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# Electronics Today

INTERNATIONAL

March 1984

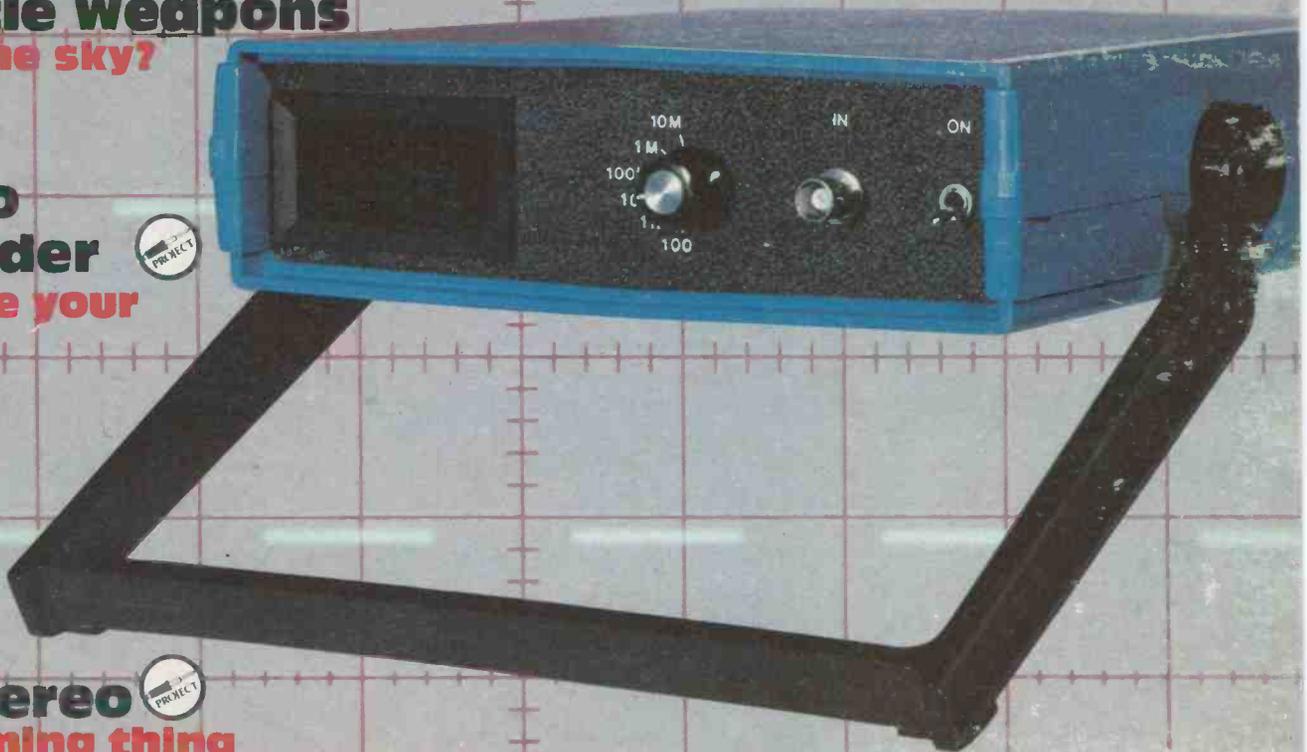
**Frequency Counter Project**  
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**Particle Weapons**  
**Pie in the sky?**

**Stereo  
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**Improve your  
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**The coming thing**



**Computer Review**  
**Commodore  
Executive SX-64**



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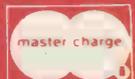
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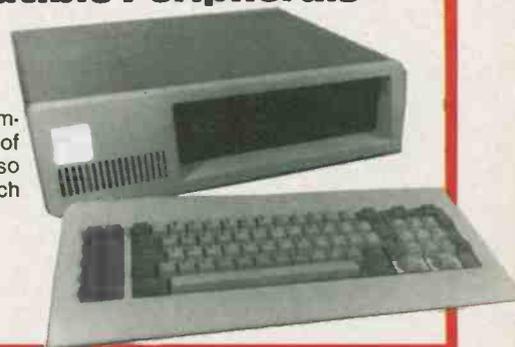
## The "BEST" IBM™ Compatible Peripherals

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**see page 18 of catalogue**

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As Reviewed in ETI May 1983



## OUR FAMOUS 6502 BOARD

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Our prices are low due to our mass production assembly, which makes it hard for others to compete.

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Our boards are professionally made, flow soldering & cleaned & use only high quality prime parts.



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## 6502/8088 Board

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ZVM-123 Green .....	\$129.00
Roland Colour 1 .....	\$395.00

## Printers

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## Our Cover

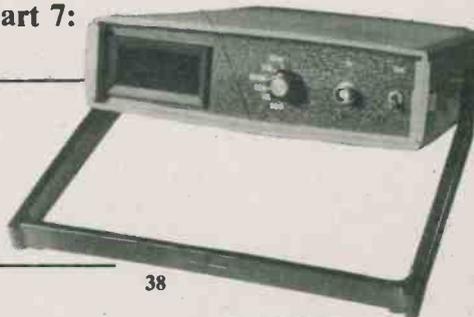
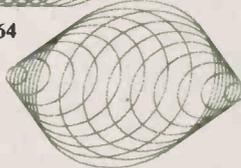
The simple-to-build Frequency Counter appears on Page 38; Photos by Bill Markwick. The Commodore SX-64 is reviewed on Page 30; Photo by Anthony DeBoer.



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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 0.1uF 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. Similarly do not ask PCB suppliers for help with projects.

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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.  
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### Editorial Queries

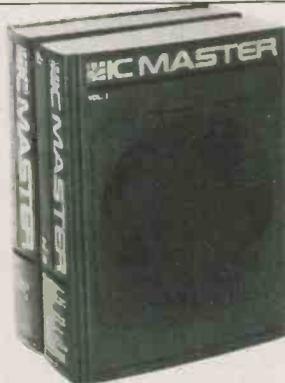
Written queries can only be answered when accompanied by a self-addressed, stamped envelope. These must relate to recent articles and not involve the staff in any research. Mark such letters ETI-Query. We cannot answer telephone queries.

An intriguing press release has arrived from Kodak Canada Ltd. Under a licensing agreement from Drivetec Inc. of California, Kodak of New York will begin manufacturing a 5.25 inch "Superminifloppy" disk drive system. The drives will be double-sided with 192 tracks per inch, and a capacity of — wait for it — 3.33 megabytes. It can also read 48 and 96 track-per-inch disks. They'll be available in the first quarter of 1984, and are aimed at personal computer users and small businesses.

## 1984 IC MASTER

The 1984 edition of the IC MASTER has been published by Hearst Business Communications and is available in Canada from Future Electronics. The newly revised deluxe 2-volume edition contains over 4,000 pages and lists key specifications for 35,000 integrated circuits, microcomputer boards and related products made by 225 manufacturers. Both new and discontinued devices are shown in the alternate source directory. This section provides information on replacements and lists approximately 55,000 IC substitutes. More than 60 manufacturers have supplemented the editorial material and tables in the IC MASTER with extensive data sheet sections. The eleven technical data sections of the 1984 IC MASTER, organized by function and key parameters are: Military, Digital, Interface, Linear, Memory, Microprocessor,

Do you live life in the fast lane, and can't be far from a computer? Radio Shack announces the portable version of their Model 4, The Model 4P. It features a 9-inch screen, and can run all Model III TRSDOS and LDOS programs via 5.25 inch drives. Also offered is memory expansion to 128K, CP/M, and a modem. The keyboard fastens across the front to protect the CRT and drives. At your local Radio Shack computer dealer.

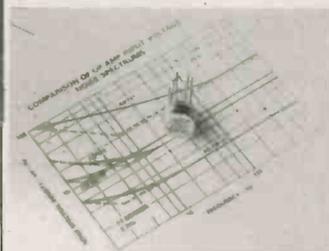


Microcomputer Board, Microcomputer Support Board, Microcomputer Development System, Custom/Semicustom IC's and PROM Programmers.

It is available in Canada exclusively from FUTURE ELECTRONICS; head office is 237 Hymus Blvd., Pointe Claire, Quebec H9R 5C7, (514)694-7710.

According to the Toronto Globe and Mail, Coleco Industries Inc. of Hartford, Conn., says it plans a new attachment that would enable its Adam home computer to run some software designed for the Personal Computer of International Business Machines Corp. of Armonk, N.Y. Coleco said it would introduce the plug-in attachment late this year. It would not say how much software designed for the IBM PC would be able to run on the Adam with the new attachment.

AN ALTERNATE source to the OP-27, the industry's lowest noise high-precision operational amplifier, has been introduced by Analog Devices, Inc. The AD OP-27 combines maximum input noise of 0.18uV peak-to-peak with maximum offset voltage and offset voltage drift of 25uV and 0.6uV/°C, respectively.



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For further information, contact: Tracan Electronics Corporation, 1200 Aerowood Drive, Unit No. 3&4, Mississauga, Ont. L4W 2S7, (416)625-7752.

## Current Sensing Resistor

The Resistive Products Division of TRW Electronic Components Group has expanded its line of power resistors with the introduction of the 4LPC Series of wire-wound fixed resistors. Developed for four-terminal current sensing and printed circuit board mounting, the 4LPC Series offers resistance values of 0.01 ohm to 1.0 ohm at 3 watts, in tolerances from  $\pm 5\%$  to  $\pm 1\%$ . Designed for circuits where accurate current sensing is required, the 4LPC is used in such applications as: power supply regulation, motor controls, RF sampling, feedback control loops and overload sensors. For additional information about 4LPC resistors, contact the Resistive Products Division, TRW Electronic Components Group, P.O. Box 1860, Boone, NC 28607 or telephone (704)264-8861.

# for your information

## Compact Disk Player

Sony has introduced a new compact audio disk. The CDP-200 has many of the same features as the CDP-101, as well as a new index search feature to help classical music buffs zero in on specific passages within individual movements. All key component parts — including the critical digital-to-analog converter LSI

cent musical selections. The Fast Scan mode enables the user to find specific portions of a selection quickly by playing a constant stream of musical "samples" as the laser sweeps across the disk. The Sony CDP-200 also has a special Index search feature to enable the user to locate a specific subcoded portion of a long classical movement. Other features in-



and the semi-conductor laser itself — have been developed by Sony. The CDP-200 features horizontal front loading, utilizing Sony's Linear Skate Drawer mechanism. Feather-touch controls on the front panel are ergonomically designed, and include Play, Pause and Reset/Stop. In addition, Automatic Music Sensing (AMS) allows instant access to any adja-

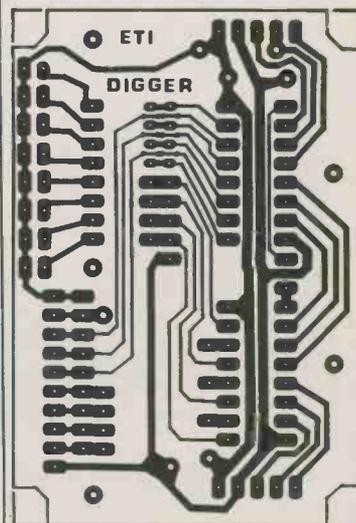
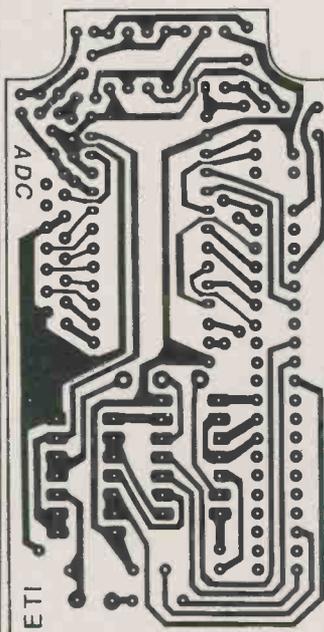
clude: a two-way repeat function that can be programmed to replay either an entire selection or any amount of music located between an A and B point; a concentrated display that provides the track and index number, plus both elapsed and time-remaining information; automatic disk sensing protection; and headphone output jack with level control.

GTE said today that it will test Sylvania Metalarc® lamps in space during the next Space Technology Shuttle mission scheduled for January 30 to February 7, 1984. "The purpose of the space experiment, which is part of NASA's 'Get Away Special' program, is to observe the operation of the efficient Sylvania lamp in a zero gravity environment," said James F. Cosgrove, vice president of research and engineering at GTE Lighting Products. "Data collected on behaviour of the lamp arc without the disturbances of gravitational convection forces should help us in design of even more efficient lamps," he stated.

An effective telecommunications system is vital to the growth and prosperity of any nation, Basil A. Beneteau, vice-chairman of the board of Northern Telecom Limited, told the plenary session of the Pacific Telecommunications Conference held in Honolulu recently. Discussing the impact of telecommunications on the economies of developing Pacific Rim nations, Mr. Beneteau said, "Nations with only minimal telecommunications tools are inhibiting their prospects for productivity improvement, industrial development, and competitiveness in an increasingly competitive world."

## Missing PCBs.

Our apologies for the omission of the ZX81 ADC and the Digger PCBs from our January issue. The person responsible has been flogged and put on short rations.



# MICRO HOUSE

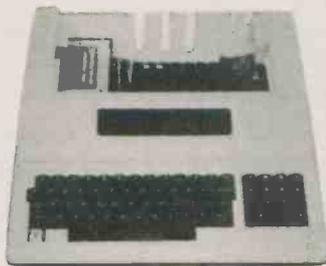
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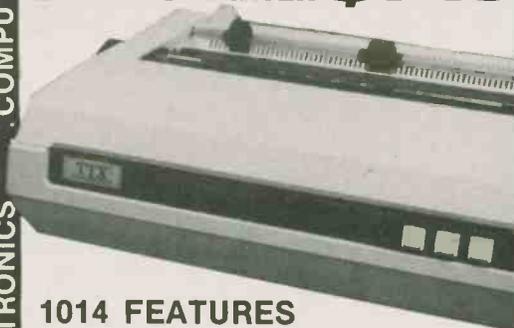
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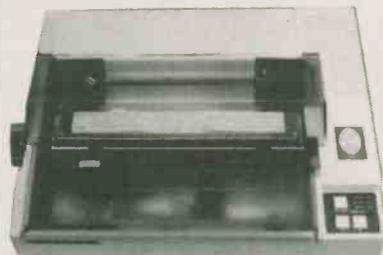
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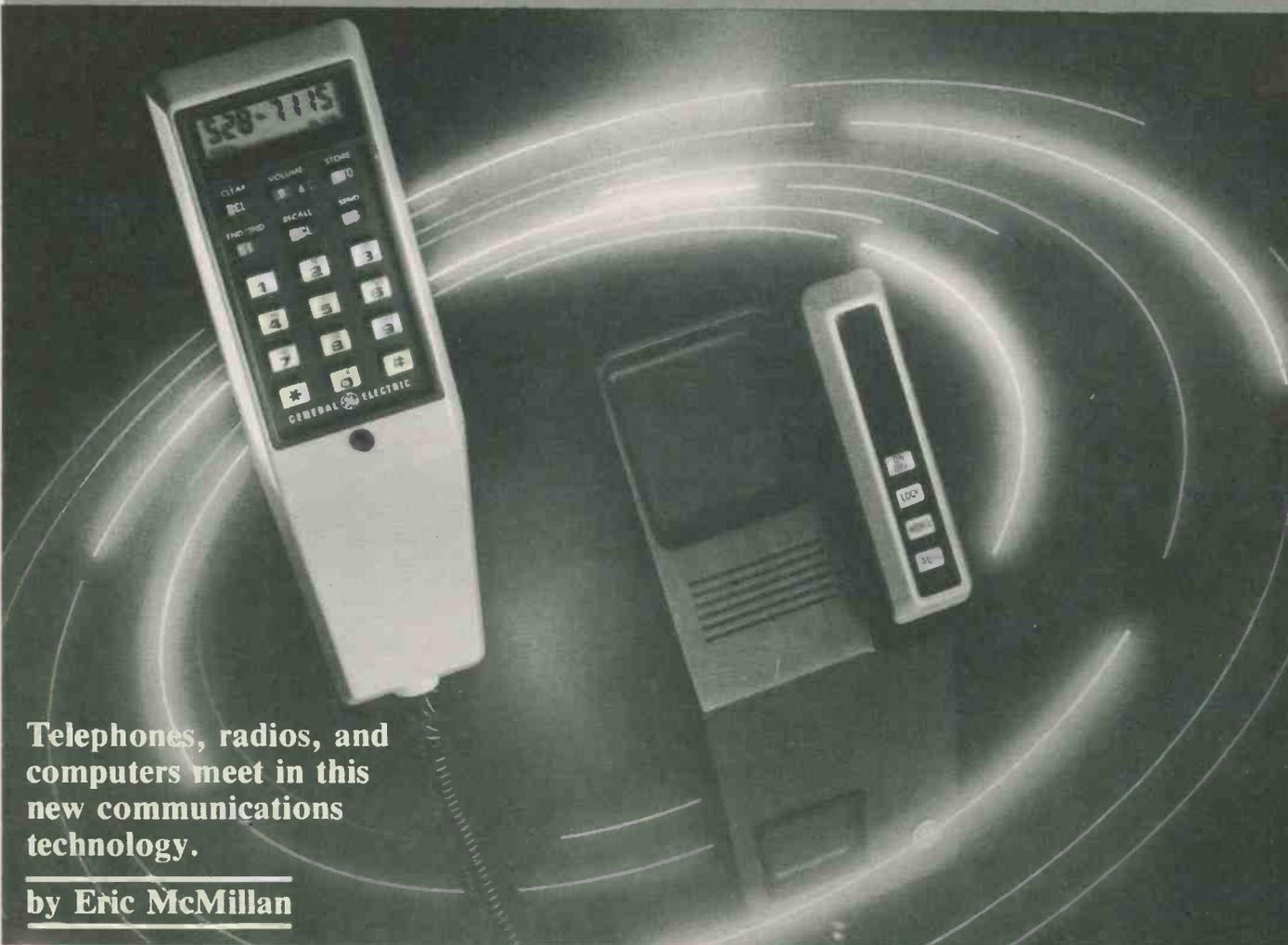
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# Cellular Radio



Telephones, radios, and computers meet in this new communications technology.

by Eric McMillan

A portable handset unit for cellular radio, offered by GE/Northern Telecom. Photo courtesy General Electric.

IN TYPING UP an important contract, a stenographer realizes that the client didn't specify whether he wanted a thousand model-156A or a thousand model-156B widgets. And the sales rep who closed the deal is on the road.

No problem. She phones the sales rep as he speeds along a highway somewhere. Without slowing down, he discusses it with her and decides to ring up the client himself. The client takes the call as he's inspecting the unfinished fourth floor of a building under construction. He checks in turn with his own head office in another city and phones the information back to the travelling sales rep, who relays the order to the waiting steno. All done without searching for telephone booths or disrupting anyone's schedule.

This is how cellular radio would work from the users' perspective — as a means

of calling between any locations regardless of whether phone lines are handy.

The handheld receiver even looks like a telephone, a cordless model with a short antenna. It fits in a briefcase, on the dashboard or in a large pocket. To operate cellular radio, the caller punches in a number as on any push-button phone and presses another button to speak.

However, the technology to handle the call is quite different from normal telephone communications. As our speeding sales rep is straightening out his client's order, a complicated process is carried out behind the scenes to keep the parties in contact.

Radio signals are transmitted to, or received from, the car phone by an antenna at a base located in the car's current vicinity. When the mobile unit communicates with the stationary office

phone, the signals are converted at the base and passed through the usual telephone lines. When it's in touch with another remote unit, such as at the construction site, the signal is relayed to a base in the receiver's vicinity and broadcast to him from there.

As the car travels out of range of the antenna, a computer automatically reroutes the call through another base whose area the car is entering. As the sales rep drives around, his calls are repeatedly switched from base to base without noticeable interruption. Moving from one urban centre to another is more difficult but possible.

Made feasible by the marriage of radio, telephone and computer technologies, the roaming capability of cellular radio allows communication between any parts of the country where a cellular

system is established. The regions are divided into honeycombs of cells, each cell up to 10 miles wide. Combined with a fourth technology, communications satellites, cellular radio can eventually be extended to remote areas that lack ground-based cellular systems.

### What the DOC Ordered

Heralded as the 'next big thing after Pay TV,' cellular radio is coming to Canada. By the time you read this, the Department of Communications (DOC) might have already approved licences for setting up cellular radio systems across the country. The Alberta Government Telephone Company has been carrying out a test with 200 mobile phones in Edmonton since last December.

Some companies say they can have cellular radio systems up and running in major cities by 1985. Although initial costs will limit the appeal to businesses for a few years, falling prices may eventually attract a wider market. A DOC regional director predicted cellular equipment will eventually become consumer items sold through stores like Eaton's, Simpsons and Radio Shack.

Cellular radio has already been established in some countries. The first commercial system was set up in Sweden, Norway, Denmark and Finland and already has over 30,000 users. Japan has a cellular system running, and Australia has it under development.

The Scandinavian system illustrates that cellular radio can cross borders as easily as conventional telephone service, provided the systems are internationally compatible. Canada is establishing its system parallel with the United States where the Federal Communications Commission (FCC) is licensing metropolitan areas. The DOC is working with the FCC to create a continuum of frequency and cell structure across the two countries. Compatibility will facilitate cross-border communications and help Canadian cellular equipment manufacturers find markets in the U.S., Ottawa hopes. Judging by past experience, the reverse is also possible. American products could flood our market. The DOC has let applicants know they want to see Canadian-produced equipment worked into their plans.

The licencing process began last October with the DOC's call for applications to run 'a high-capacity mobile radio system' in 23 urban regions across the country.

Two systems are to be licensed in each area — one operated by the local telephone company and one by a non-telephone carrier. When a call is placed from a mobile phone the pulse is detected by both systems in the area, but only one will respond, depending upon the fre-

quency which identifies the system the caller subscribes to. Both systems, however, must interconnect with the existing telephone network.

By February, the DOC was flooded with applications, including submissions from alliances of some of the largest electronics and communications conglomerates in Canada, encouraged by projections of long-term multi million dollar profits. Within a month the possibilities were narrowed down to seven private applications plus the telephone companies. In August, communications minister Francis Fox announced that only a single national licence would be awarded the non-telcos.

### The Soft Cell

Cellular radio has been called 'the rich man's mobile phone service.'

The first units will probably cost \$2,500 to \$3,500, or lease for \$100 to \$150 a month. This does not include airtime charges which could add an extra \$150 per month to the bill.

The high price is said to reflect the massive expense of installing the cellular system. Figures in excess of \$150 million have been quoted, not to mention equal amounts spent on research and development prior to installation or the continuing costs of maintaining the system.

Like other electronic products, cellular radio is expected to become cheaper in the years following introduction. With prices settling below \$40 per month plus airtime charges, one percent of the population could be part of the cellular system by 1988, according to some predictions.

One licence applicant, CNCP Cellular Communications, owned by CNCP Telecommunications and Motorola

Canada Cellular Inc., submitted a brief to the government that said such subscriber forecasts appear 'unduly optimistic' although they remained convinced that cellular telephones would benefit all Canadians.

Certainly the applications anticipate large profits can be made. Michael Kedar, a communications consultant with KVA Communications and Electronics Co., which was involved in the application by Cel Tel Corp., said, 'It's definitely a big potential money-maker. The telephone companies have monopolized this field but today cellular radio has opened it up.'

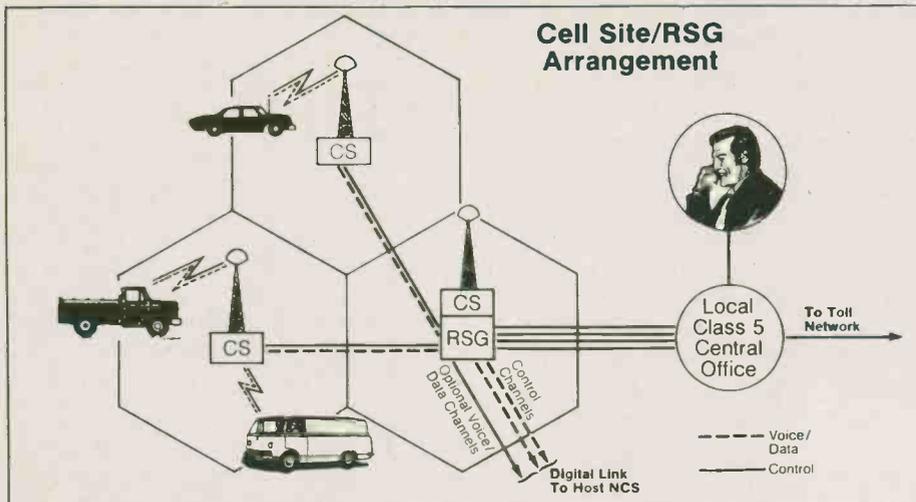
Kedar sees it in the context of related technologies that consumers might become familiar with. At the lowest of three evolutionary levels are the cordless phones with mobility up to 1,000 feet from your home phone. These are coming into fashion just now. The intermediate level, before cellular radio, is personal radio service with up to 15 miles range. This would be adequate for many users since studies have shown that 80 percent of people do not wander more than five miles from their home, according to Kedar.

Pre-cellular mobile phones are currently operated by about 50,000 Canadians through Bell Canada and the other telcos. Using mainly frequencies in the 400MHz band, only a handful of these units can place calls simultaneously in a large city. A caller is as likely to get a busy signal as to have the call put through.

One of the DOC's stated goals with introducing cellular radio was to alleviate this shortage of frequencies for mobile telephone service. The 800 MHz band, where more frequencies are available, has been set aside for cellular use. (One side effect has been the removal of UHF televi-



The familiar two-way radio may be largely replaced by the convenience of cellular radio.



The Remote Switch Group (RSG) co-ordinates the control switches. Illustration courtesy of ITT.

sion channels from around this band. For example, CITY-TV in Toronto was bumped from channel 79 to 57).

Frequency bands allocated to cellular service are split between the telcos and the non-telcos. The former will use the 835-845 MHz band for mobile transmission paired with 880-890 MHz for base transmission. The latter will use the 825-835 MHz band for mobile transmis-

sion and 870-880 MHz for base transmission. The 821-825 MHz and 866-870 MHz bands are being considered for a future mobile satellite system called MSAT.

The available 40 MHz will allow 666 two-way user channels including 21 control channels for each telco and non-telco system. Although adjoining cells must use different frequencies to avoid interference, the frequencies are reusable

throughout any metropolitan system, allowing thousands of channels in any one area.

Another advantage of the cellular method of dividing up the market, is that it is infinitely expandable. As the number of users reaches the limit in an area, the cell can be subdivided into two or more smaller cells with their own bases and channels.

### ET, Phone the Office

Mobile phone service is only one function of cellular radio, although it's likely to be the most widely used. Teleconferences and dozens of other enhanced services have been promised. Some futurists foresee a day when cellular phones will be as common as wristwatches and may in fact be worn on the wrist in Dick Tracy fashion. Everyone could get an individual telephone number that stays with them for life. Perhaps the ubiquitous SIN will double as the phone number.

Despite the benefits offered by cellular radio, one drawback for the harried sales rep comes to mind. When he can carry a phone in his pocket, it'll be harder than ever to get away from it all.

ETI

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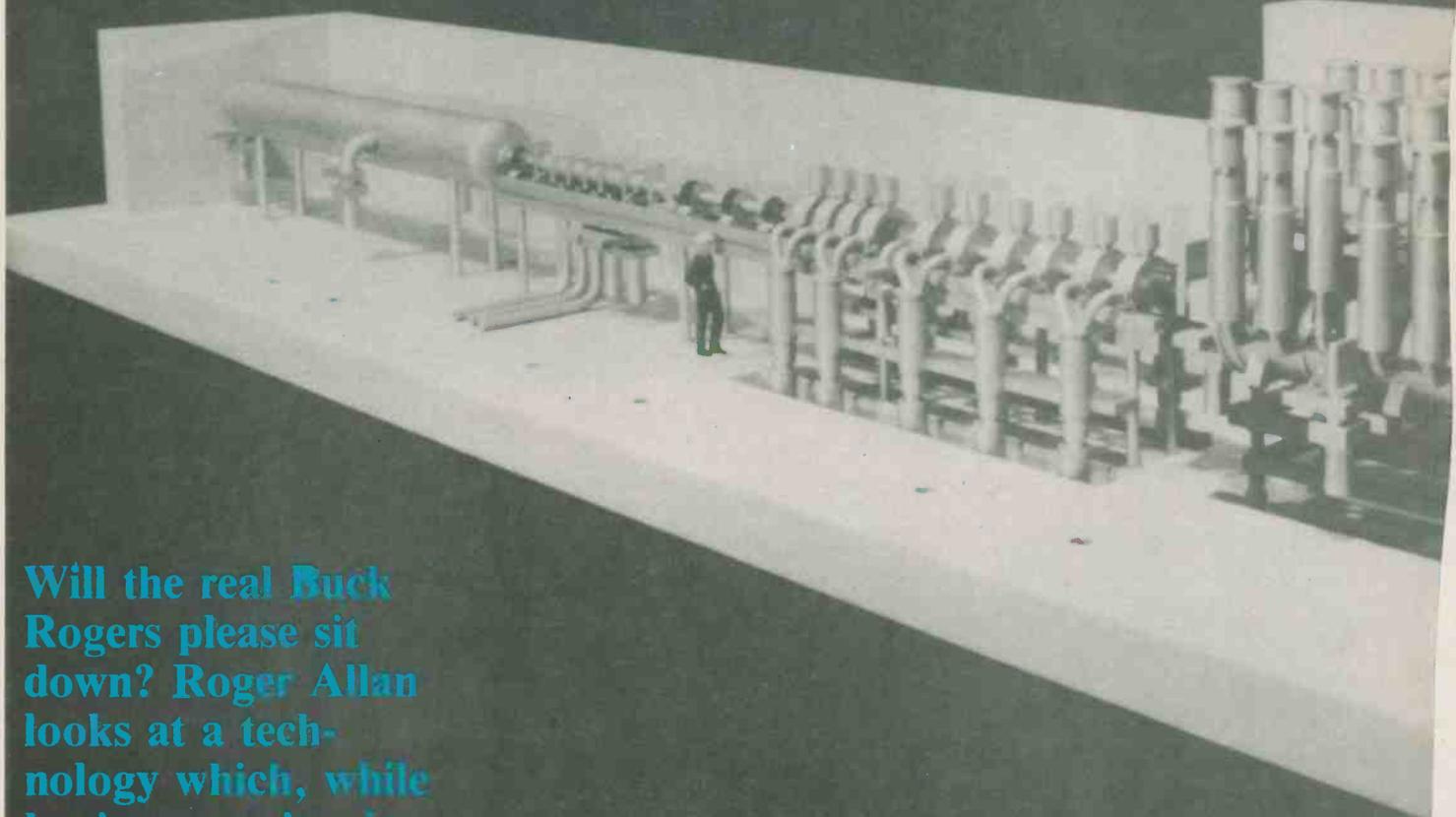
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# Particle Weapons



Will the real Buck Rogers please sit down? Roger Allan looks at a technology which, while having promise, is nowhere near being a threat yet.

A model of the Experimental Test Accelerator at the Lawrence Livermore National Laboratory. Courtesy of U.S. Department of Defense.

A **PARTICLE BEAM** is a stream of highly energetic atomic or subatomic size particles such as electrons, protons, hydrogen atoms or ions. By comparison, laser beams are composed of radiant energy photons. Presently, aside from potential applications as weapons, particle beam machines have potential for use in inertial confinement fusion for energy generation, nuclear weapons effects simulation, heating and welding, high intensity microwave generation, geophysical investigations, energy transmission, medical treatment, and basic physics experiments.

Consideration of the use of particle beams as weapons actually dates back to World War II, but the technology of the times could not support such a concept. The early U.S. Department of Defense efforts on particle beams were started by the Defense Advanced Research Projects Agency (DARPA) in 1958 under a program codenamed SEESAW.

The initial potential "mission" was ground-based strategic defense against ballistic missiles (ABM), with work centered at the Lawrence Livermore National Laboratory (LLNL) which dealt with electrons

as the particles used to form the beams. SEESAW was terminated in 1972 due to the projected high costs associated with implementation as well as the formidable technical problems associated with propagating a beam through very long ranges in the atmosphere. One of the major difficulties in beam propagation is the bending of the ray. Sub-atomic particles, no matter how small, have substance or mass, and as such are affected by gravity and magnetism. As such, at long ranges, one cannot shoot a bolt in a direct line, but rather has to take into account the earth's magnetic field, which



bends the rays. As the earth's magnetic field is in a constant state of flux, aiming the weapon is extremely difficult.

Department of Defense interest was reinstated in 1974 when the United States Navy initiated the Chair Heritage program, again involving an electron beam development program. The Navy perceived an application to defense of ships against all forms of attack by aircraft and missiles. The Chair Heritage program differed in two ways from the DARPA program, which effectively increased its probability of success. First, the required range of the electron

beam would be significantly shorter than for the SEESAW mission. Second, the beam was intended for point defense rather than for defense of large land areas, and the associated costs would therefore be lower. In 1977, the Chair Heritage program was shifted from a weapons to a technology base program due to a realization that major technological uncertainties still remain. In 1979, at the urging of Congress, the Chair Heritage program was transferred to DARPA.

In 1979 the United States Army initiated a second distinctly different path by starting the exoatmospheric, neutral beam program which is directed toward producing beams of electrically neutral hydrogen atoms. The Army also began a separate program to demonstrate "proof of principle" of a collective accelerator concept for producing high current ion beams. In fiscal year 1981 these programs were transferred to DARPA.

For several years the United States Air Force has been funding basic research on particle beam technology directed to several topics, including collective acceleration, propagation modelling and target effects. The Air Force has also been involved in developing new accelerator technology and propagation analysis for atmospheric applications, as well as initiating studies in areas that may be important for space applications: ion sources, beam control and power. The Air Force intelligence activities have also provided key information on Soviet technology efforts in particle beam development.

Beginning in fiscal year 1981, and continuing to the present day, DARPA has total responsibility for assuring technical compatibility of all United States military efforts. Due to the extremely high cost of any work in this area, and due to the poverty of funding for the programs (\$49.6 million for 1984 — absolute peanuts in any military budget) two realities of this area of study become clear: that DARPA is essentially the only organization involved in this work in North America; and secondly, that they are getting nowhere very, very, quickly due to lack of funding, with no weapon system even at the concept stage, much less on the horizon.

However, President Reagan has made public pronouncements on the use of "space age technology" as a nuclear deterrent, and so one is obligated to consider what he might mean, even if it is only hypothesis.

### Beaming Particles

There are three key components of a hypothetical particle beam weapon system: the source of the beam — the beam generator — consisting of a particle accelerator and its associated supply of electrical power, energy storage and conditioning. The accelerators are similar to those used in research in

elementary particle physics except that currents in the beam are much higher. The elementary particle research devices such as the two mile long Stanford Linear Accelerator have been widely publicized as "atom smashers." Second, there is a beam control subsystem to aim the beam at the target and determine that the beam has hit the target. Lastly, the particle beam weapon must have a fire control subsystem which acquires all the targets that need to be engaged, selects the one to engage, and tells the beam control subsystem where to look to find it. Then the fire control system decides when the target has been destroyed and designates the next target. These fire control functions do not differ materially from those of fire control subsystems for other more familiar weapons.

An appreciation of the damaging effect of highly energetic particles striking an object can be seen in many ways. The most easily visualized is the damage lightning can do when it strikes a tree or a house. In high energy physics, experimenters have long been aware of the ability of the highly energetic particles produced by atom smashers to penetrate into materials. As the beam penetrates, it transfers some of its kinetic energy from the particles to the material and, in addition, generates secondary radiation in the material which can also disable the target. If there are enough particles in the beam hitting the target, the rapid transfer of energy to the material cannot be dissipated by the material. Thus, the beam can cause a hole to be burned or melted into the material, or a fracture from thermal stresses as a result of the rapid deposition of energy. A third example of effects can be taken from discoveries in the early days of space flight. Energetic charged particles generated largely by the sun are trapped in the earth's magnetic field thereby forming the "Van Allen" belts. These natural particle beams require spacecraft designers to build shielded and resistant satellites if flights in or through these belts are to occur without damage to such "soft" components as computers or electronics.

As such, one can envision a weapon based on a stream of highly energetic particles that travel at or near the speed of light. This stream of particles would penetrate the metal skin of the target, transferring a large fraction of the energy in the beam to the target. Initially, as the beam enters the target it would damage electronic components and as the beam continues to deliver energy to the target, ignite fuels and explosives and/or create holes in the target ripping it apart.

In warfare, therefore, the theoretical beam weapon shares several "attractive" attributes with other forms of beam weapons (eg. high energy lasers. See "Military Lasers," ETI, November, 1983) in handling target tactics and scenarios that stress the capabilities of missiles and guns. For example:

## Particle Weapons

— near speed of light delivery of destructive energy on line providing the earth's magnetic field is compensated for.

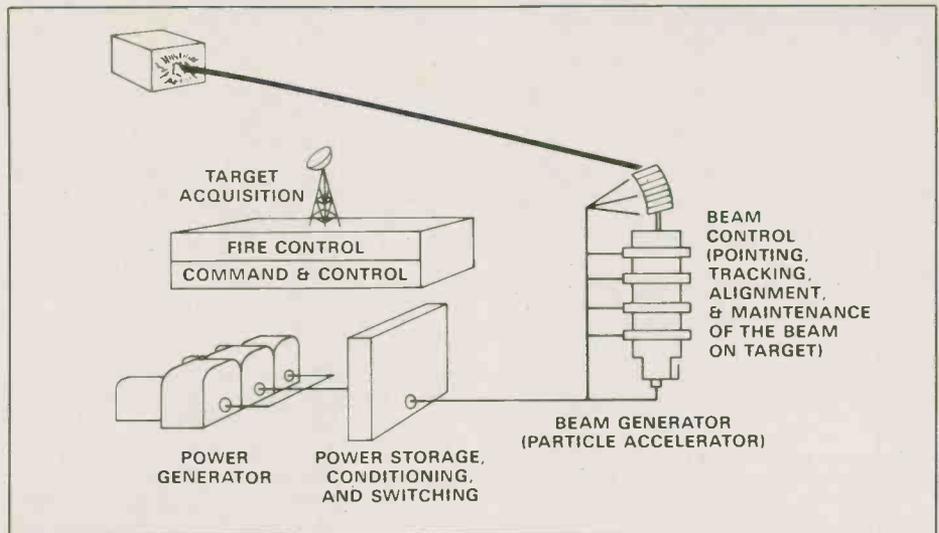
— potentially large numbers of engagements before exhausting the available "magazine" as the "bullets" of a particle beam are, in effect, generated by the electrical power input to the beam generator.

