DC/AC volts: 200 mV to 1000 V
DC/AC current: 200 uA to 10 A
Resistance: 2 K to 20 megohms
Other: True RMS reading, .05% DC accuracy.
Price: $319 from Lenbrook Electronics

Thurlby 1905A Computing DMM

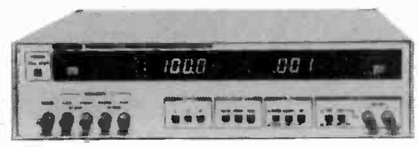
Display: 5 1/2 digit LED
DC volts: 1 uV to 1100 V
AC volts: 10 uV to 750 V
DC current: 1 nA to 5 A
AC current: 10 nA to 5 A
Resistance: to 21 megohms
Other: 20 keys for computing functions such as linear scaling, percentage deviation, dBs, etc
Price: N/A. From EDG

Fluke 77 Series DMM

Display: 3 1/2 digit LCD
DC volts: 320 mV to 1000 V at .3%
AC volts: 3.2 V to 750 V at 2%
DC or AC current: 32 mA to 10 A at 3%
Resistance: 320 ohms to 32 megohms
Other: analog bargraph, diode test, display latch.
Price: about $200 from Allan Crawford Associates.(also available from Heath)

B&K 297 Dual AC Voltmeter

Sensitivity: 300 uV to 100 V FSD
dBm range: -90 to +40
Accuracy: 3%
Frequency Response: 5 Hz-1 MHz for 10% accuracy
Input impedance: 10 megohms
Amplifier gain: 70 dB
Output: 1 V
Residual noise: less than 30 uV
Other: Dual switchable inputs
Price: $850 from Atlas Electronics



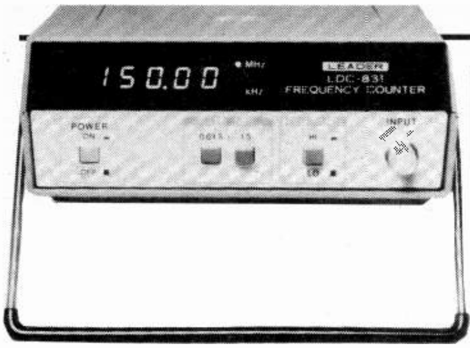
Leader LCR Meter LCR 745

Display: dual 3 1/2 digit fluorescent
Inductance: .1 uH to 200 H
Capacitance: .1 pF to 2000 uF
Resistance: .001 ohms to 20 megohms
Dissipation Factor: .001 to 2
Quality Factor: .5 to 100
Other: Can apply AC and DC bias to capacitor under test, can cancel residual components of measuring devices. CPU controlled.
Price: $2500 from Omnitronix

Counters

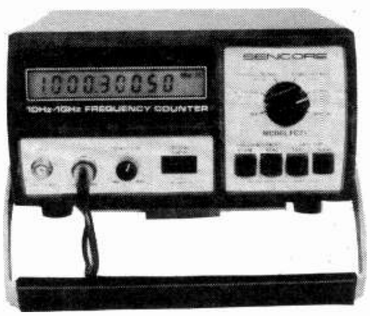
B&K 1803 Frequency Counter

Display: 8 digit LED
Minimum frequency: 5 Hz
Maximum frequency: 100 Mhz
Power: 6 AA rechargeable or AC plugpack
Filter: 100 KHz lowpass, switchable
Price: $304 from Atlas Electronics



Leader LDC-831

Display: 4 1/2 digit fluorescent
Range: 5 Hz to 150 MHz in 2 ranges
Gate time: selectable .01 S or 1 S
Sensitivity: 50 mV
Input impedance: 1 M (lo) or 2.5 K (hi)
Other: battery power or AC.
Price: $831 from Omnitronix



Sencore 1 GHz Counter

Display: 8 digit LCD
Range: 10 Hz to 1 GHz in 4 ranges
Accuracy: .5 ppm
Sensitivity: typ. 5 mV, adjustable
Input impedance: 1 megohm to 100 MHz, 50 ohms on higher ranges.
Price: $895 (US) from Sencore.

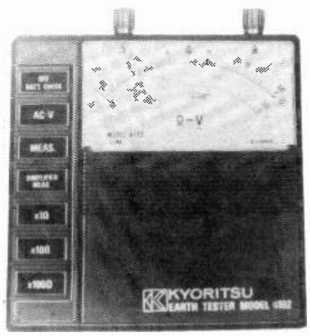
Miscellaneous

Kyoritsu 2012 Power Meter

Display: 10 mm LCD
Ranges: power to 200 kW, volts, amps
Other: no power interruption, autoranging, display hold, output terminal.
Price: $1,149 from Omnitronix

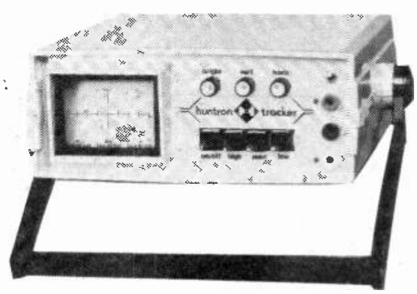
Bell CG100D Current Gun

Display: 3 1/2 digit LCD
Range: to 200 A
Frequency Response: DC-1 kHz
Other: non-contacting, scope output, auto reading hold.
Price: $397 from Allan Crawford Assoc.



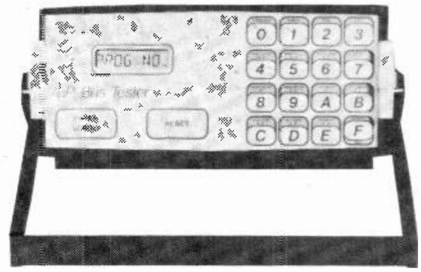
Kyoritsu Earth Resistance Tester

Range: 1 ohm to 1 K in four ranges
Accuracy: 3%
Voltage range: to 30 V
Other: protected to 1500 V, minimum of influence from earth voltages
Price: $309 from Omnitronix



Huntron Tracker

Uses: in-circuit testing of all analog and digital devices.
Display: CRT plot of I-V curve
Other: devices can be tested with or without circuit power, interface available for switching between good and unknown units.
Price: N/A. From Cyprus Products

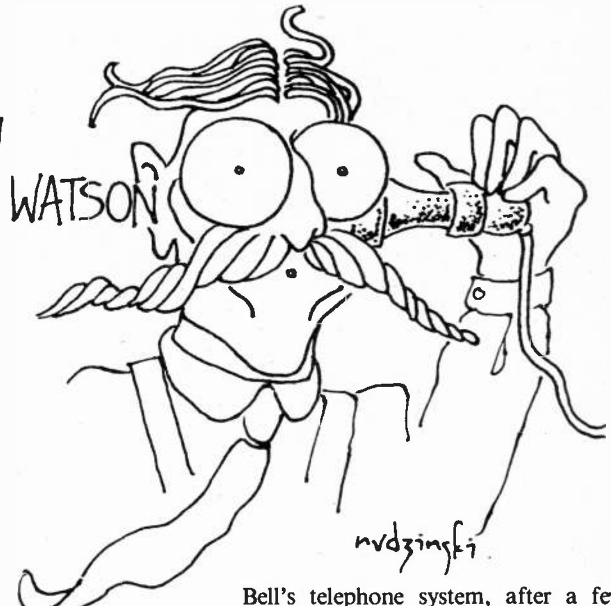


Polar Micro Bus Tester B2000

Uses: replaces CPU in faulty micro. Test sequences determine if fault is in ROM, RAM, I/O or CPU.
CPUs tested: Z80, 6800, 6502
Display: Built-in printer, small LCD
Price: $2166 from Atlas Electronics

continued on page 14

Alexander Graham Bell



A brief historical look at the man who devoted his life to more than just the telephone.

by Ian Sinclair

YES, of course you've heard of *him,* Bell of telephone fame and founder of the Bell Telephone Co., "Ma Bell" to millions of North Americans who take for granted a standard of first rate telephone service. But did you know that the decibel is named after him, or that he invented the telephone as a deaf aid? Read on, and discover more about the life of this remarkable pioneer.

Alexander Graham Bell was born in Edinburgh in 1847, to a family who had dedicated their lives to the service of the deaf and dumb — his father was the inventor of the hand signals which are still used to this day. His parents were established authorities in elocution and speech correction (what would they have made of CB?), and they did not send Alexander to school, preferring to draw on the considerable talents of the family for his education. The success of this education, unhindered by local authorities or social workers (not yet invented), gained Alexander his first job in 1864, as resident master at Weston House Academy, a small boarding school in Elgin, a cold grey town in the Highlands.

Devoted To The Deaf

In 1870, however, the whole Bell family decided to emigrate, like so many Scots before and since, in search of a better living in Canada, and they moved to Brantford, Ontario. Alexander found nothing to his liking there, and shifted again to Boston, Mass. in the USA, to open a small school, in 1872, for training teachers of the deaf, a topic in which he took a passionate interest.

He had very considerable success, and in a remarkably short time established a nationwide reputation for his methods of training teachers, particularly in the "hand alphabet" which his father had devised. This, incidentally, is a subject of controversy at the moment because it is no longer being so widely taught, and the change is bitterly resented by many deaf people who feel that a valuable method of communication may be lost to future generations.

As a result of Bell's success, he was asked to incorporate his school into Boston University, and he became Boston's first Professor of Vocal Physiology in 1873. It was as a result of this achievement that he was able to find time for research, with all the facilities of a University now available to him.

Telegraphy Progress

He was fascinated by the development of Telegraphy, because it was a method of communication which was open to people with severe hearing or speech defects — in fact many deaf people were trained as telegraph operators in those days, just as the tradition of training blind people as piano tuners grew up. Bell's interest in the electric telegraph led to the invention, along with his excellent but lesser known assistant Thomas Watson, of many improvements in telegraph design, and to Bell's increasing involvement in, and knowledge of, electrical circuits. Gradually he conceived a system which would convert the sound waves of speech into electrical signals, and back again, with the purpose of allowing the deaf to hear what was being said some distance away. Curiously enough, another emigre, David Hughes, was working in Virginia along similar lines.

Bell's telephone system, after a few false starts, took the simple form of a carbon microphone, a battery, and an earpiece. The carbon microphone was until very recently still being used in telephones, particularly in this country; it is now being replaced by the electret microphone, the only device sufficiently sensitive, and with a large enough signal output, to take its place.

The carbon microphone principle (which is attributed to Hughes) goes thus: a thin flexible membrane or diaphragm of metal is held in an insulating cylinder which has a metal backplate, and the space between the diaphragm and the backplate is packed with granules of carbon. Carbon is a resistive material, and the resistance depends very much on how tightly the carbon particles are packed together. With this arrangement, pressing the diaphragm inwards considerably, reduces the resistance between the diaphragm and the backplate; pulling the diaphragm outwards considerably increases the resistance. With a battery connected, the device becomes a variable current generator, with the amount of current depending on the movement of the diaphragm.

A Toast To Carbon

When a sound wave hits the diaphragm, it causes the diaphragm to vibrate at the same frequency as the sound wave, and with an amplitude (amount of movement) which depends on the loudness of the sound. In this way, sound waves hitting the diaphragm cause waves of electric current in the circuit connected to the carbon microphone. The useful and remarkable thing about the car-

continued on page 14.

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bon microphone is the size of the electrical signal that it generates, putting several volts across a load with several milliamps flowing. Until the development of electrets there was nothing that came anywhere near such an output, and the defects of the carbon microphone, such as its narrow bandwidth and the resonances which it caused, were not of great significance in telephone use.

Bell's receiver was electromagnetic, using the arrangement which, once again, has survived more than a hundred years. This uses a magnetized metal diaphragm held close to an electromagnet, usually of horseshoe shape. The varying currents transmitted by the microphone are sent through the electromagnet of the earpiece, and they cause the diaphragm to be magnetically attracted to an extent that depends on the amount of current. In this way, the current waves that flow in the circuit when someone speaks into the microphone are converted back to a sound by the action of the earpiece.

According to the notes that Bell made at the time, the first words spoken over a telephone circuit were "Come here, Watson, I want you . . .". The fact that Watson heard them and rushed through to Bell's room was the start of something big. They took out a patent on their telephone system in 1876, and the invention was recognized by the confederation of the Volta Medal on Bell in 1880 by the French Government. By this time, the Bell Corporation was being set up to exploit the invention which in a few years was to change the habits of the whole world.

Enter The Decibel

Bell, at this stage, could have simply retired from active life, content to amass a fortune as President of one of the most important and rapidly-growing corporations in the U.S. It is typical of him that he did not, preferring to devote more time to research and to the twin ideals of developing his invention and of helping the deaf. His work on sound transmission soon highlighted a shortcoming of measurement, that there was no scale of comparative loudness of sound.

From a large number of careful measurements, Bell found that the apparent loudness of a fixed frequency from a telephone receiver was proportional not to the electrical power but to the *logarithm* of the power, and so he proposed a unit for comparative loudness, the logarithm of the power ratio of two signals. This was widely adopted, and named the Bel in his honour, dropping the final "l" to avoid any confusion between unit and name.

The Bel, however, is a larger unit, and just as we use microfarads instead of farads for measuring capacitance, it's more convenient to use tenths of a Bel, or "decibels", in place of Bels. Unfortunately the decibel is the most abused and least understood of all the units encountered in electronics.

Photos On The Phone . . .

Bell also worked on developments of the telephone system, as always, with a view to helping the deaf to communicate. One notable development, well ahead of its time, was the Photophone of 1880. This was a device to transmit photographic images over a telephone, a forerunner in many ways of the Photofax process and of slowscan TV.

The principle was simple and ingenious. A transparency is fastened to a glass cylinder so that a light can be shone through transparency and glass on to a photocell (using selenium), which is inside the hollow cylinder. The cylinder is spun around, and the photocell is slowly moved from one end to the other, so that varying currents are generated in a circuit connected to the cell as varying amounts of light reach it through the transparency.

These currents could be transmitted over telephone lines, and at the receiver a photographic method was used to recreate the image. A piece of moist sensitized paper (the original sensitizing chemical was potassium iodide) was then wrapped round a metal drum, which was the ground connection of the receiver. The signals from the transmitter were connected to a brush contact, which touched the moist paper as it revolved with the drum. The current flowing through the paper caused the chemical to decompose, leaving a stain (iodine, when potassium iodide is used), and the amount of staining depends on the amount of current. Provided that the receiver drum is synchronized with the transmitter drum, the received image is a reasonably good reproduction of the transmitted one. An incidental advantage is that the picture size can be scaled up or down by making the receiving drum a different size from the transmitting drum.

. . . Letters Down The Line

The Photophone principle was developed into Photofax, and its descendents are still used. Bell followed it up with the Graphophone of 1887, designed to allow writing to be transmitted along telephone lines — and a large part of his receiver principle for this device can now be seen in the form of XY plotters for computers.

Bell died in 1922, the Grand Old Man of the telephone, and to the end a benefactor of the deaf, to whom he left much of the vast fortune he had accummulated. His other monument was the founding of the American Association to Promote Teaching of Speech to the Deaf, now known as the Alexander Graham Bell Association for the Deaf. This institute sponsors a great deal of research, much of it nowadays into electronics, resulting in a constantly improving service to the deaf. In many ways, I think that Bell would be more interested in this than in the whole telephone service if he could return to see it all. **ETI**

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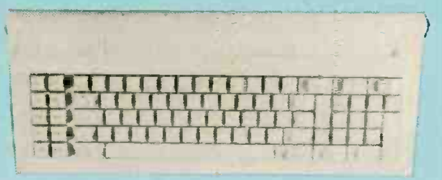

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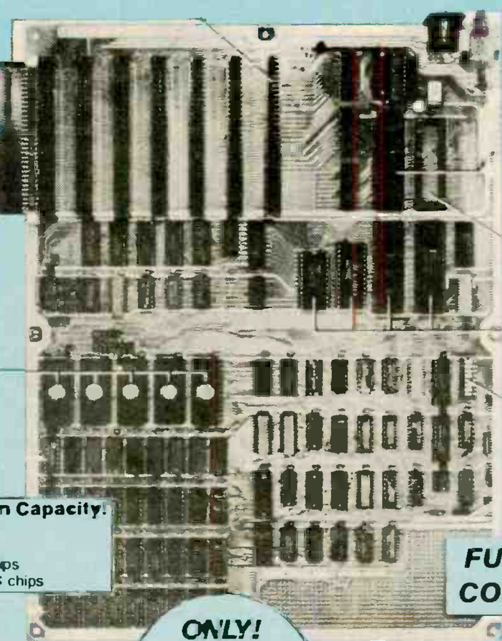

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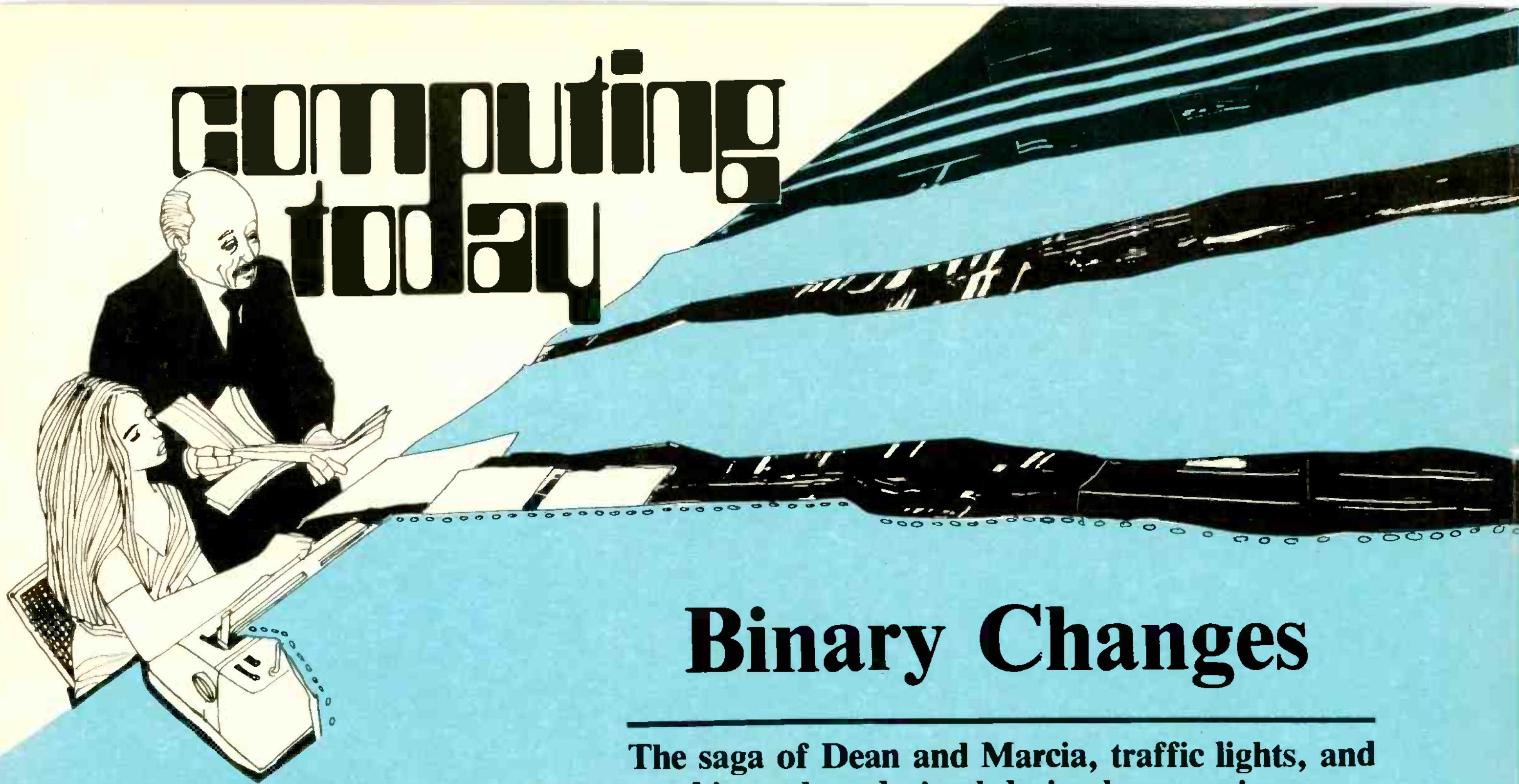

Binary Changes

The saga of Dean and Marcia, traffic lights, and binary-hexadecimal-decimal conversions.

by John Rudzinski

THE FLUORESCENT lights flicker and pop in the gymnasium as Dean approaches Marcia for their scheduled after-class talk. Sweat fairly pours from his palms as he reaches deep within himself to work up the courage to ask her the question that's been plaguing him these past long days.

Outside, the wind lashes a pedestrian who's just jabbed one of those traffic light post buttons for the forty-fifth time. The light's been against his favour for thirteen minutes.

Dean pauses as he catches Marcia's attention. Her eyes seem to sparkle in the blue half-light. She looks at him expectantly as he struggles to put his needs into a coherent query.

The sound of a pushbutton-box being ripped savagely from its moorings tears through the shrieking wind like a knife cutting corrugated iron. With red face and flailing arms, the pedestrian hurls the metallic carcass into the centre of the crosswalk. Obediently, the traffic light plays a spectrum symphony.

The question finds its bearings as Dean looks into her eyes, then surfaces like a breaker on calm waters.

"M-Marcia?"

"Yes, Dean?"

"What is the binary equivalent of 7E hex?"

To The Rescue

It's hard to calculate how many budding romances are faced with this crisis... it's just not a subject that statistics are compiled for. Still, it's a horrible thing to contemplate. What if you were caught unawares by such a pressing query?

If you've ever worked with machine code, you've no doubt had to either take pencil to paper or finger to calculator to work out conversions between binary, hexadecimal and decimal. If you've never done this before, however, it can be an emotionally scarring experience the first few times you try it. With luck, this article will save you an untold fortune in psychiatrist bills and Valium prescriptions.

7 Hex = 7 Decimal E Hex = 14 Decimal

8	4	2	1	8	4	2	1 +
0	1	1	1	1	1	1	0
7				E			

Figure 1. Hexadecimal to Binary

Binary notation, that confusing amalgamation of ones and zeros we've all come to know and love, is actually a simple counting system, yet it tends to freak out both the uninitiated and the caffeine stimulated. Why? At first glance

10011010

looks like a lottery prize without the commas in the proper places. Keep the above number in mind... I'll be getting back to it.

Hexadecimal, on the other hand, looks like someone set out to develop a counting system, got hammered on Gold Keg beer, and ended up using innocent members of the alphabet when the numbers ran out. This is partially true, though I can't vouch for the beer.

To do simple (one byte) binary to hex conversions in your head, you'll need to memorize the hexadecimal numbers from zero to 0F.

Dec	Hex
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	A
11	B
12	C
13	D
14	E
15	F

That done, we can look at the binary number we left a ways back and see if we can make any sense out of it.

Generally, any programmer can tell you that in 8-bit processors like the Z80 or 6502, eight bits make up a byte. Bisected, the byte becomes a *nybble*... four bits. Thus, our number to be converted becomes

1001 1010

To take things a step further, we're going to put more numbers above each nybble:

8 4 2 1 8 4 2 1
1 0 0 1 1 0 1 0

At this point, the conversion begins from binary to hexadecimal. Take the number, one nybble at a time, and add the decimal numbers resting atop the "1" bits of the binary nybble. Ignore the zero bits; nobody likes them anyway. Now, you should have two decimal numbers: 9 and 10. Jump back to the decimal/hexadecimal chart and look them up; you'll find that 9 decimal equals 9 hex, and 10 decimal looks suspiciously like A hex. To reiterate:

```
8421               8421
1001 (8+ 1 =9)     1010 (8+2 =10)
        =9 hex              = A hex
```

If this starts to sound like a Sesame Street flashback, forgive me, but the next thing you do is put the two hexadecimal numbers together, forming... you guessed it... 9A hex.

128	64	32	16	8	4	2	1+
1	1	1	0	1	0	1	0

= 234

8	4	2	1	8	4	2	1+
1	1	1	0	1	0	1	0
	E				A		

Figure 2. Decimal to Hexadecimal

Bubble, Bubble...

Converting 8-bit hex numbers to binary is just as simple. Take any value from 0 hex to FF, bisect it (the value of, say, F hex becomes 0 and F) and look both values up in the dec/hex table.

Zero is zero any way you look at it, and F hex translates to 15 decimal, so the first nybble will be composed entirely of zeros. The second nybble can be determined by adding the 8, 4, 2, and 1 numbers until you come up with 15 decimal. In this instance, all four numbers added are 15, so all four bits in the nybble are ones. Figure 1 better illustrates this, using the value of 7E that Dean was enquiring about.

Perhaps more useful to machine language programmers is the omnipotent hexadecimal to decimal conversion, which, alas, is just a little more complicated. This'll require two steps, actually. The hexadecimal value is first converted into binary, then the binary number is translated into the decimal.

Noting the binary outcome from the conversion of 7E hex in figure 1, we're going to reproduce it, but this time around it's not going to be separated into nybbles. Instead, we're going to follow the logical sequence of the numbers above the bits, continuing to raise them to the power of two. A slash of the pen later we have this:

```
1
2 6 3 1
8 4 2 6 8 4 2 1+
0 1 1 1 1 1 1 0
```

Adding up the numbers above the "1" bits, we get 126, the decimal equivalent of 7E hex. A reversal of the process, going from decimal to hex, requires converting the decimal number to binary, then the binary to hexadecimal. Decimal 234 is converted in figure 2.

Heathens

Organized religion and programmers both go through the rigours of conversion, though hopefully this article was helpful to the latter category. Note that these processes, as they stand, only work on numbers from zero to 255; anything larger requires some fancy multiplication soft shoe.

For a grass-roots introduction to the binary and hexadecimal systems, pick up a copy of the May issue of Computing Now! magazine. It's a serious discussion; Steve Rimmer doesn't mention wombats or trips anywhere in the text.

That about wraps it up. Dean and Marcia married after college. He's an analogue to digital toaster salesman, and she's a systems analyst for Apple Canada. The unnamed pedestrian is on City Ordinance's ten most wanted list. **ETI**

ZX Burglar Alarm

Feeling insecure? Try this neat burglar alarm interface for your ZX81.

By D.C. McMahon

THIS MICROPROCESSOR controlled security system will monitor up to eight remote switch positions each of which can be either normally open or normally closed, allowing you to use any combination of pressure mats, magnetic catches, window foil or other devices as the sensors. When triggered, it immediately sounds an alarm and then displays the number of the affected input on a seven-segment LED. It can be used with the ZX81 and quite aside from its value as an intruder alarm it provides a useful introduction to the techniques of microprocessor interfacing using machine code and the Z80 Parallel Input/Output Controller.

The Z80 PIO consists of two groups of eight lines, port A and port B, and each line can act as either a data input or output. If the IN instruction is used, the data on those lines defined as inputs is loaded into the accumulator. If the OUT instruction is used, data on the accumulator is latched onto the output lines. The PIO can be programmed to act in any one of four modes:

Mode 0 — Output mode
Mode 1 — Input mode
Mode 2 — Bidirectional mode
Mode 3 — Control mode

The first three modes require the use of the handshaking facilities and so for this design the much simpler control mode has been used, allowing easy input and output of data to and from both eight bit ports on the PIO. Port A provides the eight inputs from the sensing switches while port B is split into four inputs and four outputs, the inputs being used to enter data while the outputs feed the seven segment display. An eight bit word is entered via port B into the register which tells the microcomputer which of the input lines should be high and which low (corresponding to normally open and normally closed switches respectively). The contents of this register are then continuously compared with the inputs to port A and if any discrepancy is discovered a '9' is sent out to the display. A timing loop, formed by loading a high number into the registers H, L, and then successively subtracting one until the result is zero, ensures that the nine is displayed for at least a second or so, after which the number of the affected input is displayed. An AND gate monitors the A and D data lines into the display driver and thus goes high when the 9 is output, the delay ensuring that it remains high long enough to latch the relay and thus sound the alarm.

Construction

Most of the components, including the relay and the transformer, are mounted on the PCB, the only off board components beings the switches, the LED display, the edge connector to suit the ZX81, and the siren or other output transducer. Make sure that all four ICs are inserted the right way around, and similarly check the electrolytic capacitors C1, C4, and C7, and the diodes. Provision has been made for the use of connectors for the LED display and the input lines but if you prefer you can, of course, solder

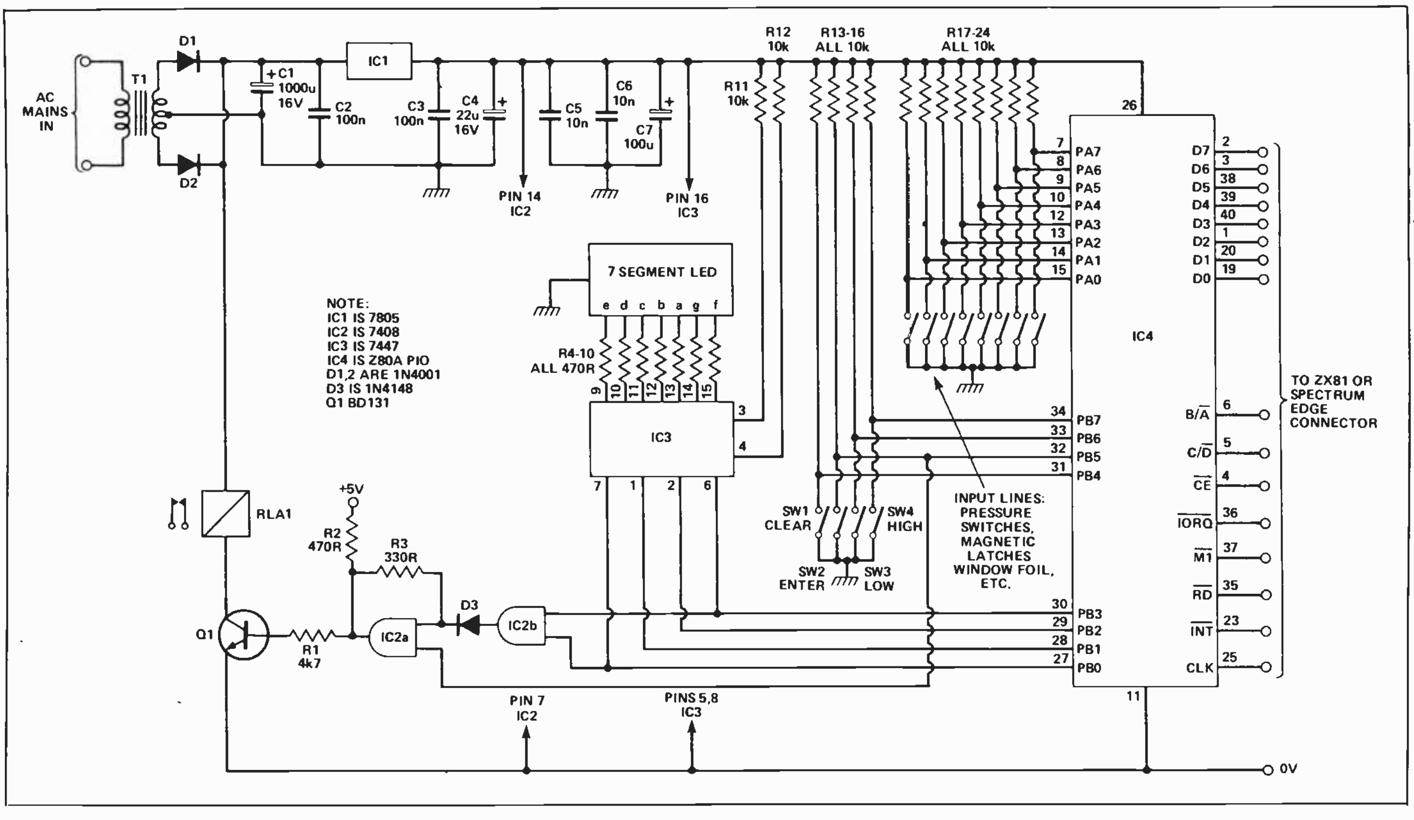

Fig. 1 Circuit diagram of the burglar alarm.

directly to the board. It is intended that the relay should switch a siren or similar device which draws its power from an external source, e.g. the mains, but if your particular application does not specifically demand an eardrum piercing, complaint eliciting siren, you might prefer to use an audible warning device of some sort instead. Providing this does not draw more than 100 mA or so and will run from 17V or less, you can connect it directly in the collector circuit of Q1 and dispense with the relay entirely. The edge connector for the ZX81 should be wired in accordance with Fig. 2.

The choice of case is left entirely to the constructor, but since there is mains on the board it is advisable to have some sort of enclosure. Mounting the switches should present no problems but the LED display is not so easy. If you're after a particularly neat appearance you would perhaps do best to go for an easily cut plastic case, and to cut out an aperture for the LED and then mount it flush in epoxy. The input lines, mains input, and connections to the microcomputer could either be taken through grommets or, if you're really fussy, through appropriate connectors, although it is probably most convenient to use a connector only for the input lines.

Programming

The Z80 PIO has six control lines, three of which (MI, IORQ, and RD) can be connected directly to their counterparts on the ZX81 edge connector. The remaining three, B/A SEL (select port A or B), C/D SEL (select either control or data carried on bus), and CE (chip enable) must be connected to the address bus. The ZX81 address bus has the following characteristics: A0, A1, A2, A3, and A4 are all normally high (they are used to control printer, loudspeaker, etc.), so we can leave these high and connect B/A SEL, C/D SEL, and CE to the remaining three lines, A5, A6, and A7 respectively. A5 low selects port A, A5 high selects port B; A6 low selects data (input and output) and A6 high selects control (programming information). A7, the chip enable, is always held low. The resulting eight bit words are shown in Table 1 and their decimal values are 31, 93, 63, and 127 respectively.

We must next initialize the PIO by sending two control words to each port. The first defines which mode and, as we are using mode three, a second must be sent to define which of the eight lines are inputs and which outputs. The format of the operation control word is shown in Table 2, and it will be seen that the relevant control word for ports A and B is 11111111, that is, decimal 255.

The second control word also consists of eight bits, each one corresponding to the I/O line with the same number, i.e., bit 0 corresponds to PA (or PB) 0, bit 1 corresponds to PA1, etc. Setting the bit high defines the associated I/O line as an input,

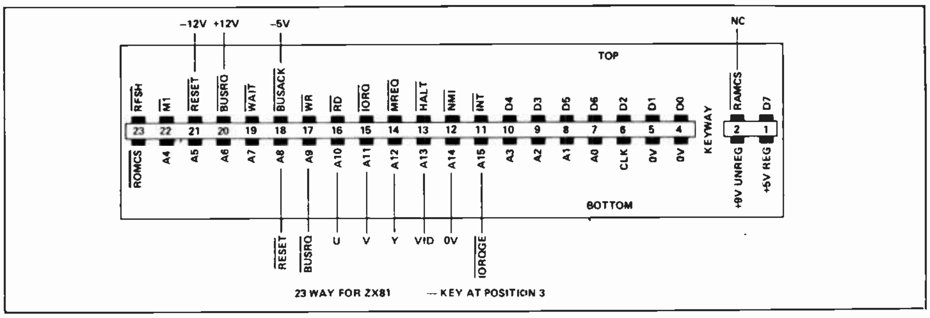

Fig. 2 Pin connections of the ZX81 expansion port

A7	A6	A5	A4	A3	A2	A1	A0	PORT
0	0	0	1	1	1	1	1	A data
0	1	0	1	1	1	1	1	A control
0	0	1	1	1	1	1	1	B data
0	1	1	1	1	1	1	1	B control

Table 1 Examples of eight bit PIO address words.

BIT	7	6	5	4	3	2	1	0
output mode	0	0	1	1	1	1	1	1
input mode	0	1						
bidirectional	1	0						
control	1	1						

Table 2 Format of the operation control word.

while setting it low defines it as an output. Since port A consists of the eight input lines from the various sensing switches, its control word will be 11111111, again, decimal 255. Port B has lines 0, 1, 2, 3 outputting data to the LED display and lines 4, 5, 6, and 7 accepting input data from the push button switches, so its control word will be 11110000, that is, decimal 240.

The first six instructions of the program therefore consist of loading the relevant control word into the accumulator and outputting it to either address 93 or address 127 (see Table 4 and the flow chart, Fig. 3).

Before the progam can be entered, you will need to reserve space for the 108 bytes of machine code by moving RAM-TOP. To do this type in:

```
POKE 16388,147
POKE 16389,67
NEW
```

and follow each statement with the Newline command. To check that RAMTOP has been moved, type in:

```
PRINT    256*PEEK 16389 + PEEK
         16388
```

and you should get 17299.

Having reserved the 108 bytes after RAMTOP in the ZX81, type in:

```
10 FOR N=0 to 107
20 INPUT X
30 POKE 17299+N,X
40 NEXT N
50 PRINT USR 17299
```

then RUN. The computer will then wait for you to type in the 108 numbers given in Table 3.

When the programming has been completed, a 1 should appear on the LED

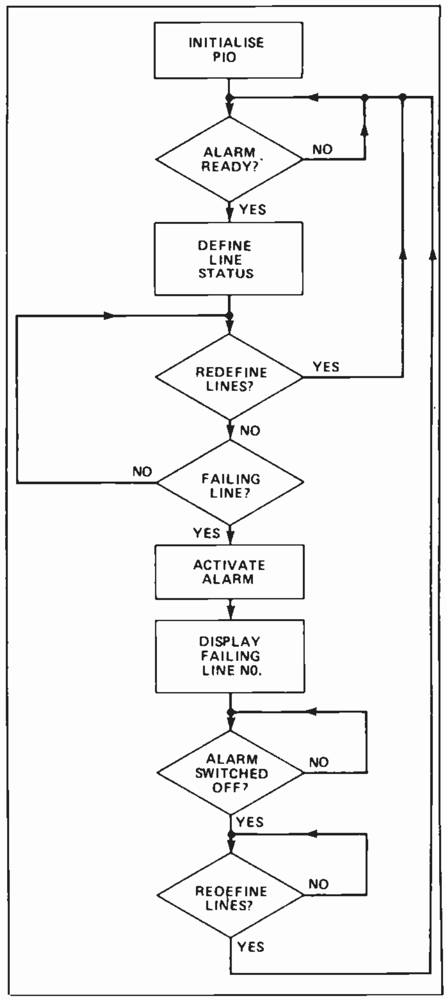

Fig. 3 Flow chart of the burglar alarm program.

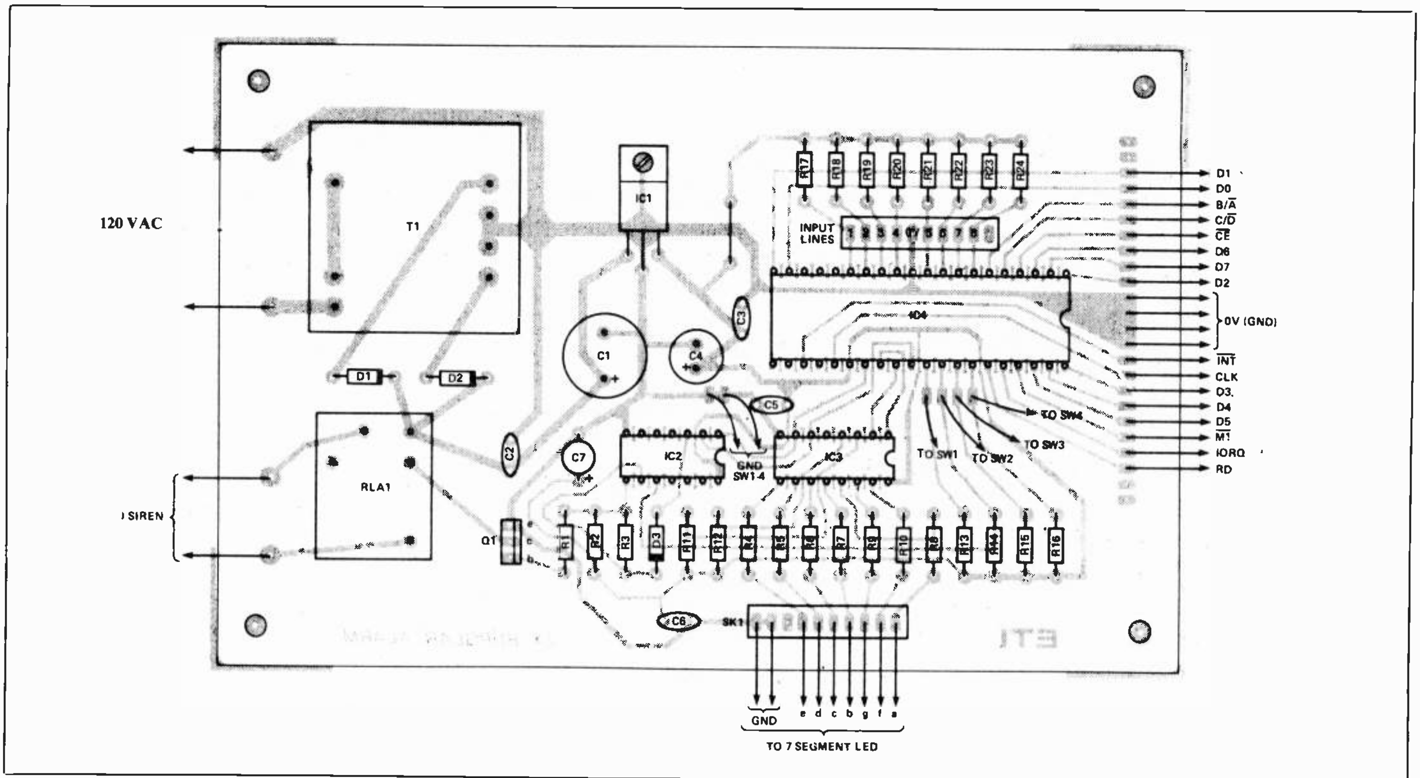

Fig. 4 The overlay diagram for the PCB. Note: the circuit was originally designed for a PC-mounting transformer which may not be available. An ordinary transformer can be mounted off the board with the leads soldered to the PC pads.

display. This refers to the first line on port A, and you must now tell the computer whether this line is to be high or low, according to what type of sensing switch you plan to use on it. To do this you first press either switch SW3 (LOW) if the line is to be normally closed or SW4 (HIGH) if the line is to be normally open, and then press the ENTER switch SW2. The LED should now display a 2, and you repeat the procedure with this and each of the subsequent lines.

When all eight lines have been entered and the register is full, the microprocessor goes into a continuous loop, checking each line against its corresponding bit in the register. Should you wish to redefine the normal state of the lines, pressing SW1 empties the register and thus stops the program. If the alarm is triggered, it can be reset by pressing first SW2 and then SW1.

```
62, 255, 211, 93, 211, 93, 211, 127, 62, 240,
211, 127, 219, 63, 203, 111, 40, 250, 6, 8,
62, 0, 30, 0, 60, 211, 63, 219, 63, 203, 119,
40, 5, 203, 127, 32, 246, 28, 219, 63, 203,
111, 32, 250, 203, 11, 16, 232, 62, 0, 211,
63, 219, 63, 203, 103, 40, 210, 219, 31, 171,
6, 8, 203, 23, 56, 4, 16, 250, 24, 237, 197,
62, 9, 211, 63, 6, 10, 17, 1, 0, 33, 222, 57,
237, 82, 32, 252, 16, 247, 193, 120, 211, 63,
219, 63, 203, 111, 32, 250, 219, 63, 203, 103,
32, 250, 24, 160
```

Table 3 The ZX81 data.

PARTS LIST

Resistors (all ¼ W, 5%)	
R1	4k7
R2, 4,5,6, 7,8,9,10	470R
R3	330R
R11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24	10k
Capacitors	
C1	1000u 16V electrolytic
C2, 3	100n
C4	22u 16V electrolytic
C5, 6	10n ceramic
C7	100u 10V tantalum
Semiconductors	
IC1	7805
IC2	7408
IC3	7447
IC4	Z80A PIO
Q1	BD131
D1, 2	1N4001
D3	1N4148
DISP1	Common anode 7-segment display
Miscellaneous	
RLA1	12V DC 400R miniature relay
T1	9-0 9V 6VA transformer
SW1, 2, 3, 4	momentary action, push-to-make

PCB: edge connector to suit ZX81; 10-way 0.1" pitch PCB plug and socket — 2 off each; case, etc. to suit.

continued on page 22


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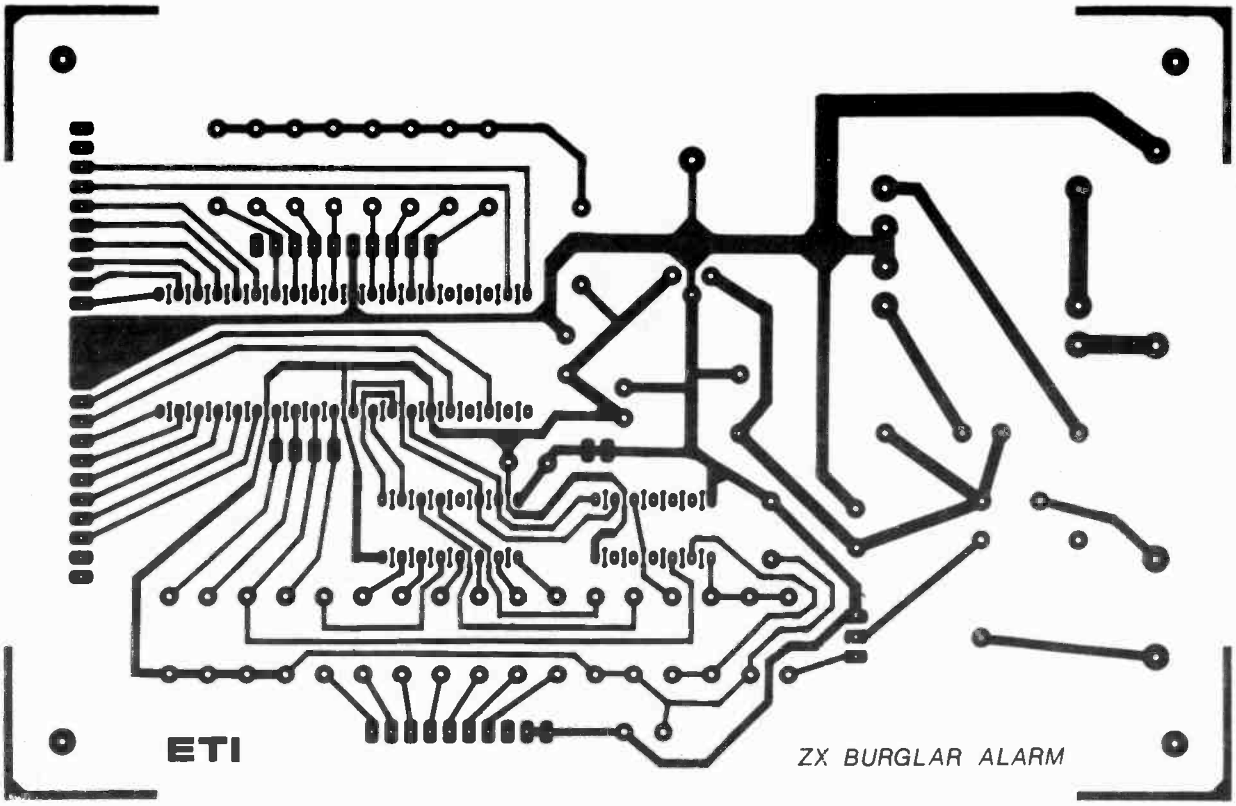

ETI
ZX BURGLAR ALARM

LD A	255	62,	255	
out A	93	211,	93	
out A	93	211,	93	
out A	127	211,	127	
LD A	240	62,	240	
out A	127	211,	127	
IN	63	219,	63	
BIT 5		203,	111	
JRZ	-6	40,	-6	
LD B	8	6,	8	
LD A	0	62,	0	
LD E	0	30,	0	
INC A		60,		
out A		211,	63	
IN	63	219,	63	
BIT 6		203,	119	
JRZ	5	40,	5	
BIT 7		203,	127	
JRNZ	-10	32,	-10	
INC E		28,		
IN	63	219,	63	
BIT 5A		203,	111	
JRNZ	-6	32,	-6	
RRE		203,	111	
DJNZ	-24	16,	-24	
LD A	0	62,	0	
out	63	211,	63	
IN	63	219,	63	
BiT		203,	103	
JRZ	-46	40,	-46	
IN	31	219,	31	
XOR E		171,		
LD B	8	6,	8	
RLA		203,	23	
.C 4		56,	4	
DJNZ		16,	-6	
JR	-19	24,	-19	
PUSH B		197		
LD A	9	62,	9	
out	63	211,	63	
LD B	10	6,	10	
LD DE.	1	17,	1,	0
LD HL	14814	33,	222,	57
SBC HL, DE		237,	82	
JRNZ	-4	32,	-4	
DJNZ	-9	16,	-9	
POP B		193		
LD A, B		120		
out 63		211,	63	
IN 63		219,	63	
BIT 5		203,	111	
JR NZ	-6	32,	-6	
IN 63		219,	63	
BIT 4		203,	103	
JRNZ	-6	32,	-6	
JR	-96	24,	-96	

Table 4 Assembler listing of the burglar alarm program.

HOW IT WORKS

The various intruder detecting switches are connected between ground and the eight lines of port A on the PIO. Each of the eight lines is connected to the +5V line through a pull-up resistor, so that when the associated switch is open a logic high level will appear on the input, and when the switch is closed the line will be pulled down to logical low. The latter four lines on port B are similarly connected so that pushing any of switches 1 to 4 takes the associated line low. The first four lines on port B are used for the display output and carry a four bit binary code. This is fed directly to the decoder/driver 7447 and then to the seven segment display.

When the program is executed it puts out a '1' and then waits for the line to be defined. Taking either line 6 or line 7 on port B low enters a 0 to 1 as desired into register E. Subsequently taking line 5 low initiates a rotate right instruction which moves the entered data one place to the right so that the register is ready to receive the next bit. The microprocessor then outputs a '2' and the process is repeated until register E is full.

The microprocessor then goes into a continuous loop, using the XOR function to simultaneously compare each input line with the corresponding bit in register E. If both bits are at the same level, either both high or both low, the XOR function will produce a 0 output, but if the two bits are at different logic levels the XOR will give a 1. The RLA instruction is used to shift each bit into the carry flag and test for a 1 and if no carry is detected the microprocessor carries on testing the lines.

When a 1 is detected, a nine is briefly sent out via port B to the display. At the same time, a large number is loaded into registers H and L and 1 is successively subtracted until the result is zero. A total of 148 140 machine cycles are needed for this, and the nine is therefore displayed for a full second or so before the micro processor removes it and displays instead the number of the failed line. The AND gate IC2b has its inputs connected to the A and D lines from port B, and will therefore go high only when a nine is put out. Its output is connected to IC2a, another AND gate, which is wired as a latch. IC2a drives the transistor Q1 which turns on the relay. The other input of IC2a is connected to line 5 of port B, and if SW2 is pressed this line will go low, unlatching the gate and thus turning off the relay.

ETI

Coleco Adam Review

Bill Markwick reviews the Coleco Adam system, a total package that needs only a monitor to get you computing.

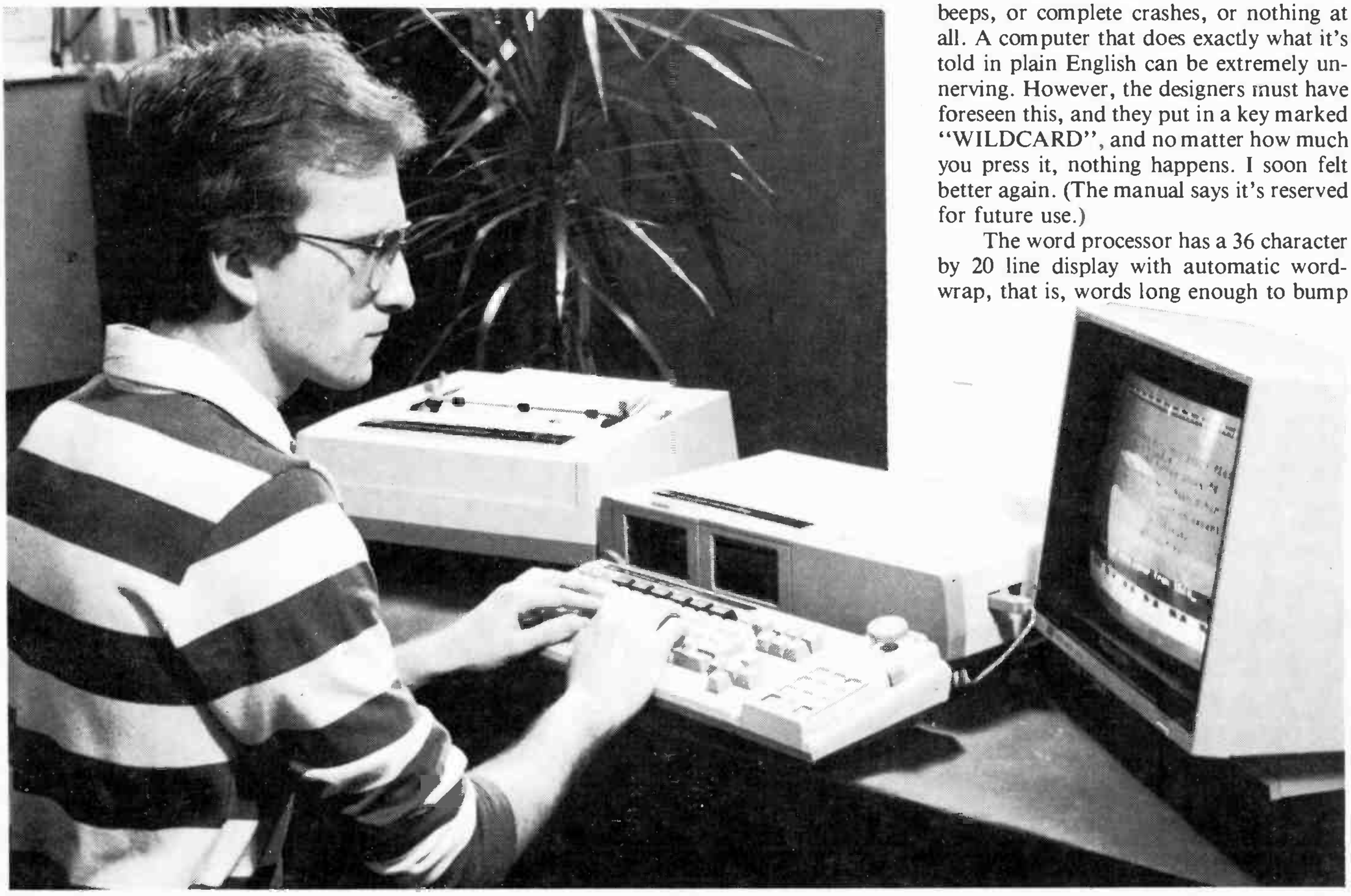
COLECO MUST have divined that many buyers of computers get annoyed at having to buy all sorts of peripherals and gadgetry to make their computers do anything useful, and are offering the Adam system. Everything you need for games, word processing, BASIC, printing, and data storage is in one huge cardboard box, and if you already own a Colecovision, there's also a version that lets you use your existing hardware and save money, too.