— instant penetration through the skin of the target to destroy or disable key internal components or to ignite fuels and explosives.

If particle beam weapons are feasible, their use of energetic particles as the "bullets" offer two characteristics that reinforce those attributed to beam weapons in general, specifically:

— Since the particles can pass into the target and damage internal components without first burning a hole in the skin, the dwell time of the beam on the target could be quite short, even on targets that are hard to penetrate using other beam types. Keeping dwell times short allows the weapon to defeat the tactic of closely spacing the targets to saturate the weapon system.

— unlike laser weapons, the particle beam weapons can penetrate clouds and rain, giving the potential for an all weather weapon.



The basic layout of a particle beam weapons system.

### Raygunomics

It is recognized by all and sundry, with the possible exception of President Reagan, that particle beam technology is in the very early research and exploratory development phase, with fundamental issues of feasibility still to

be resolved. How this is to be done, bearing in mind the high cost of experimentation and the low funding levels, is not explained. There is an enormous gulf between the technology required for fulfillment of the conceptual payoffs and the state-of-the-art. At this stage of development, DARPA has only

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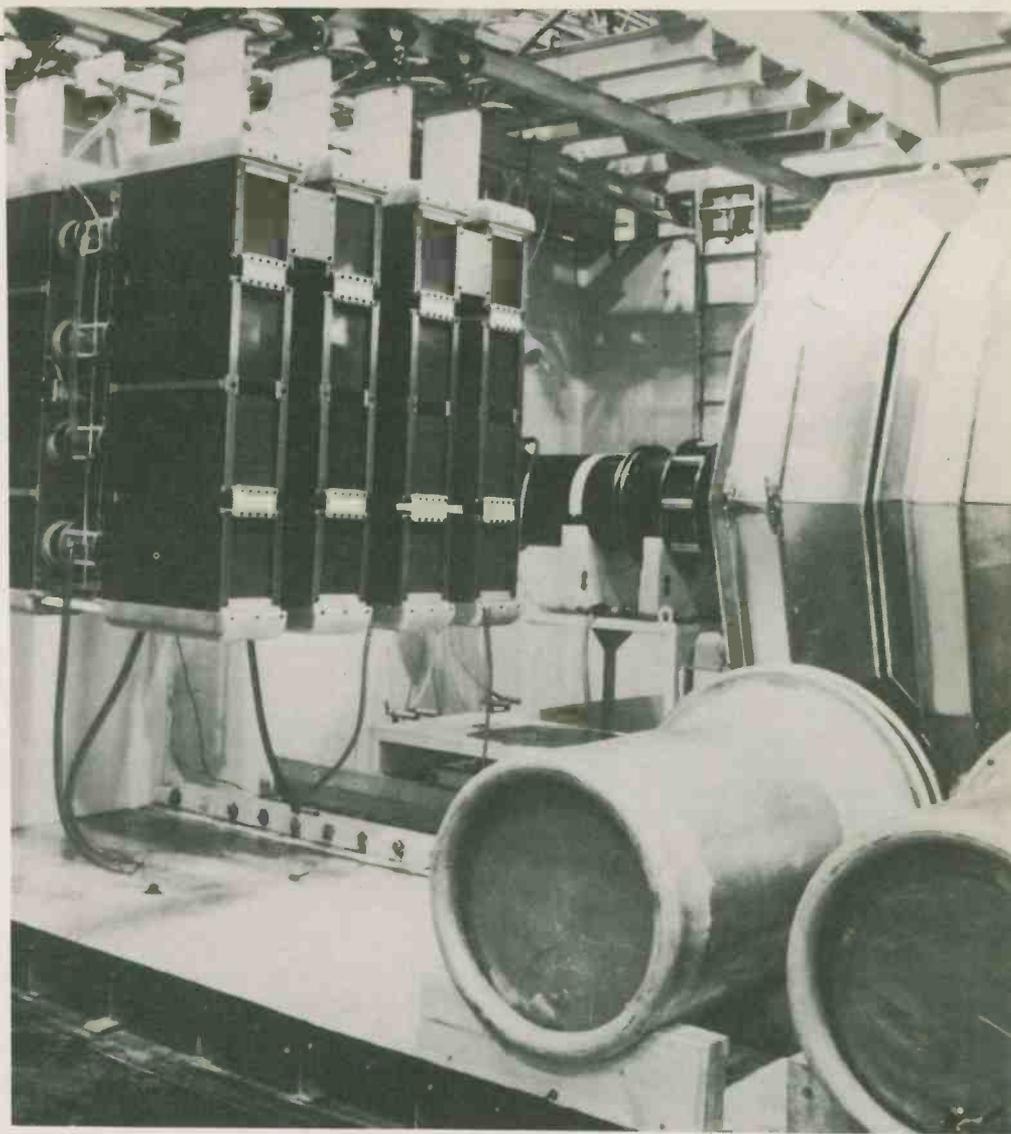
defined generic "missions" to use as a basis for setting the technology goals. The key variables in these generic missions are range required, particle types used in the beam, and whether the deployment is in the atmosphere or outside of it. Conceptually, defensive applications (eg. defense against attack by ballistic missiles, other types of guided missiles, and aircraft) are the logical underpinnings of their current research. This research is divided into a number of distinct sub-sections:

**Beam Generators:** The beam generator produces the intense, high energy beam of particles that represent the "bullets" of the particle beam weapon. Broadly speaking, charged particles are injected into an electric potential or voltage which gives the particles a "push" and accelerates them to high speeds. Kinetic energy is added to the particles by an amount equal to the product of the charge on the particle and the potential drop. Kinetic energy is proportional to the mass of the particle and increases with the velocity. Since the mass of the particles is small, their velocity is near the speed of light. The power of an accelerator beam is the product of the current in the beam and the potential drop. For example, an electron or proton has a charge of  $1.6 \times 10^{-19}$  coulomb. A potential drop of a million volts will provide it with an added  $1.6 \times 10^{-19}$  joules or one million electron volts (MeV) of energy. One ampere of current ( $6.8 \times 10^{18}$  particles per second) falling through a potential drop of a billion volts has a power of a billion watts. Finally, if the billion watt system is pulsed for a millionth of a second, the pulse energy is 1000 joules or the approximate energy equivalent of raising a 750 pound weight one foot.

U.S. Department of Defense efforts can be broken down into two major thrusts: charged particle beam accelerators suitable for use only within the atmosphere, and accelerator systems capable of producing energetic neutral atomic beams for use only outside the atmosphere.

DARPA efforts are currently being placed on the development of high-current, moderate energy charged particle accelerators which are suitable for propagation experiments. A major part of the funds applied to the particle beam effort during the funding years 1983-84 is devoted to accelerator development. The main efforts in this line is the Experimental Test Accelerator (ETA) and the Advanced Test Accelerator (ATA) which are experimental electron accelerators.

The ETA program was completed in 1981. Since then it has been used as a test-bed for ATA technology. It is currently being used to examine techniques for modifying the risetime and radial profile of electron beams to improve their propagation stability. The current program, ATA, produces 50 MeV electrons with a current of 10 kiloamps. It was completed in 1981 and is



RADLAC I as it appeared in 1981. Photo courtesy of U.S. Department of Defence.

now used regularly, though only at low power. After the electron beam from ATA has been diagnosed, sometime late this year, it will be used for beam propagation experiments. These experiments, DARPA hopes, will provide the necessary information to show that electron beams can propagate stably for useful distances in the atmosphere.

A smaller effort is being pursued under the Neutral Particle Beam Program ("White Horse") at the Los Alamos National Laboratory to develop the accelerator technology required to accelerate negatively charged ions to high energies. Once high energy is achieved the excess electron is removed, thereby forming a neutral beam which can be directed over long distances in the vacuum of space. Experimental demonstration of the feasibility of generating low-divergence neutral particle beams forms the major element in this program.

The balance of this element in the DARPA program is directed toward investi-

gation of various exploratory accelerator concepts that could have significant impact on the feasibility of this weapon system. The object of these investigations is to take advantage of new technologies which might become available for accelerator construction. An example is the Radial Line Accelerator program at the Air Force Weapons Laboratory, co-funded with the Department of Energy. The radial line accelerator concept proved feasible with the successful completion of RADLAC I in mid-1980. Presently, efforts are underway to examine a new class of transmission line accelerators in RADLAC II, scheduled for completion later this year. The RADLAC program is complementary to the DARPA ETA program in terms of the intended program physics experiments.

**Beam Control/Point Tracking:** Beam control subsystems for charged and neutral particle beams present technology requirements that are beyond the present state-of-the-art in all cases and without a technology

## Particle Weapons

basis in some cases. All are being addressed with a nominal development effort. The Air Force is principally responsible for neutral beam control and tracking. Efforts include design of a system that can sense the beam and provide the necessary extraction and pointing.

**Prime Power and Conditioning:** Efforts in prime power and conditioning are primarily associated with high repetition rate switching which is capable of handling the high currents used in accelerators suitable for charged particle beam weapon applications. Other efforts involve high voltage pulse forming networks, experimental capacitors and dielectrics, and new materials for high density storage systems.

**Propagation of Charged Particle Beams:** A major goal in the program is to provide experimental proof that charged particle beams can propagate through the atmosphere with sufficient power, arriving at the target at the ranges needed for weapon system applications. The major part of this effort is being performed by DARPA with emphasis on experiments with the ETA and ATA accelerators. The joint Air Force — Sandia National Laboratory RADLAC accelerator is used in this program.

**Material Interaction, Damage and Effects:** To understand what it takes to make a particle beam an effective weapon, research and experimentation is required to determine the interaction of particle beams with materials and components, the damage that results and the effects on target capabilities. The goals of the program for material interactions are to provide early assurance, as yet unforthcoming, that the beam can do lethal target damage. Should this element in the program succeed, the data generated will also define the beam power levels needed to assist in defining the R and D objectives in accelerator and pulsed power technology.

### Star Wars

In summary, the objectives of the particle beam technology program are to determine feasibility and to develop the critical technologies required once feasibility has been demonstrated. The great majority of the available funds in the next few years will be devoted to building accelerators that can generate the high-current, high-power beams essential to verifying existing theory, theory that, according to DARPA, predicts that beam propagation will be adequate for weapon feasibility.

As for the Soviets, their efforts are judged to be larger than that of the United States, particularly in the area of accelerators for fusion applications, and to have been in progress much longer. However, according to Department of Defense sources, there is no direct correlation between Soviet particle beam work and weapons related work.

Putting it all together, one therefore finds that there are half a dozen major problems to be solved, that some of the problems do not even have a theoretical basis for solution, and that funding for the research is strictly nickels and dimes. Perhaps President Reagan should have had a chat with his military advisors before embarking on a "Star Wars" scenario.

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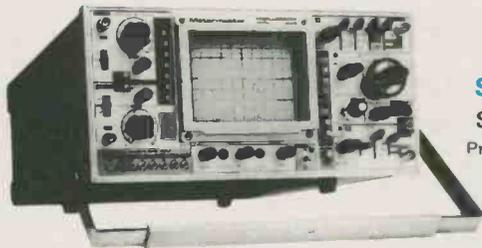
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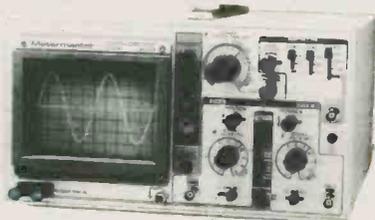
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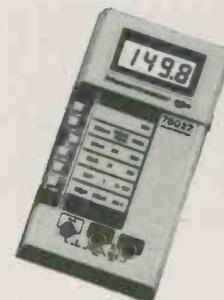
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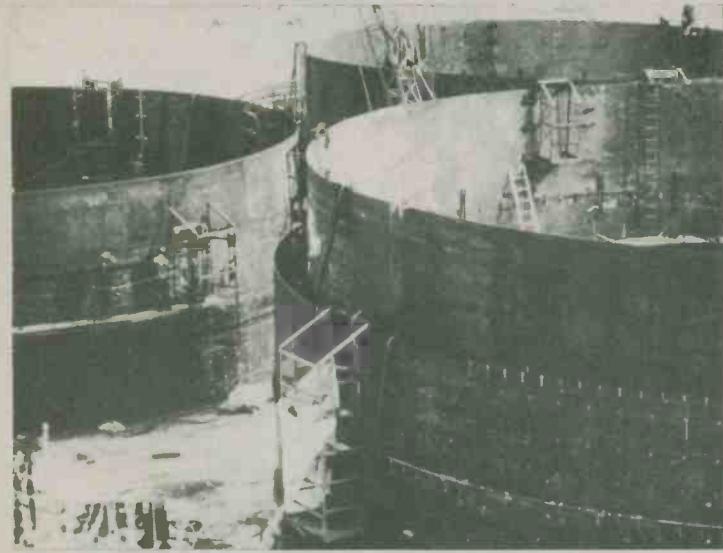
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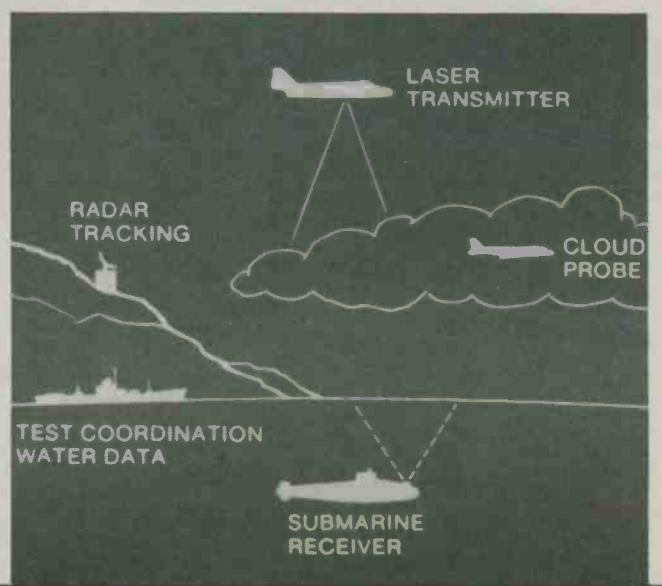


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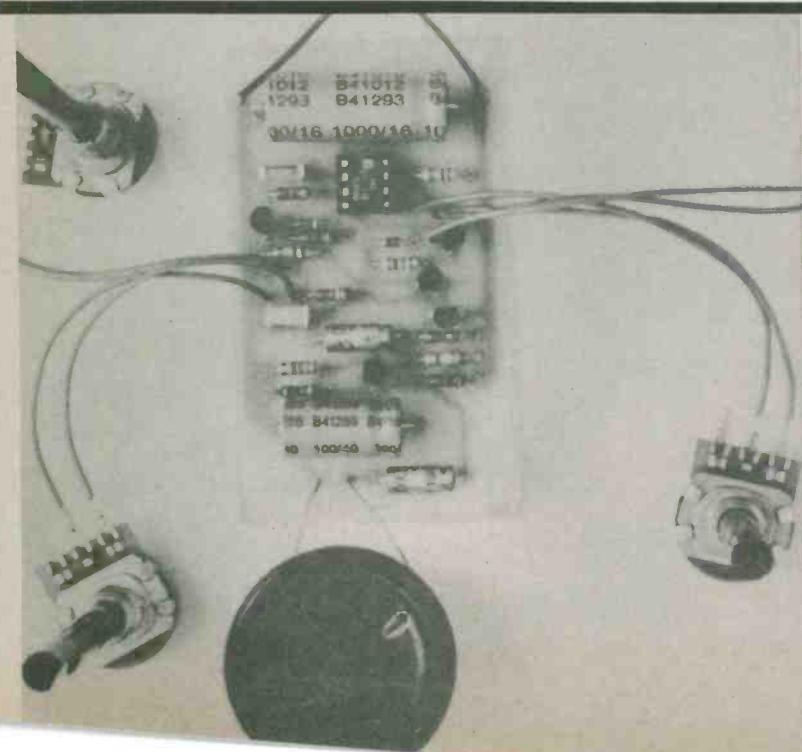
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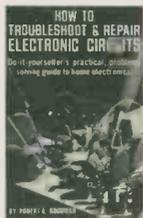
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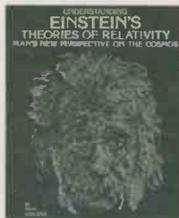
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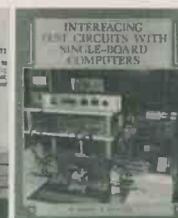
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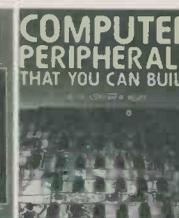
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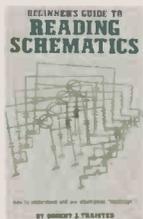
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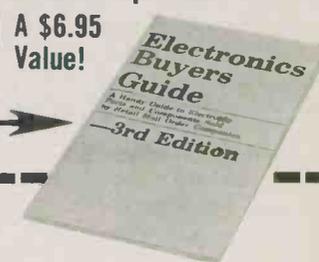


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# Stereo Spreader



**Geoff Macaulay reports on how his stereo became separated . . .**

IN THE EARLY DAYS of stereo, the channel separation used to be enormous. Stereo effect records can still be found in second hand shops that demonstrate this; a table-tennis match recorded so that the sound ping-pongs from side to side, or trains that pass through the middle of the house and so on. And anyone who has an early Beatles album in their collection will know that the vocals sound out from one side and the instruments from the other!

In those days, however, separate speakers were a novelty and the maximum separation of the speakers in a 'hi fi' radiogram was on the order of a few feet; then, they needed all the stereo separation they could cram onto a record. Since then the physical separation of the speakers has increased, while the electronic separation has decreased. So much so that many modern recordings sound like they were made by dedicated members of the "Back-to-Mono" club.

Since one cannot easily pull the walls apart to get increased separation, speaker placement is generally a matter of compromise between acceptable channel separation and the size and shape of the listening room. There is an alternative, however. It is possible to electronically separate the channels during playback, and this has the same effect as physically spacing out the speakers.

## Sound in Space

A simple but effective circuit for achieving this is the subject of this article. But first to understand how it works it is necessary to understand the difference between stereo and mono sound recordings.

A mono recording is quite simple: all the information — vocals, instruments etc. — are all recorded as one signal. A stereo recording on the other hand consists of two signals or channels, which between them contain all the information. When the recording is made a single instrument can be placed on either the left channel or the right channel by means of a 'Pan' control (actually a simple potentiometer); rotating the Pan pot to the left

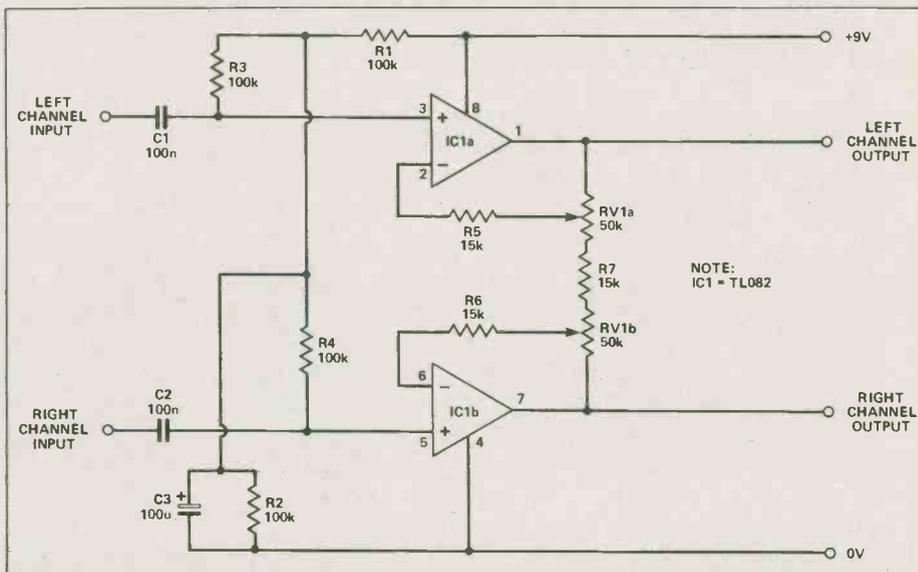


Figure 1. The circuit.

puts all that signal onto the left channel, while rotating it hard to the right puts the sound on the right. Leaving the control set to the middle position effectively places the sound in the centre of the stereo image because the sound levels recorded on the left and right channels are equal.

However, the perception of stereo-phony also depends on the phase difference between the signals on each channel and it is this phase difference, which is imparted when the instrument is recorded in stereo, that enables us to further separate the sound *after* it has been recorded; if these phase differences are emphasised we can effectively increase the stereo separation.

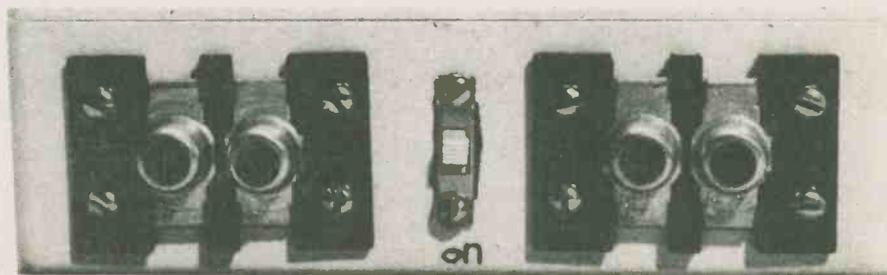
## Spaced Out Circuit

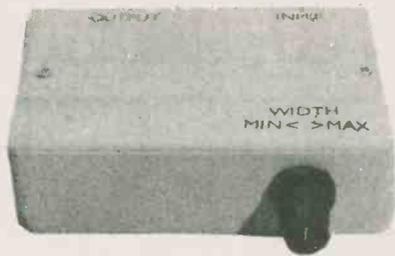
The diagram of Figure 1 shows the complete circuit of the Stereo Spreader. The Left and Right channel inputs are directly coupled by C1 and C2 to the non-inverting inputs of opamps IC1a and

IC1b. To avoid the use of two batteries the op-amps are biased to half-supply by the resistive divider network R1, 2 and 3; capacitor C3 bypasses to ground any AC signal at the junction.

The op-amp outputs are connected together via the two halves of RV1 and R7. Now both are connected as non-inverting amplifiers, with feedback from each output to the respective inverting input via RV1a or b. Like all op-amps they will attempt to keep their inputs balanced by adjusting the output until the voltage fed back to the inverting input equals that present at the non-inverting input.

If the input to both op-amps is the same — i.e., in phase — then the outputs will be the same and normal op-amps action will apply. However, if the inputs are out of phase then the outputs will no longer be identical, so that part of the output of one op-amp will be coupled via RV1a, b and R7 to the inverting input of the other amplifier. This will then com-





pensate for the extra voltage and, in doing so, will produce a larger out-of-phase 'difference' signal.

The amount by which the difference signal is amplified is determined by RV1, which sets the amount of difference signal coupled from one op-amp to the other and therefore functions as a width control. A dual potentiometer is used here for convenience, so that it is not necessary to have to adjust two controls.

### Construction

The Veroboard layout is shown in Figure 2 and, as long as the cuts are made in the right places and the board checked after assembly for unwanted solder bridges across tracks, there should be no difficulty in completing this part of the project.

For maximum flexibility the unit has been designed to be connected between the audio system's pre-amplifier output and the power amp input. If these are not

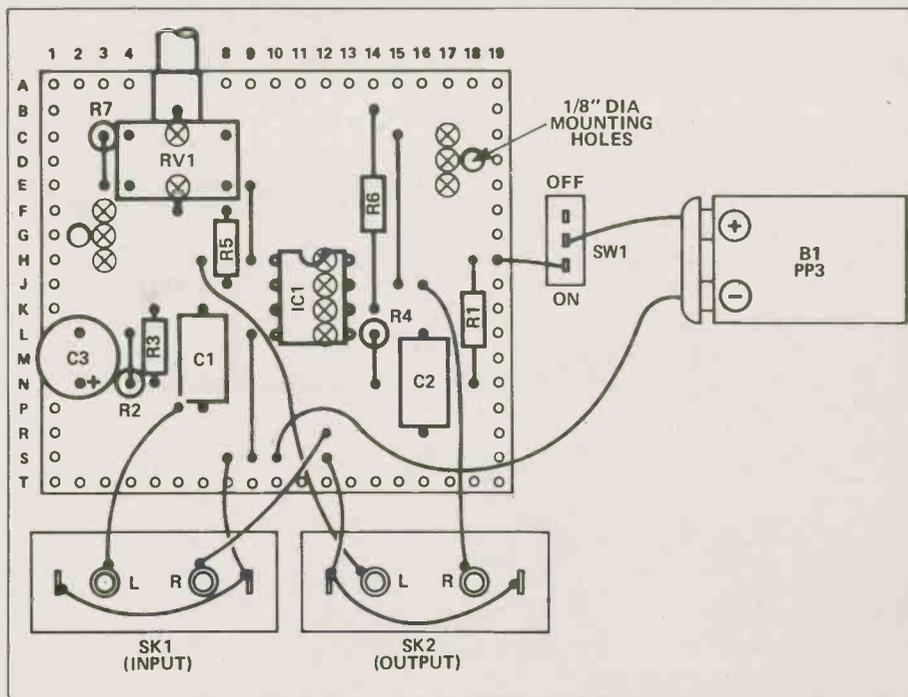
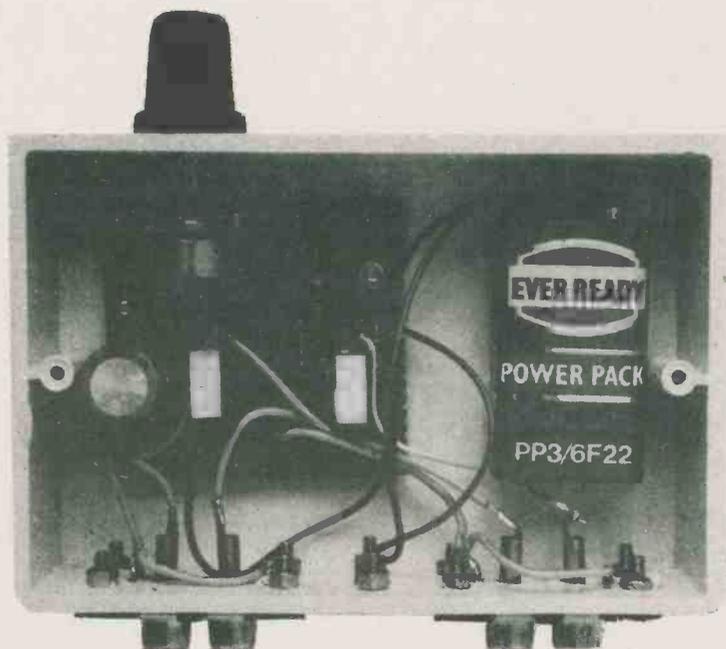


Figure 2. The Veroboard layout. The Stereo Spreader must be connected between the preamp and the power amp.

separate components in your system, check the back of the amplifier; most modern amps bring out the preamp outputs and the main amp inputs on pairs of phono sockets on the rear panel. If there is no way you can connect the Stereo Spreader between preamp and power amp, you will have to consider some other method of increasing your stereo separation, such as moving house or

demolishing some walls! The only other alternative is to use the spreader with taped music only, in which case it can be connected between the recorder output and the amplifier inputs.



### PARTS LIST

#### Resistors

(All 1/4 watt 5% carbon)  
 R1, 2, 3, 4.....100k  
 R5, 6, 7.....15k

#### Potentiometers

RV1.....50k

#### Capacitors

C1, 2.....100n polyester  
 C3.....100u 10v radial electro

#### Semiconductors

IC1.....TL082 dual BIFET op-amp

#### Miscellaneous

Veroboard, 17 strips x 20 holes; 4 phono (RCA) sockets; case (115 x 80 x 35 mm); 9V battery; wire, solder, nuts and bolts etc.

# AM Stereo



**After enough corporate angst to have warmed Karl Marx's heart, AM stereo has finally become a reality. Roger Allan has the details.**

THE PRIMARY reason for AM stereo is to allow AM stations to compete more effectively with FM stations by improving the technical quality of the AM service.

Although AM does have a higher noise level than FM, the audio quality limitation is primarily due to poor radios. Most AM stations transmit audio to beyond 10 kHz, while FM signals go to 15 kHz, about the limit of human hearing. Further, virtually all AM radios use the antiquated envelope/diode detector process to recover modulation. Envelope detectors are inherently prone to the production of various types of distortion and other undesirable effects. One way that AM radios can be improved is by extending the bandwidth for better frequency response, and by replacing the envelope detector with a synchronous detector for reduced distortion.

However, the Federal Communications Commission (FCC) and the Canadian Radio and Television Commission (CRTC) regulations prohibit, for technical reasons, the expansion of bandwidths, negating the first of the above methods of improvement; while market constraints, e.g. the replacement of several tens of millions of radios currently owned by private individuals, preclude the

changeover from envelope detectors. All that was left was the introduction of AM stereo.

The development and introduction of AM stereo over the past few years is positively Byzantine in its complexity, with many long knives being firmly embedded in many corporate backs. However, the end is in sight — we think.

Essentially, in the mid-70's, a series of researchers at Motorola in the US determined the basic groundwork for compatible quadrature modulation to provide AM stereo transmission and reception. Very quickly other companies — Belar, Harris, Kahn-Hasseltine and Magnavox — jumped into the fray and developed their own systems of reception. The difficulty was that the five systems were mutually incompatible, e.g. a radio would be able to receive the signal generated by only one of the five transmission methods. Needless to say, radio manufacturers were unwilling to produce radios under such a constraint, and an appeal was made to the FCC to choose a system which would be the industry standard.

In 1980, the FCC, for reasons best-known to themselves, chose the system dev-

eloped by Kahn-Hasseltine. Much industry objection. The FCC reverses its decision. In 1982, the FCC authorizes stereo broadcasts on AM radio stations, but does not decide which competing technology will be the industry standard. Instead the Commission will accept whatever technologies it finds feasible and allows the marketplace (in line with Reaganomics) to decide which technology, if any, will become the industry standard. Belar essentially drops out, and Magnavox lowers AM stereo's priority in its R&D budget. Harris, Motorola and Kahn-Hasseltine commence battle, each claiming its system is better than the others. Radio station execs are unsure of what to do, due to the high (40-120,000 dollar) cost of converting the station. Some jump the gun and buy Motorola, others Harris, some Kahn-Hasseltine. Most stay put and smile wanly, waiting for the dust to settle.

In late 1982, Motorola scores a coup — after extensive testing General Motors accepts their C-QUAM (Compatible Quadrature Amplitude Modulation) system for inclusion in all their car radios beginning in 1984. Much gnashing of teeth among radio station execs who have bought what now appears to be incompatible transmitting

equipment, and champagne in Motorola's boardroom.

## The Japanese Connection

Enter the Japanese — specifically Sony and Sansui. Knowing a good thing when they see one, they have independently and *very* quietly been developing a receiving chip which can accept *all* four seemingly incompatible transmission modes. Their introduction in January 1983 results in smiles of relief among radio station execs. Motorola execs revert to black coffee, as General Motors' lawyers sharpen their pencils and start hunting for contractual loopholes.

The Sansui/Sony chips are generically identical and apparently non-proprietary once one gets past the stage of whether the transmission mode is linear or non-linear. The Sansui chip, using a PLL synchronous detector instead of a conventional envelope detector, does this automatically, improving the signal to noise ratios and expanding frequency response. The Sony chip, while producing the same final result, requires the operation of a switch to determine whether the incoming signal is linear or non-linear.

It is not the purpose of this article to tiptoe through the bells and whistles of the four systems detailing their intricacies with the reverence of a Papal acolyte, but rather



to demonstrate the essential differences between the two main thrusts in the technology — linearity and non-linearity.

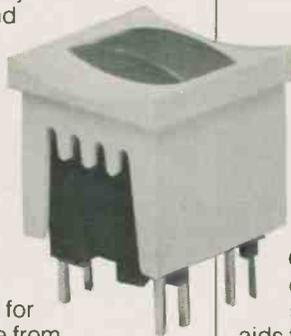
A linear system is one in which superposition applies, that is, the system response to several inputs applied simultaneously is the same as the sum of the system responses when the inputs are applied individually. A non-linear system is one in which superposition does not apply.

Non-linear systems are best known from their application in the modulation of FM broadcasting. It has several advantages, the most prominent of which is its noise rejecting characteristics. However, such systems are dependent on spread spectrum systems (FM or PM, e.g. phase modulation)

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which trade improved noise rejection for increased RF bandwidth. But, in both the US and Canada, broadcast channel bandwidth allocation does not allow any increase in bandwidth — therefore no signal to noise ratio improvement can occur. In fact, non-linear AM stereo systems actually decrease the signal to noise ratio. Envelope modulation of L+R and angle modulation for L-R are present simultaneously and when the L+R signal changes the envelope modulation to reach -100% (known as pinchoff), the L-R signal disappears entirely, and no L-R modulation can be recovered.

Proponents of non-linear modulation techniques have not done so to improve signal to noise ratios (since non-linear systems actually degrade it) but rather as an attempt to obtain compatibility with envelope detectors already in place in most radios. The envelope detector, being a non-linear device, produces a distorted version of the amplitude modulation applied to it. By pre-distorting the I (In Phase) and the Q (Quadrature phase) elements of an AM stereo signal, it is possible to compensate for the distortion of the envelope detector. The pre-distorted non-linear AM stereo signal has an infinite number of sidebands, and in practice 3 or 4 orders of these sidebands are significant. To achieve compatibility with envelope detector receivers, all of the pre-

distorted sidebands must be present at the receiver. However, this is not possible with most AM radios because the narrow IF bandpass filter the signal must pass through changes the relative amplitude and phase relationships. The only effect filtering at this stage will result in is distortion of components on mono as well as stereo receivers.

There are two types of compatibility distortion with non-linear systems: harmonic distortion and difference tone intermodulation distortion. Essentially, harmonic distortion occurs when a tone is transmitted and the high order sidebands of the linear system are altered in amplitude or phase. Difference tone intermodulation distortion on non-linear signals occurs in the opposite instance: in this case the desired signal is rejected by the radio, and only the accompanying low-frequency predistortion signal is received. This type of radio artifact is particularly objectionable since it is uncorrelated with any other signal in the radio output. This difference-tone distortion mechanism causes high-frequency programs to "throw trash" into the low-frequency range.

Proponents of this type of system argue that this type of distortion is of little significance since the program material generally contains high frequency energy. However, the use of pre-emphasis, that is, the boosting of higher modulated frequencies by as much as 20 to 30 dB (which is customary in radio transmissions for aesthetic reasons) severely aggravates the filtering related compatibility problem of non-linear systems' signals.

As mentioned above, linear systems are those for which superposition applies. There are two important characteristics of linear systems, specifically that only one set of sidebands is produced on the same bandwidth as mono transmissions, and the linear product detection in both L+R channels means that there is no "noise burst" problem. The stereo signal consists of a monophonic sum signal with the linear addition of a double sideband suppressed carrier L-R signal in quadrature with the carrier. Since both signals have only one set of sidebands, and since addition is a linear process, the resulting stereo signal also has only one set of sidebands. No new frequencies are created by adding the two signal components. Further, this system is compatible with pre-emphasis and with synchronous detection (eg. non-envelope detection). A synchronous system has the advantage that there is no distortion due to receiver mistuning, selective fading or AM multipath (signals bouncing off buildings and suchlike).

### Listening to the Radio

Yet, the proof of the pudding is in the eating, or rather, in this case, in the hearing by real live human beings. When defining the compatibility of the system with the human ear, the general evaluation is

customarily considered to be low distortion. Distortion is usually taken to mean total harmonic distortion, or THD. The criteria for the evaluation of distortion should accurately represent the sensitivities of the human ear. For example, second order harmonic distortion is only objectionable when very large. On the other hand, difference tone intermodulation distortion is quite objectionable to the ear and should be of more consideration to the designers of these systems. In comparing non-linear with linear systems, it appears that while the linear systems have a higher THD than non-linear, that the bulk of the THD produced is in the second harmonic. In general, even order harmonic, such as second, fourth, sixth, etc., are less objectionable than odd-order harmonics. Further, the lower the order of the harmonic the less objectionable and audible it is. As such, second order harmonic distortion, which is produced more in the linear systems than in the non-linear systems is in fact less objectionable than the converse.

Essentially then, quadrature modulation is very appealing for application in AM stereo, since it will provide a chance for AM stations to compete with FM more effectively. Of the several systems in place, some simply reduce the amplitude of the L-R channel, thereby incurring a signal to noise ratio penalty. Other systems sacrifice the linearity of the system in various ways, forcing the transmitted envelope to be  $1 + L + R$ . These non-linear systems occupy excessive bandwidth, and in spite of the fact that the transmitted envelope is  $1 + L + R$ , radio IF bandpass filtering causes the non-linear system to generate distortion at the radio's envelope detector.

While Australian and British stations have been experimenting with the various systems, it is in the United States where the majority of AM stereo stations exist, currently numbering about 100. Here in Canada, the CRTC has licensed (for three months, extendable upon application) 15 stations across the country for AM stereo usage. The cost for the chips manufactured in the US, such as Motorola's, is about \$2 (US), with volume production coming on stream at the end of 1983. As for the Japanese, their chips and radios with the chips already built in are being snapped up as fast as they can produce them, with the bulk of shipments to this country being purchased by radio stations for testing and promotional purposes, though some are now beginning to appear in the shops. Further, when volume deliveries of the Japanese chips become available, it will be possible to retrofit them into radios already equipped for FM stereo reception with only minor auxiliary parts required, the major part being a ceramic resonator.

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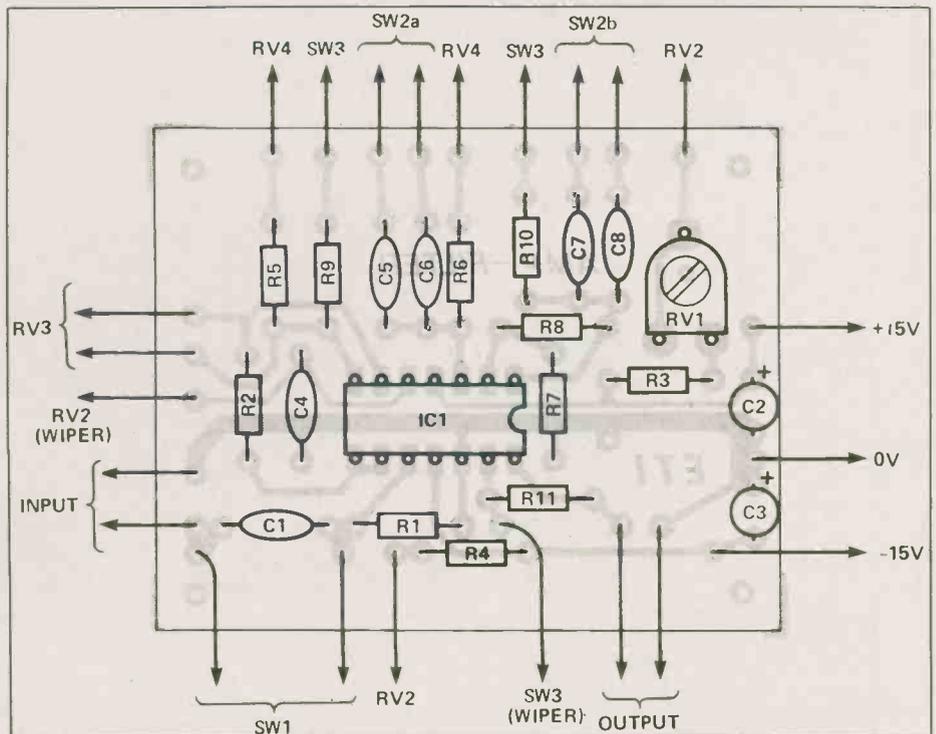
# DAC/ADC Filter Amplifier



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ANYONE WHO HAS ever seriously experimented with analogue interfaces to home computers must be all too aware of the problems involved — if you're not too careful you wind up with op-amps everywhere in a variety of hastily concocted amplifier, buffer, and filter circuits. And some of them won't even be hastily concocted; some of them will have taken up a considerable amount of your precious time in the designing. What you need is a handy little unit that will perform any or all of the functions of amplifier, buffer, and filter at the mere twiddle of a control or two. What you need is the ETI filter-amplifier.

The filter-amplifier consists of two active blocks together with input and output buffers and switchable AC or DC coupling. The two active blocks are an amplifier with a variable gain of 0 to 100 and a plus or minus five volt variable offset followed by a low pass filter whose cutoff frequency may be varied over the range 16 Hz to 30 kHz and which may be switched out of circuit when not required. It can be used as an amplifier to match low level signals to the input of an ADC, as a buffer to correct mismatching of signal sources, as a filter to



Component overlay for the PCB.

smooth the stepped output of a DAC, and for a multitude of other similar purposes.

## Construction

Assembly is simplified by the use of a single quad op-amp for the four stages, and the

only point to check on the PCB itself is that this IC and the two electrolytic capacitors (C2, C3) are inserted the right way around. Take care with the wiring of the potentiometers and switches, especially SW2 which has two separate elements whose wiring

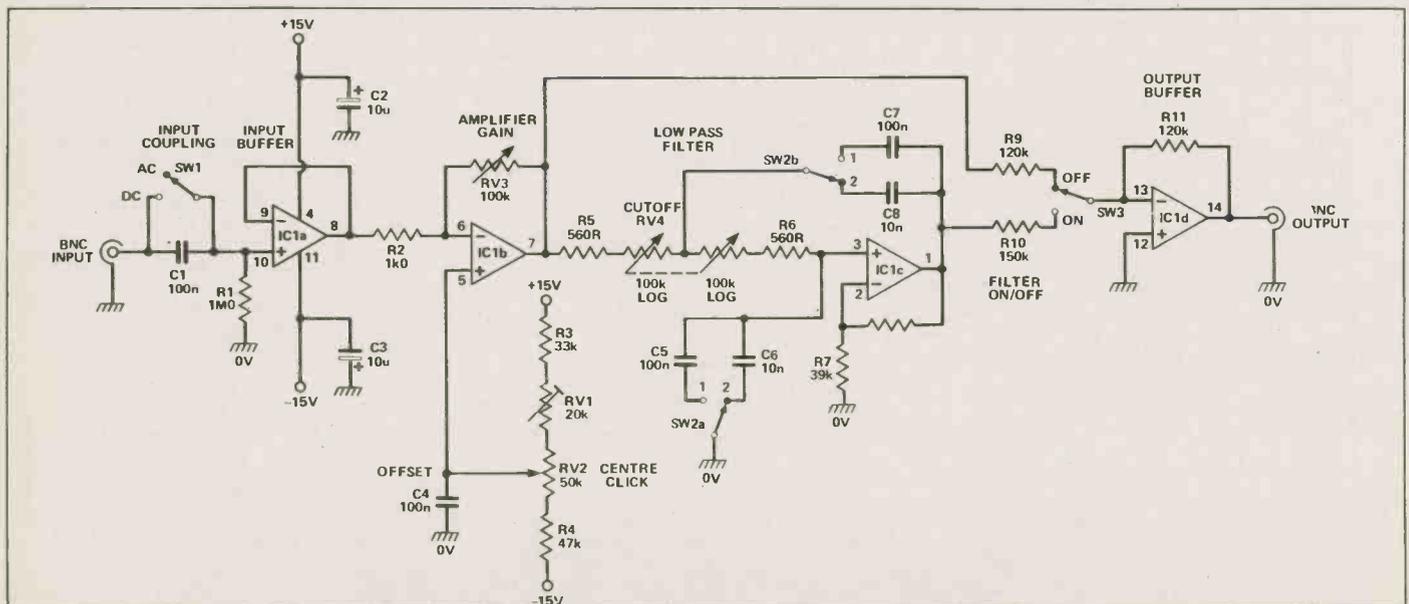


Fig. 1 Circuit diagram of the filter-amplifier.

must be in agreement if the filter is to work correctly. Note also the wiring around RV4 and the connection between this potentiometer and SW2, as shown in Fig. 2.

We have not shown either a case or a power supply for this project because it is intended more as a building block than as a complete, self-contained unit. For the really serious experimenter there is obviously a lot to be gained from having several of these filter-amplifiers built into a single unit and equipped with a common power supply, whereas for others, one would probably be sufficient and could be powered from whatever you're using to supply the ICs you're experimenting with.

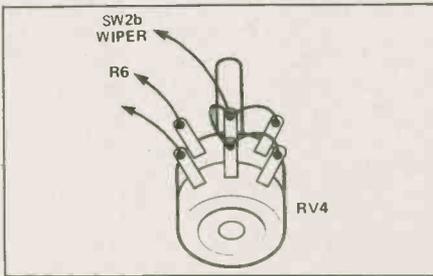
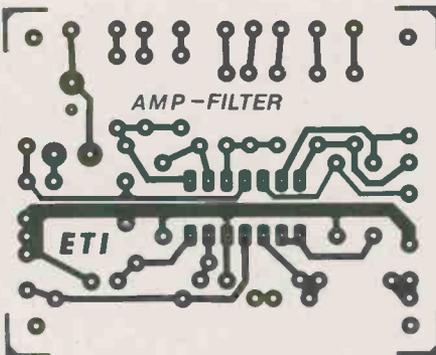


Fig. 2 (below) Connections to RV4



PCB for the DAC/ADC filter amplifier.

#### HOW IT WORKS

The input signal is passed via either C1 or SW1 to IC1a, the first stage of the TL074 quad BIFET op-amp, which acts as a buffer. The signal is then amplified by IC1b, the gain being set by R2 and RV3. RV1 and RV2 set the offset voltage, RV1 being preset such that the offset is zero when RV2 is in its centre click-stop position.

IC1c and its associated circuitry form a low pass filter of the second order Bessel type which is well suited to the smoothing of stepped signals, such as those obtained from DAC outputs. The filter's cut-off frequency may be adjusted using RV4 and the range switch SW2, the latter selecting either 16Hz to 3 kHz (position 1) or 160 Hz to 30 kHz (position 2). The gain of the stage is set by R7 and R8.

SW3 selects either the amplifier or amplifier plus filter outputs via R9 and R10, the slight difference in their values being necessary in order to allow for the gain (approx. 2.3 db) of the filter. The signal then passes through IC1d, the final buffer stage, to the output.

#### PARTS LIST

##### Resistors (all 1/4 W, 5%)

R1	1M0
R2	1k0
R3	33k
R4	47k
R5, 6	560R
R7	39k
R8	10k
R9, 11	120k
R10	150k
RV1	20k horizontal trimpot
RV2	50k linear with centre click-stop
RV3	100k linear

RV4 100k dual gang log

##### Capacitors

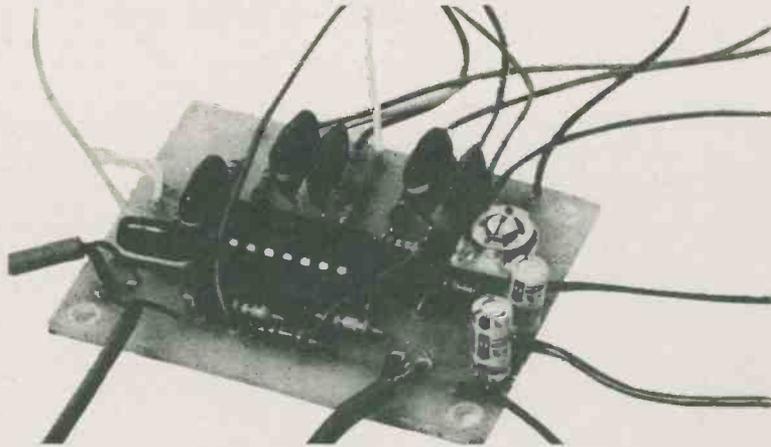
C1, 4, 5, 7	100n polyester
C2, 3	10u 35V tantalum
C6, 8	10n polyester

##### Semiconductor

IC1 TL074

##### Miscellaneous

SW1	SPST
SW2	DPDT
SW3	SPDT
PCB; case, input and output sockets, knobs, etc. as desired.	



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# Commodore Executive SX64

## CBM packages the popular 64 in a portable case complete with a disk drive. Bill Marwick takes a look

COMMODORE BUSINESS Machines has decided to enter the portable computer field by packaging the workings of the Commodore 64 in a sturdy metal case with one disk drive and a five-inch colour monitor. Add to this Commodore's software for business applications, and you have the makings of a product that could be aimed at the commercial or educational market. One of the strong selling points is compatibility with existing software and peripherals for the VIC-20 and 64. It has all the familiar functions: 64K RAM, sound synthesizer, sprites, 320 by 200 pixel graphics, and others. The suggested list price is \$1200.

Since the Commodore 64 was reviewed in ETI, July, 1983, this review will look at applications of the SX64 rather than tinkering under the hood.

Starting with the packaging: you'll find the case good and solid, fairly heavy at 12.5 kg, and sized at approximately 43 by 43 by 13 cm. You wouldn't want to go jogging with it, but it sure beats doing a balancing act with a monitor, a power supply, a 64, and a drive.

### A Quick Tour

Unlatch and remove the front cover; on the inside of it is a full-size keyboard with 66 keys identical to the regular 64. A cable plugs easily into the keyboard and awkwardly into the computer's underside, and the usual three-pin power cord plugs into the back. During your travels, you can fold the cords into a storage space above the disk drive; Commodore supplies you with a cord case evidently made from floppy disk boxes, but everybody will probably cram them into the computer anyway.

On the top of the computer, you'll find the slot and connector for ROM cartridges, and on the rear panel are the two joystick ports, the DIN plug for audio/video, the DIN plug for another disk drive, the expansion bus, a fuse, and the power switch. Current consumption is

one ampere at 117 volts. In other words, it has exactly the same features as the regular 64, except for slightly higher power consumption because of the add-ons. There's a carrying handle which doubles as a tilt stand if you fight with two little latches that let it rotate around the front of the computer.

### The Monitor

A five-inch monochrome monitor is hard enough on those of us who don't have microscopes for eyes, but a colour unit? Since it's safe to say that potential customers will at least view the screen before buying it, it isn't necessary to go on at length. Suffice to say that the apparent resolution is coarse, very coarse; passable for video games, but colour bleed makes text difficult to read.

A good giggle was to load in an 80-column word processor; the screen was just one big smear. It was usable on 40-column.

Some improvement can be made by changing the screen to black and white; this is POKE 53281,0 CTRL 2. This



## Computer Review

doesn't work if your software uses its own colour control codes to reset the colour anyway. You can also fiddle with the display controls; behind the CBM logo on the right-hand side is a tiny door which conceals colour, tint, contrast, and so on. There's also a volume control for the internal speaker.

### The Disk Drive

The ordinary 64 can use a CBM 1541 disk drive with 170K of storage capacity and a serial in/out system. The apparent reason for this is to simplify the wiring for hooking several peripherals together ("daisy-chaining"); it keeps your carpet from looking like a trawler net. The disadvantage to the minimum-wire serial system is that the data feeds in or out one bit at a time instead of one byte at a time — obviously everything runs much, much slower than, say, a CBM 4040 parallel drive.

Commodore has made the peculiar decision to incorporate this 1541-type



drive into the Executive. This means that loading a program is painfully slow: a large program took two minutes to amble into the memory; compare this to the ten seconds or less taken by an Apple running CP/M. This waiting around isn't exactly outrageous, and it's acceptable for noodling about with games on a lazy Saturday, but it's annoyingly tedious for any serious work with spreadsheets, word processors, or other business software.

The name Executive implies a business-oriented computer; the decision to use the serial drive proves a serious drawback in light of this. On the other hand, if you have to use up a warehouse full of 1541s...

### CP/M?

CP/M is the famed disk- and file-handling system which does such a great job of almost instantly locating and loading any file from any disk with simple commands instead of all those frustrating syntaxes used by most small micros, including CBM's. Commodore is not selling the necessary option in Canada, supposedly not until the spring, though they may have it together by the time you read this. Of course, CP/M would be slowed down considerably by the serial drive anyway.

Should you have been dead keen on CP/M, though, a Toronto firm called Computer Workshops Ltd. has come up with the necessary Z80/80-column additions. You can contact them at 465 King St. E., Unit 9, Toronto M5A 1L6. Keep in mind that 80 columns are not usable on the Executive without an external monitor.

### CBM

Commodore Business Machines supplied the computer for review with no manuals and no further information. Several calls to the company produced two manuals; they were the same ones you can get for the ordinary 64, and they hadn't sent any information about the disk operating system. If this wasn't just an oversight, a lot of customers will be left puzzled, because there's very little disk information in the computer manuals. We're left wondering about things that are not apparent from staring at the computer itself. There's a little Reset button near the video controls, for instance, and it didn't seem to do much. Is it for those unfortunate moments when a program hangs up? You

## Computer Review

might well ask. We also received American press releases showing the Executive with dual disk drives, but the local public relations people said that only a single drive is now available. An interesting marketing approach.

### A Trial Run

They did manage to include some optional software, though. The first was the Easy Script word processor. This consisted of a manual, a quick reference card, and two apparently identical disks containing the program. I'm not sure if the two disks were a mistake, but it's nice to have a backup.

The main menu, which appears after two minutes of loading, asks you to configure the program to suit: text width, disk/tape, and printer type. The text width doesn't change the size of the characters, but makes the screen into a window which scrolls over the text width you've selected (up to 240 columns).

The Easy Script is generally nice to use; the function keys become control codes, which is convenient. It has a few oddities, of course: calling up the disk directory munches through your text if

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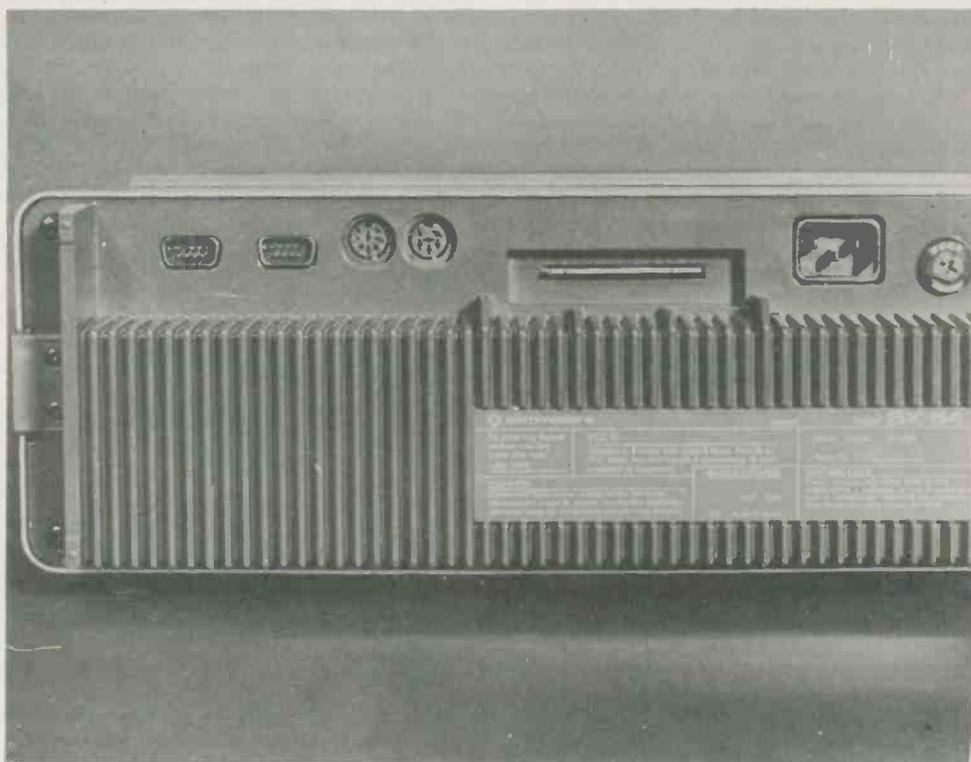
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you didn't happen to notice in the manual that you should have saved it to disk first, and the cursor commands are a bit cumbersome: end-of-text, for instance, is F1/G/E(R). This is needlessly complicated; software writers seem to think we're a nation obsessed with touch-typing. There is also no automatic justification of the right margin; this has to be done manually with RETURNS; this is a real pain if you're used to auto wordwrap, but probably no bother if you're coming into it from a typewriter or similar word processor.

**The Manager**

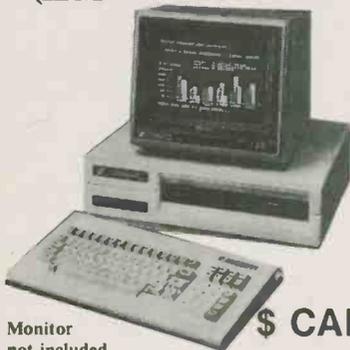
If you have a computer with everything included in the case, it would make sense to have a business program with all sorts of applications included on the disk. Such a program is The Manager, supplied for the 64 by Commodore. It consists of a manual and a disk.

After a two minute load, you're presented with a menu which lets you format a disk, among other things. Good thing, too. There must be a lot of 64 owners out there phoning their dealers to say that they can't find anything in the



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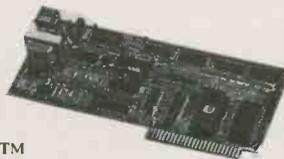
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manual about formatting. Some of the other things you can do are Arithmetic, Create/Revise files, Report Generate, Manipulate Files, and Word Process.

Well, let's see. Think I'll select the word processor. There we are. Hmm. It wants me to insert an Easy Script disk into the machine. I've already covered Easy Script, so I'll press F1 to get back to the main menu. Thank goodness for F1. Some software makes you reload because you can't get out of a loop. Anyway, here goes. Odd, it has to go and get Arithmetic from the disk, and it takes 40 seconds to load. I guess this is software for managers with time on their hands: if you loaded the word processor and then decided to transfer the text to a Manager function, you'd be staring at the ceiling for about three minutes.

Ah, there we are in Arithmetic, and it's asking for a filename. Okay, "PLORK". Now it says "file not found — directory?" Yes, thanks, I'll have the directory. Right, we'll try to manipulate the "Checkbook" sample. Now it's asking for line and column and length numbers, and it isn't doing what the manual says and I can't get out of it without F1. Apparently I wasn't meant to start with Arithmetic, which likes to work inside an existing user file. You'd have to want to do arithmetic pretty badly to wait through the loading.

I'll try Create/Revise, since it's first in a very confusing manual; it isn't clear about having to do things in order. After a 50 second reload, PLORK has been created as a file in its own write (sorry). You can then type in whatever format your file would like; areas for future data entry, for example, can be delineated by vertical arrows.

OOPS! I just hit RESTORE, which is above the RETURN key, and the disk just took off. After 30 seconds, the screen announced that I would like to back up a diskette. I would?

I don't think I can stand another 50 second reload just to get back to a test file.



This time I try Enter/Edit (another reload) and ask for the "Checkbook" sample. Up it comes, after a while. The graphics are quite good, with a c-h-e-q-u-e displayed in various colours. Amounts (and other information) could be typed into the appropriate spaces. The same goes for the Christmas List sample program, which lets you store away all sorts of facts about your friends and enemies.

OOPS! That RESTORE key got nudged again... abandon ship.

## Calc Result

This spreadsheet arrived with the Executive, but is actually published by Handic Software. It's a manual, a disk, and a ROM cartridge. After loading for some minutes, it asks you which of a number of languages you'd like; I mean humanoid ones, not computer languages. This is a nice touch. Now it would like you to make a backup disk and a work disk; this takes over ten minutes, although you only have to do it once.

Thereupon, a sheet is spread for you. F5 gives you a help menu, though I could only get it with the original disk; it didn't seem to be present on the backup. The screen layout itself is nine columns by 21 rows; the cursor can be scrolled over the entire spreadsheet, which is 63 by 254. Co-ordinates can be typed in to move the cursor directly to any spot, and there's auto-repeat on the cursor as well.

You can enter either labels or numerals, and even enter an arithmetic operation; Calc solves the arithmetic and enters the value at the desired co-ordinates. Then you can specify various operations from one spot to another: B2-B4, 40% of B2, and so forth. The final result (the famous "bottom line") appears; if you change any value, the whole works is re-calculated.

Like most spreadsheets, Calc Result lets you split the screen. To show the entire sheet would require a screen the size of the wall; splitting it lets you look at rows and columns that are too far apart for the normal display.

This program was friendlier than the others, and didn't require interminable loading whenever you wanted an option. The Restore key didn't dump things for you, either.

## Summary

Keeping in mind that the colour screen is a wee bit hard on the eyes, and that the disk drive will appeal only to those who've never used anything but cassette loading, \$1200 suggested list isn't too steep a price to pay to get all your peripherals in one box, especially if dealers discount the price.

The software sent to us seemed too slow and cumbersome for any business use except the occasional weekend dip into the bytes. However, if you're intrigued with the Commodore 64 and its many possibilities, and want the convenience of portability, this is a good unit to investigate.

## Quick Reference

### Commodore Executive SX-64

<b>Mfg:</b>	Commodore Business Machines
<b>Price:</b>	\$1200
<b>CPU:</b>	6510
<b>RAM:</b>	64K
<b>User RAM:</b>	38K
<b>Software Included:</b>	BASIC 2.0
<b>Screen Format:</b>	40 x 25
<b>Graphics:</b>	320 x 200
<b>Colour:</b>	16 available
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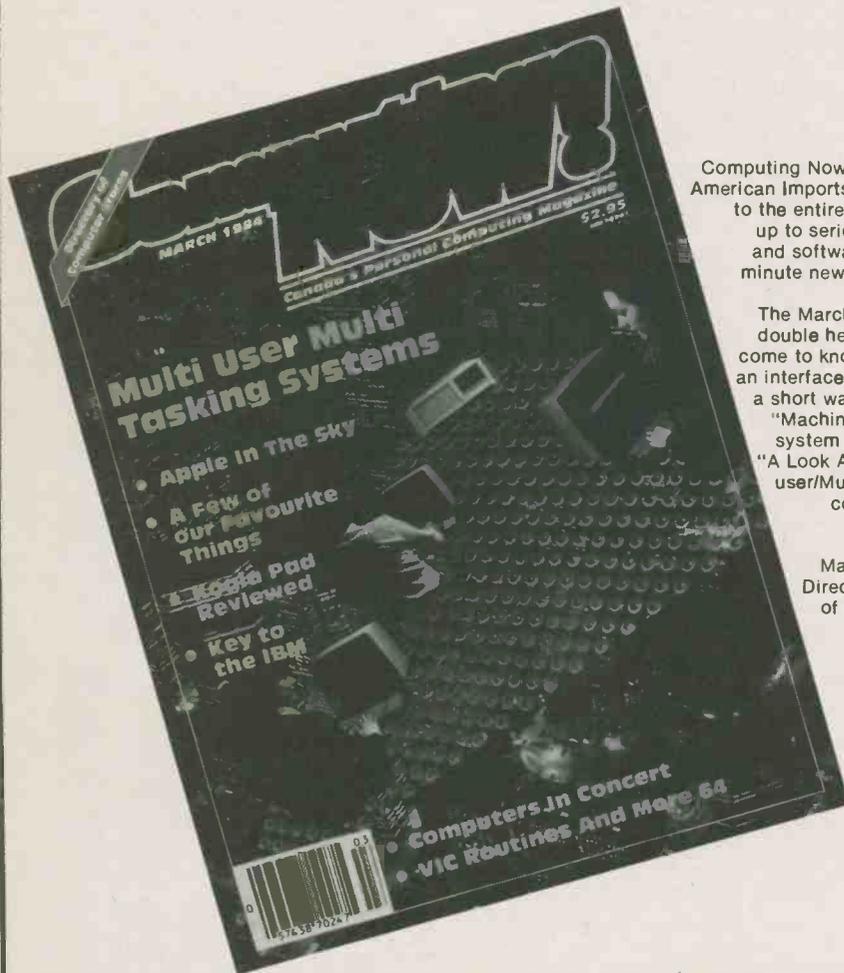
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The March issue of CN! for example, will be featuring the usual double helping of articles and features that CN!'s readers have come to know, including "Receiving Radio Teletype on an Apple", an interface to allow one to pick up news wire transmissions from a short wave radio and decode them into text. There will also be "Machine Language on VIC-20's and 64's" to help Commodore system users to explore the inner workings of their machines. "A Look At Dedicated Terminals" and "An Introduction to Multi-user/Multi-tasking Systems" will dispell a lot of the myth and confusion that's built up around this aspect of high end business micros.

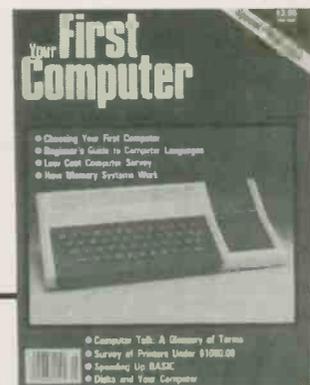
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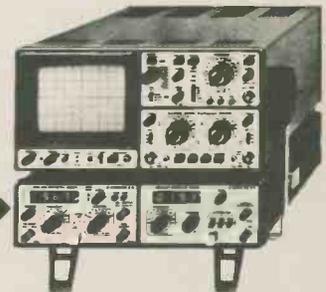


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# Book Review

## How To Maintain and Service Your Small Computer

SOONER OR later you may have the bad luck to become the owner of a misbehaving computer. The trouble will usually be one of two types: the first is the permanent fault, which is always there, and the second is the maddening glitch that only appears after you've typed in three pages of programming; it may only change one word to something else, or it may ignore the keyboard and stubbornly refuse to let you do anything but pull the plug.

The first type of trouble is the easiest to find, because the fault will hold still to be measured. The second is a little more challenging. In either case, where do you start?

**How To Maintain And Service Your Small Computer** is a very good place indeed. This 208-page softcover is a wealth of information for someone reasonably familiar with basic test equipment, such as multimeters, logic probes and scopes. At least you now have a place to start, once you get under the hood and realize that there's a lot going on in there, and all of it looks hard to find.

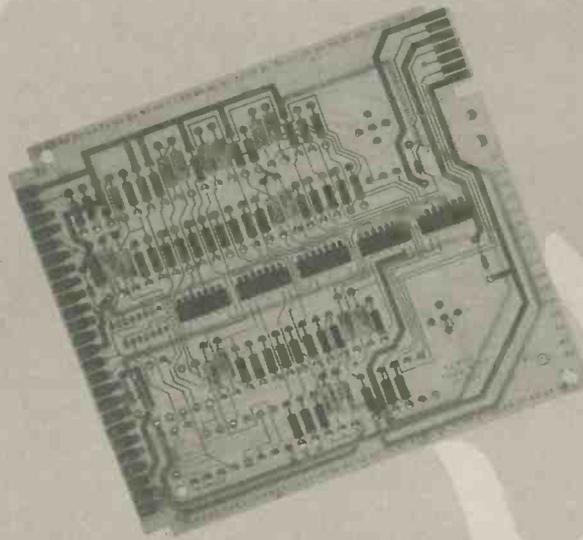
The book begins with some sensible advice concerning the quality of the power line, disk care, and interference with your TV set. There isn't much point in crunching through your computer's innards if the fault lies with 5 KV spikes coming down the hydro wires.

The next part gets a bit silly; there's a guide to what basic meters look like, the types of screwdrivers, and even advice on how to lift heavy objects safely. Oh, well; you never know. Perhaps someone who doesn't know how to lift heavy objects can find their way through computer circuitry. Once you get through this, though, there's an excellent guide to the structure of the circuitry; the function and in-circuit testing of passive components is well covered and explained. Occasionally it's just a bit misleading for the inexperienced: advice is given on how to test the power switch with an ohmmeter, but the authors recommend turning off the power instead of pulling the plug. It might be smoky ohmmeter time.

Chapter Seven has an excellent explanation of the computer's layout, and how you go about using a scope and logic probe to trace the signals. Naturally, a

## How To Maintain And Service Your Small Computer

John G. Stephenson and Bob Cahill



John G. Stephenson, Bob Cahill. Howard W. Sams and Co., Indianapolis, Indiana, 1983. Distributed in Canada by Copp Clark Ltd., 517 Wellington St., Toronto, Ontario.

book this size can't possibly include all the different makes and their methods; the reader is expected to have some ingenuity at translating the generic approach into his computer's specific hardware.

Chapters Eight to Twelve cover repair and maintenance of disk drives, printers, cassette systems, and power supplies. There's also a quick look at modems, monitors, and game controllers. As with the computer explanations, the reader shouldn't expect an exhaustive

study, but the topics are explained in enough depth to provide a good beginning.

The book concludes with five appendices of which the IC pinouts and troubleshooting charts will be the most useful. In summary, you may not become skilled in computer repair overnight, but you'll at least know what to look for and where to look for it.

Bill Markwick

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4567 Lougheed Highway, Burnaby, B.C. V5c 3Z7 (604)299-5511 Ext. 322  
Computers from IBM, Apple, Hyperion and Zenith. Eaton's also has one of the widest selections of business, educational, and entertainment software.

H&S Microsystems  
125-5665 Kingsway, Burnaby, B.C., V5H 2G4

Logistics  
7053 Buller Ave., Burnaby B.C. V5J 4S  
(604) 437-9919

Orlon Computer Systems Ltd.  
5480 Pandora St., Burnaby, B.C., V5B 1M1  
(604)291-6141

R-A-E Data Systems Div.  
3455 Gardner Court, Burnaby, B.C. V5G 4J7  
(604)291-8866  
MO CAT  
Wholesale/Retail distributor of Data General 'Desktop Generation' and 'Nova' 16 bit computers and peripherals.

### Castlegar

Castlegar Computers  
2217-10th Ave., Castlegar, B.C., V1N 2Z8

### Clearbrook

Computer Age  
2451 Clearbrook Road, Clearbrook, B.C. V2T 2Y1 (604)859-4151  
Authorized Apple, IBM Personal Computers, Okidata, Transtar, Brother dealer. Specialize in business, professional and education.

FVL Computerage  
102-2451 Clearbrooke, Clearbrook, B.C.

### Coquitlam



Computer Innovations CN  
100-2929 Barnet HW. Coquitlam, B.C. V3B 5R5

Paragon Computer Group Ltd.  
567 Clarke Road, Coquitlam, B.C., V3J 3X4  
(604)939-6461

Radio Shack  
435 North Road, Cariboo Shopping Centre, Coquitlam, B.C., V3K 3V9 (605)931-7533  
Radio Shack TRS-80 Models II, III, 16 and colour computers. Hardware and software for each, plus all related peripherals.

### Cranbrook

Cranbrook Photo & Computers Ltd.  
800 Baker St., Cranbrook, B.C., V1C 1A2  
(604)489-5336  
MO  
Franklin Ace 1000, Corona (desktop and portable).  
Printers, peripherals, software (Apple & IBM)

Roberts Computer Systems  
1139-D Industry Rd. #3, Cranbrook, B.C., V1C 5A5

Tarus Computers  
223 Cranbrook Street, Cranbrook, B.C. V1C 3R1 (604)426-7588  
Business and personal computer specialists.  
Authorized Apple and Atari dealer.

### Dawson Creek

NCS Office Equipment  
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### Grand Forks

KB Computer Centre  
7383-2nd. Street, P.O. Box 1405, Grand Forks, B.C. V0H 1H0 (604)442-3217  
MO  
Sales and service for Franklin Ace & Columbia Data computers, Okidata & Smith-Corona printers, Sharp calculator products.  
Apple & I.B.M. compatible software.

### Kamloops

Conti Computer Systems  
439 Seymour St., Kamloops, B.C., V2C 2G7

Radio Shack Computer Dept.  
450 Lansdown, Thompson Park Shopping Centre, Kamloops, B.C., V2C 1Y3

### Kelowna

Computerland  
1649 Pandosy Ave., Kelowna, B.C., V1Y 1P6  
(604)860-1622  
Retailer of IBM, Apple, Digital, Hyperion and Compaq hardware and software. Complete line of peripherals including Epson, Okidata, C-ITOH, Mannesman Tally printers. Full service centre on-site.

Dynamic Computer Centre  
6-1960 Springfield Rd., Kelowna, B.C., V1Y 5V7

Micro West Data Systems Ltd. ETI/CN  
2340 Hunter Rd., Kelowna B.C., V1X 6C1  
(604)860-4844  
MO

IBM personal computers, Micom word processing, IBM Selectric III typewriters, Brother typewriters, Phillips dictation, Code-a-phone telephone answering.

### Langley

Net Software  
102-20351 Duncan Way, Langley, B.C. V3A 7A3  
(604) 534-1233  
Manufactures of Software for Education and Recreation.

Vulcan Computer Systems  
20571 Fraser Hwy., Langley, B.C., V3A 4G4

### Maple Ridge

Maple Ridge Video  
22403A Dewdney Trunk, Maple Ridge, B.C., V2X 7X7

### Nanaimo

Radio Shack  
2159 Departure Bay Rd., Northbrook Mall, Nanaimo, B.C., V9S 3V5 (604)758-9595  
Radio Shack TRS-80 Models II, III, 16 and colour computers. Hardware and software plus related peripheral equipment.

### Penticton

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Computer Mania ETI/CN  
P.O. Box 1045, Penticton, B.C., V2A 7N7  
(604)493-4565  
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Future World  
126-2111 Main Street, Penticton, B.C. V2A 6W6 (604)493-7777  
MO

Eagle, Kaypro, Franklin business systems. Specialists in TRS80 support. Atari hobby systems. Software support for Apple, Atari, TRS80, Colour, TRS80 model III, VIC 20, Commodore 64, IBM personal, T1 99 4/A, Intellivision, Atari 2600, and Timex Sinclair.

Radio Shack  
209 Main Street, Penticton, B.C., V2A 5B1  
(604)492-5712  
Radio Shack TRS-80 Models II, III, 16 and colour computers. Hardware and software plus related peripheral equipment.

### Port Alberni

Compu\*Mart  
3061-3rd. Ave., Port Alberni, B.C. V9Y 2A4  
(604)724-4733  
MO  
Atari, Commodore, and Sinclair computers, and a wide selection of software for Atari and Commodore machines. Also Percom and Rana disk drives, and Epson printers.

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Datum Electronics Inc.  
11-3000 Lougheed Hwy., Port Coquitlam, B.C. V3B 1C5 (604)464-4424  
Corvus, NEC APC, Columbia, Apple

# Directory of Computer Stores

## Port Moody

Sabre Computer System  
1-2810 St. John St., Port Moody, B.C. V3H 2C1 (604)461-1322  
MO

An authorized service centre offering sales, service and support for business and home computers product lines.

## Powell River

Tomorrowland Computers Ltd.  
145-7100 Alberni St., Powell River, B.C. V8A 5K9 (604)485-6960

## Prince George

Radio Shack Computer Dept.  
1669 Victoria St., Prince George, B.C., V2L 2L5

Sight and Sound Computer Centre  
657 Central St., Prince George, B.C., V2M 3C6 (604)562-0356  
MO

Business and personal applications on most major computer products. Dealer for Apple, Commodore, Atari, Corona, Epson and Timex.

## Richmond

Compucentre  
9945300 Landsowne Park Shopping Centre, No. 3 Road, Richmond, B.C., V6X 2X9

Northwest Digital  
150-10991, Shellbridge Way, Richmond, B.C., V6X 2W8

Paragon Computer Group  
6-4040, No. 3 Road, Richmond, B.C., V6X 2C2

Sound Chaser Computer Music Stm.  
3331 Jacombs Road, Richmond, B.C. V6V 1Z6

## Sechelt

Digitronic Systems  
103 Teredo Square, Box 1897, Sechelt, British Columbia, V0N 3A0

## Sidney

Sidney Compupower  
8720 Pender Park Dr., Sidney, B.C., V8L 3Z5

## Surrey

Clovercity Computers  
13563-King George Hwy., Surrey, B.C., V3T 2V1 (604)581-1615  
MO

TRS-80, MTI, Apple compatibles, Gemini, Okidata, Teitex printers and complete line of software.

Computerworld  
15175 - 101 Avenue, Quelford Village Square, Surrey, B.C., V3R 7Z1 (604)588-2311  
Sales: IBM, Wang, Apple & Hyperion microcomputers.

Sprite Computers Ltd.  
10217 King George Hwy, Surrey, B.C., V3T 2W6

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Complete selection of Apple and IBM compatible computers, software and accessories. Large stock of bare boards and accessories to build computers. Sell kits and components.

## Terrace

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## Vancouver

Active Components ETI/CN  
3070 Kingsway, Vancouver, B.C., V5R 5J7 (604)438-3321  
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Byte Shop Computer Store  
2151 Burrard St., Vancouver, B.C., V6H 3H7

Computer Innovatlons  
674 Granville St., Vancouver, B.C., V6C 1Z6 (604)682-5877  
IBM-PC and XT, DEC Professional, Apple IIe and III, Lisa.

Computer Innovatlons  
1500 West Georgia, Suite 100, Vancouver, B.C., V6G 2Z6

Computerland of Vancouver West  
2156 West Broadway, Vancouver, B.C. V6K 2C8 (604)736-0101-Sales, service and training for IBM, Digital, Hyperion, Compaq, and Apple micro computers.