On opening the large box, you'll find a daisywheel printer, a computer console about 46 by 27 by 10 cm with a cassette drive and 80K of RAM in it, two joysticks, a keyboard, three cassettes, and fistful of manuals. The printer connects to the wallplug, the computer connects to the printer, the keyboard connects to the computer, dem bones, dem bones... The printer is an essential part of things, because it contains the power supply and the power switch.

Once all the cords are inserted, you can connect either a TV set or a proper monitor. The monitor is better, and a colour monitor is best, because both video games and the word processor use various colours that fade to a uniform grey on a black-and-white set.

When you power up, the printer will burp and the screen will say that it's an electronic typewriter. Sure enough, there's even a typewriter roller produced by the graphics, and when you press a key, the printer prints it.

Now that it's lit up, we'll start with the word processor, because it follows from the typewriter mode if you press "WP".



WP

The word processor is much easier to use than most of the low-end types, because all the control codes are single keypresses. No need for jargon: the "PRINT" key, believe it or not, makes the printer work. The "UNDO" key, ah, undoes any recent deletion and restores the text to the screen. The top of the keyboard sports six function keys, called Smart Keys, and their particular function is denoted by labels along the bottom of the screen. If you press "SEARCH", for instance, the computer asks you for a word and then searches your file for it.

I don't understand this. Every other computer I've ever used replied to its commands with puzzling little error codes, or beeps, or complete crashes, or nothing at all. A computer that does exactly what it's told in plain English can be extremely unnerving. However, the designers must have foreseen this, and they put in a key marked "WILDCARD", and no matter how much you press it, nothing happens. I soon felt better again. (The manual says it's reserved for future use.)

The word processor has a 36 character by 20 line display with automatic wordwrap, that is, words long enough to bump into the right margin are transferred whole to the next line. When printing, the text width is automatically stretched out to the full 80 columns of the printer. To minimise the confusion of the two different formats, the top of the screen displays a linear indication of which space you're at and the margins that have been set. The audio section of the computer makes a sort of chiming noise to alert you to various conditions; thankfully, you can shut this off with one of the Smart Keys.

Now, you have to realize that word processor fans eventually develop a religious fervour about their favourite processors, and no other software can even come close to their particular baby; I'm no different, and would rather be burned at the stake than give up my WordStar. However, I actually got to like the Adam word processor; I especially liked the Smart Keys that are labelled in English, that peculiar language so foreign to the minds of most computer designers. It really is easy to use, and will be even better when the optional 80-column card is available as promised by Coleco. Only the cursoring is weird: the cursor stays on the graphic "roller" and all the text scrolls. You do get used to it.

When I returned to my WordStar, it wouldn't talk to me.

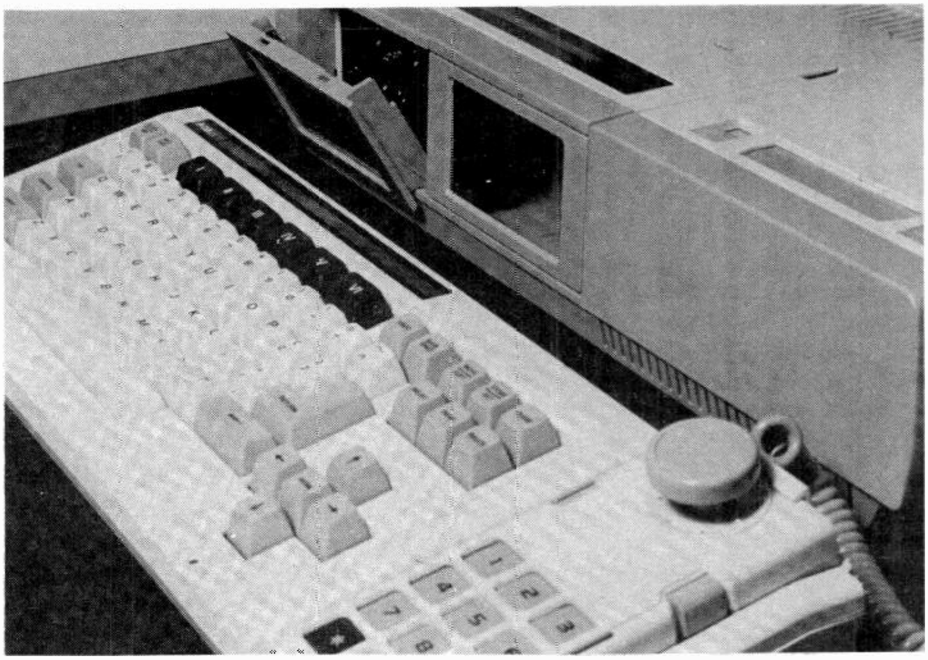
Now Loading

You'll eventually want to store your pearls of wisdom, and you can fish out the blank cassette that comes with the system and plonk it in the cassette drive. I know, Coleco calls it a "digital data pack", but it looks just like an audio cassette, except that the record-protect notches have been moved around to prevent you from inserting audio types. There's some wisdom in this, because audio cassettes seem to cause a lot of drag on the high-speed Adam mechanism (yes, I cut new notches in an audio cassette to see what would happen).

When you decide to store a file, you press a button marked, of all things, "STORE". The directory is recorded on the middle part of the tape to minimise the search time. If you decide to get your file back, you press "GET". How illogical. The file menu then appears, and you load your selection with the cursor keys and a Smart Key.

The searching and loading times of the digital data pack are greatly improved over the standard audio recorder, but the serial-access cassette design naturally means a lengthy wait if the computer has to find the directory and then locate a file near the end of the tape. In some cases, retrieval required only ten seconds; in others, particularly saving, it could take up to two minutes.

This is where the first drawback appears. The cassette tape is first wound to the directory, and thence to the requested



file. This high speed mode is fairly rapid as cassettes go, but the frigging noise! I couldn't find out whether it was caused by the tape itself or by the mechanism, but it emits a high-pitched shriek in the fast mode; two of my gerbils fainted dead away. Perhaps not all production models do this, but we got a humdinger.

Games

The next cassette in the box was the Buck Rogers Planet of Zoom video game. After a lengthy (two minute) load, you're the pilot of a spaceship zipping down a sort of tunnel, and all sorts of weird aliens come gunning for you. The included joysticks are a bit inelegant, and no match for the more expensive variety, but they do the job; if your evasive tactics and gunnery succeed, you're popped to a more difficult level. The graphics are really fine, with a good three-dimensional look to them, and the action is more than enough to keep you busy for hours. The disadvantage is that the complex program requires numerous accesses to the cassette, and the aforementioned shrieking gets a bit annoying, especially to other members of the household who aren't all that interested in the fact that you survived flying under the bridges and are nearly in sight of the Command Ship.

Coleco is well known for their wide range of video games, and the Adam lets you use either cassettes or ROM packs; the latter plug into a slot on the top of the console.

BASIC

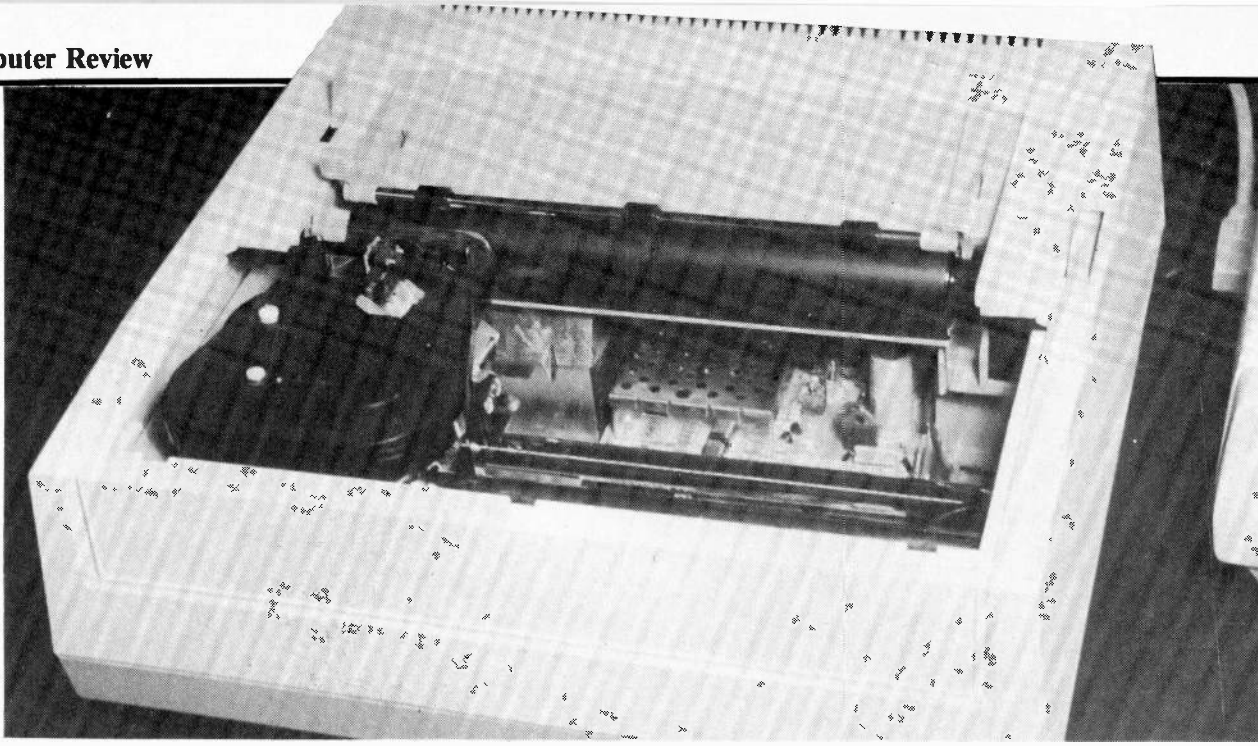
The third cassette included is called SmartBASIC. After loading it, you're presented with a cursor that looks remarkably like the cursor used in Applesoft. Noodling through the language and the manual would also indicate quite a similarity, and some of the Adam dealers have even gone so far as to claim Apple compatibility. However, it's not totally for real just yet — it's mock Applesoft. All the simpler commands and syntax are the same: PRINT, SAVE, CATALOG, GR, SPEED, and so on. However, the Adam is Z80-based, and the Apple's use of a 6502 means that something has to give. In the case of the Adam, it's commands such as POKE and PEEK; these are unique to the Adam due to the different memory layout. this means that you can't run Apple software unless it's pretty simple stuff. You also won't be able to work in assembler; such commands as CALL-151 (enter monitor) will have no effect. Some of the CALLs, in fact, dump you right out of BASIC.

A spokesman for Coleco said that all is not lost, however. In the works is a new SmartBASIC II which will have much better compatibility.

Docs

The documentation included is reasonably good; there's certainly lots of it. The word processor has a comprehensive book and a quick-reference folder; there's also a folder for general operating tips and another for setting up the system in case you've never before seen a connector cord with anything but a two-prong power plug. The BASIC Manual is adequate, but like most of its kind, lacks a really good index. It guides you along well enough from beginning to end, but makes life difficult when you want to find something specific.

None of the manuals are the least bit technical or in-depth; if you're a real keener, you may have to wait for third-party manuals to arrive.



The Printer

As I mentioned before, you have to take the printer as part of the deal. It comes in the box. It's rather slow; Coleco claims 10.5 characters per second, although ours worked out at 9.5. The slowness is to be expected from the daisy wheel approach; you trade speed for the high quality of the print produced.

The main problem is that it's very noisy; the slackness in the mechanism means that it makes a very loud clack with each character. You won't be able to print out your great Canadian novel after the family goes to bed unless you have a soundproof garage.

It's adequate if you just print the occasional letter or program listing, and the characters are sharp and well aligned. The ribbon has to be the Coleco film types; the daisy wheels can be changed to obtain various characters sets.

CP/M

CP/M is a file handling system that replaces the SAVE, LOAD business associated with most computers. No more Opening and Closing and so on; just type a filename and up it comes. There are lots of good utilities included with the CP/M that let you write and debug programs, fix errors, examine memory, and more. It's an old medieval system, as computers go, but the basic functions are really so good that it's finally trickling down from minicomputers to home micros.

And yes! Coleco plans to introduce a disk drive system for the Adam based on CP/M, though we don't have any firm dates or prices yet.

Inside

If you lift the lid on the console, you'll see the compact cassette drive with room for one more beside it, and behind it, lots of space for three plug-in expansion modules. Some of the modules are the 64K additional memory, an 80-column card, and a language card for converting the word processor to French, German, etc.

There are two external connectors unmentioned in the manuals; an expansion module edge connector and a telephone-type jack marked 'AdamNet''. The former is presumably for extra features other than games or memory, and the latter would allow several Adams to be networked together.

After removing enough screws to hold a '57 Chev together, you can peer into the inner sanctum. This consists of two boards. One is the Z80 CPU, 16K RAM, and associated widgetry, and the other contains the ROM and another 64K of RAM. Both boards are very well shielded with metal covers and the whole works connected together with a bonding cable; I never had the slightest problem with static crashes.

Summary

In general, the Adam is a very well-thought-out package indeed. For a grand or so, you get everything you need except the monitor, and the operation is very simple and straightforward thanks to the novel idea of making things do what the label says. There probably isn't a better system for introducing someone to computers, because confusion has been minimized.

On the negative side is the fact that you have to buy a printer which you may not want; it's clattery and slow, and you're stuck with it unless Coleco decides to sell the components separately and offer a dot matrix printer as an alternative. You're also stuck with a slow and noisy cassette operating system which uses very expensive cassettes (about $20), even if they do offer a disk system later.

It's difficult to compare the Adam system to other computers due to the package deal. If you compare it to clones, or the Commodore 64, you'll get befuddled with the various expansion cards required; for instance, both Apples and Commodores require printer controllers if you want to use some of the low-cost printers around, and the 64 uses the 1541 serial disk drive which is about the same speed as the Adam's cassettes. To generalise, you can probably outfit a clone with one disk drive and a dot matrix printer for a bit more than the Adam (though you won't get the software or joysticks thrown in). The price of the forthcoming Adam disk drive may change the picture considerably. As it is, the Adam is very impressive system and well worth looking into.

Quick Reference

Coleco Adam System

Mfg.	Coleco, USA
List Price:	$1200 complete, $999 for use with Colecovision
CPU:	Z80A
RAM:	80K
Software Included:	Word processor, BASIC, video game.
Screen Format:	36 x 20
Colour:	16 available
Outputs:	TV, video, audio
Other:	includes daisywheel printer, two joysticks, one cassette drive, one blank cassette.

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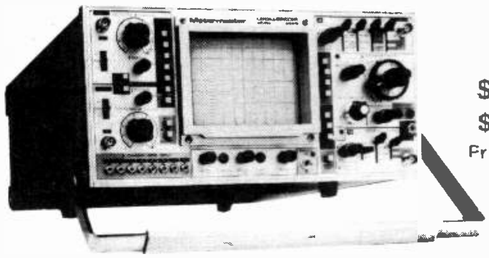

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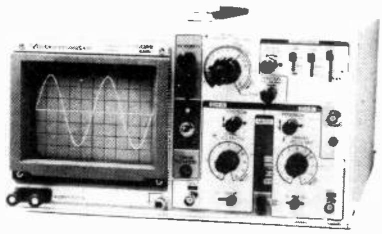

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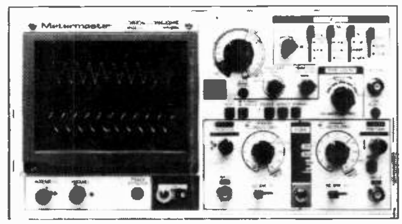

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Designing Micro Systems Part 9

In conclusion of this series, Owen Bishop takes a look at the two main methods of storing and retrieving information.

WHILE THE MICRO is in use, a lot of information may be held in ROM and in RAM. When the power is switched off, all the information in RAM is lost. This might consist of programs, tables of data, and information of various other kinds. If we want to retain this information for use on a future occasion, it must be stored in a form in which it can easily be put back into RAM when required. For certain applications RAM is not large enough to hold all the information we have to deal with. A business might be running a data-base program and require access to names and addresses of thousands of customers. These cannot be held simultaneously in RAM, so they must be loaded in and dealt with batch by batch. A complicated program may be too long to be held in RAM, but can be broken down into sections which are loaded individually for use when required. Some system of transferring information into and out of the micro is therefore almost essential.

The two methods of storage most commonly used involved transferring the information to a magnetic medium. Almost all micros provide a means of transferring information between RAM and a cassette tape. The other method makes use of a plastic disc coated on one or both sides with magnetic material. This is often referred to as a *floppy disc,* to contrast it with the *hard disc* which is often used with minicomputers but (at present) rarely with micros. Discs are made in two standard sizes, 8" and 5¼" in diameter. The smaller of these is the kind most often used with micros and is more correctly described as a *diskette.* Diskettes of even smaller diameter are now being produced, most notably for the ZX81 microcomputers (the Sinclair Microdrives).

Tape Measures

Information is stored on tape in the form of a square wave. Successive regions of the tape are magnetized in one direction or the other. The prime requirement is for a tape with low noise and freedom from blemishes. With an audio tape the occasional region with faulty coating makes little difference to the sound, but when the tape is being used for recording binary digits, such a 'drop-out' may convert a 0 to a 1 or the other way around, rendering the recording useless from that point onward. Although it is possible to use ordinary tape for recording computer programs, most people prefer to use specially tested 'digital' tapes which are guaranteed free from such defects. They are usually supplied in shorter lengths than audio tapes. For example, C10 and C15 are two commonly available lengths. A program of 16K (or slightly longer) fits into a single side of such a tape when recorded at the standard rate of 300 baud. If your program is longer than this, you will probably prefer not to wait as long as 10 minutes or a quarter of an hour to load it and will be thinking of investing in a disc drive.

Figure 1 shows the circuit of a typical cassette output circuit. It occupies a single address in the memory stage of the computer. Data is fed to it as a series of 0s and 1s and a corresponding voltage is fed to the recorder. In the example shown, a positive voltage represents 1, 0V represents 0. In the absence of a signal the output voltage is one half of the '1' level. However, there is little standardization of microcomputer outputs to cassette recorders, and there are many variations on this theme.

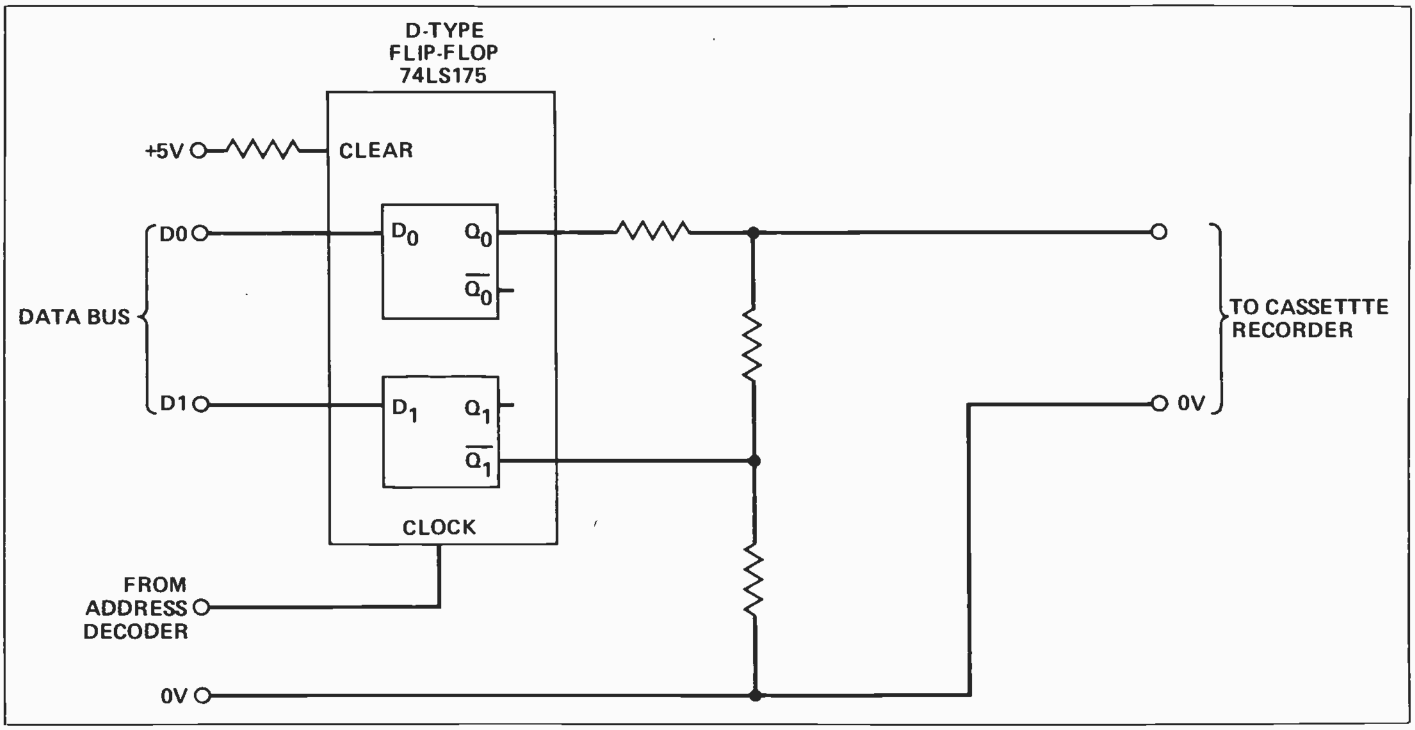


Fig. 1 Typical cassette output circuit (based on the TRS-80). Data is transferred to the outputs Q and Q when the clock input is made low. It is then latched until the next write operation. The resistors are chosen to give suitable ouput levels with different combinations of outputs from the flip-flops.

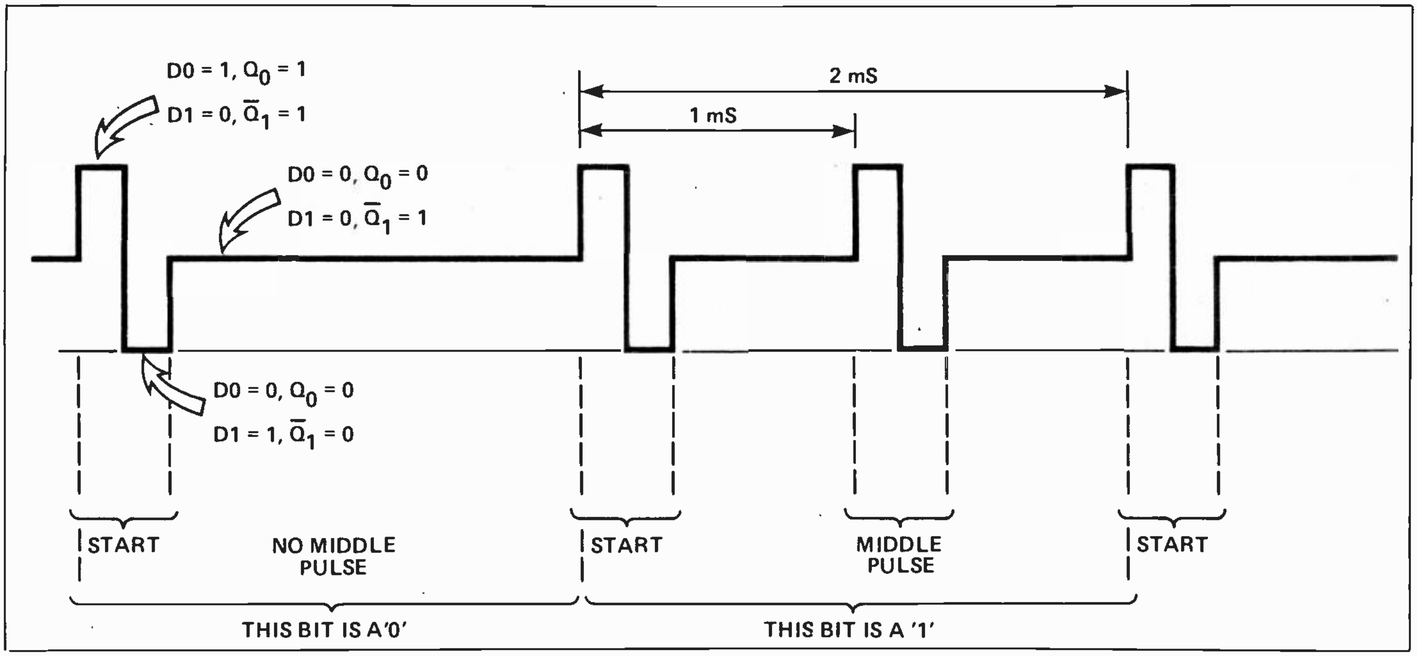


Fig. 2 The coding of the bits in the TRS-80.

All micros record and load the data serially, that is to say, one bit at a time. Before a byte of information is recorded it is broken down into its eight bits and each bit is sent separately to the cassette output circuit. Methods of coding the information vary widely from one micro to another. This is why it is almost impossible to load one micro with a program saved on a machine of different make.

Bits and Blips

Not only does each micro have its own system of formatting the tape — the way it begins and ends each transmission of data — but the 1s and 0s may be represented in several different ways. The TRS-80, for example sends data at the rate of one bit every 2 mS (500 baud). It indicates the beginning of each bit by a 'start pulse' or 'blip' as in Fig. 2. This is a short swing to high, then to low and finally a return to the 'no-signal' level. If the bit is a 0, no further signal is sent. After 2mS the next 'blip' indicates the start of the next bit. If the bit is a 1, a blip is sent exactly 1mS after the start pulse.

When the tape is played back the signal is taken in through a circuit as in Fig. 3, where the 'blips' are detected. Though they do not have exactly the same form as the original signal, the timing is the same and this is all that matters. The micro is programmed to wait until a signal is detected and to sample the input exactly 1 mS later. If a signal is detected at this stage too, the bit is taken to be a 1. If no pulse is detected, the bit is taken as a 0. It then awaits the arrival of the next signal to indicate the beginning of the next bit. At each stage it stores which kind of bit (0 or 1) it has received. When it has received eight bits these are assembled into a byte and stored in RAM. If a flaw in the tape causes a bit to be missed, or an extra bit to be recorded, this upsets the decoding of all bytes for the remainder of the recording. An incorrectly-read bit may alter only the byte it is part of. This too can affect the interpretation of the whole of the remainder of the recording, especially if the recording is a machine-code program.

Another system of recording data depends on *frequency shift keying* (FSK, for short). This method is also used in transferring data from one micro to another by wire. Two standard frequencies are used, one of them having perhaps twice the frequency of the other. When we say 'standard' we mean standard for that model of micro, but for tape recording different makes of micro almost invariably work to different standards. A 0 is represented by a short tone burst of one frequency and a 1 by a burst of the other frequency. On playback (or on receiving the transmission over a line) the computer can easily measure pulse length and so find out which frequency is being sent at each instant. This information is then converted into 0s and 1s and assembled into bytes to be stored in RAM.

Tape Versus Disc

Tape recording computer programs and data files has some considerable advantages which must be matched against considerable disadvantages. The main advantage is cheapness. Within the computer we need relatively simple output and input circuits. The tape recorder itself can be a simple and cheap mass-produced model. Many intending microcomputer owners already possess a tape recorder, so the only expense is the lead to connect it to the micro. A sophisticated hi-fi recorder often gives trouble owing to its noise reduction circuits which turn up the volume during periods of no signal, so feeding the computer with amplified tape noise and confounding its signal detection program. It has often been said the cheaper the recorder, the better it is for use with a micro. However, certain micros give problems when loading from tape, and make it necessary to set the playback volume fairly carefully to avoid either too small a signal or a large signal which saturates the input circuits.