Computerland  
1035 West Pender St. (Oceanic Plaza), Vancouver, B.C., V6E 2M6 (604)683-6981  
Retailer of IBM, Apple, Digital, Hyperion and Compaq hardware and software. Complete line of peripherals including Epson, Okidata, C-ITOH, Mannesman Tally printers. Full service centre on-site.

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Suite 100-1027 West Broadway, Vancouver B.C., J6H 1E2 (604)732-1258  
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Conti Computer Systems  
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Commodore products and a large line of peripherals and support products.

Conti Computer Systems  
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Data Terminal Mart  
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Eaton's Business Centres ETI  
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Vancouver  
Future Shop  
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Computer books (technical, reference, instructional for home, hobby and business). Full line of computer supplies (disks, paper, ribbons, labels) and IBM software.

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Key Computer  
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Authorized dealer for Apple computers, Nec home and business computers, Columbia data systems, Timex-Sinclair. Accessories such as printers by Epson, Gemini, Okidata, Brother, Transtar.

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Computers: Kaypro, Corona, Televideo, Apple Compatible, Commodore, Tava PC, Chameleon. Printers: Gemini, Transtar, Prowriter. Monitors: Amdek, Zenith. Software: IBM, Apple, Commodore, CP/M.

Vancouver  
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Vancouver  
Omni Computer Group  
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Orlon Computer Systems  
730-601 W. Broadway, Vancouver, B.C., V5Z 4C2

Prism Data Systems  
689 East Broadway, Vancouver, B.C., V5T 1X7

Radio Shack Computer Centre  
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The Video Station  
3673 East Hastings, Vancouver, B.C., V5K 2B1

Wizard Computer Systems  
6082 Fraser St., Vancouver, B.C., V5W 2Z7

Xerox Canada Inc.  
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B.C. V6E 3K8 (604)685-9111  
Xerox 820/2 computer, Osborne Personal Com-  
puter, Xerox 16/8 & Xerox 1800 computers, Diablo  
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IBM, Digital, Compaq, Apple, Bytec, Nelma.

Computer Innovations  
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MO  
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Owen & Sons Cash Register  
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Pace Computer Systems  
744 Johnson St., Victoria B.C., V8W 1N1

Radio Shack  
3170 Tillicum Rd., Unit 125, Tillicum Mall, Victoria,  
B.C., V91 6T2 (604)381-4420  
Radio Shack TRS-80 Models II, III, 16 and colour  
computers. Hardware and software plus related  
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Radio Shack Computer Dept.  
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toria, B.C., V8Z 3K5

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Datallife diskettes.

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National Microcomputer mail order company  
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products for most micro systems.

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peripherals for systems including multuser  
and network. Home computers with games,  
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## ALBERTA

### Calgary

Abacus Electronics ETI/CN  
5659 Madigan Rd., N.E. Calgary, Alta. T2A 4P1  
(403) 273-0594  
MO CAT FREE

Ace Tech. Computer & Video  
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Active Component Sales Corp. ETI/CN  
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T2H 0J9

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MO

Altel Data  
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Allwest Communications  
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230-4272

Computerland  
1212-1st St. S.E., Suite 112, Calgary, Alta., T2G  
2H8

Computerland  
1212 First St. S.E., Suite 112, Calgary, Alta. T2G  
2H8 (403) 237-6423

Computerworks ETI  
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(403)237-5877  
Products: Hewlett Packard, North Star com-  
puters, Dysan, Commodore Bus. Machines,  
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Computer Centre  
4908-17th Ave. S.E., Calgary, Alta. T2A 0V4  
(413)272-9874

MO  
Franklin computers AMS general ledger sys-  
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applications.

Computer Cottage  
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Atari Computer Dealer, Percom Disk Drive, Op-  
timized System software.

Computer Innovations  
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IBM-PC and XT, DEC Professional, Lisa, Apple //e  
and III

Computer Innovations  
920-36th St. N.E., Suite 142, Calgary, Alta., T2A  
6L8 (403) 235-4541  
Lisa, Apple //e and III, DEC Professional, IBM-PC  
and XT.

Computer innovations  
103-723-14th St. N.W., Calgary, Alta., T2N 2A4

Computer Innovations  
111-5809 McLeod Trail S., Calgary, Alta., T2H 0J9

Computer innovations CN  
100 Anderson Rd. S.E., Calgary, Alberta, T2J 3V1

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# Directory of Computer Stores

**Kellam Business Systems**  
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Hewlett-Packard 150 Series touch screen computer. Hewlett-Packard printers, plotters, business software. Commodore 8000 series business computers, peripherals and software.

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Supplier of Apple, Digital and Hyperion personal computers. Hardware and software. Service and support including application seminars and training.

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MO CAT  
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**Radio Shack Computer Centre**  
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**Radio Shack Computer Centre**  
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Sales, service, supplies, stock and custom software, Brother, Corona, IBM, Franklin, Apple, Epson, Comrex, Hayes, Tycor, Prowriter, Skyman.

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Supplier of Apple Systems and peripherals. Store's philosophy is 'All things to business and education'.

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Retailer for Radio Shack computer products & software, also Columbia computers (IBM Compatible), software and peripherals, and IBM Compatible software and peripherals.

**Computique**  
10056-101A Ave., Edmonton, Alberta, T5J 1V8

# Computron

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**Galactica Computers**  
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**Heathkit Electronic & Computer Centre** ETI/CN  
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**Hi-Tech Computers**  
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**I&S Software Library**  
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**IBM Product Centre**  
Scotia Place, 10060 Jasper Ave., Edmonton, Alta., T5J 3R8 (403)426-7867  
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Computer Terminal  
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Computer World  
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for all computers.

Radio Shack Computer Dept.  
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## SASKATCHEWAN

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129 Main St. N., Moose Jaw, Sask. S6H 0V9  
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service. Commodore, Atari, T/I, Epson.

### Prince Albert

Allied Computer  
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Nascent Business Tec.  
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United Office Machines  
805 Central Ave., Prince Albert, Sask., S6V 5T3

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Computerland  
1504B Albert St., Regina, Sask., S4P 2S4  
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Retailer of IBM, Apple, Digital, Hyperlon and Com-  
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Micro Shack of Western Canada  
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Radio Shack Computer Centre  
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TJB Microsystems Ltd.  
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TJB Microsystems Ltd.  
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Westworld Computers  
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Authorized Dealer for QCAL Computer products,  
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Disco Post #9  
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### Grande Prairie

Pussycat Business Systems Ltd.  
10005 - 97A Street, Grande Prairie, Alta., T8V 2C2  
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and Citation software.

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Computation Systems ETI/CN  
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Radio Shack Computer Dept.  
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Alta., T1K 2S5

Radio Shack Computer Dept.  
2025 Mayor Magrath Dr., College Mall, Lethbridge,  
Alta., T1K 2S5

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Radio Shack Computer Dept.  
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# Directory of Computer Stores

**Computertime**  
240-22nd St. E., Saskatoon, Sask., S7K 0E8

**Custom Computing**  
124A-2nd Ave. N., Saskatoon, Sask., S7K 2B2

**Computer Innovations** CN  
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Sask. S7K 2B7

**Datatec Computer Systems Ltd.** ETI  
Retail Store: 150-2nd. Ave. N., Saskatoon,  
Sask. S7K 2B2, Bus. Sales Office: 436-2nd.  
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**Computer Visions**  
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**Data Terminal Mart**  
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**Memory Lane Computer**  
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**Micro Shack Ltd.**  
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**Radio Shack**  
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**Custom Computing**  
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Sask., S9H 2B4

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164-1st Ave. N.W., Swift Current, Sask., S9H 3W7

**Southwest Computer**  
4 Carmel Mall, 244-1st Ave. N.E., Swift Current,  
Sask., S9H 2B4

## MANITOBA

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**Canadian Computer Era**  
761-18th Street, Brandon, Man. R7A 5B6  
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Authorized Apple, Commodore and Epson  
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**Radio Shack Computer Dept.**  
Rosser & 8th Ave. S., Brandon Gallery, Brandon,  
Man., R7A 0L2

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**Dauphin Musical Supplies** ETI/CN  
14 - 1st Ave. N.W., Dauphin, Manitoba, R7N 1G7  
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MO  
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## Winnipeg

**Citation Software**  
1901 Logan Ave., Winnipeg, Man. R2R 0H6 1-204  
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**Computerland**  
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**Compucentre**  
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**Computer Visions**  
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ware lines - Franklin, Corona, Columbia. Cust-  
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Liberty, Qume Terminals. Ashton-Tate, Bro-  
derbund, Continental, Peachtree, Micropro,  
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Complete line of Heathkit and Zenith data sys-  
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**J. Software**  
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**Micro Mart**  
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**Mid Canada Software**  
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775-8583

**Mycroft Business Computers**  
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Winnipeg, Man. R3C 1B1 (204)942-2141  
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Columbia VP and MPC, Kaypro Portable  
Computers, Canon AS-100, Commodore, Bro-  
ther Letter Quality Printers, and Epson Dot  
Matrix Printers.

**P & S Electronics**  
P.O. Box 154, Stn. C, Winnipeg, Manitoba R3M 3S7  
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Status Systems Corp.  
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Systems Business Forms Ltd.  
1595 Buffalo Place, Winnipeg, Man., R3T 1M1

Video Concepts  
1047 McPhillips St., Winnipeg, Manitoba, R2X 2K6

Xerox Canada Inc.  
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Xerox 820/2 computer, Osborne Personal Com-  
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Printers, Hyperion products. Related peripherals.  
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## ONTARIO

### Agincourt

Kittronic  
4051 Sheppard Ave. East, Agincourt, Ont. M1S 1S8

Mr. Software  
1571 Sandhurst Circle, Woodside, Agincourt, Ont.  
M1V 1V2

### Ajax

Meridian Micro-Computer  
1391 Harwood N., Ajax, Ont., L1S 2C1

### Aurora

Computer Learning Centre Ltd. ETI  
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Computer Computer  
79 Dunlop St. West, Barrie, Ont. L4N 1A5  
(705)737-4232

Computer House of Barrie ETI  
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(705)726-0551  
Sale and service of business computers.

Karl's TV  
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Radio Shack  
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Taylor Bus. Comp.  
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### Belleville

Altair Electronics E11  
221 Front St., Belleville, Ont. K8N 4Z9 (613)  
962-0980  
MO

Hastings Data Systems CN  
Box 754, 33 Pinnacle, Belleville, Ont. K8N 5B5

Radio Shack  
390 North Front St., Quinte Mall, Belleville, Ont.,  
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Radio Shack TRS-80 Models II, III, 16 and colour  
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### Bolton

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Compucentre  
Bramalea City Centre, Bramalea, Ont. L6T 3R5  
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### Brampton

Computerland Canada  
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(416)793-9000

Computer Forum Inc.  
332 Main St. N., Brampton, Ont. L6V 1P8  
(416)453-1100

Mondecan Ltd.  
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(416)846-0755  
Mondecan specializes in developing and sup-  
plying complete systems for the medical commu-  
nity in Canada. Mondecan MEDICS allows  
physicians to submit OHIP claims on eight-  
inch diskettes produced in their own office.

Mr. Software CN  
499 Main Street South, Brampton, Ont. L6Y 1N7

Radio Shack  
499 Main St. S., Brampton Shopper's World,  
Brampton, Ont., L6Y 1N7 (416)457-8412  
Radio Shack TRS-80 Models II, III, 16 and colour  
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Robin Hood Electronics ETI/CN  
20 Strathern Ave., Brampton, Ont. L6T 4P7

SciCom CPU Corp.  
Bramalea City Centre, 41 City Centre Dr., Bramp-  
ton, Ont., L6T 3R5

### Brantford

Radio Shack Computer Dept.  
300 King George Rd., Brantford Mall, Brantford,  
Ont., N3R 5L7

Tel-Star Computer  
112 Baldwin Ave., Brantford, Ont., N3S 1H7

Tel-Star Computer Centre Inc. ETI  
P.O. Box 2138, 10 King George Road, Brant-  
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### Brockville

Altair Elect. Ltd.  
223 King St. W., Brockville, Ont. K6V 3R7

Altair Electronics ETI  
5 Courthouse Ave., Brockville, Ont. K6V 4T3  
(613)342-0885  
MO

J.R. Business Equipment  
153 King St. W., Brockville, Ont., K6V 3R4

### Burlington

Computerland  
678 Guelph Line-Burlington, Ont. L7R 3M8 (416)  
632-5722

Products include: Microcomputers, peripherals,  
software and accessories. IBM, DEC, Apple,  
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Visicorp, Helping Hands, Spinnaker and Mattel  
Software.

Computerland  
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Mannesman Tally printers. Full service centre on-  
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Compusel Computer Sales Inc.  
2349 Fairview Ave., Burlington, Ont. L7R 2E3  
(416)632-2740

Microman Consultants Inc.  
3455 Fairview St., Burlington, Ontario L7N 2R4  
(416)632-3704  
Dealer for: Epson, Mannesman-Tally, Diablo,  
Zentronics, Okidata, Printers. Computers - Xerox,  
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Radio Shack  
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ington, Ont., L7P 3B6

### Cambridge

Cambridge Elect.  
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Desktop Computers  
1000 Bishop St., Ste. 12, Box 3045, Cambridge,  
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released.

# Directory of Computer Stores

## Chatham Computer

544 Queen St., Chatham, Ont. N7M 5K1  
(519)354-6827  
Commodore, Franklin, Northstar, Sharp. Sales and service.

## Chatham Computer Sales

420 Park Ave. W., Box 14, Chatham, Ontario, N7M 5K1

## Computer House

167 Wellington St. W., Chatham, Ontario, N7M 1J4

## Computer House

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(613)230-7177, store: 230-3672  
An authorized dealer and repair depot for IBM, Apple, Hyperion, Hewlett-Packard, Texas Instruments. A complete line of peripherals and consumables is also featured.

**Computerland**  
136 O'Connor St., Ottawa, Ont. K2P 2G7  
(613)236-6411  
IBM, Compaq, DEC Digital, Hyperion, Apple, Nelma.

**Computerworks**  
430 Bank St., Ottawa, Ontario, K2P 1Y8

**Compumart**  
411 Roosevelt Ave., Ottawa, Ont., K2A 1T2

**Computer Innovations**  
171 Slater St., Ottawa, Ontario, K1P 5H7

**Computer Innovations**  
1719 St. Laurent Blvd., Ottawa, Ont., K1G 3V4

**Computer Innovations** CN  
100 Bayshore Drive, Ottawa, Ont. K2B 8C1

**Computer Innovations** ETI  
73 Rideau St., Ottawa, Ont. K1N 5W8 (613)  
230-7383

Authorized dealer for IBM, Apple, The Corona Portable, Corvus, Tallgrass, Nec, Dalsywriter, CGE, Telegraph, Micro Pro, Hayes and others.

**Computer Warehouse**  
1501 Carling Ave., Ottawa, Ont. K1Z 7M1

**Computer Worlds**  
1335 Carling Ave., Ottawa, Ont. K1Z 8N8  
(613)725-0500  
MO

Specializes in solutions for small and medium businesses. Carry Televideo, Olivetti, Kaypro and Apple Compatible computers and peripherals.

**Cots Microsystems**  
1396 Startop Rd., Ottawa, Ont., K1B 4V7

**Craig Office Products Corp.**  
329 Waverley St., Ottawa, Ont., K2P 0V9  
(613)238-5500  
IBM PC, Victor, Seiko, iF800, Oki Data, Xerox.

**Data Terminal Mart**  
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(613)729-5196  
MO

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**Eastern Micro Products**  
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Ottawa Rideau Centre, 1 McKenzie King Bridge, Ottawa, Ont. K1N 9J8 (613)560-5200  
Computers from IBM, Apple, Hyperion and Zenith. Business, educational and entertainment software. Customer training facilities and service areas.

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Equipment Ltd. 25 Montreal Rd., Ottawa, Ont. K1L 6E8

**Focus Scientific Ltd.**  
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**Heathkit Electronic & Computer Centre** ETI  
866 Merivale Road, Ottawa, Ont. K1Z 5Z6  
(613)728-3731

MO CAT FREE  
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**MGI Computer Corp.** CN  
1501 Carling Ave., Ottawa, Ont. K1Z 7M1 (613)  
722-1000

MO  
Commodore, Ajille, Televideo, Epson, Mannesman-Tally Amdek, Zenith, Sanyo, Dysan, Verbatim, Syncom, Maxell, Memorex, 3M. Full range of software, cables, Accessories, Etc.

**Micron Systems Corp.**  
2615 Blackwell St., Unit 107, Ottawa, Ont. K1B 4E4  
(613)748-1391

**Radio Shack Computer Centre**  
2280 Carling Ave. Ottawa, Ont. K2B 7G1  
(613)829-1000

**Radio Shack Computer Centre**  
181 Bank St., Ottawa, Ont. K2P 1W5 (613) 236-5812

**Shercon Ltd.**  
303-251 Laurier West, Ottawa, Ont. K1N 6P7

**Technical House**  
340 Somerset West, Ottawa, Ont. K2P 0J9  
(613)236-6433

**The Information Conn.**  
880 Wellington St., Suite 808, Ottawa, Ont., K1R 6K7

**Wackid Radio**  
312 Parkdale Ave., Ottawa, Ont., K1Y 1G3

## Owen Sound

**Owen Sound**  
ES Computing Ltd.  
868 Third Ave. E., P.O. Box 463, Owen Sound, Ontario N4K 5P7 (519)371-9795  
Retail Sales: Apple, Hyperion, Alpha Micro, Qume, Centronics, Epson, Amdek. Supplies and books.

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**The Book Worm Shoppe** CN  
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746-8813

MO  
Products carried: Books, Software, Computers: Columbia, Compaq, Kaypro, IBM, Apple compatibles. Printers: Qume Gemini. Drives: Rana, Mitac.

## Peterborough

**Computerland**  
360 George St. N., Peterborough, Ont. K9H 7E7 (705)748-2266

FREE  
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**Landmark Information Systems** ETI/CN  
753 Erskine Ave., Peterborough, Ont. K9J 7Y6  
(705)876-1177

MO  
Full sales & service. Apple dealer as well as AES word processors, Olympia Electronic typewriters.

**Microman Computer Center**  
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(705)748-5129

MO  
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**Radio Shack**  
360 George St., Unit 33A, Peterborough Square, Peterborough, Ont., K9H 7E7 (705)743-8166

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**Surtronics (405803) Ontario Ltd.**  
223 Brock St., Peterborough, Ont. K9H 2P6  
(705)748-2706

## Pickering

**Micro-Comp Ent.**  
565 Eyer Dr., Pickering, Ont., L1W 3A8

**Systime Computer Services Ltd.**  
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**Renfrew Tech.**  
863 Kedrosky Dr., Renfrew, Ont., K7V 4C8

## Rexdale

**Data Terminal Mart**  
655 Dixon Road (Skyline Hotel), Rexdale, Ont. M9W 1J4 (416)245-4780

Terminals and microcomputers from Digital, Texas Instruments, Qume, Kaypro, Anderson-Jacobson as well as printers, modems and application software.

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 143 Dennis St., Rockwood, Ont. N0B 2K0 (519) 856-9566  
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 Selling apple, Columbia, computers with interfacing and software for scientific and industrial laboratory applications. Other companies represented - Tecmar, Robographics, Trivector, International, Rana, Interactive Microware.

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**Comp-Can**  
 1477 Hunt St., Sarnia, Ont. N7S 3M8

**Keelan's Audio & Video**  
 460 North Christina, Sarnia, Ont., N7T 5W4

**Radio Shack Computer Dept.**  
 1125 London Rd., Sentry Plaza, Sarnia, Ontario, N7S 1P3

**Radio Shack Computer Dept.**  
 150 N. Christina St., Sarnia, Ont. N7T 5T9 (519) 337-4360  
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**The Computer Barn**  
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**The Computer Terminal**  
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 MO  
 IBM, Xerox, Dec, Franklin

**MD Data Systems** ETI/CN  
 485 Queen St., Sault Ste. Marie, Ont. P6A 1Z9 (705) 949-6622  
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**Radio Shack Computer Dept.**  
 293 Bay St., Station Mall, Sault Ste. Marie, Ont., P6A 1X3

**Sault Office Machine**  
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## Scarborough

**BCC Business Computer Centre Inc.**  
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 IBM PC Corona PC and compatibles, fixed and removable hard disk drives, full and half height floppy disk drives, multi-function memory expansion boards, letter quality and dot-matrix printers, complete line of business software, computer accessories and supplies, service contracts available.

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**Computerland**  
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**Computer Innovations**  
 Scarborough Town Centre, 300 Borough Rd., Scarborough, Ont., M1P 4P5 (416) 296-0023  
 IBM PC & XT, Apple //e, //ii, DEC Professional, Lisa.

**Computer Innovations Corp.**  
 3761 Victoria Park Ave., Unit 2, Scarborough, Ont., M1W 3S2 (416) 497-7522  
 IBM PC & XT, DEC Professional, Apple //e, Apple //ii, Lisa.

**Computer Junction**  
 3330 Pharmacy Ave., Scarborough, Ont.

**Computer Way**  
 31 Progress Court, Unit 31, Scarborough, Ont. M1G 3V4 (416) 439-9804

**Cycom Systems Ltd.**  
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**Eaton's Business Centres** ETI  
 Scarborough Town Centre, 300 Borough Drive, Scarborough, Ont. M1P 4P6 (416) 296-5211

Ext. 372

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**Interactive Micro Systems**  
 34 Hopecrest Cres., Scarborough, Ont. M1K 2K4 (416) 261-8411

**Light Computers Centre** ETI/CN  
 300 Borough Drive, Scarborough, Ont. M1P 4P5 (416) 296-2406  
 Authorized dealer for Apple, Gutenberg, Texas Instruments, P.C., Coleco, Adam.

**MEC Micro Elect Corp.**  
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**Micro Canada**  
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**MicroCTR of Toronto**  
 56 Marblemount Cr., Scarborough, Ont., M5H 2H5

**Microtrend Business Systems Ltd.**  
 10161 Sheppard Ave. E., Scarborough, Ont. M1B 1G1 (416) 281-1129

**Micro Mart**  
 4651 Sheppard Ave. E., Ste. 203, Scarborough, Ont. M1S 3V4 (416) 293-9444

**Nigana Computer Syst.**  
 136 Shorting Rd., Scarborough, Ont. M1S 3S6

**Radio Shack**  
 1886 Eglinton Ave. E., Scarborough, Ont. M1L 2L1 (416) 757-2367  
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**Radio Shack Computer Centre**  
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**SCI-COM**  
 2300 Lawrence Ave. East, Scarborough, Ont. M1P 2R2

**Titan Computers**  
 15 Crockford Blvd., Unit 1, Scarborough, Ont. M1L 4J9 (416) 759-8808  
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(416)292-2012

## Simcoe

Computer World  
Box 414, Simcoe, Ont. N3Y 4L2

Micro Mini Mart  
16 Colborne St. S., Simcoe, Ont., N3Y 4H1

## Smiths Falls

J-R Business Equip.  
12 Russell St. E., Smiths Falls, Ont. K7A 1E8

## Stouffville

Zetetic Data Systems  
RR2 Stouffville, Ont., L0H 1L0

## Stratford

Chipon Computers and Electronics  
137 Albert St., Stratford, Ont. N5A 3K5 (519) 273-1412  
Columbia PC, personal computers such as, Zeus 2001, Super 400, Apple Compatible and Diamond. Software for Apple, IBM, Commodore, TRS80 and Atari for business and entertainment. All peripherals for Apple, cables, printers, a large variety of books and more.

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318 Ontario St. St. Catharines, Ont. L2R 5L8 (416) 688-1187  
Products 200 Vendors include: Microcomputers, Peripherals, Software and Accessories. IBM, DEC, Apple Bytec Hyperion and Compaq Computers; Epson, C-Jtoh and Okidata Printers; IBM, Amdek, Electrohome and Princeton Monitors; and Lotus Visicorp, Helping Hands, Spinnaker and Mattel Software.

Drummondville Computer Systems  
14 Ontario St., St. Catharines, Ont., L2R 7M3  
(416)684-7766  
Zenith business systems and software, full service centre (Zenith).

International Computer  
117 St. Paul St., St. Catharines, Ont., L2R 3M4

Megabyte Business Systems Ltd.  
96 Niagara St., St. Catherines, Ont. L2R 4L4  
(416)684-4366  
Business and home computers. Dealer for Commodore, Ohio Scientific. Sales and shop on site service.

Radio Shack Computer Centre  
290 Glendale Ave., St. Catharine, Ont. L2T 2L3  
(416) 227-2063

Radio Shack Computer Dept.  
333 Ontario St., St. Catharines, Ont. L2R 5L3

Rainbow Computer Systems  
67 Queen St., St. Catherines, Ont. L2R 5G9  
(416)682-4334  
Niagara region dealers for Kaypro and Columbia micro computers.

Xerox  
63 Church St., St. Catharines, Ont., L2R 3C4

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A & B Office Equipment  
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Computerland  
Unit #19 Cedar Point Plaza, 1984 Regent St. S.  
Sudbury, Ont. P3E 5S1 (705) 522-3663

Computerline ETI  
74 Cedar St., Sudbury, Ont. P3E 1A5 (705) 674-3151  
MO

MPM Business Products  
653 Lorne St. S., Sudbury, Ont., P3C 4R3

North Star Computer Ltd. ETI  
598 Falconbridge Road, Sudbury, Ont. P3E 4K6 (705)566-6441/673-2010  
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System sales supplier. Products include IBM, Apple, AES, Minolta and 3M micrographics.

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Sonic Northern Ltd.,  
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Timmins Comp. Power  
70 Balsam St. S., Timmins, Ont., P4N 2C8

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Thunder Bay  
Computerland  
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(807)623-5434  
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Datalogic Systems  
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Advanced Micro  
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(416)762-3703

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Batteries Included  
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Brack Electronics  
129 Jarvis St., Toronto, Ontario, M5C 2H6

Compucentre  
Box 1052, 218 Yonge St., Eaton Centre, Toronto, Ont., M5B 2H6

Compucentre  
2nd Floor, Ste. 207, Eaton Ctr. Galleria, Toronto, Ont. M5B 2H1 (416)596-1300

Compucentre CN  
220 Yonge St., Suite 202, Toronto, Ont. M5B 2H1 (416)596-1300  
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(416)947-1330  
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Computerland  
1254 Bay St., Toronto, Ont., M5R 2B1  
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CAT FREE  
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Computerland  
2180 Yonge St., Toronto, Ont. M4S 2B9 (416) 485-6700

Computer Book & Supply  
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Retailer of microcomputer products for business and professional applications. Products - IBM PC & PC-XT, Apple, Texas Instruments and Digital personal computers. Software for business, education and leisure, peripherals and accessories.

Computer Generation  
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Computer Innovations  
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Computer Innovations CN  
44 Bloor Street East, Toronto, Ont. M4W 3H7

Computer Innovations CN  
176 Yonge Street, Toronto, Ont. M5C 3L7

Computer Innovations CN  
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Comspec Systems  
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Compu-Group  
2255 Sheppard Ave. E., Unit 136, Toronto, Ont. M2J 4Y1 (416)499-2900

Computer Junction  
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Computer Mat Inc.  
37 Mutual St., Toronto, Ont. M5B 2A7 (416)362-2783

Computer Shack  
567 King West, Toronto, Ont. M5V 1M1 (416)598-1777

Computer Workshop  
465 King Street East, Unit 9, Toronto, Ont. M5A 1L6 (416)366-6192

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120 Adelaide St. W., Richmond/Adelaide Centre, Toronto, Ont., M5H 1T1 (416)364-4480  
Computer retailer selling terminals and microcomputers from Digital, Texas Instruments, Dume, Kaypro, and Anderson, Jacobson, as well as printers, modems and a full range of application software.

Delphi Systems Group Inc.  
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71 McCaul St., Toronto, Ont., M5T 2X1

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Source for technology and scientific products related to computers research, science projects, consumer electronics, specialty tools, optics, microscopes, telescopes.

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First Byte  
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Gladstone Electronics  
1736 Avenue Road, Ste. 3, Toronto, Ont. M5M 3Y7

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IBM Product Centre  
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Lincoln Computer ETI/CN  
621 Gerrard St., E.(Rear) Toronto, Ont. M4M 1Y2

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Retailer of Apple and Wang microcomputers and Corvus hard disk drives. Specialists in local area networks. Hundreds of software packages.

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1240 Bay St., Suite 802, Toronto, Ont., M5R 2A7

M & W Computer Store  
407 Queen St. W., Toronto, Ont., M5V 2A5

Micronic Computer Centres Ltd.  
1710 Avenue Rd., Toronto, Ontario, M5M 3Y6

Microage Computer Stores  
2632 Yonge St., Toronto, Ont. M4P 2J5 (416) 487-5551  
MO  
Products carried: IBM, Apple, Digital, Altos computers, Epson printers, C-1TOH printers.

Micronic Computer Centre  
1 First Canadian Place, Station A, Concourse Level, Box 193, Toronto, Ont., M5X 1A6

Micron Dist.  
409 Queen West, Toronto, Ont. M5V 2A5  
Auby Mandell Software & Books.

Microcomputech Electronics Ltd. ETI/CN  
535 Queen St. West, Toronto, Ont. M5V 2B4 (416)864-0332  
MO FREE  
Deal in Apple and IBM compatible products. Carry Hitachi, Gemini, YJE, Verbatim, Tiger and other peripherals. Distributor for Multitech, Copam and ATI products.

Micro House  
72 Steeles Ave. W. Suite 208, Toronto, Ont. L4J 1A1 (416) 889-2677  
MO  
Sales of electronic boards and accessories disks, micro computer systems and peripherals.

Micro Marketing Can.  
169 Inglewood Dr., Toronto, Ont. M4T 1H8  
Manufacturers Rep. for Computer Larry Ungermano Software.

Navacel Enterprises Limited  
365 Bloor St. E., Suite 1208, Toronto, Ont. M4W 3L4 (416) 922-4910  
Complete business and computer consultants. Providing 'Total Service' in systems, hardware and software education, resource and business planning. Special markets include: manufacturing, education, database.

NIAKWA Management Systems Inc.  
56 Aberfoyle Cresc., Toronto, Ont. M8X 2W4 (416)231-9885  
MO  
Wang, Spectrix, and IBM micro & mini computers. Complete accounting and word processing software and services.

On Line Computer  
188 Eglinton Ave. E., Toronto, Ont., M4P 2X7

Parts Galore  
316 College St., Toronto, Ont. M5T 1S3

Parts Galore ETI/CN  
331 Queen Street West, Toronto, Ont. M5V 2A4

# Directory of Computer Stores

**Paule Computer**  
400-120 Eglinton Ave. E., Toronto, Ont.  
(416)482-2274

**P.C. Express** ETI/CN  
35 Queen St. W., Toronto, Ont. M5V 2A4

**Perfect Electronics** ETI/CN  
315 Queen St. West, No. 1, Toronto, Ont. M5V 2A4

**Personal Computer Institute**  
70 Yorkville Ave., Toronto, Ont. M5R 1B9  
(416)964-0724

MO  
Authorized IBM, Apple, Corona, Molecular dealer. Education including specialized and custom designed courses.

**Professional Comp.**  
111 Ava Rd., Toronto, Ont., M6C 1W2

**Radio Shack**  
329 Bay St., Toronto, Ont. M5H 2R2 (416)365-7207  
MO CAT FREE  
Exclusive TRS-80 line of computers, software and peripherals including models 4, 12, 16B, 100 and the new MS-DOS Tandy 2000.

**Radio Shack**  
1938 Avenue Road, Toronto, Ont. M5M 4A1  
(416)787-1821  
MO CAT FREE  
TRS-80 computers: models 4, 12, 16, MC-10, color computer, Tandy model 2000. Large assortment of printers and other peripherals. Classroom and service also available.

**RAM Computer Supply**  
2A Gibson Avenue, Toronto, Ont. M5R 1T5  
(416)922-0990  
MO  
IBM PC and XT and Franklin computer hardware, software, peripherals.

**Remenyl House of Music**  
210 Bloor St. W., Toronto, Ont. M5S 1T8  
(416)961-3111

**Robert Johnson Office Equip. Ltd.** ETI/CN  
273 Queen St. West, Toronto, Ont. M5V 1Z9  
(416)598-2345-6-7  
MO

**Scjcom CPU Corp.**  
1 Dundas St. W., Eaton Centre, Toronto, Ont., M5G 1Z3

**Semltronics**  
591 Gerrard E. #A8, Toronto, Ont., M4M 1Y2

**SES Computing Inc.**  
366 Adelaide St. E., Toronto, Ont. M5A 3X9  
(416)366-4242

**Simpsons Computer Innovations**  
176 Yonge St., Toronto, Ont., M5C 2L7

**Softrack** ETI/CN  
519 King St. W., Toronto, Ont. M5V 1K4 (416) 596-8911  
MO CAT FREE  
Hundreds of the latest programs available for Apple, IBM, Atari, Commodore and TRS-80.

**Sunplustronics** ETI/CN  
310 College St., Toronto, Ont. M5T 1S3

**Supertronix Inc.**  
279 College St., Toronto, Ont. M5T 1S2 (416) 927-1921  
Apple Computers, Seequa Chameleon (IBM portable compatible), Coleco Adam home computer, Pied Piper CP/M portable, Microsoft, Micropro, Lotus 1-2-3, Sorcim, Wizard, Star Gemini, Epson, QuentIn, Amdek, etc.

**Systime Computer Services**, Box 6961, Station A, Toronto, Ont., M5W 1X7

**TAF Computer Systems**  
2828 Dufferin St., Toronto, Ont., M6B 3S3

**TAF Computer Systems Ltd.**  
25 Sable St., Toronto, Ont. M6M 3K8 (416) 245-4916  
MO CAT FREE  
North Star microcomputers (ADVANTAGE and HORIZON), associated peripherals, software packages and supplies.

**The Bay Computer Innovations**  
44 Bloor St. E., Toronto, Ont., M4W 3H7

**T. Eaton Company Ltd.**  
1 Dundas St. W., Eaton Centre, Toronto, Ont., M8B 1C8

**The T. Eaton Company**  
290 Yonge St., Toronto, Ontario

**Xerox**  
110 Eglinton Ave. E., Toronto, Ontario, M4P 2Y1

**Xerox**  
335 Bay St., Toronto, Ont., M5H 2R3



of Hamilton inc.  
**13 Bold Street**  
**Hamilton, Ontario**  
**L8P 1T3 Canada**  
**527-8733**

## Uxbridge

**Uxbridge Electronics**  
Box 384, 75 Brock St. N., Uxbridge, Ont., L0C 1K0

## Vanler

**Radio Shack**  
150 Montreal Rd., Les Galeries de Vanler, Vanler, Ont., K1L 8N2 (613)748-1462  
Radio Shack TRS-80 Models II, III, 16 and colour computers. Hardware and software plus related peripheral equipment.

## Waterloo

**Abacus Computers**  
180 King St. S., Waterloo, Ontario, N2J 1P8

**Computerland**  
380 King St. N., Waterloo, Ont. N2J 2Z3 (519) 888-6011

**Compuier Software Inc.**  
500-22 King St. S. Waterloo, Ont. W2V 1N8 (519)746-1880  
MO  
Dealer for: Morrow Micro computers, Kaypro II, Micro computers, Columbia micro computers. Software manufacturer of Life Insurance related products - package and custom work.

**Digitrol Computers Inc.**  
440 Phillip Street, Waterloo, Ont. N2L 5R9 (519)884-4690

**Computerland**  
380 King Street No. Waterloo, Ont. N2J 2Z3 (519) 888-6011

Products include: Microcomputers, Peripherals, Software and Accessories. IBM, DEC, Apple Bytec Hyperion and Compaq Computers; Epson, C-Jtoh and Okidata Printers; IBM, Amdek, Electrohome and Princeton Monitors; and Lotus Vislcorp, Helping Hands, Spinnaker and Mattel Software.

**Home Computer Centre**  
295 Weber St. N., Waterloo, Ont., N2J 3H8

**Radio Shack Computer Dept.**  
550 King St. N., Conestoga Mall, Waterloo, Ont., N2L 5W6

## Walkerton

**Walkerton Electronic**  
343 Durham St. E., Walkerton, Ont., N0G 2V0

## Welland

**Compupro Micro Systems**  
81 West Main St., Welland, Ontario, L3C 4Z8

**Radio Shack**  
800 Niagara St. N., Seaway Mall, Welland, Ont., (416)732-2161  
Radio Shack TRS-80 Models II, III, 16 and colour computers. Hardware and software plus related peripheral equipment.

## Weston

**Harso Limited**  
607 165 Larose Ave., Weston, Ont. M9P 3S9

**Radio Shack Computer Centre**  
2349 Finch Ave. W., Weston, Ont. M9M 2W8 (416)741-5163  
MO CAT FREE  
Complete line of TRS-80 hardware/software and peripherals. Full support team includes educator and "Hands-on" classroom, software support. Complete showroom.

**T. Eaton Co. Limited** ETI/CN  
2233 Sheppard Ave. W., Weston, Ont. M9M 1L6 (416)744-2111  
Sell IBM, apple, Zenlth, Hyperion, Xerox, Epson and other brands of computers and peripherals. A complete assortment of software also available.

## Whitby

**CCS Computer Sales**  
106 Byron St., Whitby, Ont., L1N 4P5

**Creative Computer**  
106 Byron St. South, Whitby, Ont. L1N 4P5

## Willowdale

**Ace Acme Micro-Electronic Ltd.**  
37 Nevada Ave., Willowdale, Ont., M2M 3N9 (416)223-0110  
CAT FREE  
Apple & IBM systems.

**Computerized Business Systems**  
6979 Yonge St., Suite 201, Willowdale, Ont. M2M 3X9 (416)225-1434  
Olivetti Flash Corona PC, Morrow Micro Design, full line of printers, modems & software. Extended hours.

**Compucollege Store**  
5635 Yonge St., Willowdale, Ont. M2N 5S2

**Compugen Systems**  
150 Consumers Rd., Unit 304, Willowdale, Ont. M2J 1P9 (416)494-2979

**Computer Works**  
490 McNicol Ave., Willowdale, Ont. M2H 2E1

**Data-Ray Consultants Inc.**  
155 Gordon Baker Road, Unit 210, Willowdale, Ont. M2H 3N5 (416)494-9422

**Electronics 2001**  
5529 Yonge St., Willowdale, Ont. M2N 5S3 (416)223-8400

**General Electronics** ETI  
5233 Yonge St., Willowdale, Ont. M2N 5P8  
(416)221-6174  
MO  
Franklin computers, Tomcat computers, Apple compatible computers, Hobby parts supplies, Epson printers, disk drives, etc. Hameg-Veroboard, Unger-Ceres.

**Joh Park Elect.**  
6113 Yonge St., Willowdale, Ont., M2M 3W2

**Manhattan Computers**  
6101 Yonge St., Willowdale, Ont. M2M 3W7

**Micronic Computer Ct.**  
4211 Yonge St., Suite 210, Willowdale, Ont. M2P 2A9

**Willowdale Mr. Software Ltd.**  
5734 Yonge St., Willowdale, Ont. M2M 3V3  
(416)225-6674

**Willowdale Network Data Systems Limited**  
245 Yorkland Blvd., Suite 301, Willowdale, Ont. M2J 4W9 (416)497-0910  
MO  
Involved in the design, manufacture and distribution of specialized computer peripherals. Interfaces to convert electronic typewriters to printers and/or terminals.

**Willowdale The Compucollege Stores Inc.**  
5635 Yonge St., Willowdale, Ont. M2N 5S2  
(416)222-7787

**Willowdale The Software Shop**  
6174 Yonge St., Willowdale, Ont. M2M 3X1  
(416)223-9611  
Software for the Atari 400/800 computers, the VIC 20, Commodore 64, Apple, IBM and for the CPM operating systems. Selection over 2000 items.

**Willowdale Wordex Inc.**  
2025 Sheppard Ave. E., Unit 2111  
Willowdale, Ont. M2J 1V6 (416)499-1311

## Windsor

**Affordable Computer**  
P.O. Box 422, Station 'A', Windsor, Ontario

**Windsor Affordable Computers**  
870 University Ave. W., Windsor, Ont., N9A 5R9

**Windsor Computerland**  
1487 Ouellette Ave., Windsor, Ont. N8X 1K1 (519) 255-1000

**Windsor Computer Beginners Inc.**  
635 Charles St., Windsor, Ont. N8X 3G6 (519) 969-9246

**Computer Centre Ltd.**  
P.O. Box 2546 Walkerville, Windsor, Ont. N8Y 4T3 (519)252-0267  
MO  
Isotron computers, elephant memory systems, Franklin Ace

**Comp. Beginnings Inc.**  
321 Tecumseh Rd. E., Windsor, Ont., N8X 2R5

**Computer Mart of Windsor**  
2855 Howard Ave., Windsor, Ont. N8X 3Y4  
(519)966-5757

**Crescent TV Services**  
3033 Marentette Ave., Windsor, Ont., N8X 4G1

**Michem Electronics**  
1080 University Ave. W., Suite 202, Windsor, Ont. N9A 5S4 (519)258-8228  
MO  
Install most popular systems (8 bit and 16 bit) IBM along with related peripherals and options. DEC, E.X.O.

**Radio Shack Computer Centre**  
5407 Tecumseh Rd. E., Windsor, Ont. N8T 1C5  
(519) 948-1910

**Radio Shack Computer Dept.**  
1640 Huron-Church Rd., Windsor, Ont., N9G 2L1

## Woodbridge

**Tele-Radio Systems Ltd.**  
121 Hanlan Rd., Woodbridge, Ont. L4L 3P5  
(416)851-2231

## QUEBEC

### Alma

**Gestrix 2000 Inc.**  
512 Rue Collard Ou., Alma, Quebec, G8B 1N2

### Amos

**Centre d'Informatique Abitibi Inc.**  
582 10e Ave. Ouest, Amos, Que. J9T 1X3  
(819)732-8263  
MO  
Authorized micro and mini computer dealer including Apple, IBM and TYME. Custom programs and maintenance on computers and peripherals.

### Anclenne Lorette

**Osbyte Computer Systems**  
1409 Airport Road, Anclenne Lorette, Que.  
MO  
Consultants in data base, accounting, Cad, & graphics applications. Specializing in PC & M5 DOS. Sell and support; Columbia, Epson, comrex, Ast, Quadram, hayes, novation, Amdek, Princetown graphic.

### Anjou

**Atlantique**  
6060 Est Boul, Anjou, P.Q. H1S 1A9

### Aylmer East

**M.E. Guertin**  
30 Bancroft St., Aylmer East, Que., J9H 4N2

### Beaconsfield

**Central Micro System**  
50 St. Charles Blvd., Beaconsfield, Que. H9W 2X3

### Boucherville

**International Marketing Services**  
Box 522, Boucherville, Quebec J4B 6Y2  
(514)655-9232

### Brossard

**S.I.M. Micro Inc.** CN  
6955 Taschereau Blvd., Suite 101, Brossard, Que. J4Z 1A7 (514)656-9531  
MO  
Authorized dealer of Apple, I.B.M., Xerox, Kaypro and Epson computers. Also printers, interface cards, software, peripherals, games, joysticks, books and magazines. Courses in computer programming in BASIC. Analyzing of business needs by representatives.

**Unimicro Inc.**  
6965 Blvd. Taschereau, Brossard, Quebec J4Z 1A7  
(514)445-3600

## Brussard

**Compucentre**  
Champlain Mall, 2150 Lapiniere, Brussard, P.Q., J4W 2T5 (514)671-2186  
Commodore, Timex-Sinclair, T.I., Coleco Adam.

## Cap de la Madeleine

**Micro Enr.**  
613 Thibeau, Cap de la Madeleine, P.Q., G8T 6Z7

**Micro Systeme Mauricie Inc.**  
1029 De Mezy, Cap-De-La-Madeleine, Que. G8T 7E5 (819)373-9060  
MO  
Distributeur des produits Franklin Ace Computer pour La Mauricie, P.Q. Aussi, produits d'Informatique 3M, Imprimante Okidata, moniteur Zenith.

## Charlesbourg

**Computer Innovations** CN  
5401 Blvd., Des Galeries, Charlesbourg Ouest, Que. G2K 1N4

**Micro-Basic**  
7720 Henri Bourassa, Charlesbourg, Que. G1H 3G2 (418)628-8080  
MO  
Authorized dealers for: Franklin Ace, Kaypro Basis 108, Compaq and others.

# MICRO-BASIC

7720 Henri Bourassa, Charlesbourg, Que.  
628-8080 (418) G1H 3G2

**AUTHORIZED DEALERS FOR:**  
Franklin Ace Kaypro  
Basis 108 Compaq  
and more

## Chicoutimi

**Claude Bergeron**  
22 Dieppe, Chicoutimi, Que. G7G 1N9 (418) 549-8885  
MO

Software: special applications, new development. (Apple) Retail: Franklin, Alpha Byte, Zoom Telephonics, Corona.

**Ormic Chicoutimi** ETI/CN  
8 rue Racine Ouest, Chicoutimi, Que. G7J 1E2  
(418) 549-2029  
Authorized Apple, Commodore, Eagle, NEC, Gimix, Epson, Centronics, Sharp. Complete library, full software suppliers and Ormic diskettes. Complete line of computer furniture.

**S.I.I.F.** ETI  
1584 Boul. St. Paul, Chicoutimi, Que. G7J 3C5 (418)696-3666  
The computing solution with Alpha-Micro, Commodore, Hewlett-Packard, IBM (système Cie), Télé Video, Centronics, Okidata, Epson. French word processors for Commodore with traitez 8000 and traitez 64.

**L.S.L. Informatique**  
930 Jacques Cartier Est, Suite D-415, Chicoutimi, Que. G7H 2B1 (418)545-5599  
MO  
IBM PC and Columbia MPC retailer.  
Research and development in software for the utilization in network and multiuser environment with UNIX operating system/and on database environment.

# Directory of Computer Stores

## Dollard-Des-Ormeaux

Compu-Nord CN  
3343C Sources Blvd., Dollard-Des-Ormeaux,  
Que. H9B 1Z8 (514)685-1557  
MO CAT FREE  
Authorized DEC, Altos, Northstar, and Apple  
dealers. We sell, support and customize M.B.S.I.  
accounting packages, as well as our own church  
admin., golf club handicapping, and needle  
trade packages.

## Dolbeau

Micro I.D. Inc. CN  
1230 Boul. Wallberg, Dolbeau, Que. G8L 1H2

## Dorval

Microserv J.B.F.  
369 Dorval Ave., Dorval, Que. H9S 3H6 (514)  
631-4557

## Drummondville

Cosanco Informatique  
104 Marchand, Drummondville, Quebec, J2C 4M9  
(819)478-0181  
Apple dealer, consultant, software developer.

## Gatineau

Atlantique  
Centre De L'Outaouais, Gatineau, P.Q. J8T 6G3

Radio Shack Comp. Dept.  
1100 Maloney Blvd. W., Gatineau, Que. J8T 3P9

## Granby

Brosseau Ateliers  
31 Evangeline, Granby, Quebec, J2G 6N4

Simco Inc. (ORDIN)  
322A Rue Principale, Granby, P.Q. J2G 2W4

## Grand-Mere

Electro 3000  
758 6E Ave., Grande-Mere, P.Q., G9T 2H7

## Greenfield Park

Addax Micro Inc.  
208 boul. Taschereau, Greenfield Park, P.Q., J4V  
2H4

Compucentre ETI  
827 Taschereau Blvd., Greenfield Park, Que.  
J4V 2H9 (514)672-0020  
MO

Authorized dealer of IBM, Texas Instruments,  
Hewlett-Packard, Hyperion, Osborne and Ap-  
ple. Specialists in communications, L.A.N. 3-D  
Cad applications, and office automation.

Radio Shack Computer Centre  
377 Boul. Taschereau, Greenfield Pk., P.Q. J4V  
2H7 (514) 465-0441

## Hull

Deltranik  
256 Boul. St. Joseph, Hull, Que. J8Y 3X8  
(819)777-3232  
Computers: Corona PC, Printers: Mannesmann-  
Tally, TTX Brother. Monitors: Amdec. Spec-  
ialize in micro-computer training, such as: Word  
processing, Introduction to microcomputers,  
LOGO, D-Base II, Visc calc.

Lalond Elect.  
173 boul. St. Joseph, Hull, Quebec, H8X 3X1

Radio Shack  
425 boul. St-Joseph, Le Village Place Cartier, Hull,  
P.Q., J8Y 3Z8 (819)776-4737  
Radio Shack TRS-80 Models II, III, 16, and colour  
computers. Hardware and software plus related  
peripheral equipment.

Ordinateur 2000  
146 Pl Du Portage #4, Hull, P.Q. J8X 2K3

## Joliette

Le Centre De L'ord.  
Logi-Ciel Inc. 346 Notre Dame, Lollette, P.Q. J6E  
3H4

## LaSalle

Cezar Elect.  
7640 Newman, LaSalle, Quebec, H8N 1X8

F. & T. Associates  
P.O. Box 513 LaSalle, Quebec, H8P 3J4

## LaSarre

Informat R.G.M. Inc.  
315A Rue Principal, Bur. 1, La Sarre, Quebec, J9Z  
1Z4

## LaTuque

Centre Ordinateur  
63 Iberville, La Tuque, Que. G9X 3Z5 (819)  
523-3916  
MO

## Lachine

Central Micro System  
350 Des Erables, Lachine, P.Q. H8S 2P9

## Laval

Compucentre  
Carrefour Laval, 3035 le Carrefour, Laval, P.Q.,  
H7T 1C7

JJGS Micro  
3184 boul. St. Martin W., Laval, P.Q., H7T 1A1

La Maison de L'Ord.  
3195 boul. St. Martin W., Ctr. Commer 2000, Laval,  
Quebec, H7T 1A3

Mambo Elect.  
400 boul. Cartier, Laval, Quebec, H7N 2K7

Memorissime Inc.  
3340 Eduard St., Laval, Quebec H7P 2M7  
(514)622-1390

Media-Tronique  
3517 boul. Concorde, Laval, Que. H7E 2C6  
(514)661-2804  
Columbla (I.B.M. compatible), Franklin Ace.  
Software, French logo and Sprite logo.

Montcalm Elect.  
97 Boul. Des, Laval, P.Q. H7G 2T2

Radio Shack Computer Centre  
1970 Boul. St. Martin, Laval, P.Q. H7S 1M9 (514)  
687-4454

## Levis

Becterm Inc.  
12 Trans Canada West, Levis, Que. G6V 4Z2  
(418)837-5894  
MO  
Aztec Multi-Micro, modems, plotters, Okidata,  
Diablo, Qume., Datasouth, Sharp PC1500-A  
Sharp PC5000, TI professional computer,  
boards, hard disks, interfaces, controllers.

Ormic Levis ETI/CN  
104 Rte. Kennedy, Levis, Que. G6V 6C9 (418)  
659-3858  
Authorized: Apple, Commodore, Eagle, NEC,  
Gimix, Epson, Centronics, Sharp. Complete  
library, full software, supplies and Ormic disk-  
ettes. Complete line of computer furniture.

## Longueuil

Boucher Elect. Ctr.  
1604 Ste-Helene, Longueuil, P.Q. J4K 3S7

Futur Byte  
1295 Chambly, Longueuil, Que. J4J 3X1  
(514)677-5264  
Products: IBM - Dec - Apple - Commodore -  
Hyperion - Televideo - Cromenco - Dec.  
Printers: Epson - Centronics - Smith Corona

U.F.Q. Elect.  
2665 Chamble Rd., Longueuil, Que., J4L 1M3

## Montreal

Active Components ETI  
5651 Ferrier St., Montreal, Que. H4P 1N1  
(514)731-7441  
MO CAT FREE  
Complete electronic components and com-  
puter products needs. Texas Instruments, Mot-  
orola, Fairchild, General Instruments, Anadex  
printers, Keytronics keyboards, Star Microics  
printers, Micro Professor computers, Tandon  
drives, AP products, AMP, Erskin Multicore  
Solder, Ungar, Weller, OK Industries, Vaco,  
Xcelite.

Albacor Microsystems  
101-38 Notre Dame West, Montreal, P.Q. H2Y 1S6

Als Inc.  
1470 Peel St., 117, Montreal, Quebec H3A 1T1  
(514)842-4818

Byte-Ryte  
12255 St. Evariste, Montreal, Quebec H4J 2B8  
(514)331-4946

Central Microsystems  
1460 City Councillors / 350 d'Eserables / 50 St.  
Charles, Montreal, P.Q., (514)849-7533 / 364-4980 /  
694-8940  
Apple, Lisa, and Columbia dealer.

Centre De Micro Scl  
870 Est Boul., Montreal, P.Q. H2L 1Y7

CESCO Electronics Ltd. ETI  
4050 Jean Talon St. West, Montreal, Que. H4P  
1W1 (514)735-5511  
MO CAT FREE  
Televideo, Texas Instruments printers and sys-  
tems, Centronics printers, 3M scotch diskettes,  
Amdek monitors, software, connector cables,  
Epson printers, Lobo drives, Novation modem.

Central Distributors, 1460 Councillor St., Mon-  
treal, P.Q., H3A 2E5

Citybyte  
4730 Queen Mary Rd., Unit 12, Montreal, Quebec  
H3W 1W8 (514)341-3201

CNCS Ltee.  
8375 Rue Bougainville, Montreal, P.Q., H4P 2G5

Compucentre  
Galerie D'Anjou, Montreal, Quebec, H5A 1C4

Compucentre  
P.O. Box 146 Place Bonaventure, Montreal, P.Q.,  
H5A 1G1

Compucentre  
Place Versailles, Montreal, Que., H1N 1E9

Computerland  
4160 Ste. Catherine, Ouest, Montreal, P.Q. H3Z  
2Y5 (514) 933-4949

Computerland  
2075 University Ave., Montreal, P.Q., H3A 2L1  
(514)845-0131  
Retailer of IBM, Apple, Digital, Hyperion and Compaq hardware and software. Complete line of peripherals including Epson, Okidata, C-ITOH, Mannesman Tally printers. Full Service centre on-site.

Coronet Electronics  
649A Notre Dame St. W., Montreal, Que.  
M3C 1H8 (514)288-6731  
MO CAT FREE  
Apple "Clones", peripherals, Disc-drives, monitors, printers, etc. Semi and parts.

Computer Innovations CN  
La Bale Centre-ville, Carre Phillips, Montreal, Que.  
H3C 3Y5

Computer Innovations CN  
977 Ste. Catherine St. O., Montreal, Que. H2L 2E8

Concept Audio Visuel  
8355 Boul., St. Laurent, Montreal, P.Q. H2P 2M7

Control Microsystems Inc.  
6390 Notre Dame St. West, Montreal, Que.  
H4C 1V4 (514)933-1136  
Commodore - OEM and Hewlett-Packard dealers. Industrial computer control systems using personal computers.

Data Terminal Mart  
3575 Parc. Ave., No.4306, Montreal, Que. H2X  
3P9 (518)288-1555  
Texas Instruments, Digital, Kappro, Aglie, Software, modems, Okidata, Qume.

Digitalc  
5970 Cote Des Neiges, Montreal, P.Q. H3S 1Z5

DOS Ltd. ETI/CN  
491 Viger Ouest, Suite 103, Montreal, P.Q., H2Z  
1G6 (514)879-1714  
MO  
Epson Products: printers, QX-10, HX-20 — Felix computer.

D.O.S., Montreal Ltd.  
1001 Lenoir Ste. 406, Montreal, P.Q., H4C 2Z6

E.P.L. Informatique  
6895 Beubien Est., Montreal, P.Q., H1M 3B2  
(514)252-8094  
Franklin, Memo, Texas Instruments, Gemini, Epson. Disk: 3M, Datalife, BASF. Stock Tab, etc.

Futur Byte  
1189 Phillips Sq., Montreal, Que. H3B 3C9  
(514)861-2831  
IBM, Dec, Apple, Commodore, Hyperion. Printers: Epson, Centronics, Smith-Corona, Nec. Cromemco, Sharp.



**FUTUR  
BYTE**

**Centres de conseils  
en ordinateurs**

**1189, Place Phillips, Montreal, QC  
H3B 3C9 (514) 861-2831**

Futur Byte  
6846 Est. Jarry, Montreal, Que. H1P 1W3 (514)  
327-3121  
Products: IBM-Dec-Commodore-Hyperion  
Printers: Epson-Centronics-Smith-Corona  
Software.

Futur Byte  
1178 Place Phillips - Suite 104, Montreal PQ.

Futur Byte  
489 Place Phillips, Montreal, Que. H3B 3C9  
(514)861-2831  
Products: IBM-Apple-Cromemco-Hyperion-Commodore-Dec. Peripherals. Centronics-Epson-Smith-Corona printers-Qume-Nec printer.

Heathkit Electronics & Computers Center ETI  
1400 Sauve West, No.1508, Montreal, Que.  
H4N 1C5 (514)332-3666  
MO CAT FREE

IBM Product Centre  
1 Place Ville Marie, Unit 11301, Montreal, P.Q.,  
H3B 3Y1 (514)874-7852  
IBM Personal computers and selected software and hardware for the family of IBM Personal computers. IBM typewriters and supplies.

IPL Informatique  
111, Ave. Laurier O., Montreal, Que. H2T 2N6  
(514)270-2092  
MO  
French and English books covering data processing, word processing, computers. Software, French and English.

Innovations en Informatique ETI/CN  
1080 Beaver Hall, Suite 730, Montreal, P.Q., H2Z  
1S8 (514)866-6571 (2366)

Key Punch Service (KSR) Ltd.  
1478 West St. Catherine St., Suite 201, Montreal,  
P.Q., H3G 1S8 (514)937-6124  
Micro computer dealer - Columbia data products - Peripherals, custom software: municipal taxation - Accountants professional fee schedule - general accounting package - Insurance broker program - church administration - finance.

La Place  
2050 St. Laurent Boul, Montreal, P.Q. H2X 2T2

Les Systems Videotex  
8571 Rue St. Denis, Montreal, P.Q. H2P 2H4

Malsion Bit Inc.  
5172 Ch. Queen Mary, Montreal, P.Q. H3W 1X5

Micro Age ETI  
1115 Sherbrooke West, Montreal, Que. H3A  
1H3 (514)845-1115  
MO  
IBM, Dec, Aitos, Franklin. Software personalized and packages. Education: Lotus, Wordstar, Phase II.

Micro R.G.S. Inc.  
751 Carre Victoria, No. 405, Montreal, Quebec H2Y  
2J3 (514)845-1534

MIP Inc.  
1460 Rue Mackay, Montreal, P.Q. H3G 2H7

Magic Touch TV Radlo  
5343 Ch. Queen Mary, Montreal, P.Q., H3X 1T9

Microville  
5800 Cavendish Blvd., Montreal, P.Q. H4W 2T5

Parmic Centre de Micro  
1010 Ouest Rueherbro, Sherbrooke Rue, Montreal,  
P.Q., H3A 2A7

Parmic  
1010 Sherbrooke West, Montreal, P.Q., H3A 2RF7

Radio Shack Computer Centre  
2001 Rue Universite, Montreal, P.Q. H3A 2A6 (514)  
849-2031

Radio Shack  
1255 Guy, Montreal, P.Q., H3H 2K5 (514)931-4494,  
932-4260  
CAT FREE  
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Spirale Computers  
1470 Peel St., No.117, Montreal, Que. H3A  
1T1 (514)842-4818  
MO CAT FREE  
Importer and distributor of micro computers and related accessories.

The Focus Centre  
6584 Rue Sherbrooke West, Montreal, P.Q. H4B  
1N5

Thomas Electrique  
4169 boul. DeCarle, Montreal, P.Q., H4A 3J8

Tremicord Inc.  
4846 Saint Denis St., Montreal, Quebec H2J 2L6  
(514)844-6712

### Universal Computer Systems

A Division of COPAM Electronic  
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6955 Lacordaire Blvd.

Montreal, Quebec

H1T 2K5

Tele: (514) 254-7810

Canadian Computer and Peripheral

Wholesalers

Dealer Inquiries Invited

William Mayers Assoc.  
2050 Mansfield St., Montreal, P.Q. H3A 1Y9

Xerox Canada Inc.  
329, rue de la Commune ouest, Montreal, Quebec  
H2Y 3T6 (514)288-2600  
Xerox 820/2 computer, Osborne Personal Computer, Xerox 16/8 & Xerox 1800 computers, Diablo Printers, Hyperion products. Related peripherals. Modems, monitors, software.

ZONE 2000 Inc. ETI  
5130 Boulevard Metropolitan Est., Montreal,  
Que., H1S 2V7 (514)374-6222  
Apple IIe, III, Lisa, Nestar, Nec Information Systems Inc., Nec-Advanced Personal Computer, Televideo, software.

### Pointe Claire

Compucentre  
Fairview Shopping Centre, Pointe Claire, Quebec,  
H9R 1C3

Computer Innovations CN  
Simpsons Centre D'Ochats Fairview, 7555  
Autoroute Trans-Canadienne, Pointe Claire, Que.  
H9R 1C3

Compu-Nord Inc.  
61 Place Frontenac, Pointe Claire, Quebec H9R  
4Z7 (514)842-4696

Informatique PC Ltd.  
23 Valois Bay Ave., Pointe Claire, P.Q. H9R 4B4

### Pierrefonds

Pierrefonds  
Kidbits Computer Outlet Inc.  
4763 Sources Blvd., Pierrefonds, Que., H8Y  
3C6 (514)684-7743  
MO CAT FREE  
Apple compatible and Atari hardware and software. Peripherals and accessories. Educational dealer.

### Quebec City

Computerland  
888, rue St. Jean, Quebec, P.Q. G1R 5H6 (418)  
524-5265

# Directory of Computer Stores

Cesco Micro-Ordinateurs  
909 Charest Ouest, Quebec City, Que. G1K 6W8 (418)687-4231  
Dépositaire des produits: Apple, Televideo, Centronics, Texas Instruments, Corvus, 3M. Le meilleur à Québec par la qualité de son service.

**CESCO MICRO ORDINATEURS**

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Quebec  
418-687-4231**

Computerland  
888 rue St. Jean, Quebec, Que. G1R 5H6 (418) 524-5265  
FREE  
IBM, Compaq, DEC Digital, Hyperion, Apple, Nelma.

Compucentre  
5401 boul. des Galeries, Les Galeries, Quebec, P.Q., G2K 1N4

Concept Audio Visuel  
375 boul. Charest W., Quebec City, P.Q., G1N 2E7

Micro I-D Inc. ETI/CN  
3285 - 1st. Ave., Quebec City, Que. G1L 3R2 (418)622-0842  
MO  
Franklin Ace, Columbia, Televideo, Spectra-  
video, TEQ Tiger, Moniteurs, Logiciels, Im-  
primantes, Librairie.

**MICRO I-D**  
LE CENTRE DU MICRO-ORDINATEUR

- Franklin Ace
- Columbia
- Televideo
- Spectravideo
- Teo - Tiger
- Moniteurs
- Imprimantes
- Logiciels
- Librairie
- Peripheriques

Quebec Dolbeau  
418-622-0842 • 418-276-7642

PME Ordinateurs  
1375 Charest Blvd., Quebec, Quebec G1N 2E7 (418)683-5140

Simco Inc.  
900 Place D'Youville, Quebec, P.Q. G1R 3P7

Selectronic  
600 Bevedere, Quebec, P.Q. G1S 3E5

Quebec Elect.  
621 St. Jean St., Quebec, P.Q. H1R 1P7

## Rimouski

J.L. Ornnateur Ltée. CN  
133 St-Germain Ouest, Rimouski, P.Q., G5L 4B6 (418)724-6800

MO CAT \$1.50  
Computers: Apple, Commodore, Digital, Gescom, Sharp. Softwares: Ediciel, Logidisque, Vifi Sogiciel. Monitor: Zenith, Amdek; Printer: Epson, Centronics, C-ITOH Electronics Inc.; Accessoires: Talos.

Ormic Rimouski ETI/CN  
133 St. Germain O., Rimouski, Que. G5L 4B6 (418)724-6800  
Authorized: Apple, Commodore, Eagle, NEC, Gimix, Epson, Centronics, Sharp. Complete library, full software, supplies and Ormic diskettes. Complete line of computer furniture.

## Rouyn

Logicon (Rouyn) Ltée  
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## Rosemere

Radio Shack  
315 boul. Labelle, Galeries des Mille Iles, Rosemere, P.Q., J7A 2A7 (514)437-1211  
Radio Shack TRS-80 Models II, III, 16, and colour computers. Hardware and software plus related peripheral equipment.

## Sept Iles

Services Informatiques de Sept-Iles Inc.  
461 Brochu, Suite 202, Sept-Iles, Que. G4R 2X1 (418)968-8910  
Commodore and 3M dealers for computer products. Books on computing from beginners to programmer. Software and games from various sources.

## Sherbrooke

Computerland  
2524 rue King Ouest, Sherbrooke, P.Q. J1J 2E8 (819) 564-1534

D.O.S. Sherbrooke  
1578 Rue King Ouest, Sherbrooke, P.Q. J1J 2C3

Futur Byte  
1576 King St. West, Sherbrooke, Que. J1J 2C3 (819)564-1202  
Consulting, analysis, programming, supplies. Authorized dealer for Apple, Commodore, Televideo, Xerox plus various lines of peripherals.

Les Systems Data Du Canton Inc.  
2341 King St. N., Sherbrooke, Que. J1J 2G5 (819)564-4448  
Apple, Columbia.

Radio Shack  
3050 boul. Portland, Carrefour de L'Estrle, Sherbrooke, Quebec, J1K 1L1

Vislontroniques Ltd.  
218 Rue Alexandre, Sherbrooke, P.Q. J1H 4S7

## St. Anne Des Mont

Dani-L'Ordinateur  
26 Route Du Parc, Ste. Anne Des Mont, P.Q., G0E 2G0

## St. Bruno

Compucentre  
162 boul. des Promenades, St. Bruno, P.Q., G3V 5K1

Mico-Mars Inc.  
1364 Roberval St., St. Bruno, P.Q. J3V 5J2

Radio Shack  
271 boul. Des Promenade, Les Promenades, St. Bruno, P.Q., J3V 5K3

## St. David

Micro-Contact Inc.  
463 Route 132, St. David, P.Q., G6W 1H5

## St. Foy

D.O.S.  
3440 Quatre-Bourgeois, Ste. Foy, Que. G1W 4T3 (418)651-1882  
MO  
Also D.O.S. centers at Moncton, Montreal, Sherbrooke. We are also a builder for the Fellx Microcomputer.

Computerland  
2600 Boulevard Laurier, Ste. Foy, Q.B. G1V 2L1 (418) 659-6540

Ordinateurs IRISCO  
2014 Boul. Charest Ouest, Suite 100, Ste. Foy Que., G1N 4N6 (418)681-0061  
Commodore, Hewlett-Packard & Columbia dealers.

Ormic Ste. Foy CN  
999 de Bourgogne, Ste. Foy, Que. G1W 4S6 (418) 659-3858

Authorized: Apple, Commodore, Eagle, NEC, Gimix, Epson, Centronics, Sharp. Complete library, full software, supplies and Ormic diskettes. Complete line of computer furniture.

Radio Shack Computer Centre  
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## St. Georges de Beauce

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11197 2 Ieme Ave., St. Georges de Beauce, Que G5Y 1V9 (418)228-0005  
MO  
Micro-computer products, peripherals & accessories, software. Cdn. General Electric computer products, memorex, Visicorp, Centronics. Authorized Apple dealer.

## St. Hubert

Brousseau Ateliers  
3256 Grande Allee, St. Hubert, Que., J4T 2S5

## St. Hyacinthe

Microstat Inc.  
740 Casavant west Blvd., St. Hyacinthe, Que. J2S 7S3 (514)773-1361  
Everything for Commodore, Sharp Computers, Senith data systems. Hardware, software, peripherals.

Salon De L'Elect.  
2783 Rue Nichols, St. Hyacinthe, P.Q. J2S 2X2

Simco Inc.  
2040 Des Cascades West, St. Hyacinthe, P.Q., J2S 3J6 (514)773-7843  
Apple dealer. Peripherals and software. Apple only at 3 stores. Other stores: 900 Luce D'Youville, Daniel Gregoire, Ouites, P.Q., G1R 3P7 (418)692-4430 — 322A Principale, Alain Lamothe, Granby, P.Q., J2G 2W4 (514)378-2107.

## St. Jean sur Richelieu

Info Service Electronique Inc.  
224 Champlain, St. Jean-sur-Richelieu, Que. J3B 6V8 (514)347-3375  
MO  
Apple, GBC, Sharp, diskettes and accessories. Maintenance, customized systems.

## St. Jerome

Academie De L'Ordin  
Carrefour Du Nord, 900 Blv. Grignon, St. Jerome, P.Q. J7Z 3S7

Infovideo Inc.  
291 LaBelle, St. Jerome, Que. J7Z S12 (514)  
431-1414  
Apple computers, Texas Instruments, Televideo  
systems, Epson, Comrex. Livres et Revues.

### St. Laurent

asap Computer Products  
6969 Trans Canada Hwy., Suite 114, St. Laurent,  
Que. H4T 1V8 (514)337-2280  
MO  
Authorized dealers for: IBM Personal Computer,  
Hyperion. IBM compatible software and  
hardware.

CompuDesign  
3680 Cote Vertu, St. Laurent, Que. H4R 1P8  
(514)335-2000  
MO  
Dealer of Apple, Apple compatibles, IBM compatibles,  
Epson printers, peripherals and software for Apple and IBM,  
computer supplies and publications.

JMT Inc.  
2400 Modugno St., St. Laurent, Quebec H4R 1W6  
(514)337-6139

Hamilton Avnet  
2670 Sabourin, St. Laurent, Quebec, H4S 1M2

Protec  
725 Decalre Blvd., Unit 202, St. Laurent, Quebec  
H4L 3L4 (514)744-3363

Radio Shack C. Dept.  
3205 Cote Vertu, Pl. Vertu Shop, St. Laurent, P.Q.,  
H4R 1Y8

Radio Shack Computer Centre  
8092 S. Service Rd., St. Laurent, P.Q. H4S 1M5  
(514) 337-2741

St. Laurent Micro Computers  
824 Decarie Blvd., St. Laurent, Que. H4L 3L9  
(514)744-4956  
Timex/Sinclair, Franklin, Basis, Kaypro, Epson  
printers.

Universal Infor.  
5990 Vanden Abeille, St. Laurent, Quebec, H4S 1R9

### St. Leonard

Zone 2000 Inc. CN  
5130 Boul. Metro E., St. Leonard, Que. H1S 2V1

### St. Ursule

Indusol Industrial  
2050 Principale, Ste. Ursule, Quebec, J0K 3M0

### Thetford Mines

Lessard Eq de Bureau  
236 Notre Dame Sud, Thetford Mines, P.Q., G6G  
1J6

Ordinatel Inc.  
236 Notre Dame Sud, Thetford Mines, Que.  
G6G 1J6 (418)338-2365 or 335-5172  
Apple compatible, and Televideo line of computer  
and associate supplies.

Thetford Elect.  
163-4th St. W., Thetford Mines, P.Q., G6G 5A3

### Tracy

Pro-Micro  
6870 Plaza Blvd., Tracy, Que. J3R 4L7 (514)  
743-2825

### Trois Rivières

Futur Byte  
1366 Boulevard des Recollets, Trois Rivières,  
Que. G8Z 4L5  
Products: IBM-Commodore-Hyperion-Televideo  
Dec. Printers: Epson-Centronics-Smith-Corona.  
Software.

Ormic Trois Rivières  
1500 Notre Dame, Trois Rivières, Que. G9A  
4X5 (819)373-7020  
Authorized: Apple, Commodore, Eagle, NEC,  
Gimix, Epson, Centronics, Sharp. Complete  
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Complete line of computer furniture.

Radio Shack  
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Radio Shack TRS-80 Models II, III, 16, and colour  
computers. Hardware and software plus related  
peripheral equipment.

### Tracy

Pro Micro Enr.  
6870 Plaza Blvd., Tracy, Quebec, J3R 4L7

### Valleyfield

Claude Gendron Elect.  
173 Rue Victoria, Valleyfield, P.Q., J6T 1A6

### Val D'Or

Centre D'informatique Abitibi Inc.  
548-3rd Ave., Val D'Or, Quebec, J9T 1S4

### Victoriaville

Co-Ordinateur 551 In.  
551 boul. Bols-Frances Su., Victoriaville, P.Q., G6P  
5X6

### Ville D'Anjou

Compucentre (H.O.)  
9200 Claveau, Ville D'Anjou, P.Q., H1J 1Z4  
Head office is not an authorized dealer.

Compucentre (H.O.)  
9001 Louls H. Lafontaine, Ville D'Anjou, P.Q., H1J  
1Z4.  
Head Office is not an authorized dealer.

### Ville LeMoyné

Gregoire Elect.  
200 Rue Charron, Ville LeMoyné, P.Q., J4R 2K6

### Westmount (Mtl.)

Computerland  
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(514)933-4208  
FREE  
IBM, Compaq, DEC Digital, Hyperion, Apple,  
Nelma.

## NEW BRUNSWICK

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Bayco Business Products Ltd.  
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548-4558  
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Commodore and Olivetti computers. Complete  
sales, service and support for our products.

### Dieppe (Moncton)

Datamaster  
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Apple T.I., DY-4 micros and local area networks.  
Specialize in business applications.  
Software, including proprietary software accounting  
package.

### Dieppe

Computerland  
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Retailer of IBM, Apple, Digital, Hyperion & Compaq  
hardware and software. Complete line of peripherals  
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### Fredericton

Datamaster  
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454-8953

Apple T.I., DY-4 micros and local area networks.  
Specialize in business applications.  
Software, including proprietary software accounting  
package.

Interactive Computer Systems Ltd.  
554 Queen St., Fredericton, N.B. E3B 3W4  
(506)454-7691

MacDonald Ventures (Sof Tec) Ltd.  
30 Main St., Fredericton, N.B. E3A 1B8 (506)  
472-1678

MO  
BASF magnetic media distributor for the Atlantic  
provinces. Franklin Ace Computers. Customized  
software. Supplies and accessories for all micro  
computers.

Radio Shack  
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(506)454-0930  
MO CAT FREE

### Moncton

Computerland  
550 Paul St., Dieppe, N.B. E1A 5T5 (506) 855-6696

D.C.T. Systems Inc.  
15 Archibald St., P.O. Box 832, Moncton, N.B.  
E1C 8N6 (506)389-1222  
Data consulting and timesharing (PDP 11/34)  
Xerox micro computer and software. Pearl software,  
RDM Pascal data base, and micros peripherals.

Interactive Computer Systems Ltd.  
827 Main St., Moncton, N.B. E1C 1G1 (506)  
389-3333  
MO  
Corona, Kaypro, Victor, Epson

Radio Shack Computer Centre  
801 Main St., Moncton, N.B. E1C 1G1 (506)  
854-2203  
MO CAT FREE  
TRS 80 computers and software. Printers,  
peripherals and user items.

### Saint John

Compucentre ETI  
Brunswick Sq. Fashion Centre, Saint John,  
N.B. E2L 4V1 (506)652-7580  
MO  
Commodore, Atari, ColecoVision/Adam, Mattel,  
Texas Instruments, Hewlett-Packard, Casio,  
Sharpe, Canon

Datamaster  
156 Union St., Saint John, N.B., E2L 1A8  
(506)693-1132  
Apple T.I., DY-4 micros and local area networks.  
Specialize in business applications.  
software, including proprietary software accounting  
package.

Radio Shack Computer  
621 Fairville Blvd., Saint John, N.B. E2M 4X5  
(506)674-1926  
Complete line of TRS-80.

# Directory of Computer Stores

## NOVA SCOTIA

### Dartmouth

Data Terminal Mart  
800 Windmill Road, Dartmouth, N.S. B3L 2E2  
(902)469-3782  
DEC, Texas Instruments, Anderson-Jacobson,  
Kaypro personal computers; Qume, DEC, Okl-  
data, Texas Instruments printers, ADDS, DEC,  
Qume video terminals; Anderson-Jacobson  
modems.

Radio Shack Computer Centre CN  
133 Wyse Rd., Dartmouth, N.S., B3A 4K9  
(902)463-4910  
MO CAT FREE

### Greenwood

Innovative Systems Ltd.  
P.O. Box 130 Greenwood, N.S., B0P 1N0  
(902)765-4222  
Apple computers, peripherals and software for  
Apple computers.

### Halifax

Atlantis Microcomputer  
1558 Argyle St., Halifax, N.S. B3J 2B7  
(902)422-3500

Basic Computer Sales  
6100 Young St., Halifax, N.S. B3K 2A4 (902)  
454-8344  
MO CAT FREE  
Texas Instruments TI-99/4A computers, peri-  
pherals and software, Okidata microline prin-  
ters, Smith Corona and Panasonic. Hewlett-  
Packard calculators and P.C.'s. Texas Instru-  
ments calculators.