Manual Controls

Provided that the user requires only to save and load relatively short programs, the cheapness and availability of cassette recorders outweighs their disadvantages. If a large amount of data is to be handled and if time is costly, the balance of advantage swings firmly toward the disc. One of the disadvantages of the cassette recorder is that its 'record', 'play' and tape winding controls cannot be operated automatically by the computer. They must be operated by the user, with the inevitable consequence of making a mistake. At the least, this wastes time and, at the worst, may cause a valuable program or set of data to be erased.

The only control which micros have over the recorder is to start and stop the motor at the beginning and end of each recording. There is a small relay in the computer which is connected in place of this 'on/off' switch often found on the stem of a microphone. This relay is controlled by the MPU, having its own address or addresses in memory. Usually there is a flip-flop which is toggled by writing to one address or the other. Figure 4 is a typical motor-switching circuit. Such a circuit is very simple and therefore found in all except the very cheapest micros.

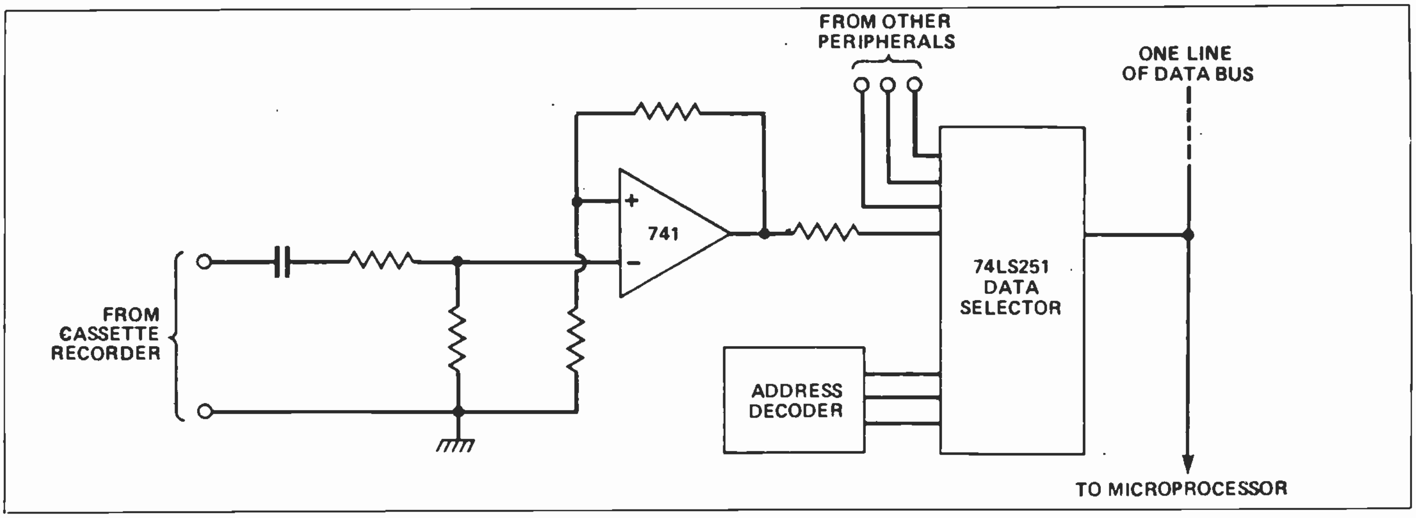
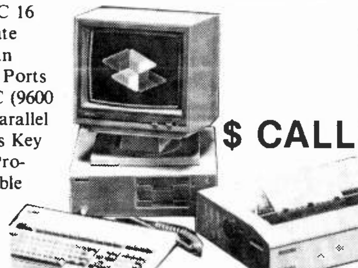
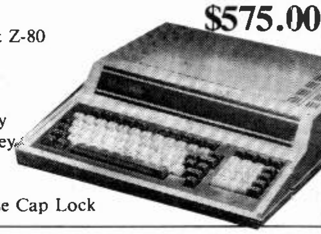
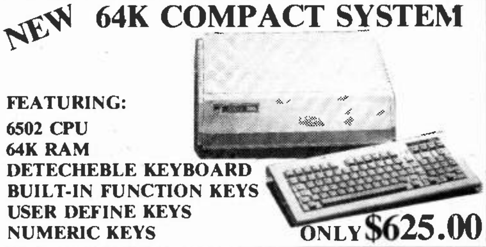


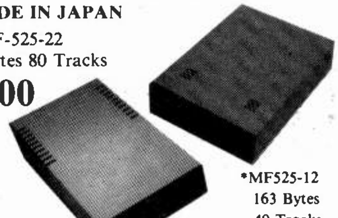
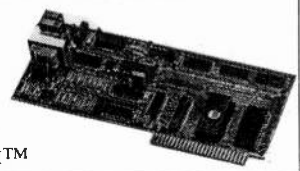
Fig. 3 A typical cassette input circuit has an op-amp wired with positive feedback so that it saturates and its ouput swings fully in either direction. The data selector is used to send the input from the recorder or from other peripherals such as games controllers.

A cassette tape passes over the recording/playback head at the standard speed of 1 15/16 inches per second (50 mm/S). At this relatively low speed the rate of recording is limited to a few hundreds of bits per second. Consequently it takes several minutes to record a program which is more than a few kilobytes long. This results in excessively long delays when running data-bases and similar programs.

Other problems with tape are connected with the fact that programs or data files are recorded one after the other along the length of the tape. Recordings can be played back only in the order on which they were recorded. If you want to return to a recording which is earlier on the track, it is necessary to operate the recorder manually, rewinding it to a position in advance of its new starting point. This takes time and is a tedious operation even with the aid of the footage meter. If the item of data you need is part of a long recording, you have to play the recording through from beginning to end to retrieve the single item you need.

Discs have none of these advantages and are altogether more reliable than cassette tapes. One the other hand, a disc drive is considerably more expensive than an ordinary cassette recorder. But if we abandon

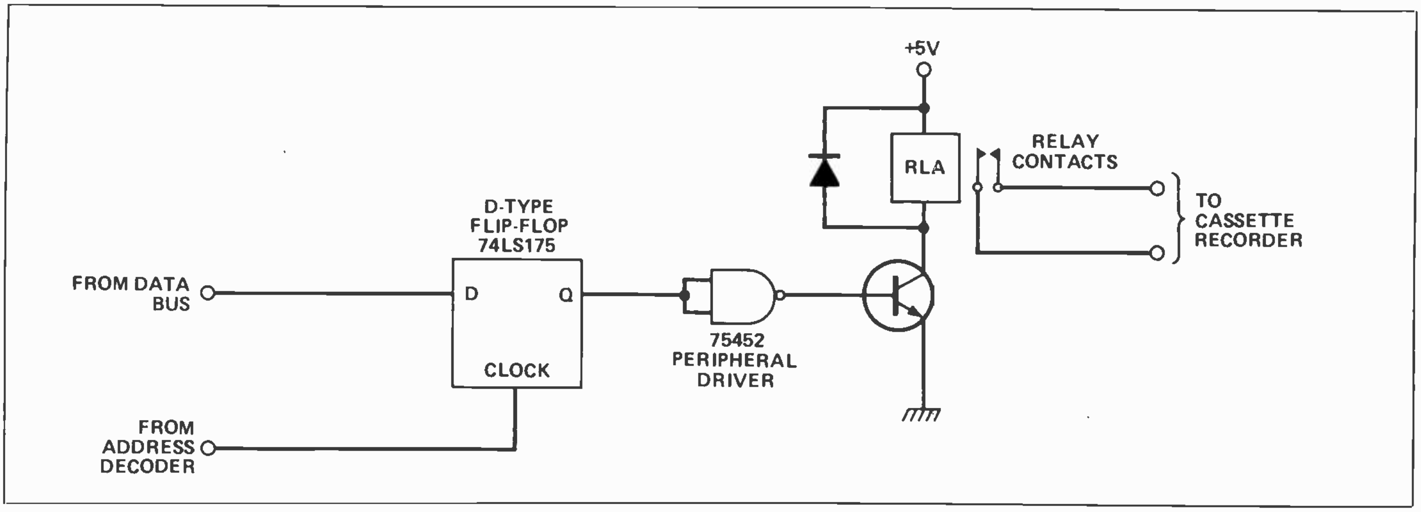



Fig. 4. A circuit for operating the cassette motor switch. When the data input is low, and the flip-flop is addressed, Q becomes low, the output of the driver goes high, the transistor is turned on, and the relay is energized. The relay contacts close and so the cassette motor is switched on.

the idea of cheap data storage, we can take advantage of the best available technology and design a device which is ideal for its purpose.

Spin A Disc

The recording medium, disc or diskette, consists of a disc of mylar film coated with magnetic oxide; it may be coated on one side only or on both sides. The magnetic head is very close to the disc when reading and writing data and the disc rotates at high speed, so it is essential to exclude particles of dust. Even the dust from cigarette smoke can cause malfunction (another good reason for giving up — Ed). The disc is therefore sealed in a plastic sleeve, lined with a textured material which lubricates the surface of the disc and removes debris. The case has a slot (Fig. 5) to allow the magnetic head access to the disc. It also has a small hole through which the *sector holes* are visible. These are holes punched in the disc and spaced regularly around it. There is a fixed number, depending on the system on which the disc is being used. Commonly there are 16 such holes, giving a 16-sector disc. The effect of these is that the tracks on the disc, which are concentric, are divided into 16 sectors. The disc drive has a light source located on one side of the disc to shine through the sector holes as the disc spins around. A phototransistor on the other side of the disc detects when a hole passes. This aids the drive in sensing the position of the disc.

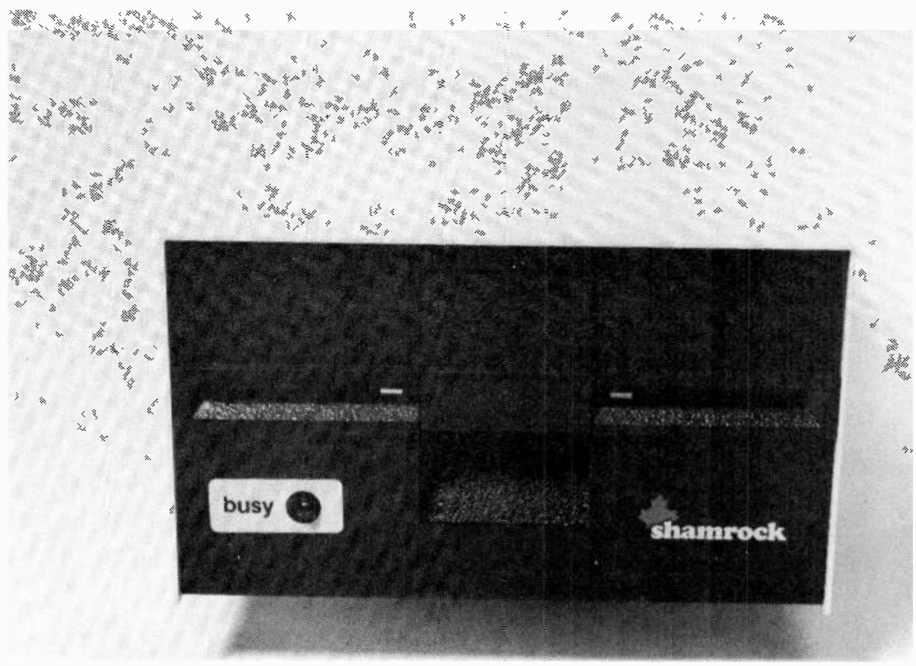
Discs which have holes to mark the sectors are known as *hard-sectored* discs. An alternative system has a single hole for detecting each rotation of the disc but relies on software for dividing the track into sectors. Such a disc is known as a *soft-sectored* disc.

Another phototransistor in the drive is used to detect whether the disc is 'write-protected'. There is a notch in the edge of the case of the disc: light shines through this notch from below and falls on the phototransistor. The user may fix a sticky tag over this notch to prevent light from passing. In this event, the phototransistor is not activated and the writing action of the drive is inhibited. This serves to prevent the accidental or intentional overwriting or altering of data or programs. This is simply a safety measure: the tag is peeled off should further writing be required.

The Faster Format

In a typical disc drive the disc is rotated at a constant speed of several hundred revolutions per minute. For example, the Siemens FDD 100-5 drive rotates at 300 RPM. At the middle track, this gives the magnetic material a speed of about 1400 mm/S relative to the head, compared with 50 mm/S in the cassette recorder. As a result of this and the physically small size of the read/write head, data can be recorded and read at 125 kilobits per second. Reading and writing of data is therefore extremely fast. There is a delay of one second while the disc comes up to full speed: the head takes an average of 300 mS to find the required track and a further 15 mS to settle into position. After that, data is transferred at the rate mentioned above. Should the head need to change from one track to another, as it will if much data has to be transferred, it takes only 25 mS to move from one track to another.

It is evident from the description above that access to data is very much quicker and more direct than is the case with tape. Instead of having to run from one end of a tape to the other, the head can go directly to the track, then to the sector within the track,



A typical single disc drive unit. The disc (still in its cover) is inserted in the slot which runs almost the full width of the case. The LED is lit to indicate when the drive is in operation.

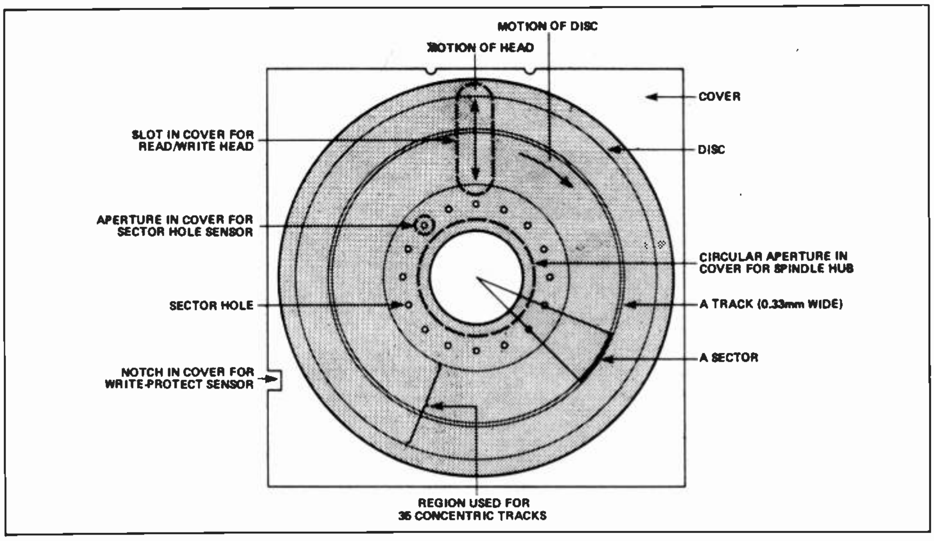


Fig. 5 'See-through' diagram of a hard sectored floppy diskette in its cover. Normally, of course, you cannot see the disc itself.

to find what is required. Changing from one track to another is effected by a stepper motor connected to a worm gear which moves the head radially. The signals from the sector hole sensor tell the drive when the required sector is in position to be read from or written to.

Naturally, the operation of the drive cannot be manual. The drive contains a complicated array of electronics (see photo) to control the disc, the stepper motor, the raising and lowering of the head, as well as those circuits responsible for handling the signals which are to be put on to the disc or have been taken from it. Synchronizing these operations requires an impressive amount of logic circuitry: some of the more advanced disc drives even incorporate a microprocessor to take charge of the operation. This has several advantages, especially with a soft-sectored disc. The rate at which the medium passes the head depends on the radial distance from the centre: consequently data is more compressed on the inner tracks and widely spaced on the outer tracks. For reliability, it is the speed on the innermost track which limits the maximum rate of data transfer. Using a microprocessor, it is possible to perform rapid calculations which allow the drive to vary the rate of data transfer according to the radial position of the head. Data is stored at about the same density on all tracks but the outer tracks can have more sectors, so the overall storage capacity of the disc is markedly increased.

On the whole, the standard method of storage is adequate. A 5¼" mini-diskette may have 31 tracks each of 16 sectors, and each sector stores 256 bytes. This gives a total storage of 124 kilobytes on a single-sided disc. Double-sided discs store twice this amount, and the capacity can be further increased by using 'double density' discs in which there are almost twice as many tracks, placed closer together.

Keeping Track of the Tracks

The disc referred to above which has 31 tracks available for storage of data or programs also has four additional tracks reserved for use by the disc operating system. In order to make sufficient use of the disc space, in which items of data may be continually written, replaced, and deleted, it is essential for a large amount of 'book-keeping' to be done. The system must know on which sector of which track each item has been placed. Items longer than 256 bytes occupy more than one sector, so the system must know how to direct the head from sector to sector to pick up all the data in the correct order.

The reserved tracks contain an index or directory of the contents of the disc so that the whereabouts of every item of data is known. The directory also helps the head to find vacant sectors when a new item of data is to be placed on the disc. The reserved tracks also hold a special program, the disc operating program, which is loaded into RAM when the micro is first powered up. This provides the instructions for accessing the directory tracks and obtaining whatever information is required, and for placing new information on the disc. This program (provided it is well written, which some are not) together with the hardware of the disc drive itself, completely automates the transfer of information between micro and magnetic storage medium. The operator is almost unaware of what is happening except for the comforting clunks and whirrs emanating from the drive. With a well-made drive and by observing a few simple precautions in gentle handling of the discs themselves, the reliability is far higher than with tapes, making this a relatively expensive but infinitely preferable method of data storage. **ETI**

VHSIC: High Speed Chips

Tracking systems, much as the British Rapier Tracker shown above, require the input of a vast amount of information at extremely high speeds. Units such as the Rapier could well benefit from the technology of VHSIC.

Dealing with vast amounts of information in a short time means a superfast chip, and Roger Allan reports on the state of art.

ONE OF the major difficulties faced by the Western Alliance's defence weapons systems is the inability to integrate on small enough scale the electronic circuitry required to deal with battlefield conditions. While the generic circuitry available is adequate in itself to provide the means of guidance, electronic warfare, communications, etc., of a defence system, the circuitry involved is simply too large to fit into weapons operable on the battlefield if they are to do all of the things that military commanders would like them to do.

As such, in 1980, the Office of the Under Secretary of Defence for Research and Engineering (OUSDRE) in the United States established a tri-service/Department of Defence seven year project to develop the technology necessary for a Very High Speed Integrated Circuit (VHSIC) set of systems. Its expected cost is $680M (US).

The basic design criteria for VHSIC is the creation of operational military electronic systems that have a functional throughput 100 times greater than commercially available integrated circuits, are hardened to tactical environments, include built in test and redundancy systems, and result in better reliability and lower cost than those currently available.

The potential ramifications for the success of this project both militarily and commercially are enormous, reminiscent in fact of the Japanese Fifth Generation computer project. However, depending on which Pentagon Official one speaks to (and having had a reasonable amount to do with the Pentagon over the last year, this author assures the reader that frequently their left hands don't know what their right ones are doing), the VHSIC program is either on track, faltering but still heading in the right direction, or quietly collapsing. Perhaps the most accurate statement to date is that there is a major reassessment in progress.

Phase 0 of the program, commenced in 1980, was quite simple: design specifications for an initial program goal of 1.25 micron geometry and a call for tenders.

Phase 1 was commenced in May of 1981, in which six prime contractors were chosen with the contractual objective of producing pilot production lines for silicon chips in the 1.25 micrometer size and associated brassboards by mid-1984. These were generic-function brassboards, designed to cover a fairly wide spectrum of potential uses. They include an imaging infrared signal processor (Honeywell), a spread-spectrum psuedo-noise communications processor (Hughes), a sonar-acoustic signal processor (IBM), a combined infrared and antiradiation homing sensor (Texas Instruments), an electronic warfare signal processor (TRW) and a programmable tactical radar signal processor (Westinghouse). Pentagon sources state that all the brassboards have been built, but only the specifications of one have been released.

The TRW Chip

The publicised unit is the TRW VHSIC chip. A signal processor, it is a matrix switch IC which performs crossbar switching. It operates at 25 MHz, contains 13,500 transistors and resistors, measures 200 x 200 mil in a 132 pin package. In operation this 3D bipolar chip dissipates 2.5 watts of power. Analogues to a telephone crossbar switch, it can interconnect any one of eight input lines to any unused output line every 40 nanoseconds. It represents a major step forward in electronic warfare defence capabilities. In this type of warfare, the critical task is to be able to sort pulses from many different radars, including frequency hopping radars, in a dense emitter environment. With current technology, a processor can handle about 100,000 pulses a second. TRW's brassboard chip is able to handle 2 million pulses/sec, in about one-fifth the volume and at one-twentieth the power consumption.

Phase 2, which was to have begun in the early part of this year, is either under review and no decisions have been taken, or has been reviewed and decisions have been taken, but nobody is saying what they are.

Essentially, this phase, among other things, was to result in the development of VHSIC microcircuits with 0.5 micron feature sizes. While at least the TRW device was above design specifications (it involves 1.0 micron sizes rather than the contracted 1.25 micron sizes), contractors and researchers have recognized that the 0.5 micron sizes will be far more difficult to achieve than was expected when the project was initiated. Apparently, many of the difficulties are fundamental to the laws of physics; essentially, there is some thought that they cannot be overcome theoretically, much less in practice. Also, it is believed that further reduction in feature sizes may not yield proportionally greater functional capability due to the problem of interconnecting an increased number of devices on a single chip. Even with the use of three layers of metal interconnections, as in the TRW 1.0 micron chip, the interconnections occupy more than 90% of the chip area. If the designers went to, say, five levels of circuitry, this would adversely affect the yield of good devices, primarily due to heat generation in the middle layers and the inability to dissipate that heat.

The current review, then, apparently revolves around the argument of whether to go for 0.5 micron sizes as originally planned, or whether to go for 0.75 micron sizes. More specifically, if the Phase 2 portion had gone ahead as previously planned, it would have resulted in submicrometer silicon technology which operated at at 100 MHz clock rate with a throughput of 10^{13}gate Hz/cm^2. Should the project drop back to 0.75 micron technology, this author has been unable to determine the effect on the clock or gate rates.

Consolidating ICs

Another difficulty faced by the Department of Defense (DoD) is their reliance on commercially available integrated circuits which then have to be interconnected to each other to produce the design specific military application. Since commercial producers are quite obviously interested in commercial applications for their products, the variety of integrated circuits available for specific military applications is, surprisingly, limited. As such, an adjunct to the VHSIC program is being developed known as the Technology Insertion Program (TIP); specifically a computer-aided design (CAD) technique to enable defence system suppliers to customer design very complex function chips for specific military applications. The envisioned system, currently under development, would include a work station that could be used to block out the design of the entire system, establish parameters for each subsystem, and design the specific chip required to do the job. The output would be a magnetic tape that could be sent to an appropriate semiconductor manufacturer, or 'silicon foundry', which would fabricate the chips using VHSIC techniques.

In other words, rather than purchasing a series of 'off-the-shelf' ICs, and then connecting them together on some sort of motherboard to achieve a desired end with all the concommitant waste in space, weight, heat generation and power consumption, a single chip or a very few chips could be designed and built for specific purposes such as a new radar. As an example, using current brassboard VHSIC technology, the DoD can now put both an infrared-seeker and an anti-radiation homing capability in a 5" fire-and-forget missile previously unobtainable with commercially available ICs. If the silicon foundry idea above can be made to work, these two systems could be reduced to the size of a pack of cigarettes.

Further, there is an adjunct project to take the VHSIC project results and retrofit them to existing weapons systems. For example, a Sidewinder air-to-air missile uses (largely) off-the-shelf ICs for its control and guidance systems. By retro-fitting VHSIC chips to do the same job, a significant weight saving is achieved. For a given amount of fuel, this weight saving is translated into increased range, hence making the Sidewinder more lethal.

As part of TIP the DoD intends to ensure that the largest number of DoD contractors will have access to VHSIC design technology and information at the levels appropriate to their needs. This effort has begun with the development of a comprehensive VHSIC hardware description language (VHDL) which will allow designers to communicate to each other in a common language and permit their access to the VHSIC database. The long term thrust of this element is for the development of an integrated design automation system (IDAS) running from system partitioning to logic design and mask generation through to the silicon foundry manufacturing stage. Believed to be potentially a particularly powerful design tool, it should help the DoD to quickly respond to new developments in military hardware and reduce the time and expense involved in moving from idea to hardware testing on the weapons range.

It is this element which has led the DoD to clamp down very tightly on the security aspects of this project. While the Department freely concedes that there would be many civilian applications for VHSIC technology (*a la* the Japanese Fifth Generation Computer project) the defence aspect is considered to be so important at the present time that civilian applications and non-military contractors are not being granted access to the technology. This security aspect will remain until it is felt that the civilian benefits outweigh the military ones, eg., when the Soviets independently come up with the same sort of technology.

ETI

See page 46

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Super

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The MULTIFLEX video terminal was originally designed as a low cost access unit. This terminal is a semi-intelligent system which is controlled by a Z80A microprocessor and a 6845 CRT controller chip. The keyboard is fully ASCII encoded and the character generator contains the full 128-character set as well as a 128-character alternate set both of which are in the 5x7 dot matrix format. The screen display is 80 characters by 24 lines if the unit is hooked to an external monitor (not included) or 64 by 24 if run through an RF modulator to a TV. There are 3 software selectable attributes (dim, reverse video, and alternate character set) which can be chosen one at a time for the whole screen. This attribute can then be switched on and off for each individual character. A 2K buffer is provided for normal operation. However when the optional 6K memory upgrade is purchased, 4 screen pages can be loaded from the host machine, edited locally, and then downloaded back to the host again saving on connect time and phone line bills. One RS232 port (provision for optional second port) one for a modem and one so that a printer can be attached to the terminal. The baud rates on these ports are software programmable and can range from 110 to 9600 baud.

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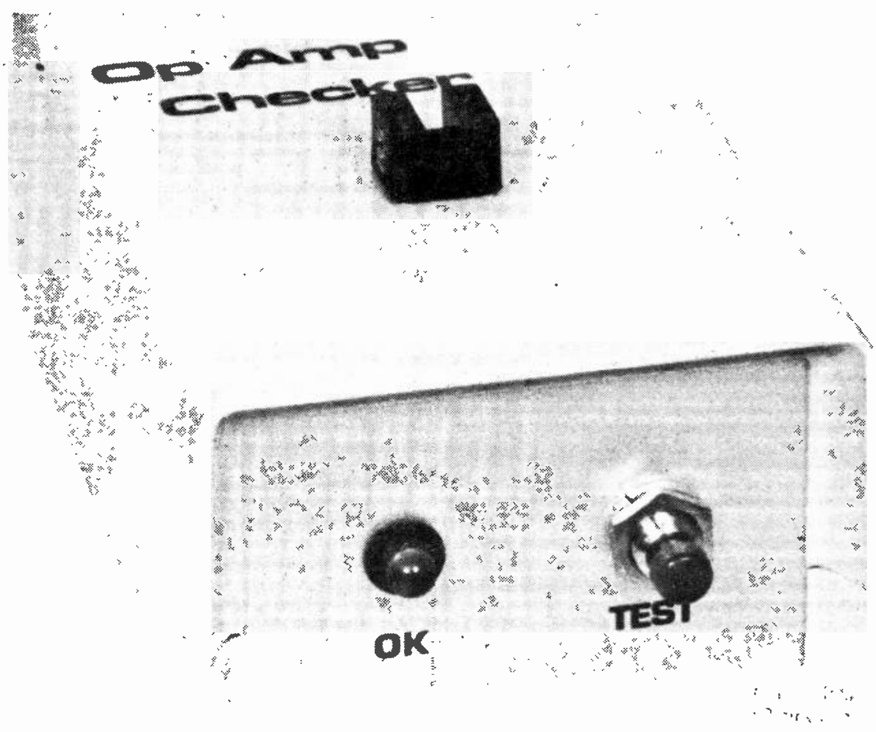
Op Amp Checker

Construct your own vital test equipment with ETI. An ideal first-time project which will be handy for many years to come.



The ETI Op Amp Checker is a useful device designed to give easy and quick checking of IC operational amplifiers having the standard 8 pin DIP (Dual-in-line package) and pin connection layout (or TO-99 types with their leadouts formed into an 8 pin DIP configuration). The op amp is inserted into a DIP socket situated on the lid of the case, and if it is working and LED indicator flashes on and off when a "push to test" switch is operated. However, if the op amp is faulty in any way, the LED remains either on or off, giving an instant check on the op amp's state.

The device is simple to construct and use and is very cheap, as it relies totally on the operation of the IC under test rather than any active components of its own. A handful of resistors, capacitors and an LED form the circuit which is constructed on veroboards. However, you could try your hand at designing and making your own P.C.B. if you wish, as the circuit is quite a simple one.

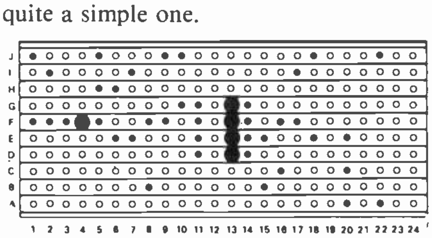


Figure 1. The underside of the board showing "break" points.

Construction

As far as construction of the circuit itself is concerned there is nothing unusual. The veroboard layout is uncluttered and neat, and builders should find no problems to hold them back.

However, our prototype has a rather novel method to interface with the outside world. We have used a wire-wrap socket to "piggy-back" with the IC socket mounted on the veroboard. The wire-wrapping socket is mounted on the top of the case — after 8 small holes have been drilled in the case to allow the eight wire wrap tags to go through! Pushing the veroboard up onto the wire-wrap tags conveniently mounts the board as well as making the necessary connections between the op amp under test and the rest of the circuit.

Figure 4 shows this in detail. Be careful that you get the veroboard the right way round i.e. pin 1 of the wire-wrap socket going to pin 1 of the normal IC socket. Mount PB 1, the test push button and LED 1, the indicator LED into the front panel.

All that remains is to connect your battery and find an op amp that needs testing!

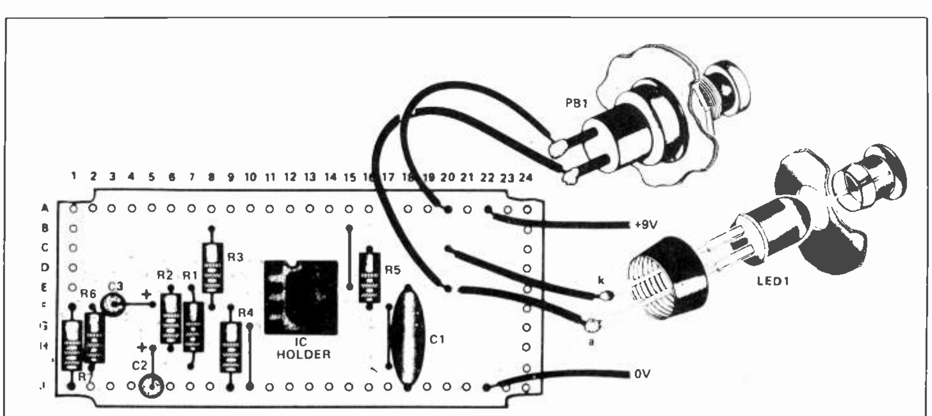


Figure 2. Board layout and wiring connections of the OP Amp Checker.

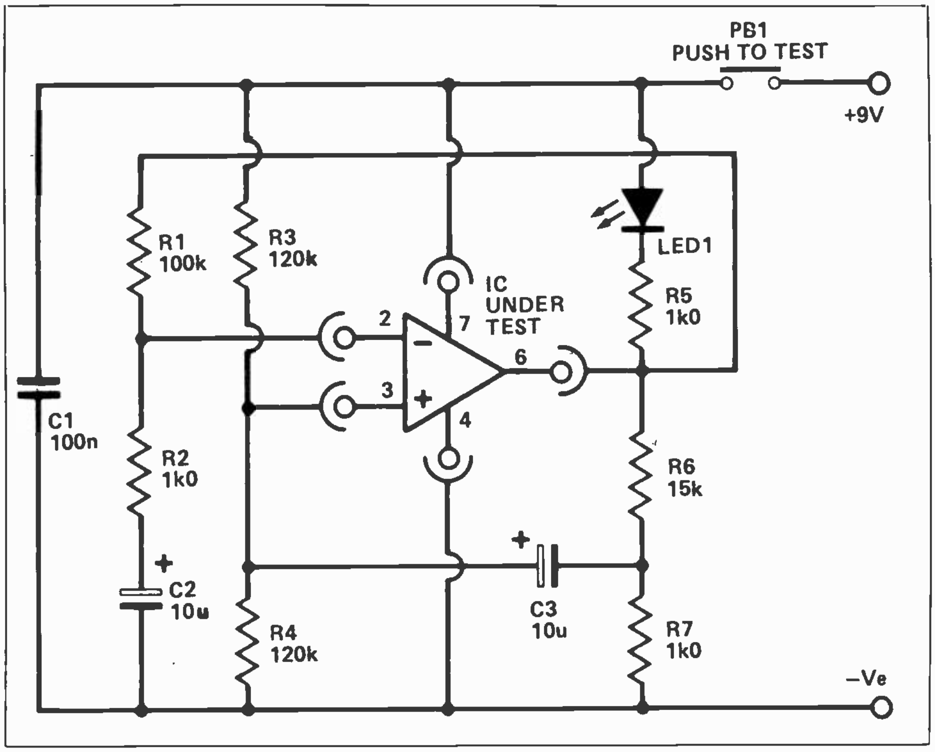


Figure 3. The circuit diagram of the Op Amp Checker.

HOW IT WORKS

The device being tested is connected up as a non-inverting amplifier, with the non-inventing (+) input biased by R3 and R4, R1 and R2 are a negative feedback network giving a closed loop voltage gain of 101 times (closed loop voltage gain equals R1 plus R2 divided by R2). The open loop voltage gain of an op amp is the gain without any feedback applied — this is generally of the order of 100,000, a value much too high to be of any use. Applying negative feedback reduces this to a reasonable value — the closed loop voltage gain. LED 1 is the LED indicator and is connected to the output of the op amp via current limiting resistor R5. The LED will switch on when the output of the test device is in the low state, and off when it is high.

R6 and R7 attenuate the output voltage of the amplifier, giving a nominal sixteenfold reduction in the output signal amplitude. C3 couples the output from the attenuator to the non-inverting input of the test device, providing some positive feedback. If the test device is functioning properly, the voltage gain it provides will considerably more than compensate for the losses through the attenuator, and the circuit will oscillate at a frequency of a few Hertz when SW1 is operated and power is supplied to the circuit. The repeated changes in the state of the output will cause LED 1 to flash on and off, indicating that the op amp is working correctly. Of course, a dud device would almost certainly fail to provide any significant voltage gain and its output would then remain in a fixed state.

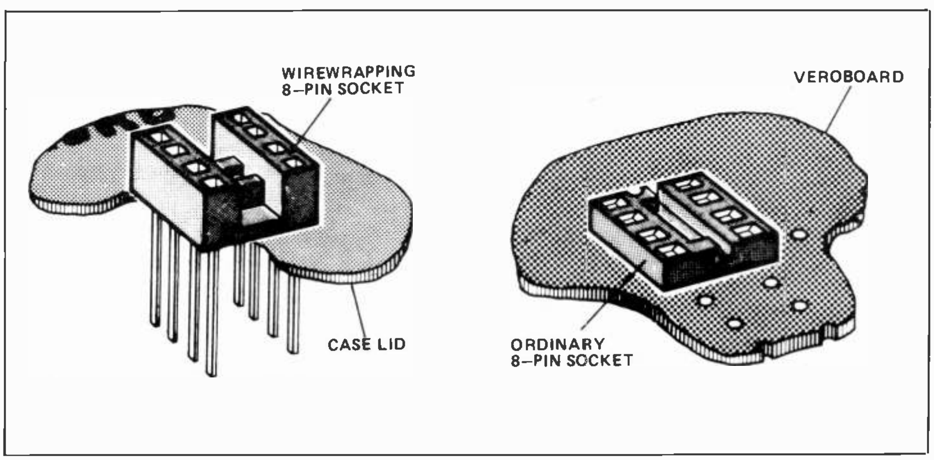


Figure 4 shows the method of construction using a wire wrapping socket provide connections between the IC under test and the board.

PARTS LIST

RESISTORS (all ¼ W, 5%)

R1	100k
R2, 5, 7	1k0
R3, 4	120k
R6	15k

CAPACITORS

C1	100n polyester
C2, 3	10u 10V electrolytic

SEMICONDUCTORS

Led 1	0.2" Red LED

MISCELLANEOUS

10 strips x 24 hole 0.1" veroboard
PBI — push to make switch
8 pin IC socket
8 pin wire wrapping socket
Case to suit
9V battery and clip

ETI

DESIGNER'S Notebook

Optocoupler Devices and their applications

Ever wanted to control one circuit with another without having any intermediate electrical connection? Devices that provide coupling via a beam of infra-red light are called 'optocouplers' and they're just perfect for the job. Here's a run down on a host of popular optocouplers and how to use them in practical circuits.

THE ELECTRONIC circuit designer is often faced with the problem of providing a high degree of isolation between two circuits which must nevertheless be able to pass alternating signals from one part of the circuit to the other.

For example, one may wish to have one part of the circuit completely isolated from the mains, yet use signals from this part of the circuit to control the flow of the mains current through a load. Another example occurs in patient monitoring equipment where the small voltages developed by the beating of a heart can be coupled into mains powered equipment without any danger of the equipment causing a current to flow through the heart.

Optocouplers

Optocouplers use a beam of infra-red radiation (or occasionally, visible light) to convey the signal from one part of the circuit to the other without any electrical connection whatsoever between the two parts. They are sometimes known as photon-coupled devices or as optoisolators. They may be employed to replace conventional relays when a fast response is required or when sparking at relay contacts must be avoided in an explosive atmosphere.

An optocoupling device consists of an infra-red emitting device or other lamp on its input side and some form of detector for the radiation on the output side, both the emitter and detector being in a light-tight enclosure. The silicon detector itself may be a phototransistor, a photo-Darlington device, an opto-triggered triac or even a field effect phototransistor.

No matter which of these device types is employed, the silicon detector has its maximum sensitivity at a wavelength quite near to that at which the gallium arsenide device emits with its maximum intensity. In other words, the devices are spectrally well matched so that a small emitter device current can produce a reasonably large response in the detecting device.

Types

A very large number of types of optocoupler have been marketed with the electrical characteristics of both the emitter and the detector having to be specified in every type. Rather than involve readers with a mass of type numbers, the article will concentrate on a limited number of readily-available devices.

The 4N26, 4N28 and MCT2 devices are examples of those using a phototransistor as a detector, the 4N33 has a Darlington output stage, the 5N139 (equivalent to the MCC671) has a 'split-Darlington' fast output device, the MCT6 is a dual device and the MOC-3020 has a triac output for 240 V mains supplies.

Dual-in-line

Although some optocoupled devices are fabricated in circular metal packages, the most common types, including those listed above, are produced in dual-in-line (DIL) packages with a typical construction like that shown in Figure 1. The emitter and detector are placed fairly close together with a clear insulating material between them. The black silicon body of the device prevents stray radiation from falling on the detector. A circuit symbol is shown in Figure 2.

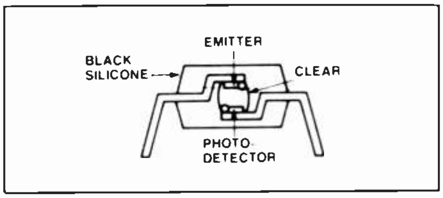


Figure 1. Cross-section through an optocoupler.

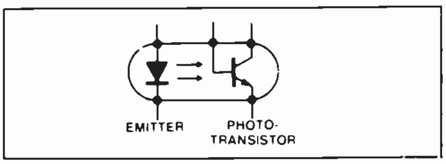


Figure 2. Symbol for an optocoupler having a transistor ouput stage.

In most DIL devices the radiating emitter is connected to pins on one side of the device, while the detector is connected to pins on the other side. This arrangement provides the maximum possible electrical isolation between the input and output circuits. Many of the simpler optocoupled devices differ from most other dual-in-line devices in that they have a total of only six connecting pins.

The basic internal circuitry of the devices under discussion is shown in Figures 3 to 7 inclusive. The three devices 4N26, 4N28 and MCT2 with a single phototransistor ouput all have the connections shown in Figure 3. The dual device type MCT6 is housed in the 8-pin package of Figure 4 so that the additional pins required are available.

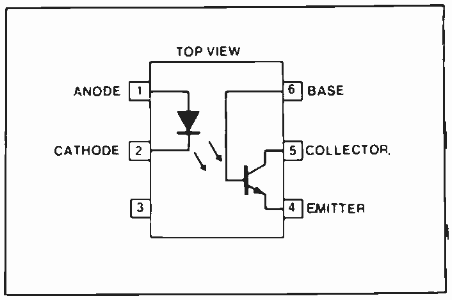


Figure 3. Pinout for the 4N26, 4N28 and MCT2 devices.

The 4N33 with its high-gain photo-Darlington output device is encapsulated in a 6-pin package with the same type of connections as the phototransistor output types of Figure 3; except for the performance differences, these devices are pin-for-pin replaceable.

The 6N139 'split-Darlington' output device has its ouput transistor base brought out to a separate pin, so the 8-pin dual-in-line package of Figure 6 is employed; this enables the input diode connections to be kept on the opposite side to all of the output connections.

Finally, the MOC-3020 with its triac output stage, is housed in a 6-pin dual-in-

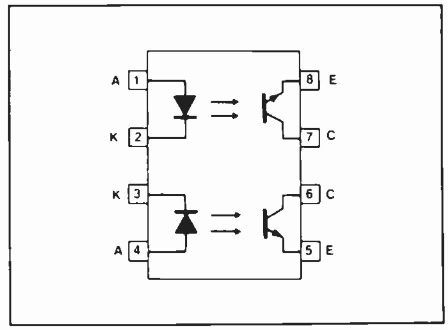


Figure 4. Pinout the MCT6 dual optocoupler device.

$V_{DRM} = V_{RRM} = 400$ V
Trigger current 5 mA (typ.), 20 mA (max.)

Holding current 100 uA (typ.) at $V_{AK} = 3$ V
Maximum output current 100 mA RMS

DEVICE TYPE	4N26	4N28	MCT2	MCT6 (dual)	4N33	6N139	MOC-3020
Output device	← Phototransistor(s) →				← Darlington →		Triac
CTR (%) Min.	20	10	—	5	—	400	—
Typ.	50	30	—	50	500	—	—
Isolation (kV) (min.)	1.5	0.5	1 5	1 5 (0.5 between channels)	1 5	3	7.5 (max 5 sec)
Isolation resistance (Typical ohms)	10^{11}	10^{11}	10^{12}	10^{12}	10^{11}	10^{12}	—
Isolation capacitance at 1 MHz (pF)	1.3	1.3	0 5	0 5	0 8	0 6	—
Maximum emitter current (mA)	80	80	60	60 per emitter	80	20	50
Typical emitter voltage at 50 mA	1.2	1 2	—	—	1 2	1.5 (at 1.6 mA)	—
Maximum reverse input voltage (V)	3	3	3	3	5	5	3
Input capacitance (pF)	150	150	250	—	150	—	—
Maximum power (mW) Total	250	250	250	400	250	—	300
Input	150	150	200	100	150	35	
Output	150	150	200	150	150	100	
Output transistor:							
BV_{CEO} (min.)	30	30	85	85	30	—	
BV_{CBO} (min.)	70	70	165	—	50	—	
BV_{ECO} (min.)	7	7	14	13	5	—	
h_{FE} (typ.)	250	250	60	—	5000	—	
I_{CEO} (nA typ.)	50	100	50	50	100	1000	
$V_{CE(SAT)}$ (typ.)	0.2	0.2	0 24	0 24	1 0	—	
Typical I_c for $I_F = 10$ mA	5	3	—	—	—	—	
Typical bandwidth (kHz)	300	300	150	150	30	—	
Package	Figure 3	Figure 3	Figure 3	Figure 4	Figure 5	Figure 6	Figure 7

Table 1. Basic data on the types of optocouplers discussed.

line-package with the connections shown in Figure 7.

The basic parameters of these devices are listed in Table 1, but it cannot be overemphasised that some of these values apply only under certain operating conditions stated on the data sheet which cannot all be shown in a table of a reasonable size.

It can be seen that most of the specifications required for the MOC-3020 differ from those of the other devices in their nature owing to the fact that the output triac must be specified in a different way to transistors and Darlingtons.

Which Type?

If one wishes to use an input signal to control alternating current from the mains in a load, the MOC-3020 will generally be the best device from those under discussion. This optocoupler will be discussed separately from the others.

If one has to design a circuit which requires two separate control coupling systems, this can be done using the dual MCT6 device provided that phototransistor outputs are suitable for the particular application concerned. Indeed, two of these MCT6 devices can be inserted into a 16-pin dual-in-line IC socket so that one has a quadruple coupling system. (Quad devices in a single package are manufactured, but are not so common as the types under discussion.)

This leaves us with a choice, in the case of single devices, of those using a phototransistor or those employing a phot-Darlington output stage. The types using a phototransistor are most commonly employed, since they provide a fast response and can usually handle input signals with frequencies of over 100 kHz (see Table 1).

Photo-Darlington output devices provide a higher gain, but the bandwidth (or maximum usable signal frequency) is about an order of magnitude less than devices which use a simple phototransistor output; in addition, devices using a photo-Darlington output stage may be priced 50% higher than those employing a phototransistor output, although this is not always the case.

The single devices of Figures 3 and 5

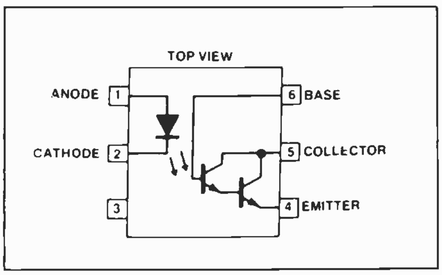


Figure 5. Pinout of the 4N33, and optocoupler having a photo-Darlington output stage.

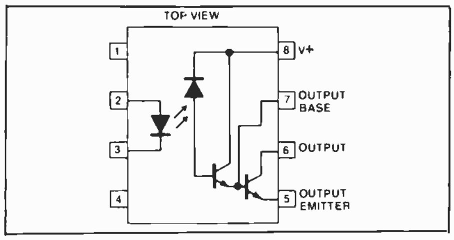


Figure 6. Pinout for the 6N139 (or MCC671) device which has a separate photodiode for maximum speed and a Darlington output for high gain.

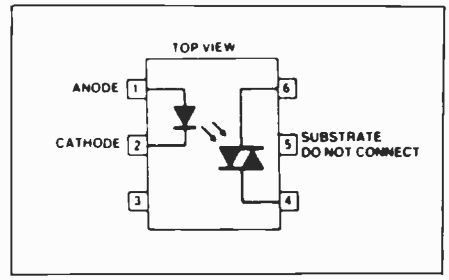


Figure 7. Pinout of the MCO-3020, which has a triac output stage.

continued on page 60

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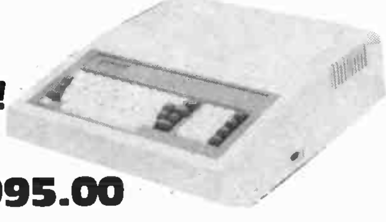

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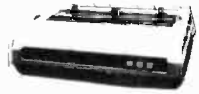

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Electronic Maps

David P. Dempster explains a new navigational aid for pilots in which a map of the terrain is generated by computer graphics.

The airborne map system showing a plan view looking from Tacoma to Seattle, Washington.

The system can show shaded relief perspective views: the display above is Mount St. Helen's before the eruption.

YOU'RE A PILOT in the cockpit of a modern tactical aircraft flying extremely fast and very low. You're darting through valleys and mountain passes to avoid detection. It's essential that you know precisely where you are and what the terrain below is like.

Unfortunately, considering the situation you are in, there is no way you have the luxury of pulling off the highway to read your map as you would if you were driving your car, nor do you have the time to refer to it in a leisurely fashion. All is not lost, however, and an answer is at hand. A prototype Airborne Electronic Terrain Map System (AETMS), developed for the U.S. Air Force by Hughes Aircraft Company's Radar Systems Group, makes incockpit map reading as simple as pushing a button. "AETMS uses a Defense Mapping Agency digitized terrain data base to provide a real time, colour-coded, moving electronic map of the area over which the aircraft is flying," explains Bill Weber, manager of RSG's Display Systems Laboratory. "The map can be projected on standard colour or black-and-white cockpit CRT displays or on the aircraft's head-up display (HUD)."

Like the multi-fold paper charts it is designed to replace, the map can show the aircraft's actual position or it can be "unfolded" electronically to let the pilot look ahead, much as a driver unfolds a road map to locate a turnoff.

"AETMS is the first device of its kind to offer so much flexibility in the number and kinds of formats available to a pilot," Weber added.

The map can be presented in a shaded relief plan view, much like a standard paper chart, or in a perspective view as though the pilot were looking at the terrain ahead of the aircraft. Tactical symbols can be added, as needed, with another touch of a button, reducing clutter and improving the display's readibility.

"A pilot can correlate or update the electronic map with information from the aircraft's radar and/or other sensors, from visual observation, and from information transmitted to the aircraft in flight," Weber said. "AETMS and the aircraft's sensors will complement and supplement one another. For example, a pilot can use sensors over friendly territory to update an aircraft's position. By entering that data on an AETMS display and coupling AETMS to an aircraft's inertial navigation system, a map is updated automatically."

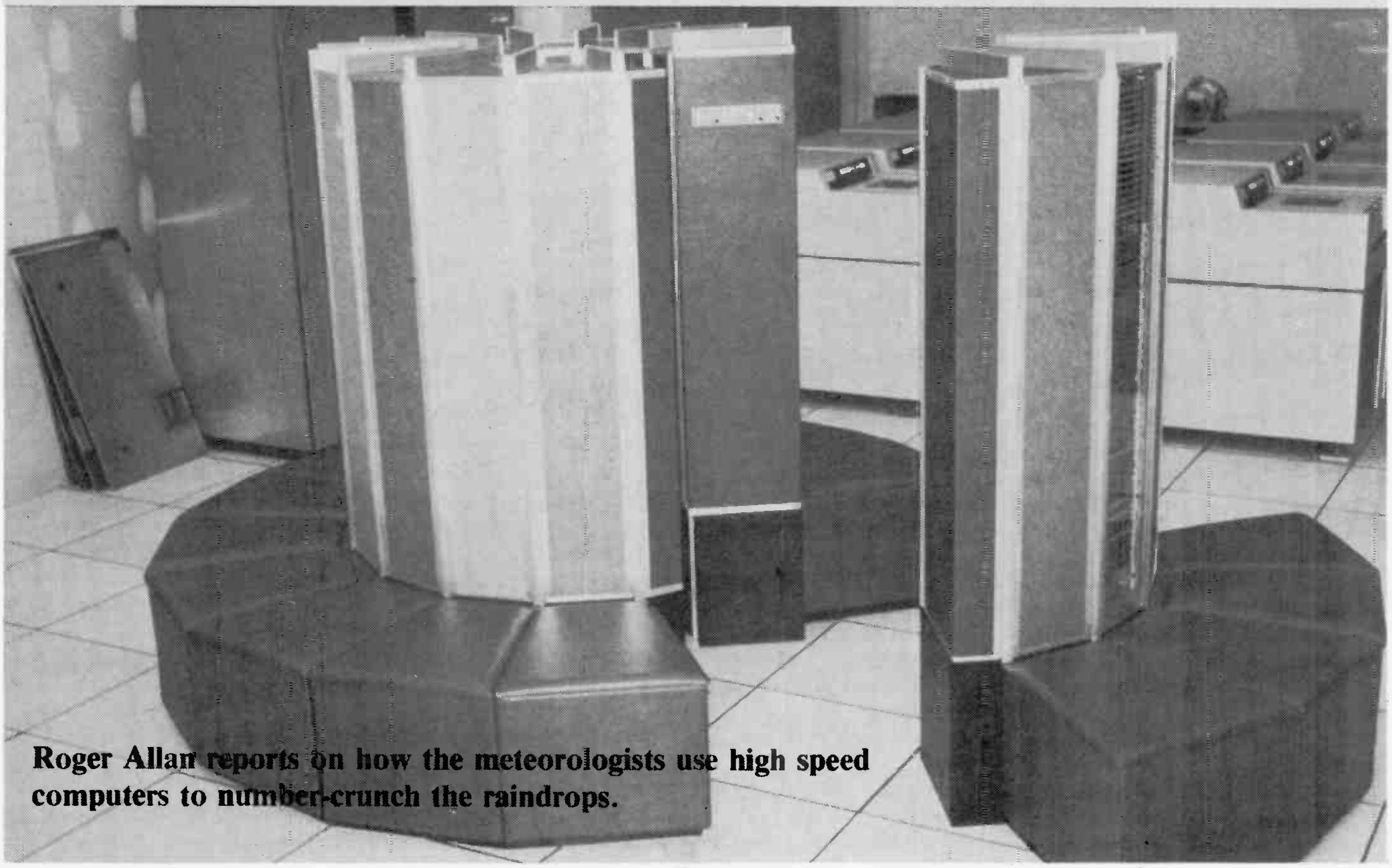
For a low altitude mission, AETMS' colour coding enables a pilot to plot a course following the contours of the land, using terrain to "mask" the aircraft from ground-based radar and other threats.

"With available technology, AETMS stores enough digitized data on a commercial disk to produce detailed maps of an area up to 250,000 square miles," Weber said. "We are still studying other memory devices, including bubble memory and solid state memory. Whatever device develops to best meet the system's requirement for ruggedness, storage capacity, and rapid access is what we'll use in the next generation system."

"Hughes has been working with electronic maps for more than a dozen years, but they were not practical until the Defense Mapping Agency began preparing its digital data base in the latter '70s," he added.

It was in 1981 that Hughes was selected by the Air Force to build the flyable prototype. This resulted in the AETMS being delivered to the Air Force's Avionics Laboratory in October, 1983. ETI

Computerised Forecasting



Roger Allan reports on how the meteorologists use high speed computers to number-crunch the raindrops.

Environment Canada's Cray 1 supercomputer in Dorval, Quebec. Photo courtesy of Atmospheric Equipment Service.

EVER SINCE man was first conscious of the weather and its effect on his crops or hunting success he has tried to predict it. With the passage of time, certain relationships became apparent even to the most primitive of peoples: the size and density of the clouds regarding the possibility of rain or the direction of the wind regarding the possibility of snow, with the unlettered coalescing of these observations into catch phrases: "red sky at night, sailors delight," etc. Native peoples the world over passed these relationships down through the centuries either through the instruction of their shaman, or through their legends. In Canada, records were kept by explorers, missionaries and fur traders, starting with Jacques Cartier in 1534.