Computerland  
6021 Young St., Halifax, N.S., B3K 2A1  
(902)454-8676  
Retailer of IBM, Apple, Digital, Hyperion and Com-  
paq hardware and software. Complete line of  
peripherals including Epson, Okidata, C-TOH,  
Mannesman Tally printers. Full service centre on-  
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Mensa Computer Systems  
1867 Granville St., Halifax, N.S. B3J 1Y1 (902)  
421-1127  
MO  
Lisa dealer carrying Apple computer products.  
Dealer for NEC computers.

Minlcomp Systems Ltd.  
6174 Quinpool Road, Halifax, N.S., B3L 1A3  
(902)421-7122  
Full system Commodore dealer.

Unitron Computer Corp.,  
20 Rockingstone Rd., Halifax, Nova Scotia, B3R  
2C6 (902) 477-9391  
Apple and IBM compatible Computers. One Year  
Warranty. Complete line of interface cards and ac-  
cessories including colour and amber monitors,  
modems, printers, speech synthesizers, and voice  
recognition. Dealer Enquiries Invited.

Xerox Canada Inc.  
Mezzanine Floor, Bank of Commerce Bldg., 1809  
Barrington St., Halifax, N.S. B3J 3K8 (902)425-6400  
Xerox 820/2 computer, Osborne Personal Com-  
puter, Xerox 16/8 & Xerox 1800 computers, Diablo  
Printers, Hyperion products. Related peripherals.  
Modems, monitors, software.

### Kentville

Future World Computers Inc.  
142 Aberdeen St., Kentville, N.S. B4N 4H8  
(902)678-0101

### Lunenburg

Bluenose Computer Shop CN  
35 Falkland St., Lunenburg, N.S. B0J 2C0  
(902)634-8856  
MO  
Apple dealer.

### New Minas



**kobetek  
systems  
limited**

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Commodore systems and Actrix portables.  
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data manager and accounting package; stat-  
istical package for Commodore, Coin con-  
trols Joysticks, Time Accountant for pro-  
fessionals.

### North Sydney

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115 King St. P.O. Box 459, North Sydney, N.S.  
B2A 3M5 (902)794-7273  
MO  
Commodore systems and consumer products.  
Specialize in business systems and custom soft-  
ware. Complete in-store service.

### Timberlea

Micro Computer Atlantic  
2777 St. Margrets Bay Rd., Timberlea, Hfx.  
B3L 4J3 (902)876-2920  
MO  
Jemini multiuser business system computers  
(Turbodots), Qume video terminals, Seagate  
hard disks, Okidata printers, Transtar daisy-  
wheel printers, Elephant Memory Systems  
diskettes, Hayes modems.

### Truro

Kelly's Electronic World  
914 & 918 Prince St., Truro, N.S. B2N 1H5  
(902)895-6674  
MO  
Yould's Limited  
564 Prince St., P.O. Box 1319, Truro, N.S., B2N 5N2  
(902)893-9481  
Halifax — 3600 Kempt Road, Halifax, N.S., B3K  
4X8  
MO CAT FREE  
Victor 9000, Franklin Ace, Texas Instruments.  
Sales, service, leasing.

## PRINCE EDWARD ISLAND

### Charlottetown

Jeta Systems Ltd.  
33 Belmont St., Box 2857, Charlottetown, P.E.I.,  
C1A 8C4

Megabyte ETI/CN  
167 Queen Street, Charlottetown, P.E.I. C1A 4B4

Radio Shack C. Dept.  
96 Queen St., Charlottetown, Prince Edward  
Island, C1A 4B1

### Summerside

R.T. Holman Ltd.  
250 Water St., Summerside, P.E.I., C1N 1B7  
(902)436-2222  
MO  
Branch stores: R.J. Holman Ltd., Confederation  
Court Mall, Charlottetown P.E.I.  
R.T. Holman Ltd., Main St., Alberton, P.E.I.

## NEWFOUNDLAND

### Stephenville

DSG Enterprises Ltd.  
Box 221, Stephenville, N.F. A2N 2Z4

### St. John's

Carlbou Computers  
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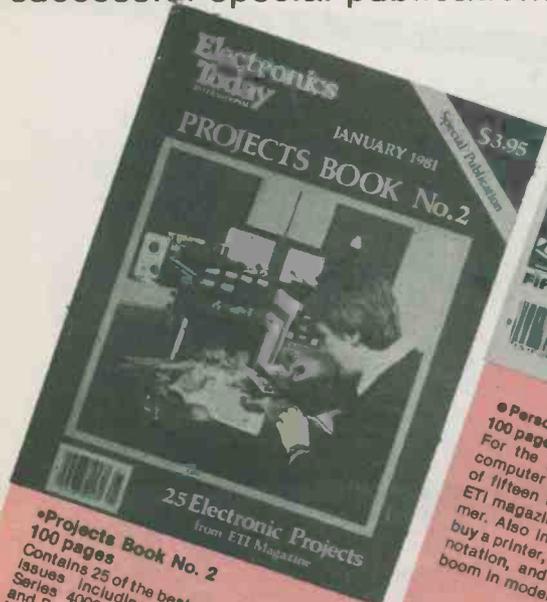
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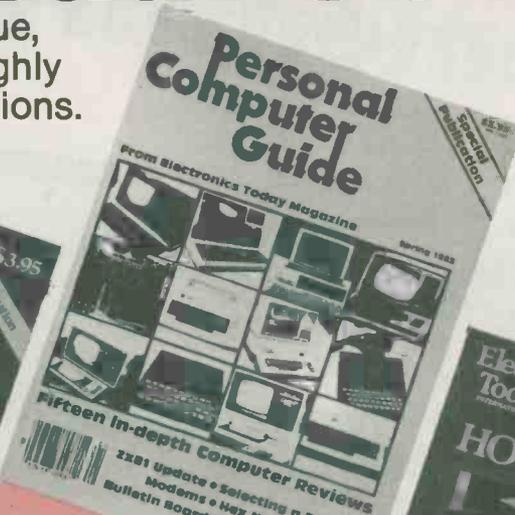
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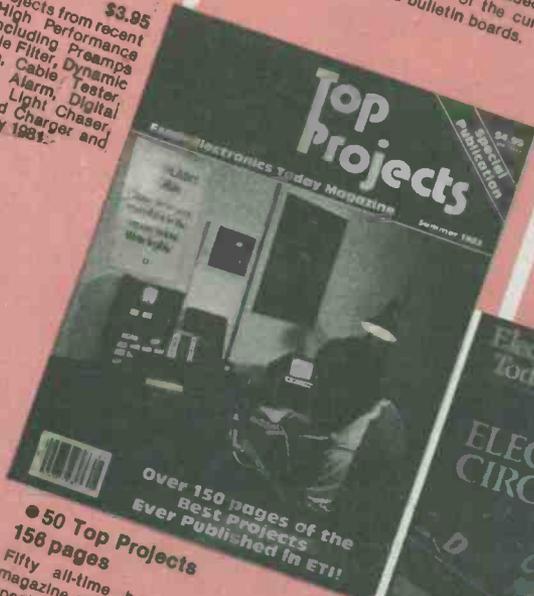
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SOMEWHERE FAR off in the lonely, airless reaches of space is a lot of lonely hardware. A hundred years ago, nobody would have dreamed of how obsessed modern man (or at least some modern men) would become with putting hardware 'way up there where he couldn't reach it. Back then they would never have understood that nowadays it isn't cool anymore to take a piece of hardware in hand and use it. You have to use it by remote control, ideally from as far away as possible. Ask anyone who's ever used a TV remote control. Who knows, maybe it was the invention of the car bomb that started this mad stampede away from modern technology. In any event, the epitome of this phenomenon is the geostationary communications satellite, orbiting 22,300 miles above the heads of those who live on the equator. Up here in Canada, we use the things, but we don't have them hanging over our heads.

*The Birds of Babel: Satellites for the Human World* is a book about satellites — how they've developed, what they've done, what they're likely to do in the future, and why. The book focuses primarily, but not exclusively, on communications satellites, those that are in that 22,300 mile orbit. It tells how the orbit was discovered by science fiction writer Arthur C. Clarke, who was the first to realize that at a certain critical height, a satellite would orbit exactly as fast as the earth turns, and would thus appear to stay over a fixed point on the planet, capable of broadcasting signals to about a third of the earth's surface. A reasonably non-technical description of how satellites work is given, along with descriptions of some of the companies, such as INTELSAT, that are putting satellites up there.

The book is quite well written, and very readable. It is by no means a technical manual, and does not try to give you enough information to build your own satellite, but rather looks at them from the point of view of those who use them and benefit from them — or in other words almost everyone in a country like Canada, or in fact in virtually every country around the world. In other words, it's a good book.

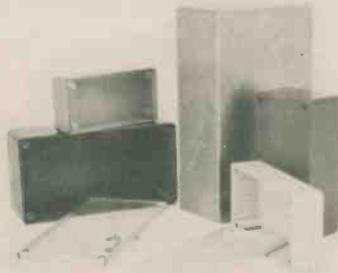
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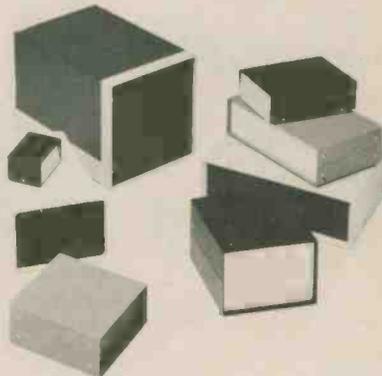
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# Frequency Counter



For those who need frequencies counted, ETI presents a simple, easy-to-build digital frequency counter. Design by Dave Bedrosian



A FREQUENCY COUNTER is a very useful piece of test equipment as it can be used for troubleshooting both analog and digital circuitry. The design shown in this article uses readily available TTL and CMOS ICs for measuring frequencies from below 10 Hz up to 10 MHz.

This counter differs from others in several important areas:

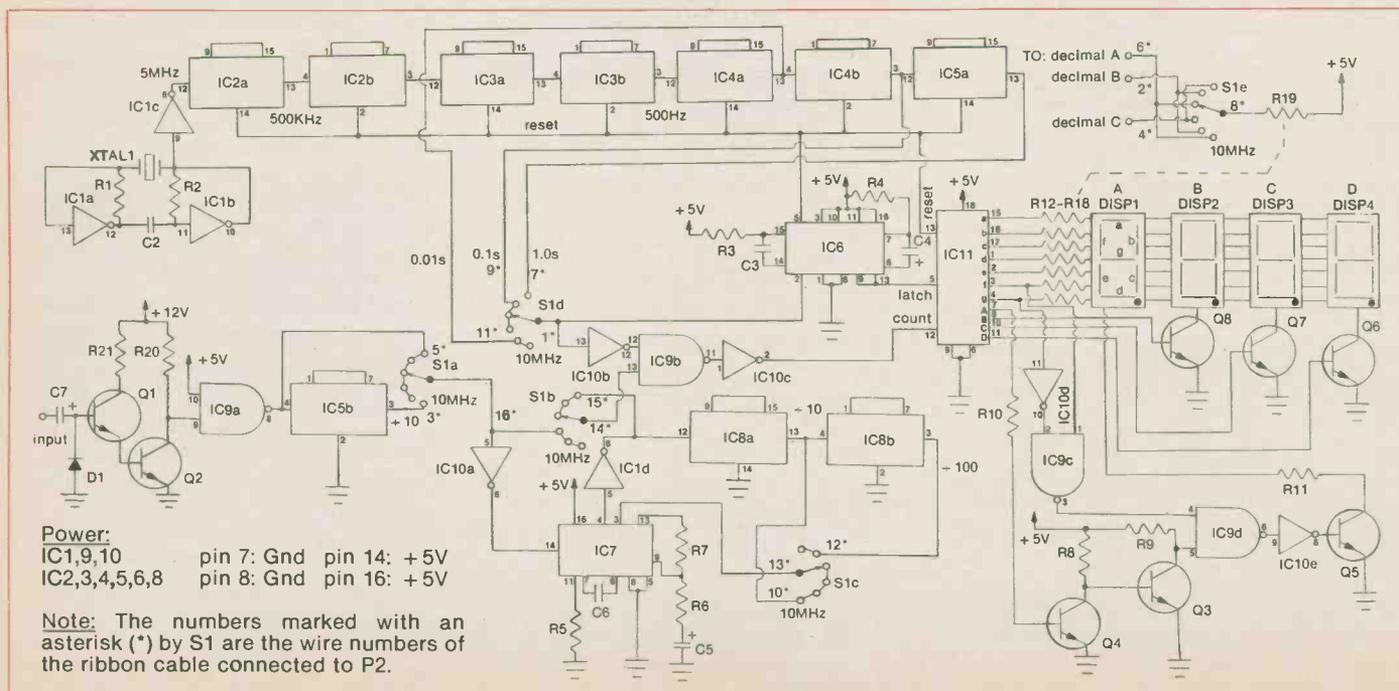
The gating times are generated by a crystal controlled clock which is very accurate and will not drift significantly with time as opposed to the more commonly used monostable multivibrator.

When measuring low frequencies (below 10 KHz), the input signal is multiplied by up to 100, thereby reducing the reading time to one second or less.

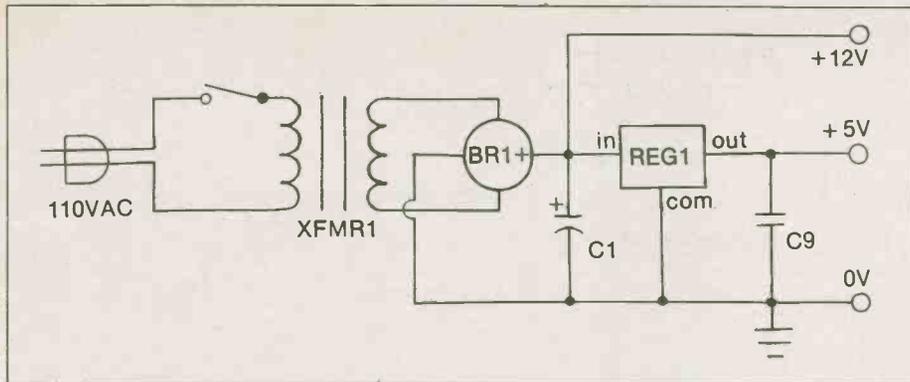
This frequency counter automatically updates its display about three times every second (approximately once per second on the 100 Hz range), and a latch is used to provide a flicker-free display of the input frequency.

A block diagram of the frequency

counter is shown in figure 1. The input signal, after being conditioned by the input circuit, is "anded" with the gating pulse and the resulting signal is fed to the counter, which counts the number of high to low transitions at its input. This count is then latched and displayed on the four



Schematic diagram for the frequency counter.



Power supply schematic for the frequency counter.

seven-segment displays. If, for example, the gating pulse is set at one second and the input frequency is 2259 Hz, the counter will 'see' 2259 high to low transitions in the one second gating period and thus 2259 will be displayed. Refer to the "How it Works" section for a more detailed description of the frequency counter.

### Construction

The printed circuit boards shown in this article are recommended to speed construction and reduce the possibility of wiring errors; however, wire-wrapping techniques could be used if desired. The following construction details apply when the suggested Hammond case is used with the printed circuit boards.

Start by assembling the large board. First solder in the jumpers; there are 24 of them. Use a short piece of insulation to insulate J1 from the crystal leads. Next, solder in the IC sockets and the power supply parts. Be sure to attach heatsinks to both the bridge rectifier and the regulator before soldering them in place. Neither silicone nor mica insulators are required for either heatsink. The remaining parts can now be soldered in place. Pay attention to the orientation of the tantalum capacitors, transistors and diode.

Before inserting the ICs, temporarily apply power to the board and check the

power supply. The input to the regulator should be 9V or greater (depending on the transformer used) and the output of the regulator should be 5V, within half a volt. Check each IC socket separately for +5V and ground (excluding the two 16 pin header sockets and the DIP resistor socket). Pin 7, 8, or 9 should be ground and pin 14, 16, or 18 should be +5V for 14, 16, and 18 pin sockets respectively. If there is a problem, check that all of the jumpers are installed correctly. With ground and +5V at each IC socket, power should be removed and the ICs inserted; note the proper orientation of each one. The DIP resistor obviously can go in either way; if, however, it is not available eight 33 ohm resistors bent for 0.4 inch insertion can be used instead.

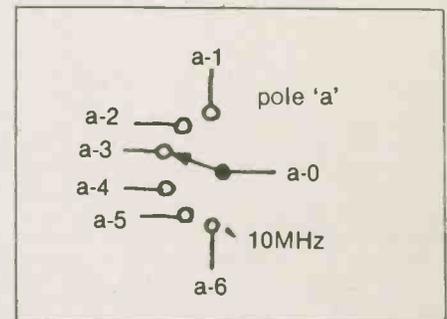
With the main board completed, the display board can be assembled next. Solder in the ten jumpers and the two IC sockets, then insert the four displays using the parts overlay and figure 2. The decimal point of each display should be on the bottom half of the display board. Next a six inch sixteen pin header cable should be made as indicated in figure 3 and connected to both boards as shown on the parts overlay.

Having completed both printed circuit boards, the rotary switch can be wired. Initially it should be tested with an ohmmeter to verify that each position of

Table 1

Wire Number	Switch Location
1	d-0
2	e-2, e-5
3	a-6
4	e-1, e-4
5	a-1, a-2, a-3, a-4, a-5
6	e-3, e-6
7	d-1
8	e-0
9	d-2, d-3, d-4
10	c-3, c-4, c-5, c-6
11	d-5, d-6
12	c-1, c-2
13	c-0
14	b-0
15	b-1, b-2, b-3
16	a-0, b-4, b-5, b-6

Table 1. Wiring table for switch 1.



each pole is operational; this may save considerable time if troubleshooting is required later. Use table 1 to connect an eleven inch piece of ribbon cable to the switch.

At this point in construction the unit can be fully tested. With the rotary switch and the display board connected properly, apply power to the main board. If all is well the display will read '000' or '001' and the leftmost digit will be extinguished. If there is a problem, refer to the troubleshooting section, otherwise continue testing. Apply about a 2V peak to peak signal to the input for each of the six ranges; in each case the display should read out the correct frequency. For frequencies above approximately 200 KHz, a TTL equivalent signal should be applied to J17, bypassing the input circuit since it only responds to signals below this frequency. With a signal applied to J17, the frequency counter should read signals up to 9.999 MHz. Also check that the leftmost digit is extinguished when it is zero, and that the decimal point moves according to the rotary switch position. If all ranges work properly, continue construction by mounting all parts inside the cabinet.

The front and back panels which come with the cabinet are over three inches high and should both be cut down to the two inch mark and appropriate holes drilled. The display board and bezel can be mounted to the front panel followed by

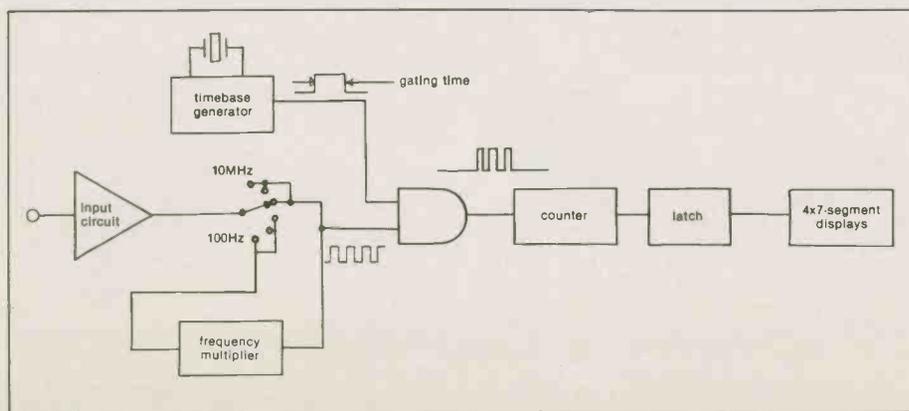


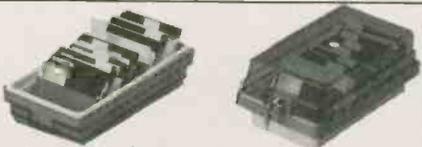
Figure 1. Frequency counter block diagram.

## Frequency Counter

Problem	Area of Problem	Possible Cause of the Problem
all four digits extinguished	display driver circuitry	- DISP1-DISP4 properly oriented - ribbon cable connected properly - DIP resistor in place - IC11 properly inserted - Q6,Q7,Q8 properly inserted
leftmost digit always extinguished	first-digit blanking circuitry	- Q3,Q4,Q5 correctly in place - R8-R11 proper values - proper insertion of IC9,IC10
decimal point	decimal point	- proper connection of ribbon cable
not on	switching circuitry	- wiring of switch 1, pole 'e' - R19 (DIP resistor) okay
display on, but unit won't count on any range	input circuit or clock circuit or reset circuit	- input BNC connector - input circuitry (Q1,Q2) - wiring of switch 1 poles 'a', 'b' and 'd' - R3,C3,R4,C4 proper values - IC6 inserted correctly - operation of the clock and clock divider circuitry (IC1-IC5) - proper insertion of IC9-IC11
operational on all but the lower three ranges	input frequency multiplier	- switch 1, pole 'c' - all parts associated with IC7 and IC8
operational on all but the 10 MHz range	input frequency divider	- switch 1, pole 'a' - proper wiring of IC5b



Table 2. Troubleshooting guide.

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the rotary switch, BNC connector and the power switch. The back panel only has the power connection. The main board is mounted inside the cabinet with the input molex connector adjacent to the BNC connector. Mount the transformer and wire the power switch followed by the BNC and power connectors. Finally, plug the two 16 pin headers into the appropriate sockets.

The frequency counter is now complete and should be tested again. If input

signals greater than 200 KHz are frequently going to be measured, the input circuit should be redesigned to respond to signals up to 10 MHz. Alternatively, a switch could be used to take the input circuit out of the signal path in which case the input signal would have to be TTL compatible.

### Use

The frequency counter is very easy to use. An appropriate signal is applied to the input BNC connector, and the correspon-

ding frequency is read off the display. If the recommended input circuit is used, the input signal should be less than 200 KHz with an amplitude greater than two volts peak to peak. When taking a reading, the highest range should be selected first and lower ranges selected until the left display is lit; this avoids misreading the counter when there is an overflow. The lower three ranges of the counter may take a few seconds to stabilize after a signal is applied while the phase-locked loop locks onto the input signal. On all but the 100 Hz range, the display is updated about once every 300 ms; the 100 Hz range, having a gating time of one second, is updated once every 1.3 s or so.

### Troubleshooting

If the frequency counter does not function properly, first check the power supply for +5V. Both circuit boards should be inspected for solder bridges and all IC leads should be checked for proper insertion. If the problem(s) still persist, use table 2 as a guide in troubleshooting the unit.

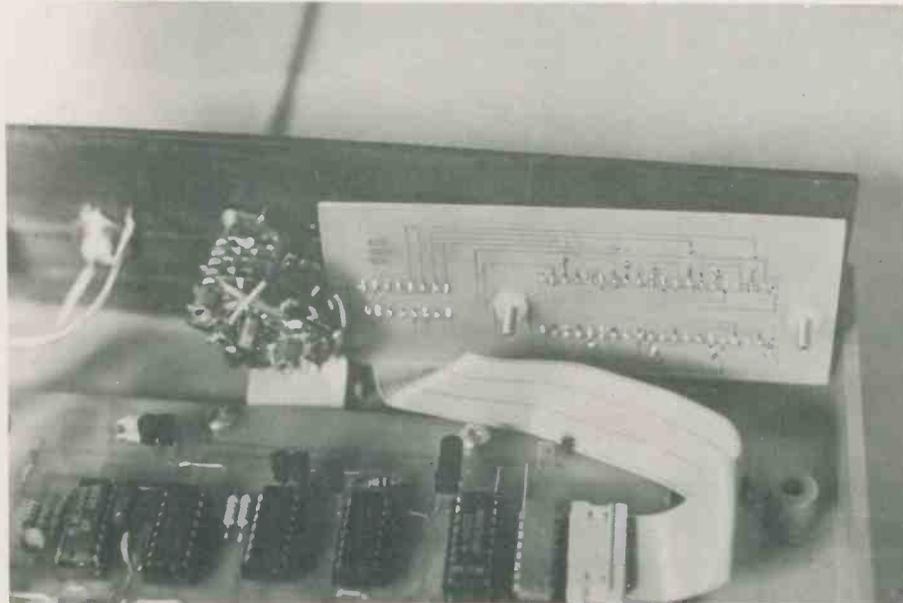


Figure 2. The display board.

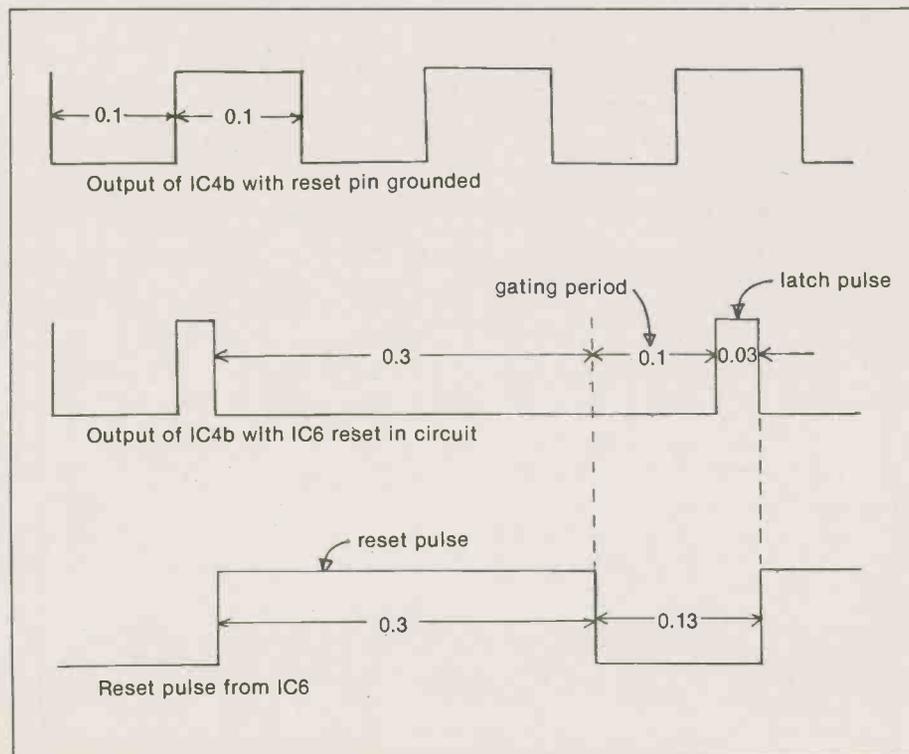


Figure 3. Timing diagrams.

### PARTS LIST

Resistors (all 1/4 W 5% unless otherwise specified)

R1,2	270R
R3,8,9,20	4k7
R4	390k
R5	18k
R6	47k
R7	10k
R10	1k
R11	10R
R12-19	33R DIP resistor (Bourns 4116R-001-330 or equiv.) *
R21	4M7

### Capacitors

C1	2200u 25 V electrolytic
C2	10n ceramic
C3,8,9,10,11	100n ceramic
C4	1u tantalum
C5	4u7 tantalum
C6	50p silver mica
C7	2u2 tantalum

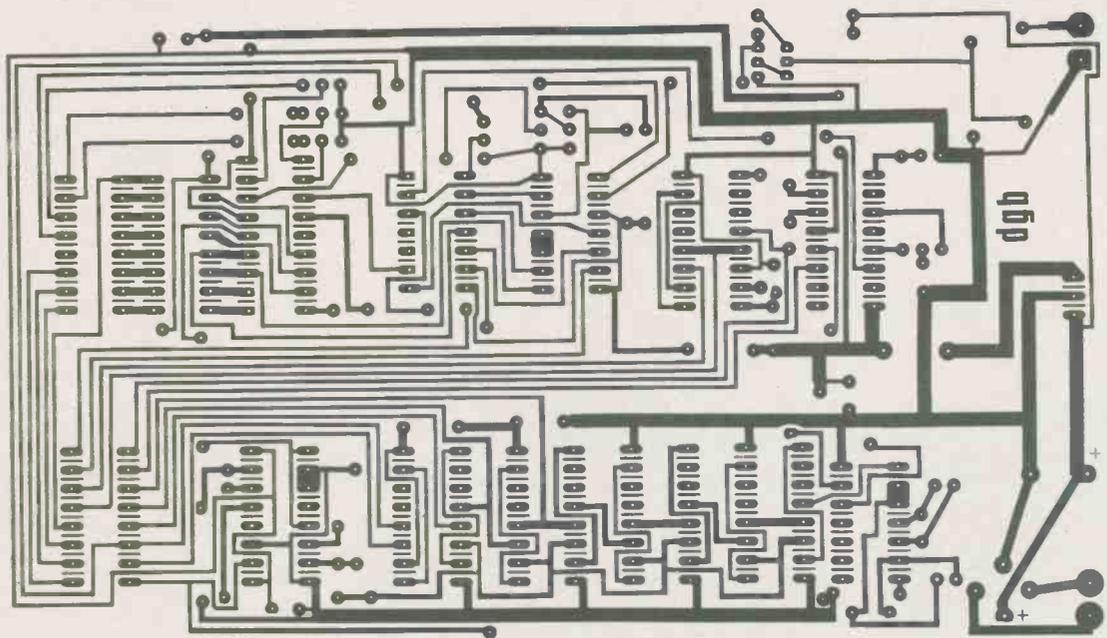
### Semiconductors

Q1-Q8	2N3904 or equiv.
D1	1N4148 or equiv.
BR1	1.5A, 200 V bridge rectifier with heatsink (W02M or equiv.)
REG1	5V, 1A regulator with heatsink (LM7805)
IC1,10	74LS04
IC2,3,4,5,8	74LS390
IC6	74LS221
IC7	MC14046B
IC9	74LS132
IC11	74C926 (National)

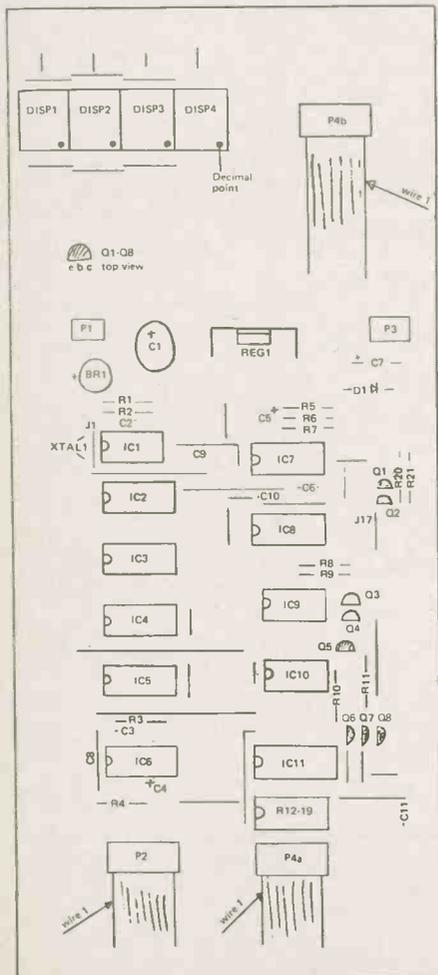
\* These parts are available at Newark Electronics, 271 Attwell Drive, Rexdale, Ontario, M9W 5B9.

The 74C926 is a National part available at Zentronics and other National distributors.

# Frequency Counter



The printed circuit layouts for the main board and display.



Parts overlay for the frequency counter.

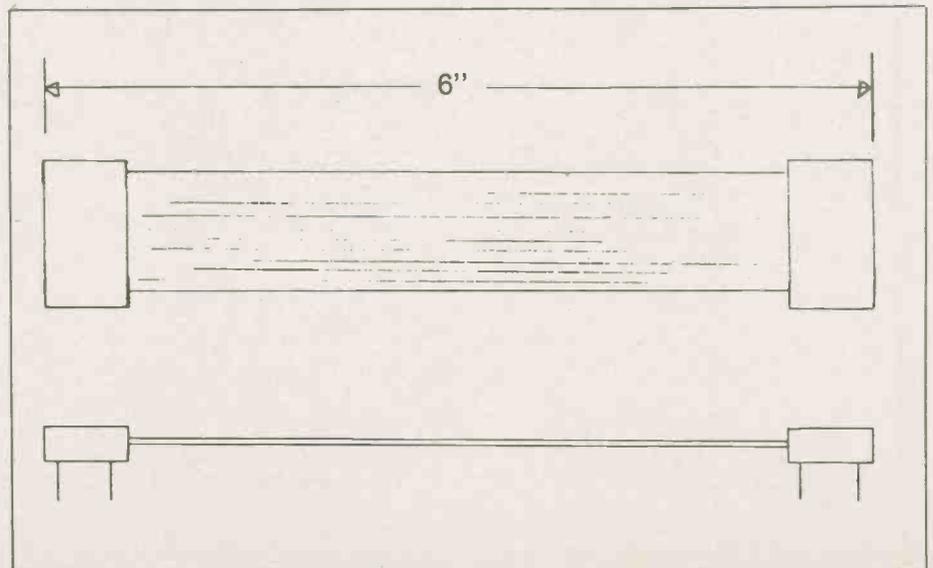
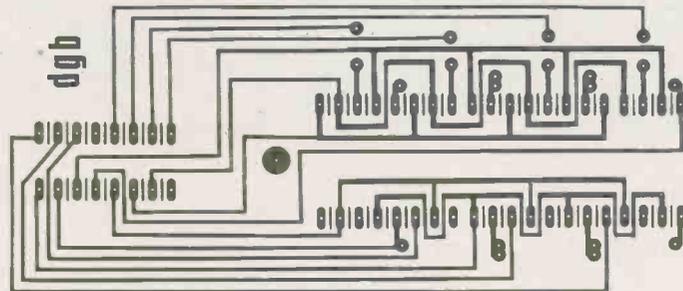


Figure 4. Header cable diagram.

## HOW IT WORKS

The frequency counter can best be understood if it is broken down into five separate sections: the power supply, the input circuit, the frequency multiplier, the clock generator and divider, and the counter/display driver.

### Power Supply

The secondary voltage from the transformer is full wave rectified by BR1 and filtered by C1; it is then fed to the regulator where it is regulated down to 5 VDC. The output of the regulator is used to drive all of the ICs and the unregulated 12 VDC (or so) is used in the input circuitry. C9 improves the stability of the regulator.

### Input Circuit

Input signals are fed to the main board via the BNC connector on the front panel. C7 removes any DC component from the input signal, and D1 clips off the negative half of the signal. Q1 and Q2 amplify the input to a square wave which is fed to the input of IC9a; the output is connected to both a decade divider (IC5b) and switch 1 pole 'a'. While on the 10 MHz range the divided signal from pin 3 of IC5 is used; on all other ranges the direct output from IC9a is used. The output from S1a feeds both switch 1 pole 'b' and the frequency multiplier.

### Frequency Multiplier

An MC14046B phase-locked loop (PLL) is

configured to multiply the input frequency by 10 on the 10 KHz range and by 100 on the 100 Hz and the 1 KHz range. The signal from S1a is buffered and inverted by IC10a and is fed to the input of the PLL (pin 14). This input signal is compared to the output of the decade dividers IC8a and b, and a comparison signal is generated at pin 13; this signal is filtered by C5, R6, and R7 and drives the voltage controlled oscillator input (pin 9). The VCO output at pin 4 is buffered and inverted by IC1d and drives both the decade dividers and the input of IC9b. The VCO adjusts its frequency until the input signal and the comparison signal from the decade dividers are equal. At this point the PLL is locked, and the output frequency is either 10 or 100 times the frequency at pin 14, depending on the position of the rotary switch.

### Clock Generator and Divider

IC1a, b, c, and the crystal are configured to oscillate at a frequency of 5 MHz. The 74LS390 decade dividers reduce this frequency to produce the required gating times of 0.01s, 0.1s, and 1.0s. Switch 1 pole 'd' selects which of the gating times will be used; the following explanation assumes a gating time of 0.1s. At the end of the 0.1s, the output of IC4b will swing from low to high, triggering one half of IC6 (a dual one-shot timer). This one-shot generates a

'high' pulse approximately 300us wide (determined by the time constant of R3 and C3) at pin 13. This pulse transfers the output of the counter into a latch and triggers the second one-shot. A 300ms pulse is produced at pin 5, resetting both the decade dividers and the counter, but not the contents of the latch. With the decade dividers reset, another gating pulse is generated and the contents of the latch are updated. The gating pulses from S1d are inverted and 'anded' with the conditioned input signal to produce the 'count' signal. A timing diagram showing the clock signals is given in figure 4.

### Counter/Display Driver

The 74C926 is a complete counter, latch, and display driver. The count, latch, and reset signals are connected to IC11 and the appropriate display signals are generated. R12-R18 limit the current to the displays and Q6, Q7, and Q8 drive the common cathode of DISP4, DISP3, and DISP2 respectively. DISP1 is blanked when it is zero, and therefore requires some extra circuitry. Note that DISP1 is zero when segment 'f' is on and segment 'g' is off. Q3, Q4, IC10d and e, and IC9c and d decode this condition and blank the display. Switch 1 pole 'e' selects the proper decimal point to light.

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# Your Toolbox Test Bench

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ETI—MARCH—1984—43

Our Notebook topic is that much-misunderstood beast, the switched mode power supply. P.S. Wilson of International Rectifier gives a step-by-step explanation of the various types and design examples.

THE TERM 'switching mode power supply' is used to describe DC-to-DC converters and AC-to-DC converters which operate on a switching principle. Using switching techniques, voltage step-up and voltage inversion can be achieved, as well as the more common voltage step-down function. The advantages of using switching techniques over a linear solution are the reduction in the size of components (such as power transformers and output filter capacitors) by operating at high frequency, and dramatic improvements in efficiency, since the power elements are either fully turned 'on' or 'off' and do not operate in the linear mode. The disadvantages of switching mode solutions are increased noise and radio frequency interference (RFI) which is generated during the switching transitions. Circuit complexity is increased, as in addition to the control circuit, a power switch, rectifier, high frequency transformer or inductor and drive circuitry is required. Switching mode solutions are, however, cost-competitive with linear power supplies in off-line applications at and above the 100 W level. Switch mode power supplies are also used at lower power levels in DC-to-DC converters where there is a special requirement such as high efficiency, for example in solar energy conversion, or small size for mobile communications equipment, or computers.