With the enactment of Confederation, our first national meteorological service, the Atmospheric Environment Service (AES), forerunner of the Canadian Meteorological Centre (CMC) was established. It was built on the consolidation of primitive regional weather services which dated back to 1839. Hamstrung by lack of money, lack of understanding of the physical processes that underlay weather patterns (the atmosphere is a fluid), lack of reporting stations and lack of equipment, the initial weather reports were more 'by guess and by God' than by science.

Essentially, weather prediction is dependent on three sets of criteria: an adequate set of observations, an understanding of the relevant physical processes and the necessary computational capacity to do the calculations.

As for the first criteria, Canada belongs to the World Meteorological Organization (WMO), a sub-branch of the United Nations headquartered in Geneva. This organization relays weather maps and atmospheric information collected around the world from virtually every country on the planet to everyone else. Their surface observatories, under national control and funding, include some 9000 surface observation points registering temperature, wind direction and speed, atmospheric pressure, precipitation, clouds and visibility. Of these, there are 70 unmanned and 300 manned stations in Canada. Further information is received from two US weather satellite geosynchronous at 36,000 km, and two further US satellites in polar orbit at 850 km.

In Canada, the location of these observatories and the ability to predict weather only permitted weather reference points about 300 km apart. As with any modelling system, the closer the points of reference, the higher the resolution of the graph (in this case a weather front) and hence the greater accuracy of localized weather conditions. Storm fronts customarily have a minimum front of 1500 km. As such, the basic weather conditions are not too difficult to predict, at least mathematically. However, when the plotted points are 300 km apart, one runs into the problem of not being able (for example) to tell if it will be snowing in Edmonton and sunny in Calgary, or snowing at both locations.

More technically, the observations from the 370 surface observatories in Canada take their observations twice a

continued on page 49

The Electronics Today Almost Free Software Offer

The most difficult thing about understanding new software is understanding how you're going to pay for it. Even simple programs cost a mint. Thus it was that we were pretty fascinated to find that there is a vast library of really good software in the public domain.

Public domain software is free. Much of it has been written by the finest programmers around and then enhanced by dozens of other users until a lot of it is better than those nasty little disks you have to mortgage the cat to buy.

There are many splendidly useful public domain programs which have no commercial counterparts.

Unfortunately for many users, public domain software is very hard to find sources for. For this reason, we have created the Electronics Today Almost Free Software Offer.

For a limited time only . . . until the disk labels run out . . . you can get a disk formatted for your system packed with a selection of some of the finest works of the public domain. The directory includes games, programming aids, utilities and documentation files that are simply unobtainable any other way.

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- ***MODEM7*** This program will allow you to communicate with any CP/M based system and download files. See the article in this month's CN! for complete details. MODEM7 will be provided in versions for each system.
- ***PACMAN*** You can actually do PACMAN without graphics, and it clips along pretty well.
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- ***DUU*** The ultimate disk utility; this program allows you to recover accidentally erased disk files, fix gorched files, rebuild and modify your system. We recently saved a 300K dBase II file with this little gem.
- ***D*** This is a sorted directory program that immediately tells you how big all your files are and how much space is left on your disk.
- ***USQ/SQ*** allows you to compress and uncompress files. You can actually pack about forty percent more stuff on a disk with this system.
- ***FINANCE*** is a fairly sophisticated financial package written in easily understandable, modifiable Microsoft BASIC.
- ***BADLIM*** Ever have to trash a disk for just one bad sector? End your BDOS errors with this little troll. It isolates the bad sectors into an invisible file and makes the rest of the disk useable again.
- ***DISK*** This is a splendid program which allows you to move whole masses of files from disk to disk without having to do every one by hand. You can also view and erase files, all without a lot of typing.
- ***QUEST*** Life is not meaningful without dungeons and dragons.
- ***STOCKS*** This is a complete stock management program in BASIC. It's pretty fierce the way it is, but you can easily fine tune it if you feel moved to do so.
- ***SEE*** This program, also known as TYPE17, will TYPE any file, squeezed or not, allowing you to keep documents in compressed form and still be able to read them.

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day at noon and midnight Greenwich Mean Time (GMT). Within 90 minutes, this data is transmitted to the Environment Canada weather service (CMC) in Dorval, Quebec. The computers there then begin to map the weather conditions which existed when the data was collected. It then begins to project the weather movements into the future a few minutes at a time. Due to the need to get forecasts to the public within six hours of the observation, only two hours can be allotted (twice a day) for the computer to forecast the weather. By time 3 hours 30 minutes, the projected weather maps have to be transmitted to regional weather centres across Canada. There, regional forecasters utilize their knowledge of local weather conditions to translate them into local forecasts, forecasts which are then forwarded to the media for public distribution. Until recently, the longest weather prediction was for five days, though with the new equipment, this is expected to eventually reach 10 days, and with a far higher degree of accuracy.

As for the second criteria, knowledge of how the physical laws affecting fluids could be applied to understanding and predicting weather had reached the point, by the 1920s, that the British scientist L.F. Richardson was able to structure weather prediction on a series of mathematical equations. Unfortunately, he simultaneously determined that it would take some 64,000 people operating adding machines twenty-four hours a day to determine the weather for England with 50% accuracy. What the Scots and Welsh thought about that is unknown.

This last element took a step forward in 1950 when the American mathematician, John van Neumann, basing himself on Richardson's work and subsequent improvement, translated the mathematics to run on computers. With their vast number-crunching ability, the computers substantially increased the accuracy of weather prediction. This technology was introduced into Canada in 1961.

Unfortunately, the number of mathematical calculations which have to be made to provide a comprehensive weather analysis for small localized areas at various heights precluded the ability of the CMC from providing these reports within a useful period of time. As such, abbreviations and simplifications had to be introduced into the modelling to decrease the delay from data collection to published weather prediction. Such simplifications involve, for example, solar radiation, evaporation, and heat transfer from seas and land areas. Further, current models exclude data from the southern hemisphere. The mixing of weather between the two hemispherres is slow, and while not terribly important for short range forecasts, its inclusion is vital if accurate weather predictions are to be made for time spands longer than a couple of days.

It is this number-crunching bottleneck which has been the major drag on accurate weather prediction for small areas. Until recently, the CMC has been dependent on a 17-year old computer (A CYBER 176) which, while doing its level best, increasingly broke down. Further, spare parts were becoming difficult to find.

In an attempt to overcome this bottleneck, Environment Canada decided to substantially increase its computer capabilities, and hence the accuracy of the CMC's weather forecasts by the purchase of a Cray 1S/1300 computer which operates 10 times as fast as its predecessor. The Cray 1S is the most powerful computer on the market, and the CMC's is only the 56th off the end of the production line.

It is a vector computer, with 10 million bytes of memory, and can operate at the rate of 50 million operations per second, equivalent to about one million personal computers. Further, it can run 67 programs simultaneously.

Costing about $32 million spread over 6-7 years, the CMC/Cray contract has the novel feature that permits the exchange of the 1S for a more powerful computer, the Cray XMP, currently under development, with an expected delivery date in 1986. The CMC's Cray came onstream in late February.

The vast ability of this new tool will result in a number of changes in the CMC's abilities. Initially, it will permit the introduction of more sophisticated modelling for smaller areas, an extension of forecasting periods from six to ten days, and fewer two to five day temperature forecasting errors. By 1987, it will permit the automated prediction of all weather elements for longer time periods, greater accuracy in precipitation amount predictions and improved wind forecasts, as well as much larger numbers of specific locality forecasts, and will permit the inclusion of data from the southern hemisphere.

Further, the reserve capacity will permit CMC scientists and university researchers to conduct a number of environmental studies currently difficult or im-

- It will permit the modelling of long range pollutant movements such as acid rain and ozone: the sources, transport, transformation and effect. A model for this study is currently being developed for use on the CMC's Cray by Environment Canada, the province of Ontario and the Federal Republic of Germany.

possible to produce. For example:

- It will permit studies, previously unproducible, of the effect of CO_2 introduction into the atmosphere and the concomitant greenhouse effect along with its effect on weather and hence on crop production.
- Weather predictions in an emergency (such as the Mississauga train derailment, or the Three Mile Island nuclear materials release) can now be modelled and run quickly. By determining wind directions, etc., evacuation procedures can more adequately handle the human component in such situations.
- Under the umbrella of the Natural Sciences and Engineering Research Council, 10% of the Cray's time will be devoted to the Canadian research community, permitting them to undertake projects involving large amounts of computations which until February had to be undertaken, if at all, on foreign supercomputers at high rental costs.

And the cost per Canadian? Recognizing that weather related information represents in excess of 1 billion dollars a year to Canadians, the CMC's $125 million a year budget (about $5/Canadian head), seems to be one of the few bargains we get from government these days.

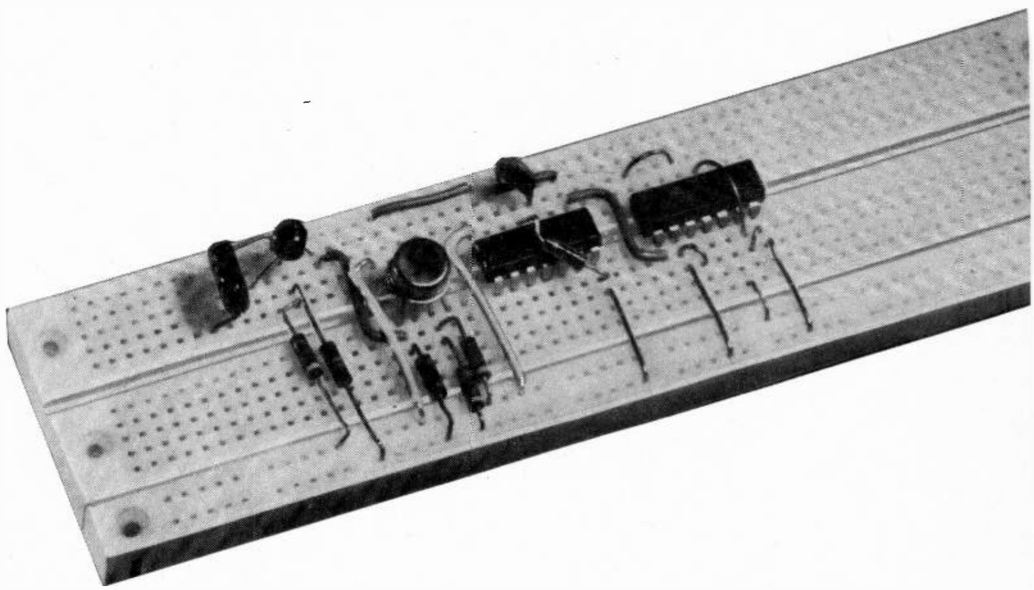
ETI

See order form on page 55.

Multiple Output Port

PROJECT

Is your computer a megalomaniac at heart? Here's a circuit that will allow it to have up to 40 slaves, by Stephen Huckstepp.



THIS PROJECT is intended for use with virtually any computer, the only prerequisite being access to the data and address buses and to the control signals IORQ and WR or their equivalents.

There can be up to 40 on/off outputs from the port, all of which can be used to drive external circuitry. The port is expanded in groups of eight, with eight being the minimum (well, you could have a port with no outputs if you really wanted . . .). As the board makes provision for the maximum number of outputs, subsequent expansion up the maximum is no problem.

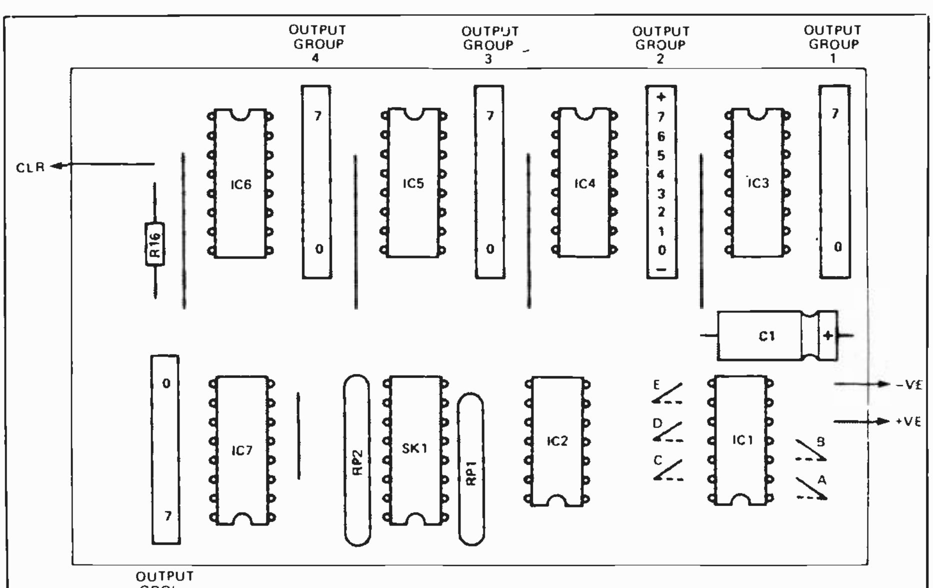
However, the main draw-back is that this circuit will be fairly slow and software-intensive to operate. This is because each write operation outputs to only one bit in any group of eight outputs, but to each group simultaneously. So, for instance, while writing to bit 3 in group 2, you will be writing to bit 3 in all the other groups (though not the same information). Most of the software you will need will involve setting up the data in the correct format to go to the port.

Provision has not been made to drive equipment that requires a handshake control. However, an alternative use for a spare output data line from the computer might be as a 'data valid'' signal, rather than as a clear as suggested in the 'How It Works' section.

Construction

There is very little to say about the construction of this project except to recommend that the usual CMOS precautions should be followed. Although all the devices used are relatively inexpensive, it is probably still a good idea to use IC sockets, as failed devices could be troublesome to remove.

When connecting up to the computer, note that the lines for D5 and D7 have been transposed on the PCB. Check your computer's memory map to set up a suitable address for the port, and use the links to make the port occupy this address.



Overlay diagram of the multiple output port; note that the pin-out for SK1 is given on the circuit diagram.

PARTS LIST

RESISTORS

R1-7	SIP resistor pack, 7 by 10k
R8-15	SIP resistor pack, 8 by 10k
R16	10k ¼ W 5%

CAPACITOR

C1	100§ 6V (min) tubular electrolytic

SEMICONDUCTORS

IC1	4069
IC2	4072
IC3-7	4099

MISCELLANEOUS

SK1	16-pin DIP socket and header plug
SK2-5	10-way SIP connectors, 0.1" spacing

PCB; case to choice; wire, etc.

HOW IT WORKS

This circuit is based on the 4099 eight-bit latch, used for IC3 to 7, which is one of the cheaper low-power latches that are readily available. The circuit shown is relatively slow to operate, but is very cheap to build!

Five address lines are used to select the port; the inverters, IC1a to e can be selected in or out using the links, so as to set up an address that is convenient.

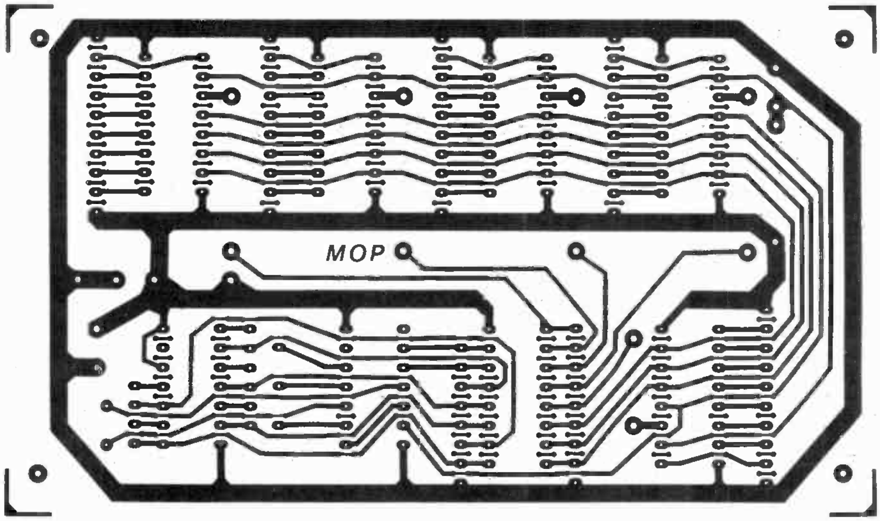
IC2 decodes both the address and the port request lines, IORQ and WR. The output from IC2b enables all the chip select lines on all the latches. Thus when a write operation occurs, the same bit on all the latches is written to at once.

Of the data bits, D5 to D7 are used to address the bit to be written to. The remaining data bits are the data that is to be written, D0 being the data for the selected bit in the first latch (IC3), D1 for the second latch (IC4), etc.

Because of the mode of addressing selected, if you want to leave a particular bit in one latch unchanged, while altering the same bit in the other latches, you must re-write the same data as before.

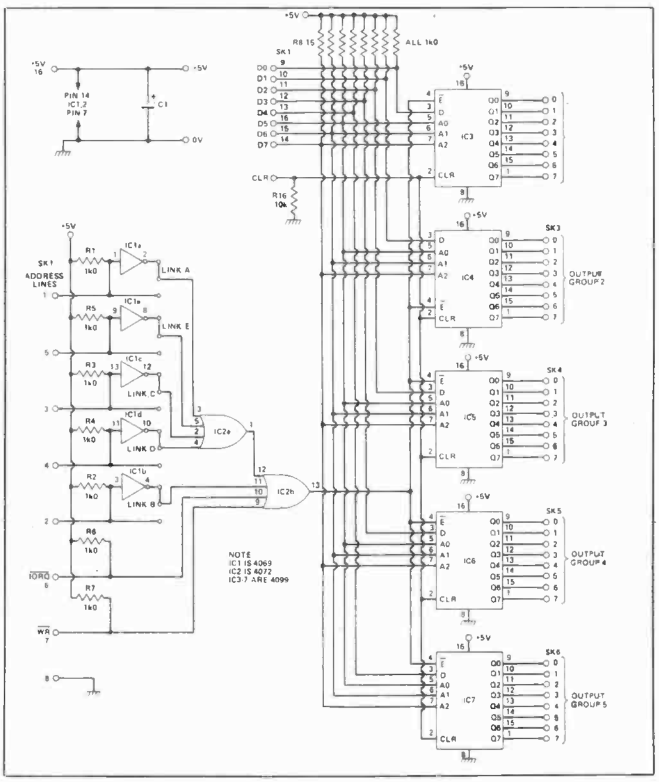
There is no need to install all the latch ICs if you do not need them, as the system will still work with just one latch in position (though you'll only get eight outputs, of course). If you don't use the full capacity, you may find it useful to connect the clear (CLR) input to one of the unused data bits.

Note that the data inputs D5 to D7 feed inputs on all five latches; this may make it necessary to buffer these lines at the computer, depending on what other peripherals are connected to the data bus.



PC board design for the multiple output port.

ETI



Circuit diagram of the multiple output port.

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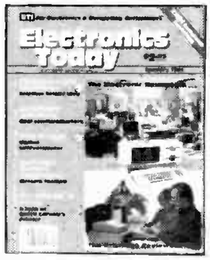

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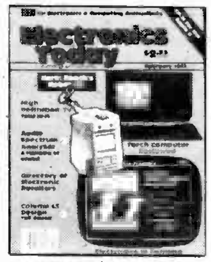

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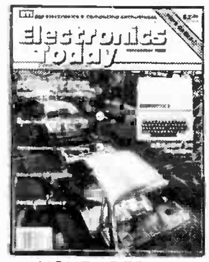

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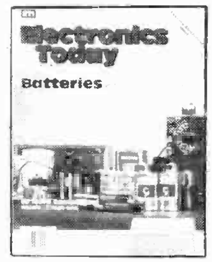

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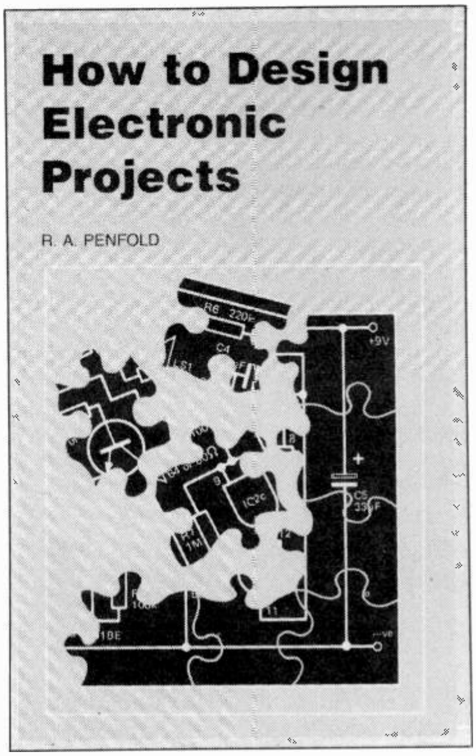

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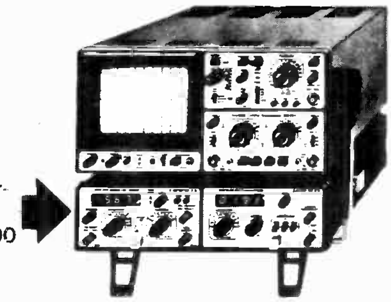

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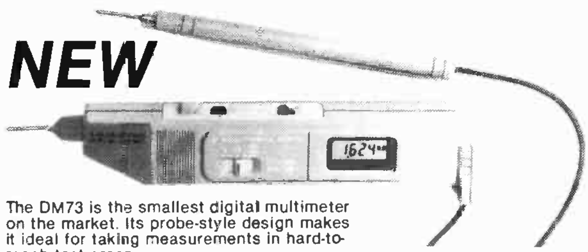

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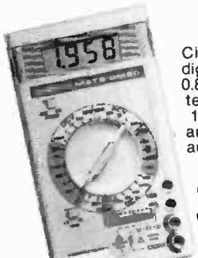

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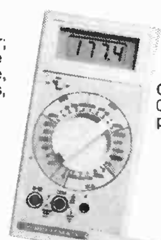

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(but not the dual device of Figure 4) have the transistor base connected to a separate pin so that suitable circuitry may be used to trade-off gain in order to obtain a better high frequency response. The maximum usable frequency will be obtained when the output phototransistor is connected as a photodiode using only the base and collector connections of Figure 3, but a relatively large input current will then be needed to produce a small output current; the CTR value may be under 0.1%.

Apart from the more limited response speed of a device with a photo-Darlington output stage, it can be seen from Table 1 that the saturation voltage (under high input conditions) is much greater for the photo-Darlington device than for a simple phototransistor. Both the speed of response and the saturation differences are inherent properties of photo-Darlington devices and are not limited to optocouplers.

CTR

In order to understand some of the figures quoted in Table 1, we must first examine the ways in which certain device parameters are specified. The user need not consider any of the internal optical design points, since the manufacturer takes care of such considerations when he is designing the devices concerned.

Optocouplers are supplied as sealed units, although opto-interrupter modules are also manufactured in which there is a slot between the emitting diode and the detector so that a metal vane passing through the slot can interrupt the beam; such opto-interrupters can, for example, be used in car ignition timing systems.

One of the most important parameters of an optocoupled device is its *current transfer ratio* (CTR) which is the ratio of the output current to the input current under certain conditions specified by the manufacturer; it is usually expressed as a percentage and, broadly speaking, may be considered as the 'gain' of the device. It may be noted that devices with a triac or a thyristor output do not have a CTR value.

It can be seen from Table 1 that typical values of the CTR in the case of devices which have a simple phototransistor output stage is of the order of 50% — which means the collector current in the output phototransistor will be about half that to the input diode emitter.

The minimum value in a device of any specified type may be considerably less than that of the typical value. However, in the case of devices with photo-Darlington outputs, a CTR value of 500% is more common — which means the output current is five times the input current.

In some special devices a short light pipe is used to carry the radiation from the emitter to the detector, inevitably with some loss, so the CTR value may be reduced in such devices which may be able to withstand a much higher voltage between their input and output sides.

Unfortunately, the CTR does not have a constant value but varies widely with the diode input current and with the device temperature. Figure 8 shows the typical variation of the CTR value of the MCT2 device (which has a simple phototransistor output state) with the forward input current passed through the emitter diode.

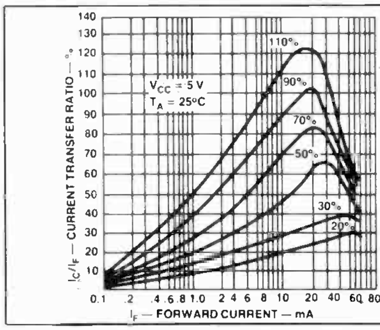

Figure 8. Variation of the current transfer ratio (CTR) with forward current in typical MCT2 devices.

Each curve is for a different MCT2 device, the wide spread being due to variation in the phototransistor gain, the emitter efficiency and the coupling efficiency between the two internal components. The percentage values quoted on each curve are those for a 10 mA input current.

The CTR value of a 4N26 or 4N28 can vary by a factor of about 2.5 between high temperatures (where it is relatively low) and very low temperatures, while devices with Darlington outputs may show variations of double this factor between temperature extremes. Rather smaller variations are more commonly found.

Isolation

Manufacturers of optocoupled device specify a maximum voltage which may be safely applied between the input and output sides of the device. In most devices this is in the range 500 to 8000 V, depending on the device type, but special types can be obtained for higher voltage isolation.

The resistance between the input and output sides of a typical device is often around 10^{11} to 10^{12}ohm. Although this seems very high, if a potential of a few kilovolts is applied across the device, a current of somewhat under 100 na can flow. This is comparable with the current through the output of a high gain device when the input current through the emitter is under 1 ma.

If an optocoupler fails under a high applied voltage between its input and output sides, a short circuit will normally develop as a track is formed between the emitting and detecting devices. The problem can be reduced by the use of suitable current limiting resistors or protective devices in either the input or output circuit.

The stray capacitance between the input and output circuit of an optocoupler is typically of the order of 1pF (Table 1). It can provide some unwanted coupling in circuits designed to be able to operate at high speeds, especially when inductive loads are being switched.

The Emitter

The emitting diode will have a maximum continuous current rating, normally some tens of milliamps as indicated in Table 1. In some devices, pulsed currents above the maximum continuous current are permissable.

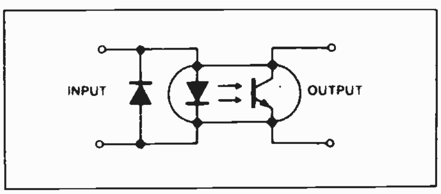

Figure 9. If a reverse voltage is likely to appear across the optocoupler emitter an external diode can be used to 'clip' it.

A maximum value is also imposed on the reverse voltage which may appear across the emitter diode. The application of a higher reverse voltage can cause it to breakdown and perhaps pass a destructive current; however, this problem is easily avoided by connecting an external diode across the emitter diode as shown in Figure 9.

Although gallium arsenide diodes have been the main type used in optocouplers, there is an increasing trend to employ gallium-aluminium-arsenide types, since the latter not only emit photons more efficiently, but also provide a slightly better spectral match to the silicon detector. Thus an appreciable increase in the CTR value can be obtained.

In many optocouplers one must be careful to observe not only the total power dissipated in the complete package, but also the power dissipated in the separate input and output devices, as indicated in Table 1.

The Detector

As with any other phototransistor or photo-Darlington, there is a certain value quoted for the maximum voltage which may be applied between the collector and the emitter with the base unconnected without risk of the device undergoing breakdown; this is BV_{CEO}. Similarly, values may be quoted for BC_{CBO} and BV_{ECO}.

A maximum collector current may also be quoted together with a maximum collector leakage current with base unconnected, I_{CEO}, under specifided conditions.

The characteristics of the detector determine the speed of response and the bandwidth, since the emitting diodes are fast. The response time can be reduced by the use of a smaller value of load resistor, but many manufacturers quote rise and fall times and bandwidths with load resistors which are so small that the circuit would have an inadequate gain for most applications.