### Basic Principles

The circuit and waveforms in Figure 1 illustrate the basic principle of the switching mode supply by comparison with a linear regulator. The circuit configuration shown is for a voltage step-down conversion. When switch SW1 is closed, the input supply voltage is applied to the inductor L1, and current flow in the inductor will rise with a ramp waveform, charging capacitor C1 and also supplying the load connected at the output of the supply. When SW1 is opened (equivalent to turning off a semiconductor device), the inductor current diverts into the rectifier, D1. The voltage at circuit node 'P' falls instantaneously to a rectifier forward voltage drop

# DESIGNER'S Notebook

## Switched Power Supplies



below the 0 V line, and the current flow in the inductor follows a negative ramp waveform. The power supply load is now supplied both from the inductor and from the output capacitor, C1. When SW1 again closes, D1 becomes reverse biased and the inductor is again connected to the input supply. In the steady state condition, the positive volt-second product applied to the inductor must balance the negative volt-second product applied when the rectifier conducts. The voltage at the output of the supply is regulated by controlling the on/off ratio, or duty cycle of the switch SW1. Because the switching element is either 'on' or 'off', the power loss is small and the efficiency of the supply approaches 100%. Comparison with the linear regulator (Fig. 1b) shows an efficiency of approximately  $V_o/V_{IN}$ .

Figure 2 illustrates how, by rearranging the circuit elements SW1, L1 and D1, voltage step-up and voltage inversion can be achieved. Provided that the current flowing in L2 does not fall to zero between the conduction phases of SW1, the circuit configuration in Figure 2a can be

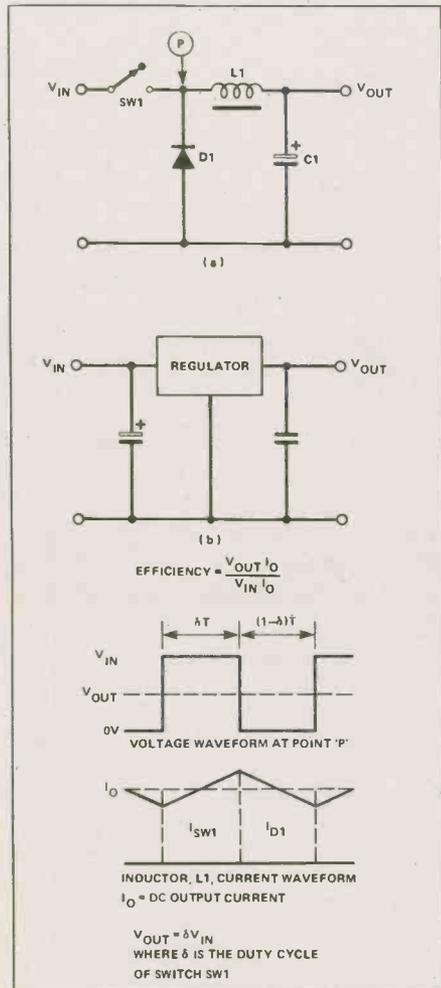


Fig. 1. Basic principles (a) The forward converter (buck converter). (b) The basic linear regulator.

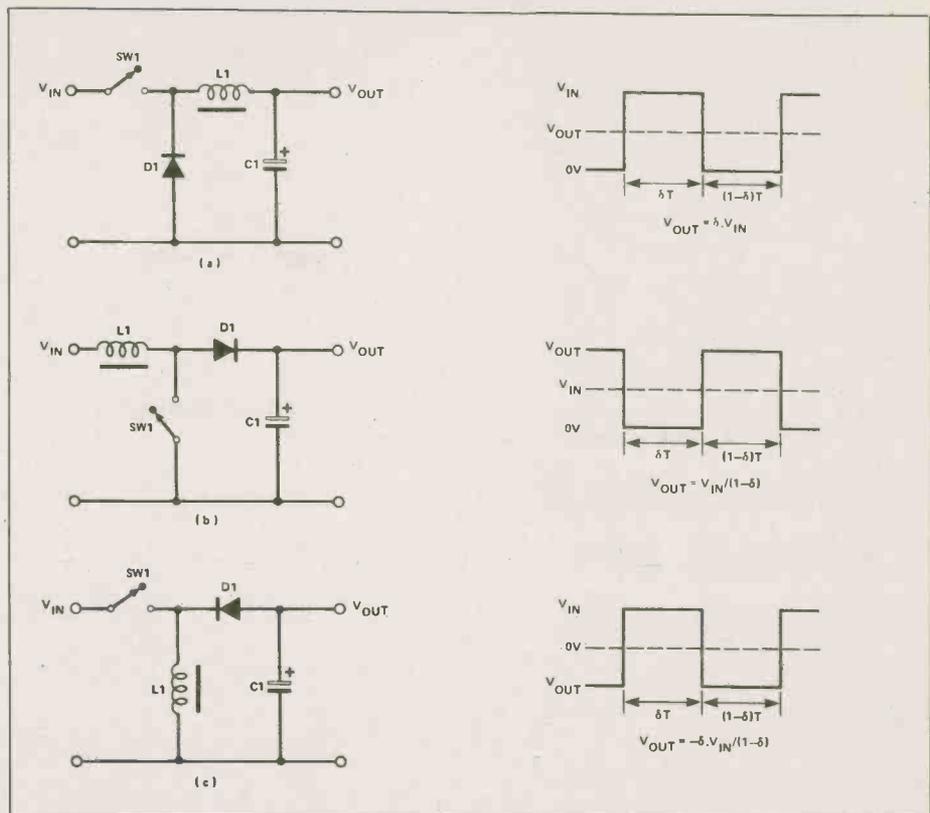


Fig. 2. Circuit configurations to achieve different  $V_{in}/V_{OUT}$ . (a) Voltage step-down. (b) Voltage step-up. (c) Voltage inversion.

said to provide a 'non-pulsating' output current. This feature allows low output ripple voltage to be achieved. The configuration shown in Figure 2b, however, will exhibit a 'pulsating' output current as the inductor current is diverted from the output when SW1 closes. The input current flow, however, can be arranged to be non-pulsating, so reducing the ripple voltage on the input supply. The voltage inverting circuit, (Fig. 2c) has pulsating current waveforms at both input and output terminals.

To overcome this apparent restriction on operating mode, transformer-coupled circuits can be used. The voltage conversion achieved is then defined by the transformer turns ratio and the polarity of the output rectifiers. Figure 3 illustrates the most common circuit configurations in use today. In addition to increasing flexibility, the transformer-coupled solution offers the option of an isolated output supply.

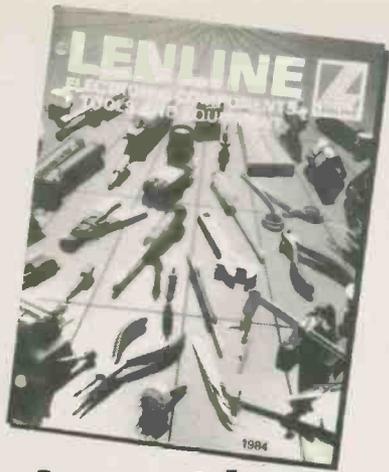
Figure 3a shows a transformer-coupled circuit configuration analogous to the voltage step-up circuit in Figure 2b. The dots against the transformer winding indicate their polarity. SW1 and D1 conduct during opposite phases of the drive signal, that is, they conduct non-simultaneously.

Figure 3b is analogous to the voltage step-down circuit in Figure 2a. SW1 and

D1 conduct simultaneously. During the switch 'off' time, current flow in L1 is diverted through a second rectifier, D2. The purpose of the third winding on the transformer is to reset the magnetic core of the transformer during the switch 'off' time. If this was not done, the magnetic core would become DC-biased and may saturate, resulting in poor performance (low efficiency and high pulse currents in primary winding and SW1).

Figure 3c, the push-pull converter, is again analogous to the circuit in Figure 2a. The difference between this circuit configuration and the forward converter shown in Figure 3b, is that the transformer is biased bidirectionally by switches SW1 and SW2 which conduct alternately. Consequently, the 'reset' winding shown in Figure 3b is not required. The output filter components L1, C1 operate at twice the switching frequency, allowing some size reduction. Each switching device (SW1, SW2) passes only one-half of the output current divided by the transformer turns ratio,  $n$ . Consequently, this solution may be preferred to the solution shown in Fig. 3b at higher power levels (greater than 100W).

Figure 3d illustrates a type of push-pull converter commonly used in off-line applications. Its main advantage, apart from the automatic resetting of the transformer core, is that the maximum



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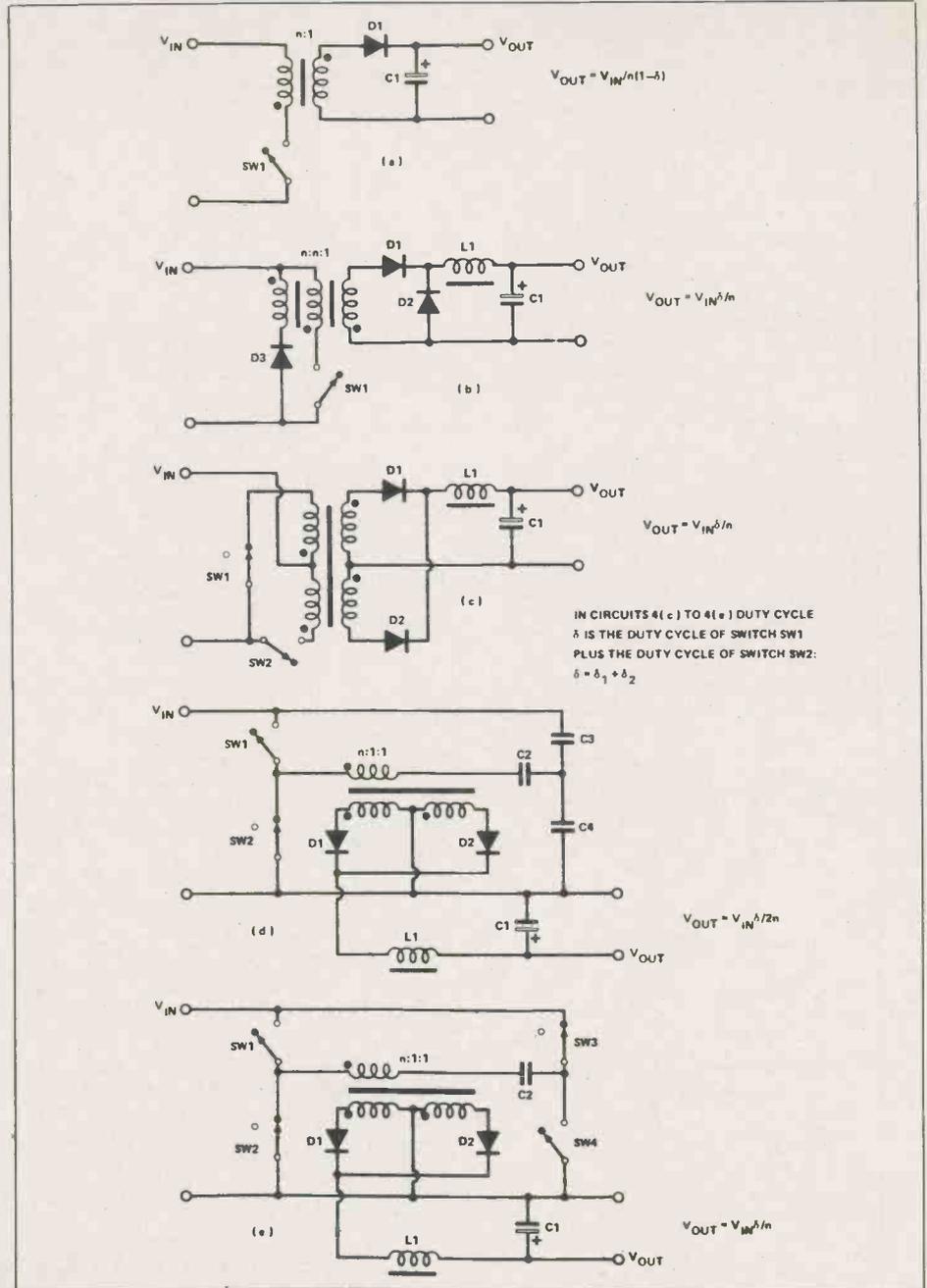


Fig. 3. Transformer-coupled switching mode circuits. (a) Flyback converter. (b) Single ended forward conver. (c) Push-pull converter. (d) Half bridge circuit. (e) Full bridge circuit.

voltage seen by either switch does not substantially exceed the input supply line voltage. Consequently, 200 V switches can be used when working directly from the rectified 120 V mains supply. Capacitor C2 prevents DC biasing of the transformer core which may otherwise arise through asymmetry in the switching waveforms of SW1 and SW2. Capacitors C3, C4 effectively divide the supply to the transformer by two.

Finally, Figure 3e represents a further modification to the basic forward converter in Figure 2a. The capacitors C3, C4 in the previous figure are replaced by two

more switches; SW3, SW4. DC magnetization of the transformer core is prevented by capacitor C2. The full supply voltage is now applied across the transformer primary as switches SW1 and SW4 and then SW2 and SW3 close simultaneously. The maximum voltage applied to any of the switches will not exceed the supply voltage significantly. This 'full bridge' configuration is used in high power switching power supplies where the size and cost of capacitors C3, C4 to replace the switches would be prohibitive. The same circuit configuration is used to drive reversible DC motors. **To be continued ETI**

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# Designing Micro Systems

## Part VII

The previous article explained how the computer handles input and output of data, but how many of us read and write in binary? This month Owen Bishop explains the operation of more user-friendly interfaces.

QUITE A NUMBER of electronic circuits produce their output in analogue form, and it is beyond the ability of a computer to read such data unless it is first converted to digital form. Examples of devices with analogue outputs are electronic thermometers, pressure transducers, audio amplifiers (for speech recognition etc.) and indeed any device which produces an output voltage varying over a predefined range. Even a simple carbon pot can be included in this list. The games controller of the Apple II, for example, uses a 150k potentiometers (there is also a push-button connected to a memory-mapped latch, but this is a digital input). The position, or setting, of the potentiometer is the analogue quantity to be measured. The computer has a quadruple timer IC, and when the games controller is plugged in to the computer board, the pot becomes part of the RC circuit of the timer. When the MPU is to read the setting of the controller, it first triggers the timer (the trigger input is memory-mapped) then measures the length of pulse produced. It does this by reading the memory-mapped output over and over again, counting how many times it reads 'high' until it eventually reads a 'low'. The number of 'high' reads is approximately proportional to the angular setting of the control knob. The analogue-to-digital conversion is crude and far from linear, but certainly good enough for its intended application.

### A-to-D Conversion . . .

Many computers have on-board A-to-D ICs such as the National Semiconductor ADC0801 (Fig. 2). This converts any input voltage in the range 0 V to 5 V, to digital output in the range 0 to 255 (00 to FF in hex). The heart of the IC is a chain

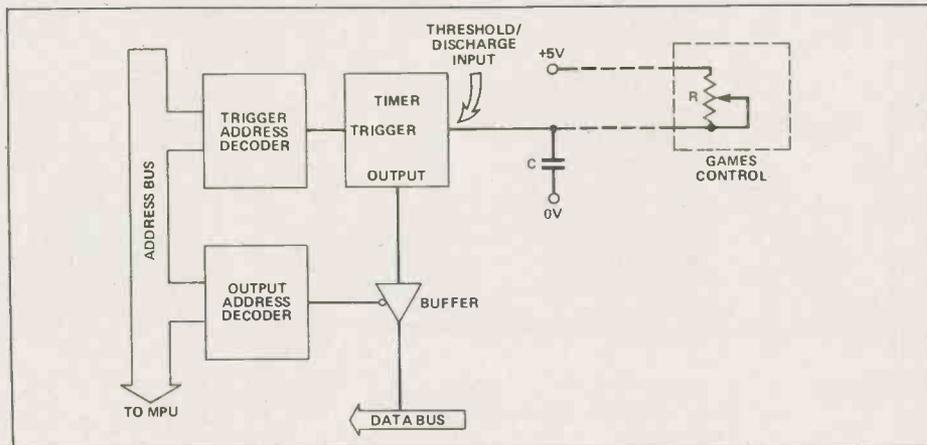


Fig. 1. Analogue-to-digital conversion for a games controller.

of resistors in series, with 5 V across the ends of the chain.

Internal logic controls CMOS analogue switches which switch resistors into or out of the chain, so producing a voltage ( $V_C$ ) which can range from 0 V to 5 V in 256 steps. At each stage, a comparator matches the output of the chain against the analogue voltage ( $V_{IN}$ ). The largest resistor is switched in and out first, to determine if the input is less than or greater than 2V5. Then the next largest resistor is switched in and out to narrow the possible range to within 1V25. At each stage the chain output and analogue input are matched more and more closely. After

eight attempts, the closest match will have been found. The logic signals which have produced the match, are then used to set the eight output buffers to one of the 256 possible combinations, which can be read as a byte (0 to 255) by the computer. This IC converts the voltage with true linearity, with an accuracy of half a step in 256 steps and takes only a few hundred microseconds to do so. If we want greater accuracy, there are similar A-to-D ICs with a 12-bit output. Note that it is the converter which does the work; the MPU only has to read the result. We do not need to write software to instruct the MPU to measure pulse lengths as with the

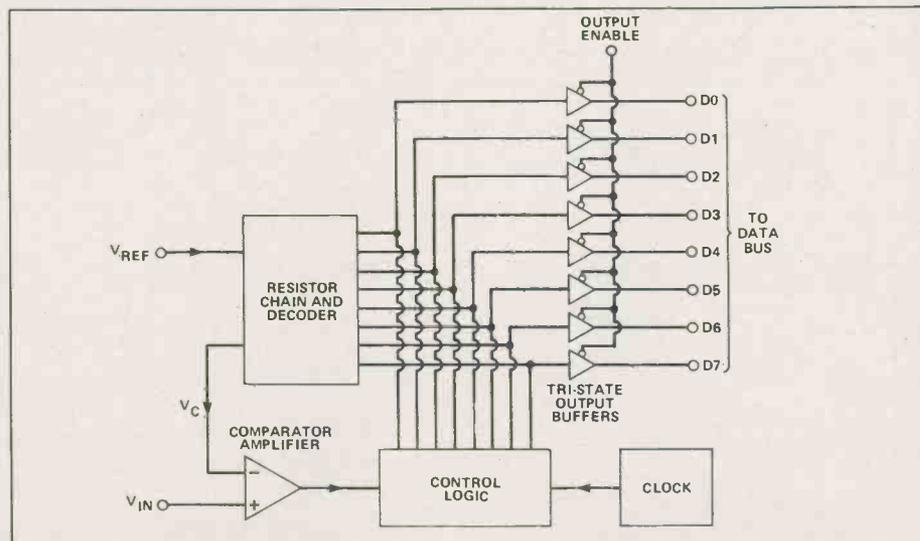


Fig. 2. Simplified block diagram of an A-to-D converter such as the ADC0801.  $V_{REF}$  is an onchip or external reference voltage.  $V_C$  is the output voltage from the resistor chain, which is compared with  $V_{IN}$ , the analogue voltage which is to be converted.

games controller. This saves time and simplifies programming.

Most A-to-D ICs have ways of altering the span of the input range, so that voltages from, say, 0 V to 2 V produce the full-scale output range, 0 to 255. In addition, you can adjust the offset so that, for example, you obtain a reading of 0 when the input is 10 V and a reading of 255 when the output is 12 V.

As might be expected, an A-to-D IC is a sophisticated circuit and is correspondingly expensive. If an application requires several analogue inputs, and high conversion time is not of paramount importance, the inexpensive 507C IC provides linear conversion in 1 mS with seven-bit resolution. This has a resistor ladder (Fig. 3), and the counter supplies current to each resistor in binary sequence. The op-amp adds the currents and the result is that the output ramps down a voltage from  $0.75 \times$  supply voltage to  $0.25 \times$  supply. If the enable input is high, the comparator gives a high output whenever the ramp voltage exceeds the analogue input voltage; thus the length of time the output is low, is a measure of the analogue voltage (Fig. 4). The MPU can find this time by using a program like that described for the games controller.

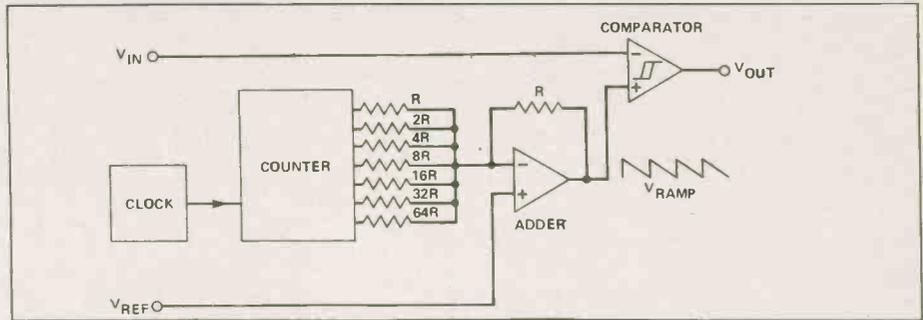


Fig. 3. Simplified block diagram of a simple A-to-D converter, the 507C.  $V_{REF}$  is an on-chip or external reference voltage.  $V_{IN}$  is analogue voltage to be converted;  $V_{OUT}$  is the square wave output.

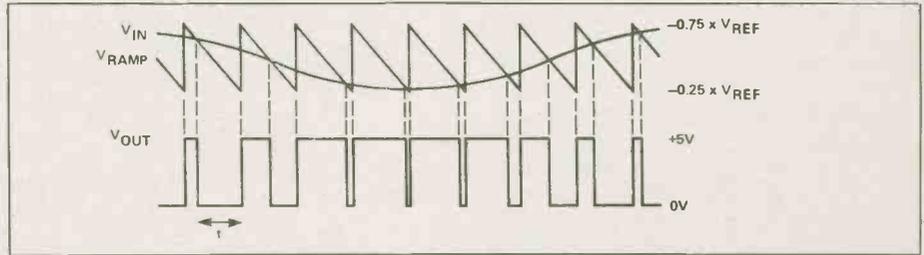


Fig. 4. The input and output voltages of the 507C A-to-D converter. The computer measures  $t$ , which is proportional to  $V_{IN}$ .



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... And The Converse Conversion

If a peripheral needs an analogue signal to control it (eg. controlling the speed of a motor), we need circuits which can convert the digital output of the computer into its analogue equivalent.

The ZN425 D-to-A converter makes use of an R-2R ladder (Fig. 5). The switches are under the logical control of the eight-bit input. As the count increases, the output voltage increases in proportion (see panel). To drive a low impedance device, the output must be buffered by an operational amplifier.

This IC may also be used to A-to-D conversion, using its binary counter. The counter is clocked by an external pulse generator, and as it counts the pulses, switches controlling the R-2R ladder are closed and opened in a binary sequence. The output is a staircase ramp of 256 steps. An external amplifier compares the output from the ladder with the analogue voltage which is to be converted. When the ramp output equals the analogue voltage, the output from the amplifier inhibits the clock. At this point, the logic output, which controls the switches, can be read as an eight-bit equivalent of the analogue input.

Screens And Printers

The way most owners receive information from their micros is through the screen. This may be a domestic TV set or a monitor unit specially designed for the purpose. Those whose main interest lies in arcade games, adventures, and the like, usually need no more than the screen, but anyone with an interest in programming soon finds that the screen alone is not enough. There is the tedium of copying long listings of favourite programs from the screen, and the frustration of being able to see only a few lines of program at any one time. Sooner or later, the serious programmer adds a printer to the system. This month we shall deal with both these ways of receiving information from the micro.

The fact that the technology of high-speed (for the time) printing was already available in the form of teletype machines, lead to the early mainframe computers having a printer but usually no screen. We are reminded of this early use of teletypes by some of the curious control codes which abound in the ASCII character set (see last month's article). The screen of the early mainframe computers, if any, was often a CRT in which the X and Y deflection plates were under the direct control of the computer. It was a kind of high-grade oscilloscope, with the computer using the electron beam to 'draw' an image on the screen. This was suitable for displaying charts and graphs, but not much use for text.

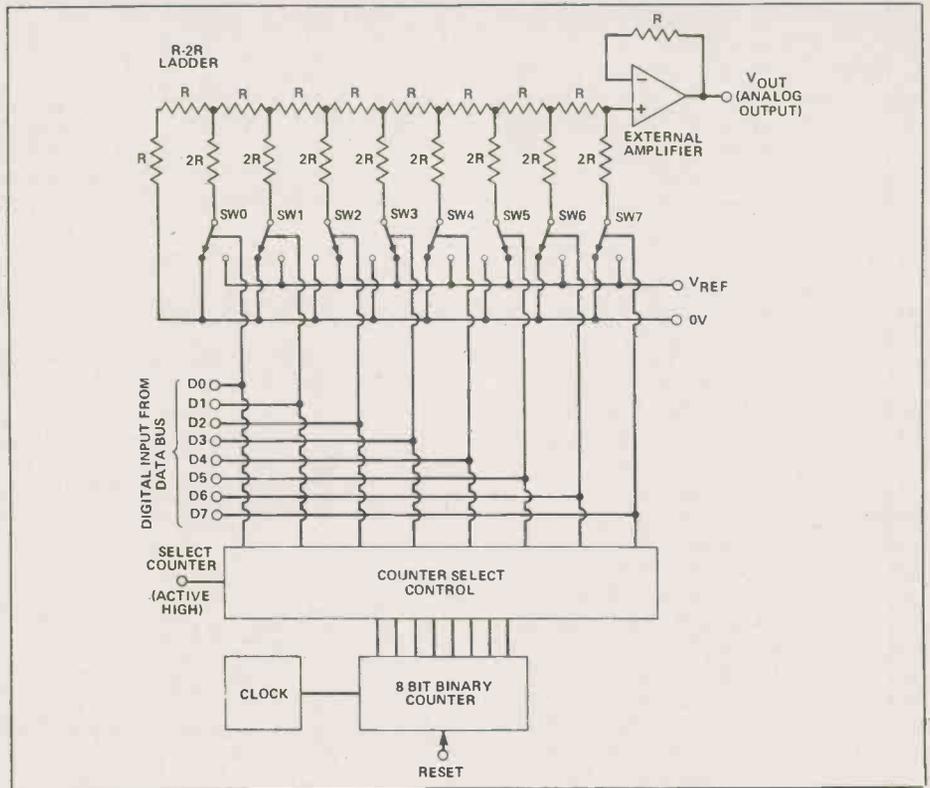


Fig. 5. Block diagram of the ZN425E D-to-A converter. V<sub>REF</sub> is an on-chip or external reference voltage. The amplifier is not on the chip, but is an external op-amp (eg. 741).

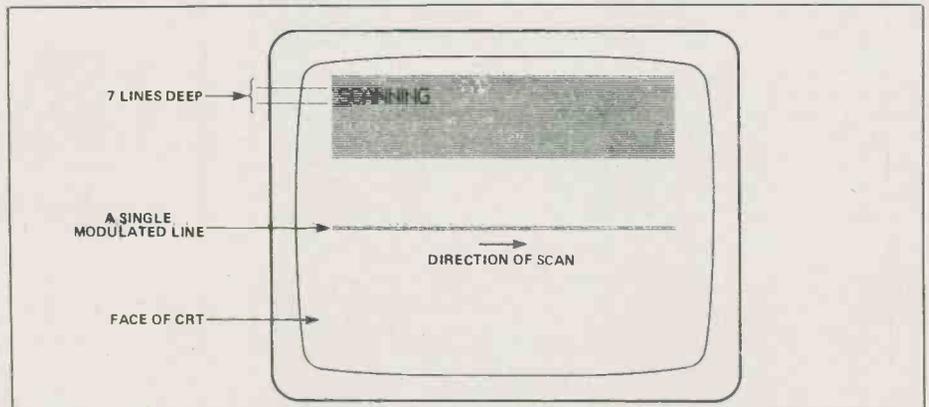


Fig. 6. How text is displayed on a TV screen.

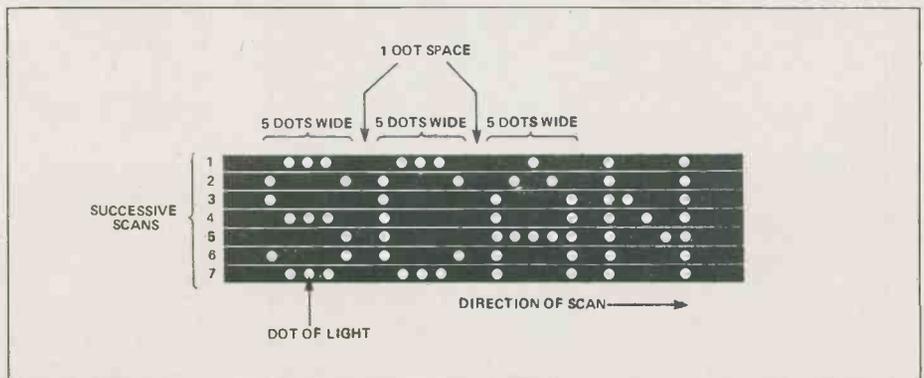
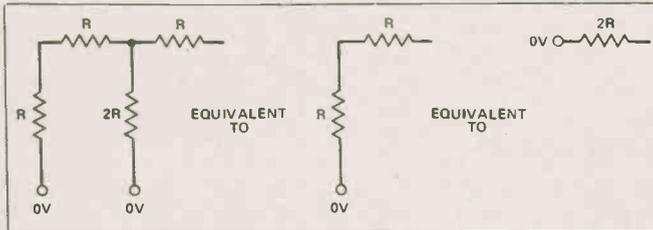


Fig. 7. Enlarged view of the first few letters shown in Fig. 6.

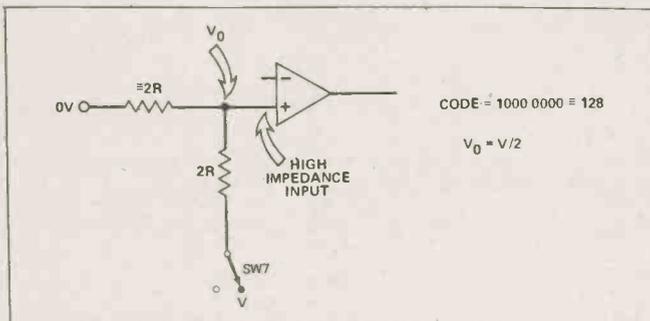


## HOW IT WORKS

Assume all switches are set to 0 V. The three left-hand resistors are equal to  $2R$  and  $2R$  is parallel, and so can be replaced by a single  $R$  resistor. Thus the four resistors shown are equivalent to  $2R$  switched to 0 V. We can carry this reasoning all along the ladder, until we reach a switch that is not set to 0 V.



If all except SW7 are set to 0 V, and SW7 is set to V (the reference voltage), we can consider all resistors to the left as equivalent to a single  $2R$  resistor, switched to 0 V. We have a potential-divider, and  $V_o = V/2$ . This corresponds to the expected output, since  $128/256 = 1/2$ .



If all except SW6 are set to 0 V and SW6 is set to V, we can consider all resistors to the left to be replaced by a single  $2R$  resistor, switched to 0 V.

$$I_o = V/3R; I_1 = (V - V_1)/2R; I_2 = V_1/2R$$

By Kirchoff's Law (sum of currents entering a point must equal sum of currents leaving a point):

$$I_o = I_1 - I_2, \text{ so}$$

$$V_1/3R = (V - V_1)/2R - V_1/2R, \text{ giving}$$

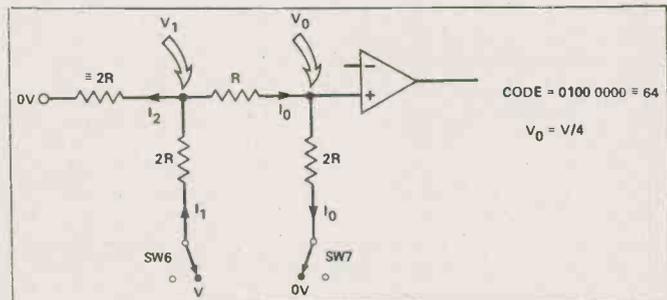
$$2V_1 = 3V - 3V_1 - 3V_1$$

$$V_1 = 3V/8$$

Now we can calculate  $V_o$ :

$$V_o = 2V_1/3 = V/4$$

This corresponds to what is expected since  $64/256 = 1/4$ .



Here both SW6 and SW7 are switched to V.

$I_o = (V - V_1)/3R$ ; but  $I_1$  and  $I_2$  are as above.

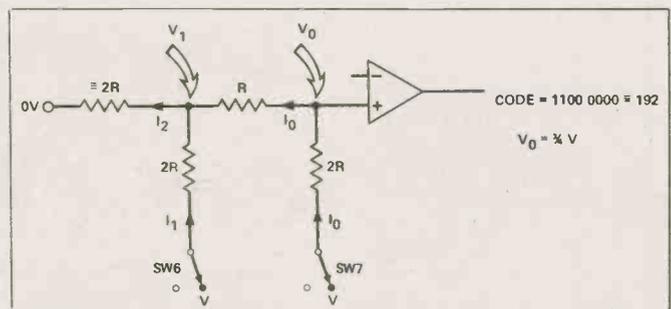
$$I_2 = I_o + I_1, \text{ so}$$

$$V_1/2R = (V - V_1)/2R + (V - V_1)/3R,$$

which simplifies to  $V_1 = 5V/8$ .

$$\begin{aligned} \text{Now } V_o &= V_1 + (V - V_1)/3 \\ &= 5V/8 + V/8 \\ &= 3V/4. \end{aligned}$$

This is what we expect, since  $192/256 = 3/4$ .



like any other part of RAM, in some micros it has its own control signals and its own data bus to connect it with the video circuit, for most of the time it operates independently of the microprocessor. The ASCII code for each character in turn is transferred to the data latch. It is held there while the next code is being fetched. The output from the latch goes to a character generator IC. This is a special kind of ROM (see Designing Micro Systems, ETI December 1983), which converts an ASCII code into the corresponding pattern of dots. It has inputs from the latch to tell it which character is to be generated, and from the synchronizing circuit, to tell it which one of the seven lines of dots is to be generated. It has five outputs that indicate which dots are to be

displayed as white and which will be black.

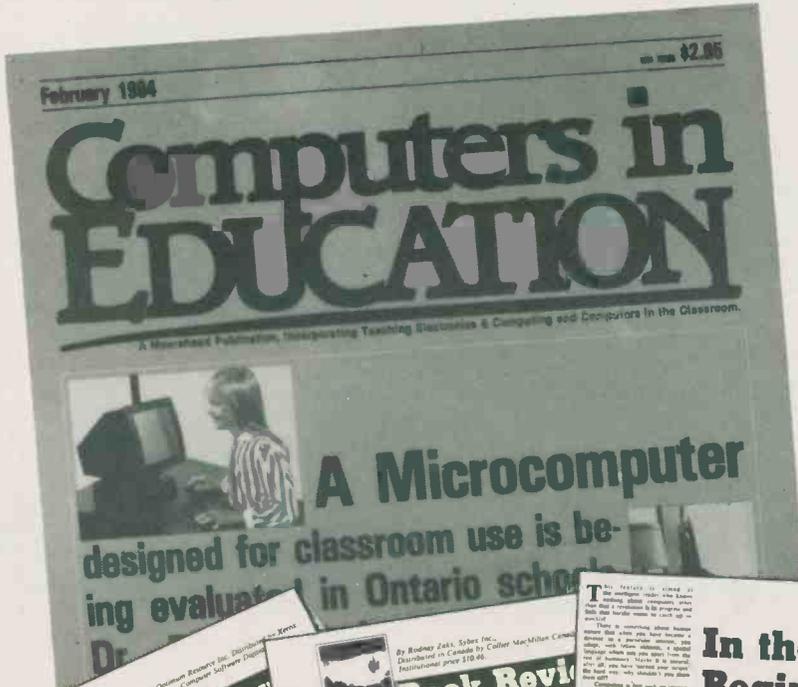
The output from the character generator is converted from parallel to serial form by the shift register. This produces a train of pulses, some high, some low, like those shown in Figure 8. These are fed to a video mixer circuit where line synchronizing pulses and frame synchronizing pulses are added. The combined video signal is then passed through a buffer circuit to the monitor.

Such a signal is not suitable for sending to a domestic TV set. The TV is expecting a VHF carrier signal from an aerial, modulated by the video signal. So, if a TV is being used, the signal from the video mixer must first go to a modulator. This produces a VHF carrier signal (usual-

ly on channel 3 or 4) with the video signal imposed on to it. When the TV receives this signal, it demodulates it, recovering the original video signal that it then uses to produce the display. The additional processes of modulation and demodulation inevitably lead to distortion; consequently, the resolution obtainable on a TV is inferior to that obtained on a proper monitor screen. A TV is acceptable when there are 40 or fewer characters per line, but when there are 60 characters or more, the use of a monitor is much to be preferred.

Next month, we look at the format of serial and parallel data transmission for communicating with peripherals. ETI

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# Infinite Improbability Detector



For galactic Hitch-hikers everywhere, the ideal travelling companion for your Electronic Thumb and Guide to the Universe. Designed and developed by Rory Holmes.



NOWADAYS THERE are many scientists of the paranormal who will assure us that a person is able to influence and control matter by the direct action of his mind alone. They call this effect psychokinesis; it's akin to the claims of the familiar ardent gambler who is convinced he can influence the throw of a dice, or the spin of a roulette wheel, to come up with his lucky number.

ETI, with an open mind, decided to design a machine which would give a clear indication of any such psychokinetic action directed on it. We thought that a 16 ton weight linked to a movement detector might perhaps give the skeptics an unfair advantage and so decided that the slightly smaller and rather more capricious nature of the electron might be more amenable to the delicate influences from the psyche. In fact, the electron itself does not have to be influenced, but rather those forces involved in producing the random movement of thermally and electrically excited electrons. These forces are completely unknown and unpredictable; that's why they're called random! It's this nature of randomness and its ultimate source which has fascinated people for years; hence the favourite pastimes of staring into the fire or watching the ocean waves.

In our machine, the random motions mentioned above are linked electronically to control the movement of a dot of light round a circle of LEDs. This dot of light

obviously shouldn't rotate too far in any one direction, but should dither around — both clockwise and counter-clockwise — keeping the same position on average. The light moves at regular clock intervals and at every movement it has, theoretically, a 50-50 chance of going in either direction.

We called it the Infinite Improbability Detector for two reasons. First, in the absence of any assumed psychokinetic intervention from a lively mind, it is incredibly unlikely that it will rotate consistently in one direction. Second, we're Douglas Adams fans. The probability against continuous rotation is, in fact, two to the power of 16 to the power of the number of revolutions. Therefore, if this occurs, *don't panic* — we have proof of an external and paranormal force.

It is hoped that if psychokinetic ability *does* exist, then it should certainly be able to bias our machine to rotate in one direction or another.