The response speed of an optocoupler can be improved by using the circuit of Figure 10 in which the collector load is effectively reduced to a very low value by the virtual ground input impedance of the operational amplifier.

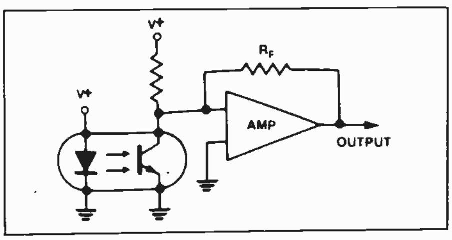

Figure 10. Response speed may be increased by the use of the virtual earth input of an op-amp.

An even simpler way of obtaining a faster response at the expense of a reduced value of the CTR involves connecting a resistor, between the base and emitter of the output transistor. As the value of the resistor is reduced, the response becomes faster until in the limit, when the resistor is a short circuit, one is using the detector as a photodiode.

If one expects to be working with a very small input current, one might expect the use of a high gain device with a photo-Darlington output would be ideal. This is not necessarily true, since the overall efficiency can fall at such currents to the point where a device with a phototransistor would be better.

Applications

Optocoupling devices can be employed to replace relays and pulse transformers in a wide variety of applications in which high isolation may be desirable or essential. They provide fast signal transfer with excellent noise immunity. They are suitable for interfacing with TTL and CMOS circuits and can also be used for analogue signal coupling.

Circuits designed for use with single phototransistor output optocoupled devices can generally employ the 4N26, 4N28 or MCT2, but note should be made of the individual differences listed in Table 1.

For example, the 4N28 is limited to applications in which the voltage across the device does not exceed 500 V, while when the other devices are selected, it may be as a great 1.5 kV.

The phototransistors in the MCT2 and in the dual MCT6 outputs are much higher voltage devices than those used in the 4N26 and 4N28.

The bandwidth of the 4N26 and 4N28 is typically greater than that of the other two types, but so is the isolation capacitance between the input and output. However, these points are not likely to be of any great importance in most applications.

Relay Control

The simple circuit of Figure 11 shows how small input current may be employed to control a reed relay. The inductive back-emf from the relay coil formed when the current ceases to flow through it is by-passed by the 1N914 diode so that this relatively high voltage pulse cannot damage the output transistor of the optocoupler.

The supply voltage used, V+, should have a value about equal to the voltage required by the relay, but should not exceed the V_{CEO} value of Table 1 for the optocoupler used.

Although the use of a reed relay is suggested so that the output current of the optocoupling device is kept quite small, other types of small relay can be controlled with careful circuit design. Obviously this type of circuit provides better isolation than many types of relay.

The circuit can easily be modified so that the relay does not close until the input has been applied for a short time. One merely connects a capacitor across the input

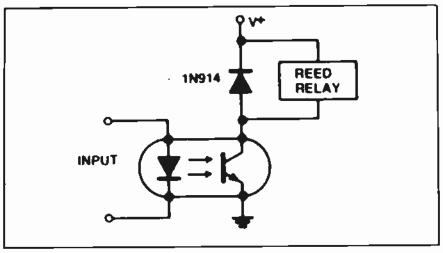

Figure 11. Using an optocoupler to isolate a reed relay.

diode and feeds this diode through a series resistor. The delay time before the relay closes will be dependent on the time taken for the capacitor to charge through the series resistor.

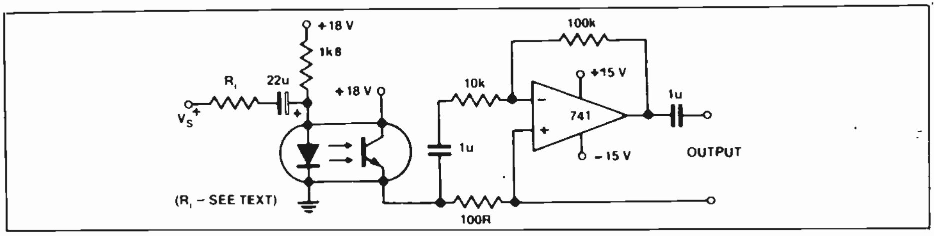

Figure 12. An isolation circuit covering the whole audio range.

Isolated Audio

The circuit of Figure 12 shows how an audio output completely isolated from the audio input signal may be obtained. A positive bias is applied to the input signal, $V+_s$, so that the emitter diode polarity is satisfied.

The value of the input resistor R1 should be chosen so as to limit the modulating input current to a maximum of 5 ma. the 100 ohm load resistor of the phototransistor results in rather a low gain, but the 741 stage provides a gain of about ten so that a resonably large output voltage is obtained.

Lab Notes

The low value of the collector load resistor enables an upper frequency up to 20 kHz to be obtained, while the lower frequency response is determined by the values of the coupling capacitors employed — about 25Hz in the case of the values shown.

The separate + 18 V suppliers are required if complete isolation between the two parts of the circuit is needed. The input resistor R_i may consist of a variable resitor in series with a fixed resistor if it is required to alter the output signal voltage without any danger of receiving an electrical shock from the output circuit when the latter is at a relatively high voltage.

TTL Interface

Optocouplers are widely used in interface logic circuits where the logic signal must be transferred from a circuit at either a high or a low voltage level to a circuit at a very different voltage level.

The circuit of Figure 13 shows how an optocoupling device employing a simple

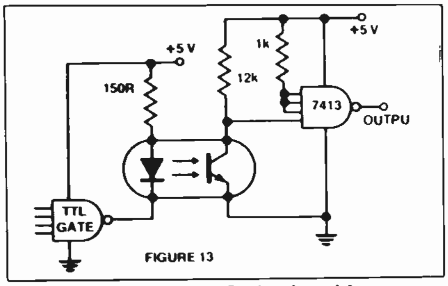

Figure 13. Isolating TTL circuits with an optocoupler.

output transistor may be employed to couple the output of a TTL gate to one of the inputs of a TTL 7413 device at a very different voltage level. The 7413 Schmitt circuit provides switching.

A Fairchild report suggests that the base of the output phototransistor of the optocoupling device should be connected to the emitter through a resistor of about 200 kilohm to prevent fast triggring of the outputs.

Another logic circuit for coupling an input to a 7413 device is shown in Figure 14, but in this case the 4N33 with its photo-Darlington output device is used.

It may be noted that in Figure 13 the load resistor (12 kilohm) is much higher than in Figure 14 (100 ohm), but the use of the higher gain of the 4N33 makes up for the lower value of load resistor.

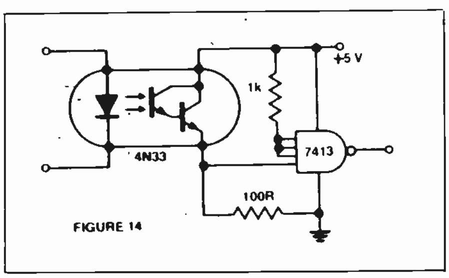

Figure 14. Control of a TTL Schmitt trigger circuit from a 4N33 photo-Darlington device.

The characteristics of the detector determine the speed of response and the bandwidth, since the emitting diodes are fast. The response time can be reduced by the use of a smaller value of load resistor, but many manufacturers quote rise and fall times and bandwidths with load resistors which are so small that the circuit would have an inadequate gain for most applications.

The response speed of an optocoupler can be improved by using the circuit of Figure 10 in which the collector load is effectively reduced to a very low value by the virtual ground input impedance of the operational amplifier.

An even simpler way of obtaining a faster response at the expense of a reduced value of the CTR involves connecting a resistor between the base and emitter of the output transistor. As the value of the resistor is reduced, the response becomes faster until in the limit, when the resistor is a short circuit, one is using the detector as a photodiode.

If one expects to be working with a very small input current, one might expect the use of a high gain device with a photo-Darlington output would be ideal. This is not necessarily true, since the overall efficiency can fall at such currents to the point where a device with a phototransistor would be better.

Simple Latch

The very simple latching circuit of Figure 15 can employ a pair of 4N33 photo-Darlington output devices. Initially, S1 is open and no current flows through either 4N33. If S1 is then closed, a current flows from the positive supply through the diode emitter in the upper 4N33 and through the emitter in the lower 4N33, the output of the upper device being shorted out by S1 during this time.

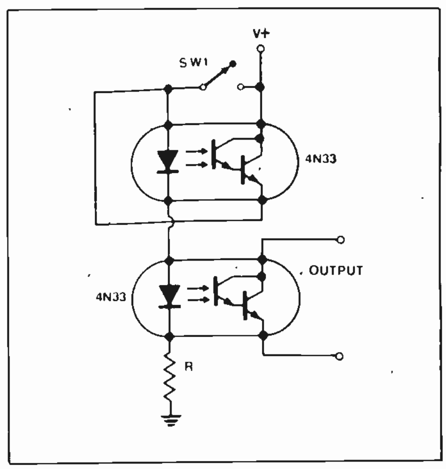

Figure 15. A latching circuit using two 4N33 devices.

When S1 opens, the short is removed from its output circuit, but the response time of the latter is longer than that of the emitter. The current therefore flows through the output of the upper 4N33, through the diode emitter of this same device to maintain the output in its conducting state and through the emitter of the lower 4N33. Thus the output of the lower device remains in its conducting state after S1 has re-opened.

The voltage across the two forward-biased emitting diodes is around 3.5 V and it is convenient to operate these diodes at about 5 ma. Thus, a suitable value for the resistor R is (V+ − 3.5)/0.005 or about 3.9 kilohm with a 24 V supply.

Bidirectional Control

The output current of an optocoupler using a phototransistor or a photo-Darlington device must flow only in one direction, so such a device cannot control alternating current.

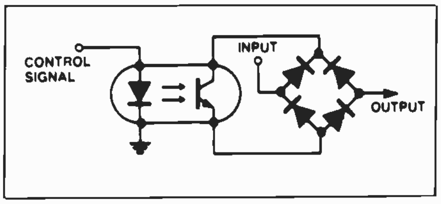

Figure 16. Controlling a bi-directional current using an optocoupler.

This problem can easily be overcome by the use of the circuit of Figure 16, in which the input-to-output current is rectified by a diode bridge circuit before being fed to the output stage of the optocoupled device.

The control signal which switches the output on and off must be unidirectional.

Power Supply

Optocoupling devices can be used to isolate the control voltage of a regulated high voltage power supply from this supply line. The basic circuit which may be used is shown in Figure 17.

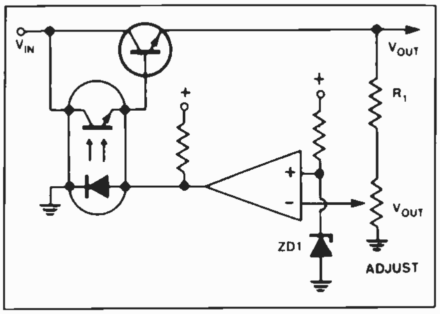

Figure 17. Using an optocoupler in a high voltage series-pass regulator.

A current flows from the stabilised output supply through the high value resistor R1 so that the variable resistor taps off a voltage proportional to the output voltage. This is compared with that across the zener diode D1 using the operational amplifier.

The output signal from this amplifier is fed to the emitter of the optocoupled device which is used to control the series pass transistor and hence to keep the output voltage constant. Thus, the amplifier device output is isolated from the high voltage supply.

A photo-Darlington device may be used in this type of circuit for higher feedback loop gain, but an external pass transistor is always required, since the output devices incorporated into optocouplers can handle only very limited power.

Fast Interface

The 6N139 with its 'split photo-Darlington' output device enables the high speed of the separate photodiode to be combined with the high gain of the Darlington connected internal transistors. Although the CTR has a minimum value of 400% at a 500 ma input current, the device output can switch in a few microseconds.

A fast non-inverting logic interface circuit using this device is shown in Figure 18. The maximum switching speed depends on the load resistor, R2, and the input resistor, R1. If R1 has a value of 180 ohm a current of about 17 ma will flow to the output of the TTL input device from the terminal emitter diode and the use of a 100 ohm load resistor for R2 will then enable data rates of about 300 kbit/s to be obtained. On the other hand, R1 may be increased to 1k8 for a 1.7 ma diode current with R2 2k2 for a maximum data rate of nearly 50 kHz.

Electrocardiograph Amplifer

The use of an optocoupled device to provide complete isolation of a patient from electrocardiography equipment is shown in Figure 19. The electrodes from the patient are connected to the programmable 4250 preamplifier stage which operates from +/-3 V battery supplies, nulling facilities being provided by the variable resistor connected between pins 1 and 5.

The same +3 V battery supply provides the bias for the high gain BC109 transistor which drives the diode emitter of the

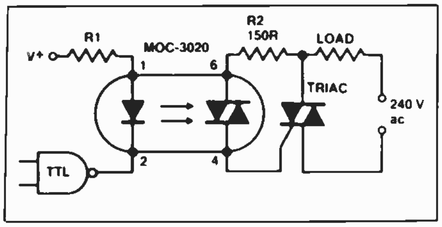

Figure 20. Control of ac power where there is a resistive load, using the MOC-3020.

optocoupling devices.

The output phototransistor of the optocoupler receives a base bias so that some current is always passing through its collector circuit. This enables the positive and negative parts of the signal waveform to be obtained at the output.

This is particularly important application of optocoupled devices, since without the isolation provided by such a device, small currents could be fed into the patient which in certain circumstance could produced death.

The MOC-3020

The small triac in the MOC-3020 output can provide a current of up to 100 ma. This is too small for controlling the mains current passing through the load in almost all applications, but is adequate to trigger an additional external triac.

A circuit of this type is shown in Figure 20 in which the output of the TTL gate, controls the emitter current of the MOC-3020 which triggers the internal triac, the latter triggering the external triac.

The latter device should be selected so that it can hold-off the applied mains voltage and also pass whatever current is required by the particular load being used.

Figure 21 shows the use of the MOC-3020 to switch the ac current through a lamp fed from the 240V mains when the lamp current is less than 100 ma. As the filament of the lamp has a much lower resistance when it is cold, care must be taken to ensure that the initial peak current is not excessive (about 1A for a very short time is permissible).

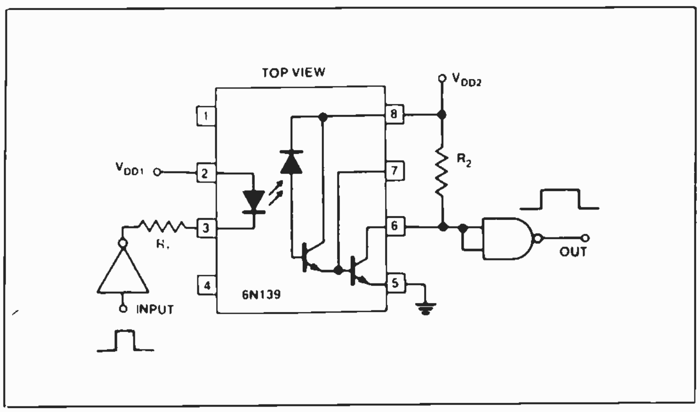

Figure 18. A fast TTL interfacing and isolating circuit using the 6N139.

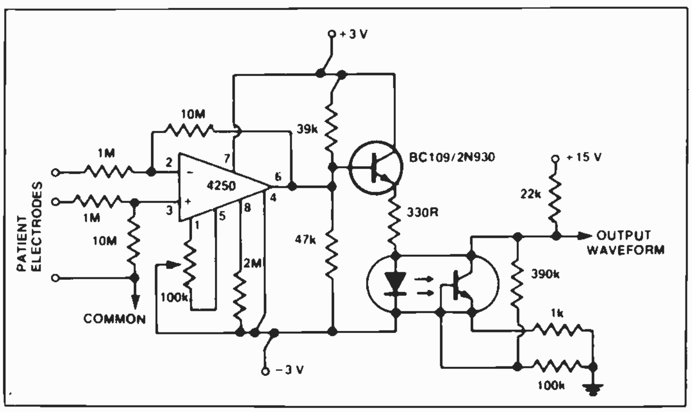

Figure 19. An electrocadiograph preamplifier circuit providing isolation of the patient from the equipment. (Litronix.)

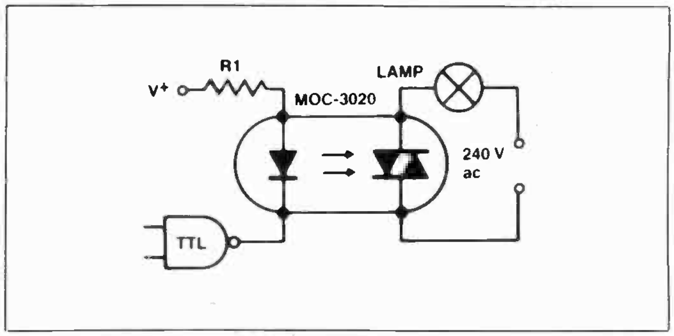

Figure 21. Controlling a lamp on the ac mains using a MOC-3020 (but watch the power rating).

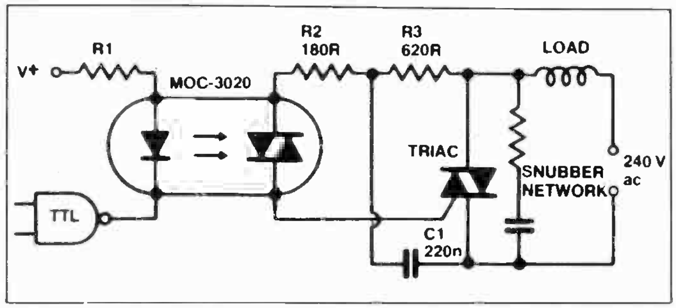

Figure 22. Control of ac power where the load is inductive (i.e. a motor), using the MOC-3020. Note the use of a 'snubber' network. Typical values for the RC network would be R = 180 ohms, C = 220n.

In the circuit of Figures 20 and 21, the load is resistive and conduction of the internal triac ceases when the mains voltage passes through zero during the course of the mains cycle.

In the case of an inductive load (such as an electric motor), however, large back-emf pulses can be generated when the current ceases to flow through the load and this could cause the internal triac of the optocoupler to operate in an improper way.

This problem can be avoided through the use of the type of circuit shown in Figure 22, the values of the components of the 'snubber network' connected across the external triac being dependent on the load inductance and resistance.

Conclusion

Simple optocoupler devices can be employed in a wide range of circuits from the simplest types to quite complex ones. At prices ranging from under one dollar up to a few dollars, they are excellent value! **ETI**

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This book, originally published in Germany by TOPP, has achieved phenomenal sales on the Continent and Babani decided, in view of the fact that the integrated circuit used in this book is inexpensive to buy, to make this unique book available to the English speaking reader Translated from the original German with copious notes, data and circuitry, a "must" for everyone whatever their interest in electronics

BP83: VMOS PROJECTS $7.70
R.A. PENFOLD
Although modern bipolar power transistors give excellent results in a wide range of applications, they are not without their drawbacks or limitations This book will primarily be concerned with VMOS power FETs although power MOSFETs will be dealt with in the chapter on audio circuits A number of varied and interesting projects are covered under the main headings of. Audio Circuits, Sound Generator Circuits, DC Control Circuits and Signal Control Circuits.

BP44: IC 555 PROJECTS $7.05
E.A. PARR, B.Sc.,C.Eng., M.I.E.E.
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. 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.

BP65: SINGLE IC PROJECTS $6.05
R.A.PENFOLD
There is now a vast range of ICs available to the amateur market, the majority of which are not necessarily designed for use in a single application and can offer unlimited possibilities. All the projects contained in this book are simple to construct and are based on a single IC. A few projects employ one or two transistors in addition to an IC but in most cases the IC is the only active device used.

BP97: IC PROJECTS FOR BEGINNERS $7.60
F.G. RAYER
Covers power supplies, radio, audio, oscillators, timers and switches. Aimed at the less experienced reader, the components used are popular and inexpensive.

BP88: HOW TO USE OP AMPS $8.85
E.A. PARR
A designer's guide covering several op amps, serving as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.

IC ARRAY COOKBOOK
JUNG
HB26 $13.75
A practical handbook aimed at solving electronic circuit application problems by using IC arrays. An IC array, unlike specific-purpose ICs, is made up of uncommitted IC active devices, such as transistors, resistors, etc. This book covers the basic types of such ICs and illustrates with examples how to design with them. Circuit examples are included, as well as general design information useful in applying arrays.

BP50: IC LM3900 PROJECTS $5.40
H.KYBETT,B.Sc., C.Eng.
The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses, and is more than just a collection of simple circuits or projects.
Simple basic working circuits are used to introduce this IC. The LM3900 can do much more than is shown here, this is just an introduction. Imagination is the only limitation with this useful and versatile device. But first the reader must know the basics and that is what this book is all about.

223: 50 PROJECTS USING IC CA3130 $5.00
R.A.PENFOLD
In this book, the author has designed and developed a number of interesting and useful projects which are divided into five general categories: I — Audio Projects II — R.F. Projects III — Test Equipment IV — Household Projects V — Miscellaneous Projects.

224: 50 CMOS IC PROJECTS $3.75
R.A. PENFOLD
CMOS IC's are probably the most versatile range of digital devices for use by the amateur enthusiast. They are suitable for an extraordinary wide range of applications and are also some of the most inexpensive and easily available types of IC.
Mr. R.A. Penfold has designed and developed a number of interesting and useful projects which are divided into four general categories: I — Multivibrators II — Amplifiers and Oscillators III — Trigger Devices IV — Special Devices.

THE ACTIVE FILTER HANDBOOK
TAB No.1133 $13.95
Whatever your field — computing, communications, audio, electronic music or whatever — you will find this book the ideal reference for active filter design.
The book introduces filters and their uses. The basic math is discussed so that the reader can tell where all design equations come from. The book also presents many practical circuits including a graphic equalizer, computer tape interface and more.

DIGITAL ICS — HOW THEY WORK AND HOW TO USE THEM
AB004 $10.95
An excellent primer on the fundamentals of digital electronics. This book discusses the nature of gates and related concepts and also deals with the problems inherent to practical digital circuits.

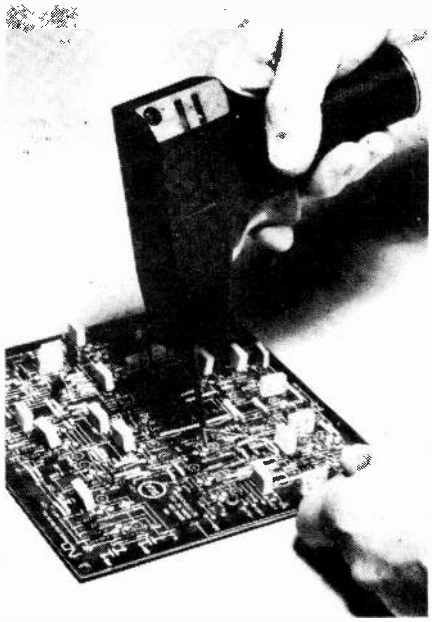
MASTER HANDBOOK OF 1001 PRACTICAL CIRCUITS
TAB No.800 $19.95
MASTER HANDBOOK OF 1001 MORE PRACTICAL CIRCUITS
TAB No.804 $23.95
Here are transistor and IC circuits for just about any application you might have. An ideal source book for the engineer, technician or hobbyist. Circuits are classified according to function, and all sections appear in alphabetical order.

THE MASTER IC COOKBOOK
TAB No.1199 $17.95
If you've ever tried to find specs for a so called 'standard' chip, then you'll appreciate this book. C.L. Hallmark has compiled specs and pinout for most types of ICs that you'd ever want to use.

ELECTRONIC DESIGN WITH OFF THE SHELF INTEGRATED CIRCUITS
AB016 $12.95
This practical handbook enables you to take advantage of the vast range of applications made possible by integrated circuits. The book tells how, in step by step fashion, to select components and how to combine them into functional electronic systems. If you want to stop being a "cookbook hobbyist", then this is the book for you.

BP117: PRACTICAL ELECTRONIC BUILDING BLOCKS BOOK 1 $7.60
Virtually any electronic circuit will be found to consist of a number of distinct stages when analysed. Some circuits inevitably have unusual stages using specialised circuitry, but in most cases circuits are built up from building blocks of standard types.
This book is designed to aid electronics enthusiasts who like to experiment with circuits and produce their own projects rather than simply follow published project designs.
The circuits for a number of useful building blocks are included in this book Where relevant, details of how to change the parameters of each circuit are given so that they can easily be modified to suit individual requirements.

PH253: ELECTRONIC DESIGN WITH OFF-THE-SHELF INTEGRATED CIRCUITS $12.95
Z. MEIKEIN & P. TACKRAY
A real help for do-it-yourselfers, this handy guide tells professionals and hobbyists alike, how to take components off the shelves, arrange them into circuitry, and make any system perform its desired function



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Electronics Today Bookshelf

RADIO AND COMMUNICATIONS

BP79: RADIO CONTROL FOR BEGINNERS $6.80
F.G. RAYER, T.Eng.(CEI),Assoc.IERE.
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 which 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 which includes a simple receiver and also a crystal controlled superhet The book ends with the electro-mechanical means of obtaining movement of the controls of the model

BP96: CB PROJECTS $7.60
R.A. PENFOLD
Projects include speech processor, aerial booster, cordless mike, aerial and harmonic filters, field strength meter, power supply, CB receiver and more

222: SOLID STATE SHORT WAVE RECEIVERS FOR BEGINNERS $4.70
R.A. PENFOLD
In this book, R A Penfold has designed and developed several modern solid state short wave receiver circuits that will give a fairly high level of performance, despite the fact that they use only relatively few and inexpensive components

BP91: AN INTRODUCTION TO RADIO DXing $7.60
This book is divided into two main sections one to amateur band reception, the other to broadcast bands Advice is given to suitable equipment and techniques A number of related constructional projects are described

BP105: AERIAL PROJECTS $7.60
R.A. PENFOLD
The subject of aerials is vast but in this book the author has considered practical designs including active, loop and ferrite aerials, which give good performances and are reasonably simple and inexpensive to build The complex theory and math of aerial design are avoided

BP46: RADIO CIRCUITS USING IC's $5.40
J.B. DANCE, M.Sc.
This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals The chapter on amplitude modulated (a m) receivers will be of most interest to those who wish to receive distant stations at only moderate audio quality, while the chapter on frequency modulation (f m) receivers will appeal to those who desire high fidelity reception

BP92: ELECTRONICS SIMPLIFIED—CRYSTAL SET CONSTRUCTION $6.80
F.A. WILSON
Aimed at those who want to get into construction without much theoretical study Homewound coils are used and all projects are very inexpensive to build

PH245: ELECTRONIC COMMUNICATIONS $16.95
Covers amplitude modulation, AM and FM transmitters, pulse modulation, and antennas Includes discussions of applications

BP70: TRANSISTOR RADIO FAULT-FINDING CHART $1.90
CHAS. E. MILLER
Across the top of the chart will be found four rectangles containing brief descriptions of various faults, vis — sound weak but undistorted, set dead, sound low or distorted and background noises One then selects the most appropriate of these and following the arrows, carries out the suggested checks in sequence until the fault is cleared

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AUDIO

BP90: AUDIO PROJECTS $7.60
F.G. RAYER
Covers in detail the construction of a wide range of audio projects The text has been divided into preamplifiers and mixers, power amplifiers, tone controls and matching and miscellaneous projects.

205: FIRST BOOK OF HI-FI LOUDSPEAKER ENCLOSURES $3.05
B.B. BABANI
This book gives data for building most types 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 for every construction showing the dimensions necessary

BP47: MOBILE DISCOTHEQUE HANDBOOK $5.40
COLIN CARSON
The vast majority of people who start up "Mobile Discos" know very little about their equipment or even what to buy Many people have wasted a "small fortune" on poor, unnecessary or badly matched apparatus

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

HOW TO BUILD A SMALL BUDGET RECORDING STUDIO FROM SCRATCH. . .
TAB No.1166 $15.95
The author, F Alton Everest, has gotten studios together several times, and presents twelve complete, tested designs for a wide variety of applications if all you own is a mono cassette recorder, you don't need this book If you don't want your new four track to wind up sounding like one, though, you shouldn't be without it.

BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING $5.00
M.K. BERRY
Electronic music is the new music of the Twentieth Century It plays a large part in "pop" and "rock" music and, in fact, there is scarcely a group without some sort of synthesiser or other effects generator

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

BP74: ELECTRONIC MUSIC PROJECTS $7.20
R.A. PENFOLD
Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category 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 a Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser-Units, Tremelo Generator etc

BP81: ELECTRONIC SYNTHESISER PROJECTS $6.80
M.K. BERRY
One of the most fascinating and rewarding applications of electronics is in electronic music and there is hardly a group today without some sort of synthesiser or effects generator Although an electronic synthesiser is quite a complex piece of electronic equipment, it can be broken down into much simpler units which may be built individually and these can then be used or assembled together to make a complete instrument.

ELECTRONIC MUSIC SYNTHESIZERS
TAB No.1167 $10.95
If you're fascinated by the potential of electronics in the field of music, then this is the book for you Included is data on synthesizers in general as well as particular models There is also a chapter on the various accessories that are available

Tab1364: DESIGNING, BUILDING AND TESTING YOUR OWN SPEAKER SYSTEM . . . WITH PROJECTS $13.95
Covers the theory of speaker construction and describes a variety of plans for speaker system projects ranging from simple setups to complex multi-driver systems Enclosure design is covered in very good detail

BP68: CHOOSING AND USING YOUR HI-FI $6.75
MAURICE L. JAY
The main aim of this book is to provide the reader with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of hi-fi equipment now on the market.

Help is given to the reader in understanding the equipment he is interested in buying and the author also gives his own opinion of the minimum standards and specifications one should look for. The book also offers helpful advice on how to use your hi-fi properly so as to realise its potential A Glossary of terms is also included.

TEST EQUIPMENT

BP75: ELECTRONIC TEST EQUIPMENT CONSTRUCTION $6.80
F.G. RAYER, T.Eng. (CEI), Assoc. IERE
This book covers in detail the construction of a wide range of test equipment for both the Electronics Hobbyists and Radio Amateur Included are projects ranging from an FET Amplified Voltmeter and Resistance Bridge to a Field Strength Indicator and Heterodyne Frequency Meter Not only can the home constructor enjoy building the equipment but the finished projects can also be usefully utilised in the furtherance of his hobby

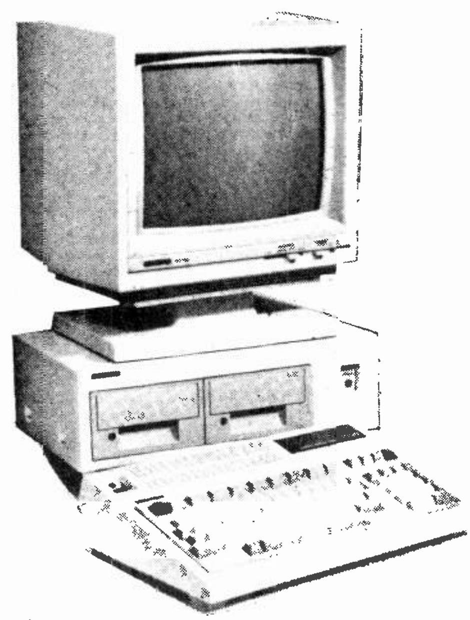
99 TEST EQUIPMENT PROJECTS YOU CAN BUILD
TAB No.805 $15.95
An excellent source book for the hobbyist who wants to build up his work bench inexpensively Projects range from a simple signal tracer to a 50MHz frequency counter There are circuits to measure just about any electrical quantity voltage, current, capacitance, impedance and more The variety is endless and includes just about anything you could wish for!

HOW TO GET THE MOST OUT OF LOW COST TEST EQUIPMENT
AB017 $9.95
Whether you want to get your vintage 1960 'TestRite' signal generator working, or you've got something to measure with nothing to measure it with, this is the book for you The author discusses how to maximize the usefulness of cheap test gear, how to upgrade old equipment, and effective test set ups

THE POWER SUPPLY HANDBOOK
TAB No.806 $15.95
A complete one stop reference for hobbyists and engineers Contains high and low voltage power supplies of every conceivable type as well mobile and portable units

PH246: ELECTRONIC TEST EQUIPMENT $19.95
Covers analog and digital meters, oscilloscopes, frequency generation and measurement, and special measuring instruments

Tab1532: THE COMPLETE BOOK OF OSCILLOSCOPES $19.95
This totally up-to-date handbook is both an in-depth reference source and a practical applications guide Information is included on both ordinary service and laboratory 'scopes, waveform analysis, vectors, vectorscopes, high and low frequency analysis, sampling, storage, digital scopes, and signature analysis The author, Stan Prentiss is one of the leading technical writers in the U S



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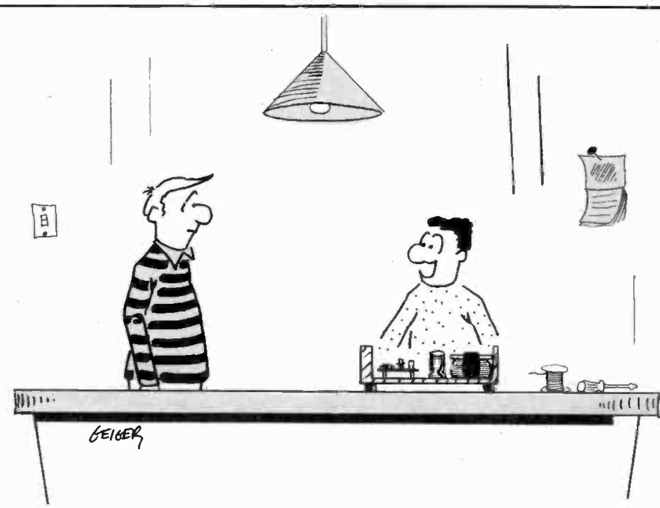
The Fun of Electronics

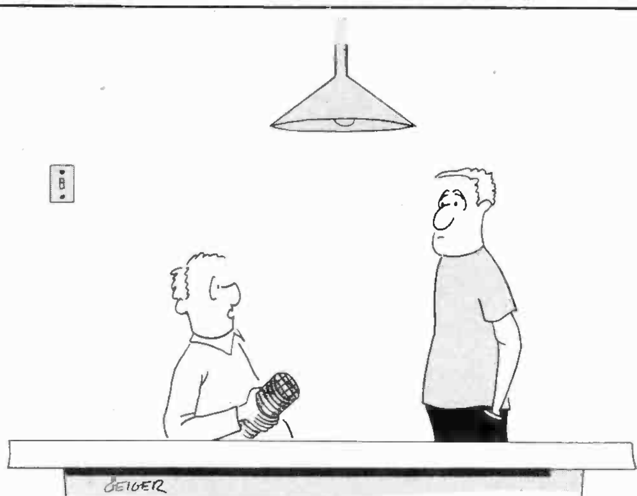
"The reason we're six months behind on the Melnyk project is that we discarded 173 faulty prototypes before realizing it was our test equipment that was broken."

"If the power stays off for ten more minutes, the back-up supply will fail, and six months of programming goes down the drain."

"I originally built it as an infra-red remote control, but I found that if I put bigger batteries in it, it can be used to cook a roast."



"I'm modernizing all my old power supplies; I'm replacing the old oil capacitors with new blow-dryer types."



"I figured out why I was getting such terrible efficiency out of these solar cells I put on my roof .... I shouldn't have stacked them."

"The meter is always at full deflection .... that's what I get for building a metal detector out of metal."

TECH TIPS

Modifications to DOS to use 40 Tracks

Yin H. Pun

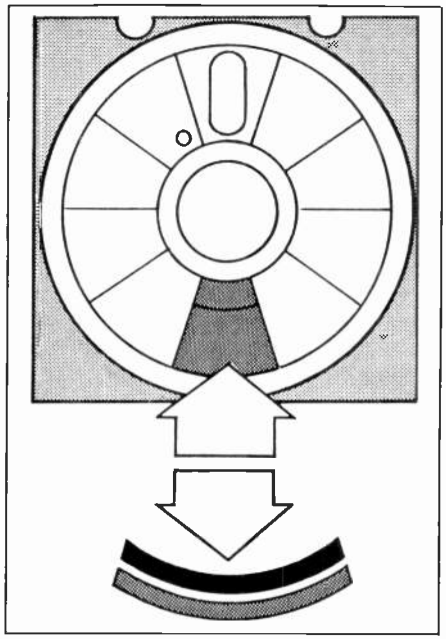
The disk storage for the Apple does not hold very much memory in comparison to other much bigger microcomputer systems such as the IBM PC or the TI Professional. Sadly, one disk only holds 143K total amount of information but only 124K is user free since the DOS and the "CATALOG" track take up 19K of the disk. Fortunately, the potential storage space on the drives is not pushed to the limit. Most disk drives, either Apple or Apple-compatible, have the ability to access 40 tracks on a disk but under normal DOS 3.3, only 35 tracks are used! Five whole tracks, that could contain 20K, are left empty. You can increase the storage space by 20K with no extra cost in hardware or software. Just make the following simple modifications to DOS 3.3

To utilize the full 40 tracks, you must create a 40 track disk. However, the normal "INIT" command of DOS 3.3 will only format 35 tracks. For DOS 3.3 to initialize a 40 track disk add these modifications to these DOS 3.3 locations:

AEB5:A0 — ALLOCATES EXTRA FREE SECTORS FOR VTOC
B3EF:28 — NUMBER OF TRACKS (40)
BEFE:28 — NUMBER OF TRACKS (40)

In APPLESOFT BASIC, type:
POKE 44725,160 : POKE 46063, 40 : POKE 48894, 40

Type "INIT HELLO" to initialize a new disk; when the drive is formatting the disk, you should hear 40 clicks instead of 35, indicating the number of tracks. The disk will have 576 usable sectors, 80 sectors more than a 35 track disk. Now transfer programs to this disk by FID (on the DOS 3.3 System Master) to test that your drive really has 40 tracks. Drives that have only 35 tracks will probably scream obscenities and give an uninviting "I/O ERROR". Most drives manufactured after 1982 should have the physical ability to read and write 40 tracks, including the original DISK][, the Quentin and Micro-Sci. Drives based on the Shugart SA400L and Shugart SA380L, should also work. Refer to the user's manual that comes with the drive or ask your dealer for further information.



Hex Keyboard Encoder

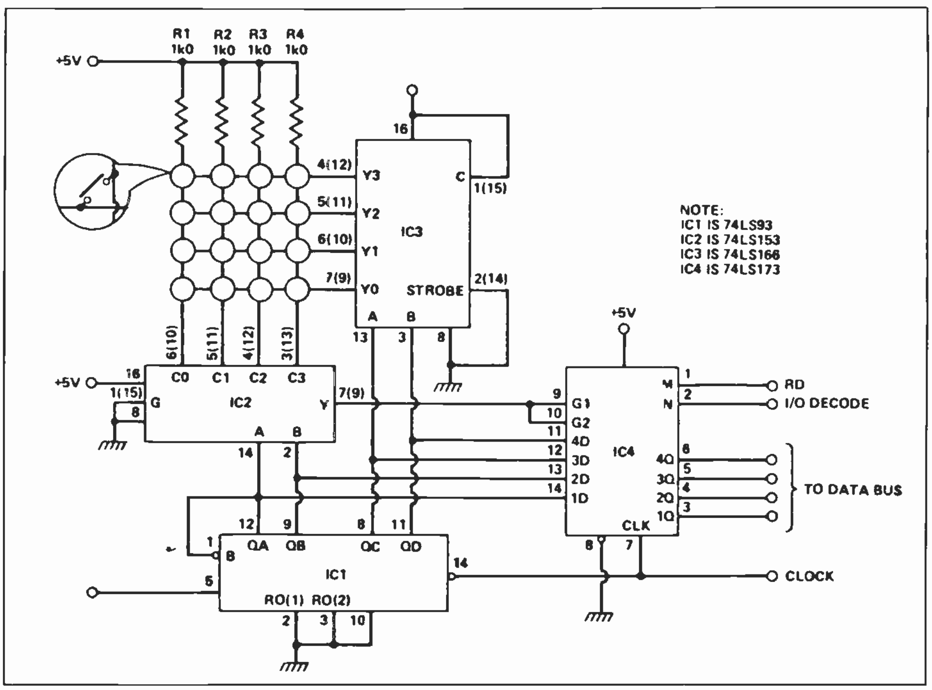
Adam Strange

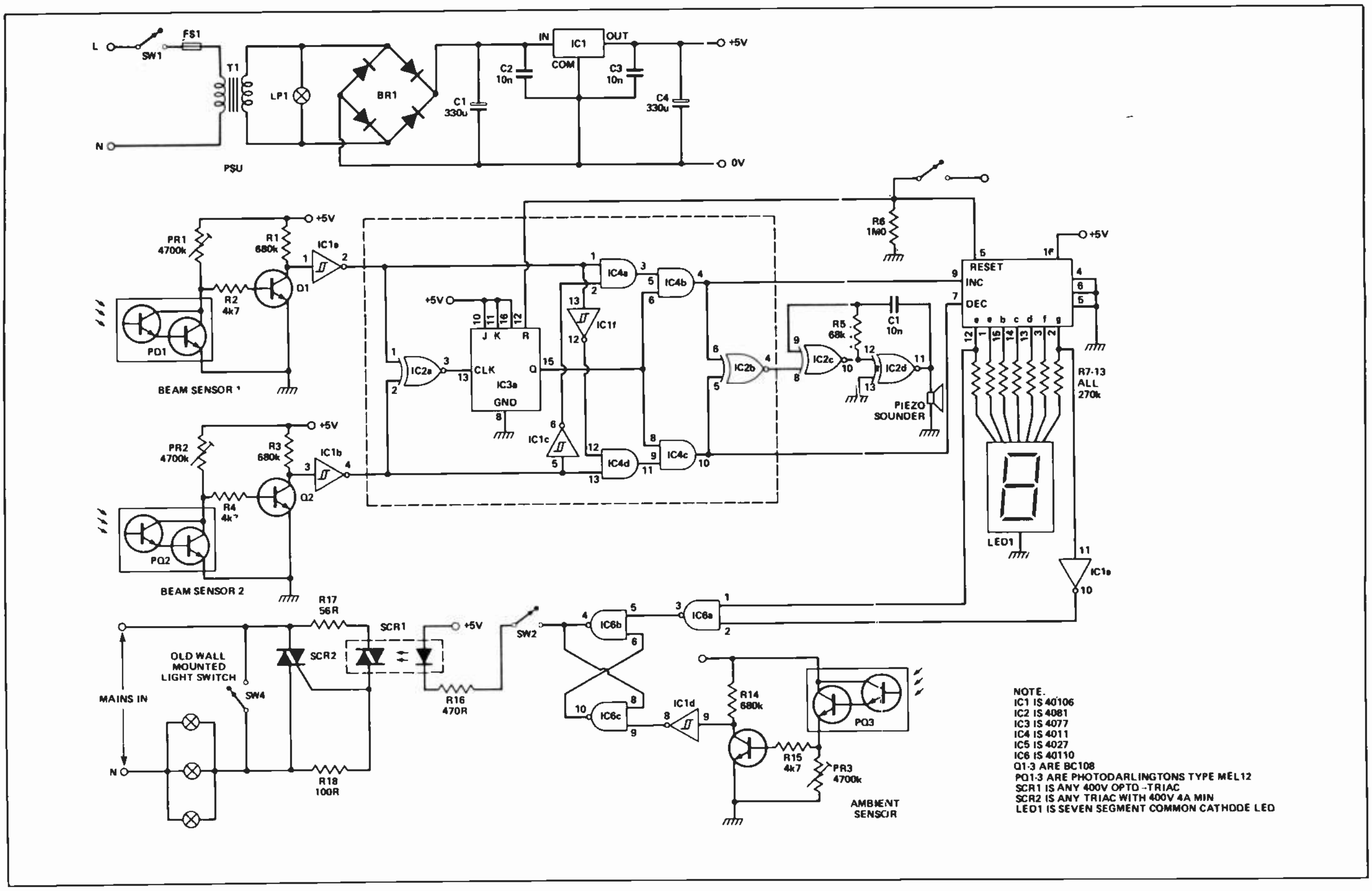
The heart of the circuit is IC1 ('LS93), a four-bit binary counter, which addresses IC2 and 3, which in turn scan the keyboard. IC3 ('LS156) is a two-to-four line decoder with open collector outputs. The two-bit address, A, B, selects which of the four outputs is low. IC2 ('LS173) is a four-to-one-line data selector; the two-bit address, A, B, selects which line is tested, the output Y going low when the selected input is low. So the address on the outputs of IC1 when output Y of IC2 is low is the address of the key pressed. (IC2 and 3 are dual devices, only one half of either being used here are alternative pin numbers are given where these are applicable on the circuit diagram).

The next step was to capture or latch this address. This is accomplished by IC4 ('LS173) which is a four-bit D-type register with tri-state outputs (handy for CPU data bus). When the clock pulse goes from high to low the address from IC1 is low, this occurring on the low-to-high clock transition. Thus IC4 will hold the code of the last key to be pressed.

All that remains is for the CPU to read the data from IC4. This occurs when the I/O decode and the RD inputs are low.

A cheap way to make the keyboard is to use an old calculator, replacing the original PCB with the one for the encoder. Suitably designed, the PCB for the encoder could be made to fit inside the calculator case — and if the display is still working, this too could be pressed into service.





Semi-Switchless Switch

Ian Sherlock

Designed to alleviate the persistent use of a wall light switch, this circuit could also be of use in households with elderly or disabled members. The circuit turns on the light when anyone enters the room (which must have a single entrance), counts the number of people entering or leaving, then turns off the light again when the room is empty.

The phototransistors each give a positive-going long pulse when the light to them is blocked; they should be about 5 to 10 cm apart, so that both beams are cut for much of the period of time it takes some-one to enter. These pulses are amplified by Q1 and 2 and IC1a and b.

The figure opposite shows the timing of these signals; only in the final section, where the pulse from PQ2 has gone low again, do the conditions for the increment pulse to reach IC5 occur, which is when Q from IC3a and the output from IC1a are both high and the output from IC1b is low.

IC5 is an up/down counter seven-segment driver which counts the number of entries and exits from the room. IC1e and 1C6a detect a zero on the display. The latch formed around IC4b and c ensures that the light will only come on if there is no light falling on the ambient light detector, PQ3, but will then stay on until the room is vacated. The remaining circuitry for driving the triac via an opto-triac is quite straightforward.

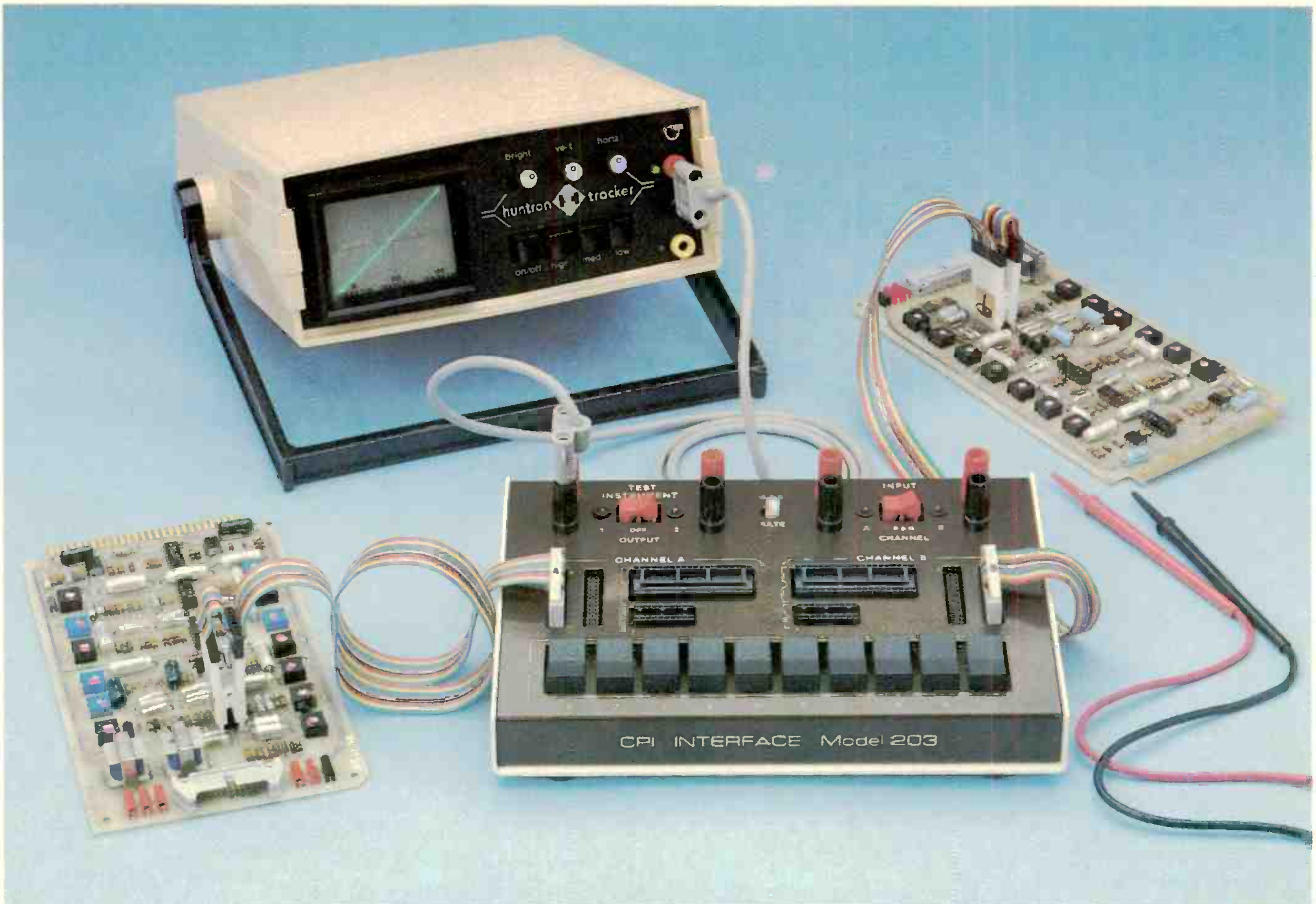
SW2 is an auto/manual switch; SW3 is the reset switch, which should be used at switch-on and whenever the house-hold children set about trying to confuse the unit.

A suggested method of construction is shown in the diagram. Standard three conductor power cable can be used to link the unit to the existing switch-plate (the cable carrying live, neutral and triac return) but note that the unit should be powered from a separate supply, and that it must be grounded to be safe. A metal box can be used to house all the phototransistors and the circuit board and transformer; the beam sensors will need light-shielding tubes (sawn-off felt tip pens could be used or something similar) which can be directed at a single light-source fitted on the opposite side of the door frame.

The ambient light sensor may need to be mounted separately, as the box may have to be mounted outside the room, depending on the direction that the door opens. The ambient light detector must be arranged so that it picks up light from only the room being monitored.

An alternative to visible light beams would be to use modulated infra-red beams, but this involves extra complexity, which is why visible light was chosen.

ETI



FAST AND EASY

For a number of years the Huntron Tracker has proven to be an effective service instrument with the ability to troubleshoot electronic circuits to the component level without circuit power applied. The patented Microprobes with their insulated, needle-sharp stainless steel tips have been ideal for point to point testing.

Now the task of troubleshooting PC boards and DIP ICs has been greatly simplified. We have developed the CPI Interface, a test instrument accessory to make it faster and easier to troubleshoot DIP ICs and PC boards, IC by IC, instead of one pin at a time.

The two input channels of the Interface provide good-bad comparison testing capability while two independent, switch selectable output channels allow a choice of test instruments.

Comparison Testing

In-circuit ICs may be tested using ribbon cables and IC clips to connect directly to the ICs on circuit boards. Out-of-circuit ICs may be tested using sockets mounted on the Interface. In either case, test signals from the device under test and a known good device are routed through the Interface to the desired test instrument.

Circle No. 20 on Reader Service Card

Comparisons and measurements are made by connecting one IC clip to a known good IC and the other clip to the suspect device. Pins to be examined are selected one at at time by activating the appropriate pin-select switch. The Interface will then automatically alternate between input channels connecting first one IC and then the other into the test circuit. This short interval switching between input channels instantly reveals even minor differences between the devices being compared. The length of time each channel is activated is operator adjustable. The operator also has the option of locking on either channel in order to examine a pin more closely.

For Power-Off Troubleshooting

With the Huntron Tracker connected to one output channel, testing or comparison of components and PC boards may be done in an unpowered state. An ohmmeter could be connected to the other output channel in order to make resistance comparisons.

For Power-On Troubleshooting

The Interface can also be used with general purpose test equipment such as multimeters or logic probes. This feature is useful when the user wishes to take measurements or make comparisons of voltages, signal levels or logic states in powered circuits.

Additional Features

The Interface also incorporates jacks for connecting Microprobes so that point to point testing may be done at any time without disconnecting the Interface from either test instrument. This permits the user to leave the Interface connected to test instruments on the service bench at all times and go from "power down" Tracker, or ohmmeter testing to "power up" measurements at the flick of a switch.

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Tek's best-selling 60 MHz scopes: Now 25 ways better for not a penny more!

Now Tek has improved its 2213/2215 scopes with brighter displays. Greater accuracy. And more sensitive triggering. At no increase in price.

The 60 MHz 2213 and dual time base 2215 have been the most popular scopes in Tektronix history. Now, Tek introduces an "A" Series update with more than 25 specification and feature enhancements — things you have asked for such as single sweep — all included at no added cost.

A brighter display and new vertical amplifier design provides sharp, crisp traces. That makes the 2213A/2215A a prime candidate for tasks like TV troubleshooting and testing, where fast sweeps are typical.

New features include 10 MHz bandwidth limit switch, separate A/B dual intensity controls (2215A only), and power-on light: additions customers have suggested for giving these scopes the final measure of convenience.

Triggering, sweep accuracy, CMRR and many more major specifications are better than ever. Check the performance chart: not bad for scopes already considered the leaders in their class!

Specification enhancement	2213/2215 "A" Series	2213/2215
CRT brightness	14 kv accel. potential	10 kv accel. potential
Vertical accuracy	3%, 0° to 50°C	3%, +20° to 30°C
Chop rate	500 kHz	250 kHz
Input capacitance	20 pF	30 pF
CMRR	10 to 1 at 25 MHz	10 to 1 at 10 MHz
Channel isolation	100:1 at 25 MHz	Not specified
A Trigger sensitivity (int)	0.3 div at 5 MHz	0.4 div at 2 MHz
TV triggering	1.0 div compos. sync	2.0 div compos. sync
Sweep accuracy (in 10X)	4%, 15° to 35°C	5%, 20° to 30°C
Delay jitter	20,000 to 1 (2215A) 10,000 to 1 (2213A)	10,000 to 1 (2215) 5,000 to 1 (2213)
Holdoff Range	10:1	4:1

The Price: Still $1848* for the 2213A and $2134* for the 2215A. Or, step up to the 100 MHz 2235 for just $2607*. Prices include two 10X probes, 15-day return policy, world-wide service backup and comprehensive 3 year warranty. Ask about our extended warranty.

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