In use the operation is simple — if a little indefinable. There is a rate control for setting the overall speed of movement of the light and an on-off switch. After switching on and setting the desired speed, the rest is really up to you. The idea is to concentrate on the moving dot of light in order to make it consistently rotate in one direction.

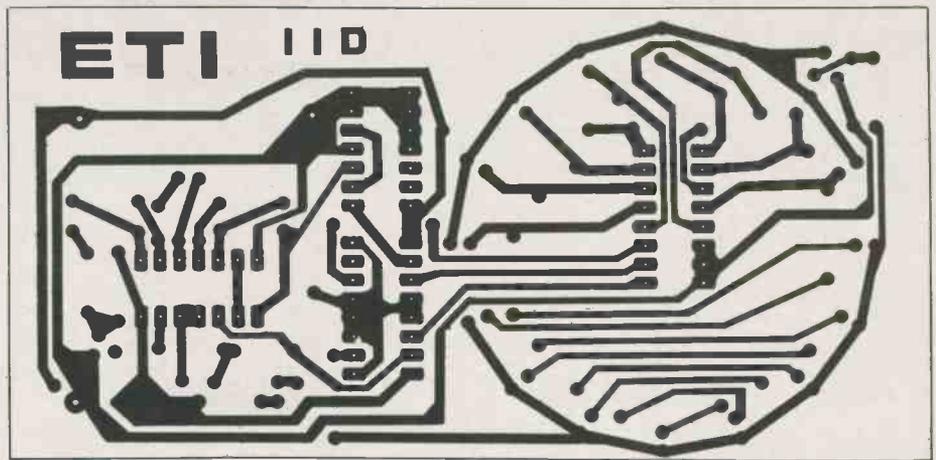
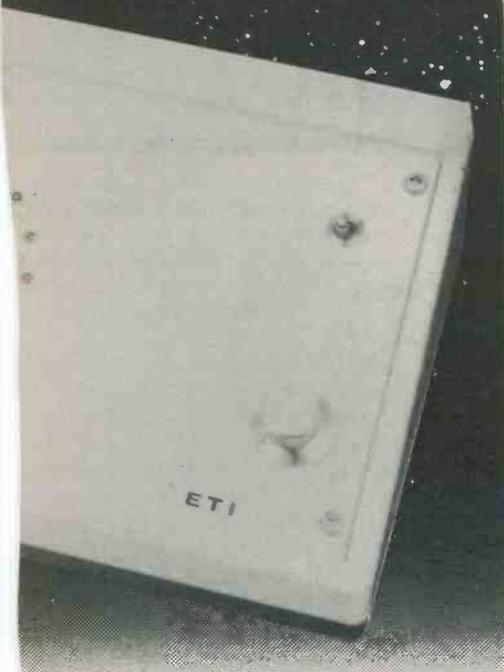
ETI would be delighted to hear from any readers who can demonstrate impressive results.

## Construction

It isn't difficult to obtain a neat and smart appearance with this project (see the photos of our prototype). There are only two front panel controls, making interwiring and assembly completely straightforward. The only point to watch during construction is the mounting of the LEDs; these should be left until the rest of the PCB is assembled.

Solder in all the other components, following the overlay guide. It's easier to start with the links and sockets first, then the passive components. Leadout wires to the pot (RV1) and battery supply can also be connected at this stage.

After assembly, the LEDs (LED1 to 16) can be mounted with their anodes towards the centre of the circle, but do not solder them at this stage — the LEDs must be fitted into their front panel holes to provide the right uniform height above the PCB before they are soldered. Take a piece of tracing paper and mark the exact hole positions from the copper track pattern. This can then be transferred to the inside of the case front panel and the positions centre-punched before drilling the holes to a width exactly the same as the LEDs. The sloping front Vero box we used has a detachable aluminum front panel which makes this an easy process. The LEDs are then fitted into the holes and the correct board clearance height can be found before they are soldered up.



The Infinite Improbability Detector board.

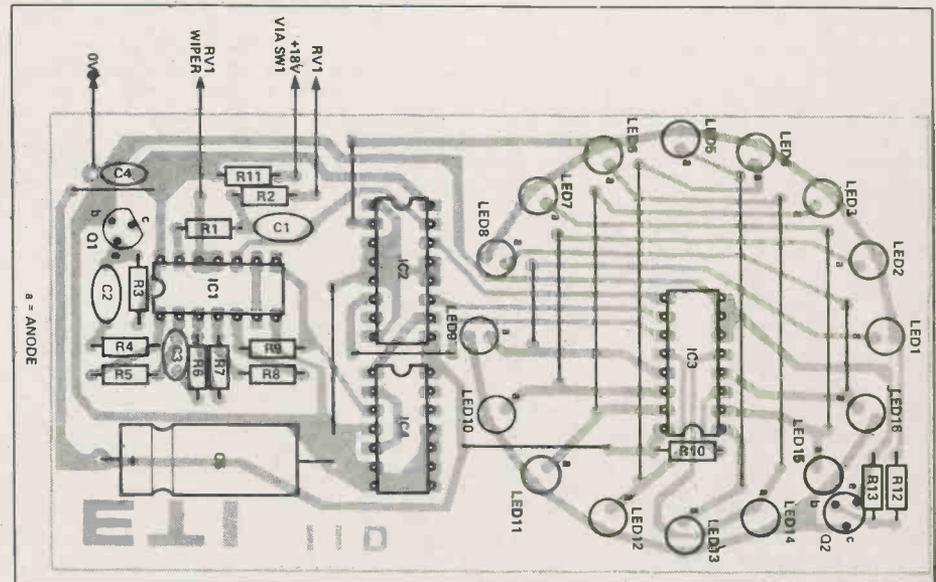


Fig. 1. Component overlay for the PCB. The LEDs are arranged in a circle with the anodes to the inside.

We found that after soldering, the good fit of the LEDs was quite enough to hold the PCB in place. Two 9V batteries were fixed inside the case with adhesive pads, and battery clips were used to connect them up to the switch and the PCB. The potentiometer and switch are mounted through two holes on the front panel, after wiring on the front panel, and after wiring them up from the overlay diagram the device can be tested.

NOTE:  
 IC1 IS 4069B  
 IC2 IS 4029B  
 IC3 IS 4051B  
 IC4 IS 4013B  
 Q1 AND Q2 ARE 2N3904  
 LED1-16 ARE 2mm RED OR YELLOW  
 LEDs

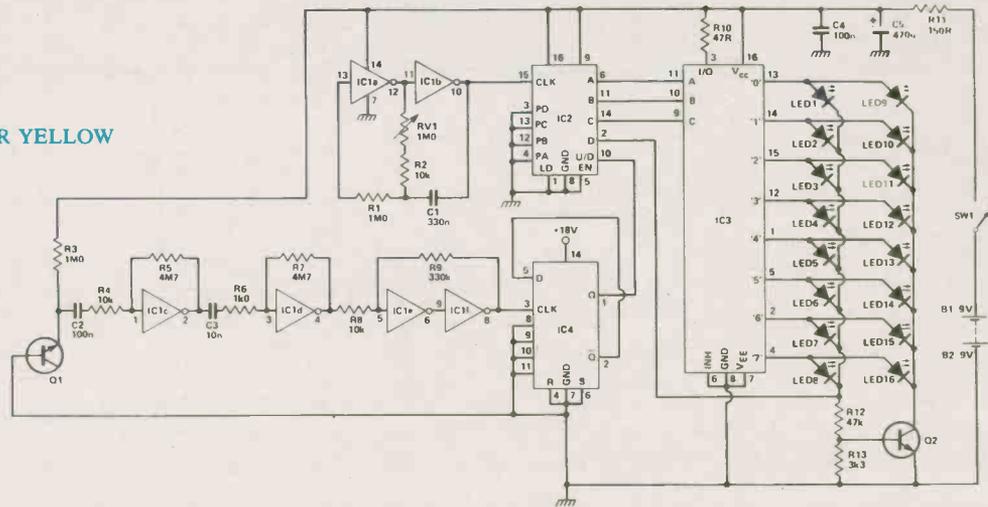


Fig. 2. Circuit diagram of the Infinite Improbability Detector.

## Infinite Improbability Detector

Switch on and set the speed control to its lowest rate; if all is well the illuminated LED should move backwards and forwards round the circle in a random manner with no preferred direction. If it does rotate in only one direction, then there is either a construction blunder, or the portion of the Universe occupied by the detector has passed through a region of Infinite Improbability.

### PARTS LIST

#### Resistor (all 1/4 W, 5%)

R1,3	1M0
R2,4,8	10k
R5,7	4M7
R6	1k0
R9	330k
R10	47R
R11	150R
R12	47k
R13	3k3

#### Potentiometers

RV1	1M0 logarithmic pot
-----	---------------------

#### Capacitors

C1	330n polycarbonate
C2,4	100n ceramic
C3	10n ceramic
C5	470u 16 V axial electrolytic

#### Semiconductors

IC1	4069B
IC2	4029B
IC3	4051B
IC4	4013B
Q1,2	2N3904
LED1-16	2 mm red or yellow LEDs

#### Miscellaneous

SW1	miniature toggle switch
PCB; two 9V batteries plus clips; case.	

### HOW IT WORKS

IC2 is a four bit up/down counter, set to count in binary mode and thus having 16 count states provided on its four output lines. These binary output lines are decoded by IC3 and Q2 to give a one-of-16 output for driving LED1 through LED16.

IC3 is a CMOS one-of-eight analogue decoder, whose outputs are connected to the anodes of two sets of eight LEDs. The select lines on pins 9, 10 and 11 will take one pair of anodes to positive via R10 for each address. When the D output of IC2 is logic low the cathodes of LEDs 1 to 8 are held low, thus illuminating one of them and Q2 will be switched off. When D goes logic high the reverse takes place, with Q2 now turned on to provide a ground for the cathodes of LEDs 9 to 16. Thus each count state will correspond to one LED being illuminated.

Assume for the moment that the up/down control on pin 10 of IC2 is kept high (the 'up' mode); then, for each clock pulse applied to pin 15, IC2 will move to its next count state from 0 through to 15. Each LED in the circle will in turn illuminate to indicate that particular count, so producing the effect of a rotating dot of light.

However, the up/down control is made to continuously change in a random fashion and at a much faster rate than the clock period. The timing diagram of Fig. 2 shows the clock as a square wave. The CMOS counter IC2 only changes state as the clock moves from low to high and the direction of its counting can only be changed when the clock is high. Thus the state of the up/down control when the clock goes low will determine the count direction when it next goes high again. The dot of light will move randomly either clockwise or counter-clockwise on each clock period. If, say, the light moves three places clockwise in succession, this is equivalent to getting three

heads in a row from a coin toss.

The random logic level generator is based on Q1, a transistor selected to provide a good noise output when connected in its base-emitter breakdown mode. This produces genuine random noise due to the completely unknown and unpredictable movements of excited electrons in the semiconductor material. The noise voltage so generated is amplified by IC1c and d. These are unbuffered CMOS inverter gates which are biased into their linear amplifying mode by R5 and R7; the gain is determined by the ratio of R4 to R5 and R6 to R7. C2 and C3 provide AC signal coupling.

IC1e and f are configured as a Schmitt trigger, with R9 providing positive feedback for a sharp switching action. Those noise spikes which pass the switching threshold will produce clean logic level pulses at the output. These random pulses are applied to the clock input of IC4, a flip-flop wired as a divide-by-two circuit whose Q output is taken to the up/down control of IC2. Although the number of random pulses in each IC2 clock period will be pretty much the same, the state of the Q output is arbitrary and will be truly random with an equal chance of a 0 or 1 (or rather, not truly random if one allows that the mind can bias this in some way).

The clock used to drive IC2 is the usual CMOS astable using IC1a and b, with timing components RV1, C1 and R2. Potentiometer RV1 is a front panel control which sets the frequency of the clock and makes available a large range of rotation speeds.

It was found necessary to limit the supply current with R11, since IC1 (the 4069B) is used in the linear mode as a noise signal amplifier and with too high a supply voltage it can start dissipating enough current to destroy itself!

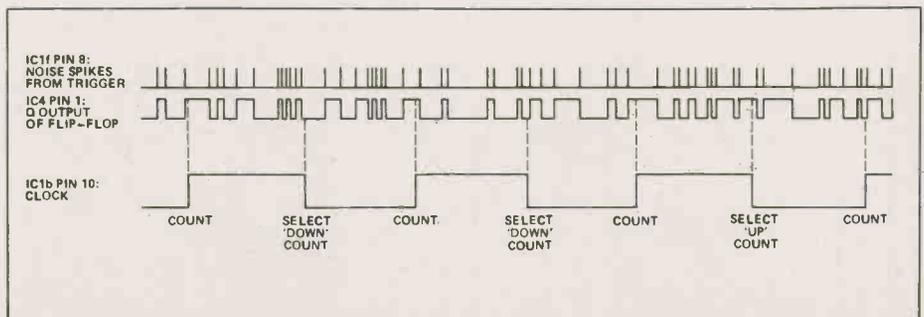


Fig. 3. Timing diagram of the circuit.

ETI



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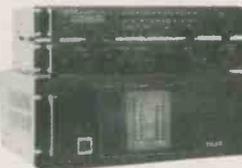
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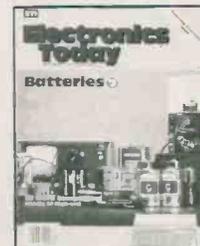
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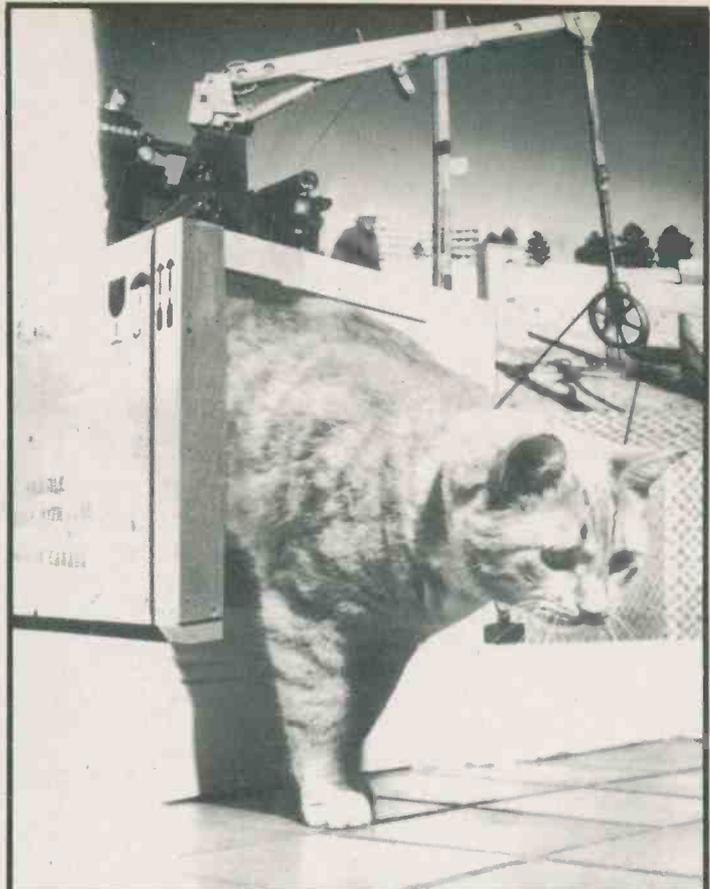
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## PROJECTS

**BP48: ELECTRONIC PROJECTS FOR BEGINNERS \$5.40**  
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 Another book written by the very experienced author — Mr. F.G. Rayer — and in it the newcomer to electronics, will find a wide range of easily made projects. Also, there are a considerable number of actual component and wiring layouts, to aid the beginner.

Furthermore, a number of projects have been arranged so that they can be constructed without any need for soldering and, thus, avoid the need for a soldering iron.

Also, many of the later projects can be built along the lines as those in the "No Soldering" section so this may considerably increase the scope of projects which the newcomer can build and use.

**221: 28 TESTED TRANSISTOR PROJECTS**  
**R.TORRENS \$5.00**  
 Mr. Richard Torrens is a well experienced electronics development engineer and has designed, developed, built and tested the many useful and interesting circuits included in this book. The projects themselves can be split down into simpler building blocks, which are shown separated by boxes in the circuits for ease of description, and also to enable any reader who wishes to combine boxes from different projects to realise ideas of his own.

**BP49: POPULAR ELECTRONIC PROJECTS \$5.75**  
**R.A. PENFOLD**  
 Includes a collection of the most popular types of circuits and projects which, we feel sure, will provide a number of designs to interest most electronics constructors. The projects selected cover a very wide range and are divided into four basic types: Radio Projects, Audio Projects, Household Projects and Test Equipment.

**EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONIC PROJECTS**  
**AB007 \$9.95**  
 An ideal sourcebook of Solid State circuits and techniques with many practical circuits. Also included are many useful types of experimenter gear.

**BP71: ELECTRONIC HOUSEHOLD PROJECTS \$7.20**  
**R. A. PENFOLD**  
 Some of the most useful and popular electronic construction projects are those that can be used in or around the home. The circuits range from such things as '2 Tone Door Buzzer', Intercom, through Smoke or Gas Detectors to Baby and Freezer Alarms.

**BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS \$8.10**  
**R.A. PENFOLD \$7.60**  
 Projects, fifteen in all, which use a 12V supply are the basis of this book. Included are projects on Windscreen Wiper Control, Courtesy Light Delay, Battery Monitor, Cassette Power Supply, Lights Timer, Vehicle Immobiliser, Gas and Smoke Alarm, Depth Warning and Shaver Inverter.

**BP69: ELECTRONIC GAMES \$7.05**  
**R.A. PENFOLD**  
 In this book Mr. R. A. Penfold has designed and developed a number of interesting electronic game projects using modern integrated circuits. The text is divided into two sections, the first dealing with simple games and the latter dealing with more complex circuits.

**BP95: MODEL RAILWAY PROJECTS \$7.60**  
 Electronic projects for model railways are fairly recent and have made possible an amazing degree of realism. The projects covered include controllers, signals and sound effects: striboard layouts are provided for each project.

**BP93: ELECTRONIC TIMER PROJECTS \$7.60**  
**F.G. RAYER**  
 Windscreen wiper delay, darkroom timer and metronome projects are included. Some of the more complex circuits are made up from simpler sub-circuits which are dealt with individually.

**110 OP-AMP PROJECTS**  
**MARSTON \$12.95**  
**HB24**  
 This handbook outlines the characteristics of the op-amp and present 110 highly useful projects — ranging from simple amplifiers to sophisticated instrumentation circuits.

**110 IC TIMER PROJECTS**  
**GILDER \$10.95**  
**HB25**  
 This sourcebook maps out applications for the 555 timer IC. It covers the operation of the IC itself to aid you in learning how to design your own circuits with the IC. There are application chapters for timer-based instruments, automotive applications, alarm and control circuits, and power supply and converter applications.

**BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING**  
**R.A. PENFOLD \$7.60**  
 We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

**PH250: EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONICS PROJECTS**  
**A. BARBER \$9.95**  
 This book takes the mystery out of solid state electronics and enables the reader to build such useful devices as: series regulated power supplies, light dimmers, solar cell operated radios, hi-fi amplifiers, light indicators for battery operated equipment and much more.

**110 THYRISTOR PROJECTS USING SCRs AND TRIACS**  
**MARSTON \$12.95**  
**HB22**  
 A grab bag of challenging and useful semiconductor projects for the hobbyist, experimenter, and student. The projects range from simple burglar, fire, and water level alarms to sophisticated power control devices for electric tools and trains. Integrated circuits are incorporated wherever their use reduces project costs.

**110 CMOS DIGITAL IC PROJECTS**  
**MARSTON \$11.25**  
**HB23**  
 Outlines the operating characteristics of CMOS digital ICs and then presents and discusses 110 CMOS digital IC circuits ranging from inverter gate and logic circuits to electronic alarm circuits. Ideal for amateurs, students and professional engineers.

**BP76: POWER SUPPLY PROJECTS \$6.80**  
**R.A. PENFOLD**  
 Line power supplies are an essential part of many electronics projects. The purpose of this book is to give a number of power supply designs, including simple unregulated types, fixed voltage regulated types, and variable voltage stabilised designs, the latter being primarily intended for use as bench supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits.

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

**BP84: DIGITAL IC PROJECTS \$7.60**  
**F.G. RAYER, T.Eng.(CEI), Assoc.IERE**  
 This book contains both simple and more advanced projects and it is hoped that these will be found of help to the reader developing a knowledge of the workings of digital circuits. To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams. Also the more ambitious projects can be built and tested section by section and this should help avoid or correct faults that could otherwise be troublesome. An ideal book for both beginner and more advanced enthusiast alike.

**BP67: COUNTER DRIVER AND NUMERAL DISPLAY PROJECTS \$7.05**  
**F.G. RAYER, T.Eng.(CEI), Assoc. IERE**  
 Numeral indicating devices have come very much to the forefront in recent years and will, undoubtedly, find increasing applications in all sorts of equipment. With present day integrated circuits, it is easy to count, divide and display numerically the electrical pulses obtained from a great range of driver circuits.

In this book many applications and projects using various types of numeral displays, popular counter and driver IC's etc. are considered.

**BP73: REMOTE CONTROL PROJECTS \$8.10**  
**OWEN BISHOP**  
 This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control. Full explanations have been given so that the reader can fully understand how the circuits work and can more easily see how to modify them for other purposes, depending on personal requirements. Not only are radio control systems considered but also infra-red, visible light and ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

**BP99: MINI — MATRIX BOARD PROJECTS \$7.60**  
**R.A. PENFOLD**  
 Twenty useful projects which can all be built on a 24 x 10 hole matrix board with copper strips. Includes Doorbuzzer, Low-voltage Alarm, AM Radio, Signal Generator, Projector Timer, Guitar Headphone Amp, Transistor Checker and more.

**BP103: MULTI-CIRCUIT BOARD PROJECTS \$7.60**  
**R.A. PENFOLD**  
 This book allows the reader to build 21 fairly simple electronic projects, all of which may be constructed on the same printed circuit board. Wherever possible, the same components have been used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects or by re-using the components and P.C.B. all of the projects.

**Tab1431: DIGITAL ELECTRONIC PROJECTS \$20.95**  
 Build a deluxe code oscillator, a digital game called Climb-the-Mountain, a clock with alarm, a metric measuring wheel, a modular decade counter, even a 14-note music generator. 17 projects in all.

**BP107: 30 SOLDERLESS BREADBOARD PROJECTS — BOOK 1**  
**R.A. PENFOLD \$8.85**  
 A "Solderless Breadboard" is simply a special board on which electronic circuits can be built and tested. The components used are just plugged in and unplugged as desired. The 30 projects featured in this book have been specially designed to be built on a "Verobloc" breadboard. Wherever possible the components used are common to several projects, hence with only a modest number of reasonably inexpensive components it is possible to build, in turn, every project shown.

**BP106: MODERN OP-AMP PROJECTS** \$7.60  
**R.A. PENFOLD**  
 Features a wide range of constructional projects which make use of op-amps including low-noise, low distortion, ultra-high input impedance, high slew-rate and high output current types.

## CIRCUITS

**BP80: POPULAR ELECTRONIC CIRCUITS — BOOK 1** \$7.75  
**R.A. PENFOLD**  
 Another book by the very popular author, Mr. R.A. Penfold, who has designed and developed a large number of various circuits. These are grouped under the following general headings: Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Project Circuits and Miscellaneous Circuits.

**BP98: POPULAR ELECTRONIC CIRCUITS, BOOK 2** \$8.85  
**R.A. PENFOLD**  
 70 plus circuits based on modern components aimed at those with some experience.

**The GIANT HANDBOOK OF ELECTRONIC CIRCUITS** \$27.95  
**TAB No.1300**  
 About as twice as thick as the Webster's dictionary, and having many more circuit diagrams, this book is ideal for any experimenter who wants to keep amused for several centuries. If there isn't a circuit for it in here, you should have no difficulty convincing yourself you don't really want to build it.

**BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS** \$5.00  
**F.G. RAYER, T.Eng.(CEI), Assoc.IERE**  
 Field effect transistors (FETs), find application in a wide variety of circuits. The projects described here include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various miscellaneous devices which are useful in the home.

This book contains something of particular interest for every class of enthusiast — short wave listener, radio amateur, experimenter or audio devotee.

**BP87: SIMPLE L.E.D. CIRCUITS** \$5.40  
**R.N. SOAR**  
 Since it first appeared in 1977, Mr. R.N. Soar's book has proved very popular. The author has developed a further range of circuits and these are included in Book 2. Projects include a Transistor Tester, Various Voltage Regulators, Testers and so on.

**BP42: 50 SIMPLE L.E.D. CIRCUITS** \$3.05  
**R.N. SOAR**  
 The author of this book, Mr. R.N. Soar, has compiled 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components — the Light Emitting Diode (L.E.D.) A useful book for the library of both beginner and more advanced enthusiast alike.

**BP82: ELECTRONIC PROJECTS USING SOLAR CELLS** \$7.60  
**OWEN BISHOP**  
 The book contains simple circuits, almost all of which operate at low voltage and low currents, making them suitable for being powered by a small array of silicon cells. The projects cover a wide range from a bicycle speedometer to a novelty 'Duck Shoot', a number of power supply circuits are included.

**BP37: 50 PROJECTS USING RELAYS, SCR'S & TRIACS** \$5.00  
**F.G. RAYER, T.Eng.(CEI), Assoc.IERE**  
 Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) have a wide range of applications in electronics today. This book gives tried and practical working circuits which should present the minimum of difficulty for the enthusiast to construct. In most of the circuits there is a wide latitude in component values and types, allowing easy modification of circuits or ready adaptation of them to individual needs.

**BP24: 50 PROJECTS USING IC741** \$3.75  
**RUDI & UWE REDMER**  
 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** \$13.75  
**JUNG**  
**HB26**  
 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.

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**AB004**  
 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.

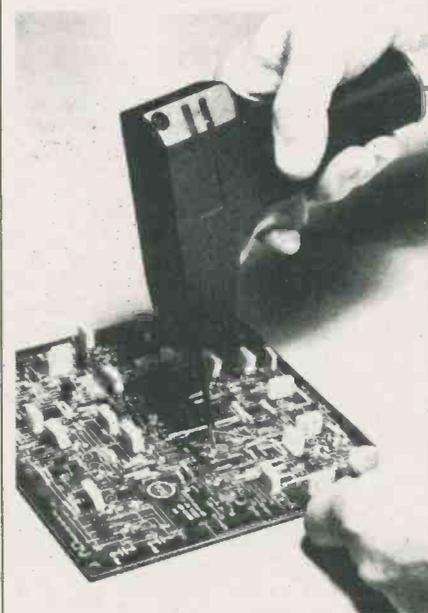
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 Here are transistor and IC circuits for just about any application you might have. An ideal source book for the engineer, technician or hobbyist. Circuits are classified according to function, and all sections appear in alphabetical order.

**THE MASTER IC COOKBOOK** \$17.95  
**TAB No.1199**  
 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** \$12.95  
**AB016**  
 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  
**Z. MEIKEIN & P. TACKRAY**  
 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.



## 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** \$15.95  
TAB No. T166

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, Tremolo 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.

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TAB No. T167

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.

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**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.

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# COMPUTING TODAY

## High-Res Circles

By Anthony DeBoer

THERE'S MORE than one way to skin a cat, as a popular expression goes, and drawing high resolution circles is no exception. The number of ways to draw a circle on a computer's screen, plotter, printer, or whatever device, is probably limited only by the imaginations of the people undertaking to do it. Some methods are much more efficient than others, however, and give better results.

The methods given here, while written in BASIC, are adaptable to almost any language or computer. The last one, in fact, almost begs to be rewritten in assembler. It's the idea that counts, not the coding for a specific machine. Although the examples are given in Applesoft BASIC, they can be adapted to virtually anything else that can do graphics.

For those unfamiliar with Applesoft, the statement `HPOINT X,Y` draws a dot at the co-ordinates (X,Y) and the statement `HPOINT TO X,Y` draws a line from the last point referenced to (X,Y). Each method is presented as a subroutine at line 100 that will draw a circle of radius R centred around the co-ordinates (U,V). Thus, a simple main program to demonstrate a circle might go like this:

```
10 U=70:V=70:R=50
20 HGR:HCOLOR=3
30 GOSUB 100
40 END
```

Note that the statements on line 20 set up the Apple's high-resolution graphics.

### Rooting in the Round

The first method of drawing circles is to use square roots. Many people should remember from highschool math classes that a circle of radius R is defined as the set of points (X,Y) such that R squared equals X squared plus Y squared. To re-express that, if you have a value for X, then  $Y = \pm \text{SQR}(R^2 - X^2)$ . You could thus, for each X, compute and plot Y. The following program fragment will do this.

```
100 S=R*R
110 FOR X=0 TO R
120 Y=SQR(S-X*X)
130 HPOINT U+X,V+Y
140 HPOINT U+X,V-Y
150 HPOINT U-X,V+Y
160 HPOINT U-X,V-Y
170 NEXT X:RETURN
```

Note that X and Y are computed for one quarter of the circle only, and that then all four quarters are done on each cycle. It will start drawing at the top and bottom, and go all four ways until the curves meet at the sides. The square of R is precomputed as S, in order to save computer time.

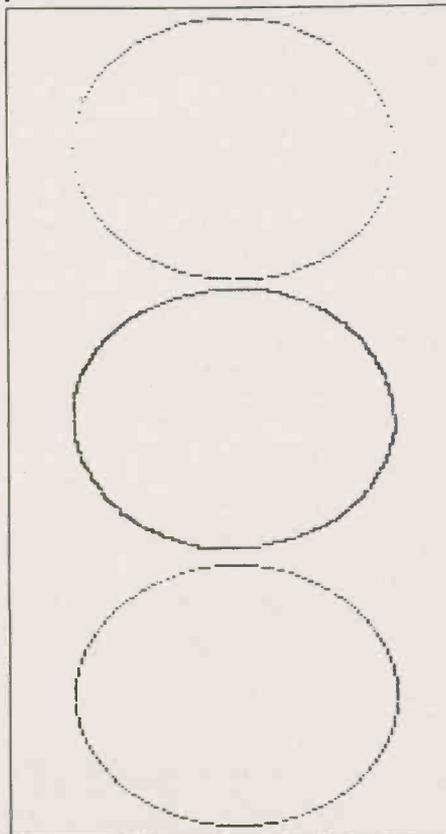


Figure 1. Top, the square root circle; middle, one of the sine/cosine circles; bottom, the binary circle. They aren't exactly circular here only because the printer they were printed on wasn't exactly square.

The circle generated by this routine is given in Fig. 1. Note that the curve is densest at the top and thinnest at the sides. This is because the X's are a constant distance apart, while the Y's are not. You could solve this by changing R, in line 100, to  $R/\text{SQR}(2)$ , and adding four more plotting statements, so that you are drawing eight eighths of the circle instead of four quarters. However, there are other ways of solving the problem.

### Elementary Trig

Another intuitive way of drawing a circle is to use sines and cosines. If you take  $X = R \cdot \text{COS}(\text{THETA})$  and  $Y = R \cdot \text{SIN}(\text{THETA})$ , for values of THETA running from zero to twice pi, you get a circle. You could do it something like this:

```
100 INCR=2*3.14159/SIDES
110 THETA=0
120 HPOINT U+R,V
130 FOR N=1 TO SIDES
140 THETA=THETA+INCR
150 X=R*COS(THETA)
160 Y=R*SIN(THETA)
170 HPOINT TO U+X,V+Y
180 NEXT N:RETURN
```

In this routine, you are actually drawing a polygon, using straight lines to connect the points. The variable SIDES (which needs to be set by the program that calls this routine) sets the number of sides. Choose 5, and you get a pentagon, and so on. To get a good circle, 40 should be sufficient. Remember that the larger SIDES is, the longer it will take to draw.

Speed of drawing is frequently a major consideration in choosing a drawing routine. If the circles you're drawing are intended to be the eyes of the aliens you're using in your new video game, you want something that will be done in the blink of an eye (sorry about the pun), even if the circles aren't perfectly circular. If, on the other hand, you're doing computer art, you want the best looking circle possible, regardless of how long it may take.

If speed is to be a consideration, bear in mind that not all computer operations

take equally much time. Any operations on integers will be faster than the corresponding operations on real numbers, although integers are not as versatile, especially with trig functions. Addition and subtraction will usually be fastest, with multiplication and division being much slower, and things like trig functions, logs, and exponentiation being the slowest. Thus,  $X^2$  is usually faster than  $X^2$ , and although the routine just presented could have been done without line 110 by setting  $\text{THETA} = N * \text{INCR}$  in line 140 each time around the loop, it is faster the way it is. The repetitive addition, it should be noted, may introduce roundoff error on some machines. If the circle doesn't join itself properly at the right side, you may need to use the multiplication after all. Sines and cosines are the worst offender in this routine, as far as speed goes, however, since they take a lot of computation for the computer to figure out. To calculate them properly, the computer might use what's called a Taylor series, which involves adding together a whole series of terms, each consisting of  $X$  to the  $N$ th power divided by  $N$  factorial. Needless to say, this takes just short of forever. Getting rid of these calculations would be a big improvement, and this can be done.

### Quick Trig

There are two ways of doing sine/cosine circles without calculating both every time. One is to start with a point anywhere on the circle and then rotate it around 360 degrees. This can be done as follows:

```
100 T = 2 * 3.14159 / SIDES
110 C = COS(T); S = SIN(T)
120 X = R; Y = 0
130 H PLOT U + R, V
140 FOR N = 1 TO SIDES
150 Z = X
160 X = C * X + S * Y
170 Y = C * Y - S * Z
180 H PLOT TO U + X, V + Y
190 NEXT N: RETURN
```

This is an improvement over the preceding method, but still more can be done. You can use what is called a table lookup routine to get the sine and cosine values each time. The idea is that at the beginning of your program, you dimension two arrays and fill them with the sine and cosine values you're going to need. You then use the appropriate elements of the array instead of computing sines and cosines as you draw your circles. The setup would run something like this:

```
10 DIM C(40), S(40)
20 T = 3.14159 / 20
30 FOR N = 1 TO 40
40 C(N) = COS(N * T)
50 S(N) = SIN(N * T)
60 NEXT N
```

This would be in addition to whatever main program you're using to call the actual circle-drawing routine, which would look like this:

```
100 H PLOT U + R, V
110 FOR N = 1 TO 40
120 H PLOT TO U + R * C(N), V + R * S(N)
130 NEXT N: RETURN
```

That's fast, at least for BASIC. The Apple takes a few seconds to do the setup (which it takes every time with the first sine/cosine routine), but then blisters around the circles when it's set loose to draw them.

Some computers may, however, already use the table lookup dodge (the Atari is rumoured to, for example). They would have a table built in, containing sine values from zero to ninety degrees, and use it to look up very quickly any sine or cosine value requested. This is great for graphics, where speed is important and accuracy needs to be no more than just reasonable, but is not so wonderful for fancy scientific calculations, where twenty decimal place accuracy is usually desired. With this method, there's a tradeoff between having a huge table with tremendous accuracy and no memory left over for anything else or having a small table and less accuracy.

### Binary Circles

The final method we're going to look at is one designed for use in fast machine code routines. It can be used in BASIC too, though, and it produces very nice looking circles.

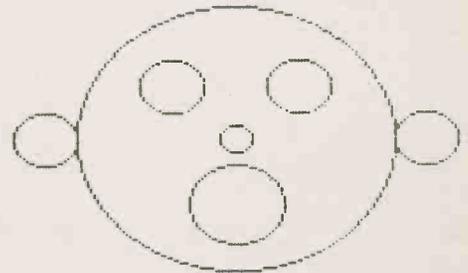
The routine was developed by J. Mitchener based on methods developed by J. Bresenham. It involves about a page of algebra just to prove it will work and to derive the method, but the idea is that the basic routine will draw one octant (eighth) of a circle one pixel at a time by moving either horizontally or diagonally at each step. The other seven-eighths are filled in simultaneously using a mirror technique as described previously. The really attractive feature is that it is done entirely using integers. No sines, cosines, or square roots need be computed, and even the multiplication is by powers of two that can easily be computed using machine-code shifts or by adding the number to itself.

The routine is given here. As before, the variables  $U$  and  $V$  are the centre of the circle, and  $R$  is the radius:

```
100 X = 0; Y = R
110 D = 3 - 2 * R
120 IF X > Y THEN RETURN
130 H PLOT U + X, V + Y
140 H PLOT U + X, V - Y
150 H PLOT U - X, V + Y
160 H PLOT U - X, V - Y
```

```
170 H PLOT U + Y, V + X
180 H PLOT U + Y, V - X
190 H PLOT U - Y, V + X
200 H PLOT U - Y, V - X
210 IF D <= 0 THEN 230
220 Y = Y - 1; D = D - 4 * Y
230 X = X + 1; D = D + 4 * X + 2
240 GOTO 120
```

In Applesoft BASIC, as the routine is presented here, it is not significantly faster than the sine/cosine method. In fact, that method might be preferable. However, if you're programming a circle routine in assembler or machine language, this is the one you'll want to use. A good assembly-language programmer can make a really fast circle routine out of this. In fact, a machine that has a CIRCLE statement in BASIC probably uses an internal routine similar to this one.



Space Invaders, anyone?

### Conclusions

The circle routine that you'll actually use depends in part on the machine that you're using. If the machine already has a CIRCLE statement in BASIC, you should be using it already and not reading this article. If your machine can't do sines, or if it can but they aren't accurate enough (or worse, if it can't do real numbers at all) you might have to skip the trig methods. You could always work out the values on a pocket calculator and feed them in as data, though. A pen plotter will need something that goes around the circle once, instead of drawing four or eight pieces at the same time. The last routine could, of course, be modified for this, but the trig routines already work this way. If you need a routine for filled circles (solid instead of outlined, in other words), the first or the last routines given would probably be the best place to start, since they will give you every point on the circle instead of a series of connecting lines. The same applies for computers that don't have line-drawing routines (the good ol' TRS-80, for example), where you need dots instead of lines.

But whatever you do, be creative. There are probably other ways of drawing circles, and likely a number of tricks that you can use on your particular computer to draw the best or the fastest ones possible.

ETI

# TECH TIPS

## Capacitor Tester Andy D'Rozario

During circuit development, situations often arise which call for a capacitor to be checked to ascertain whether or not it is functioning. The circuit shown here gives a quick audio and visual indication of the state of the capacitor by using its most basic property — that of DC blocking.

Half of the NE556 oscillates at approximately 200 kHz and is used to provide a train of positive pulses. These pulses are passed through the device under test to the two LEDs and an audio oscillator formed by the other half of the NE556.

The resultant pulses appearing at point X will vary with the device under test as follows:

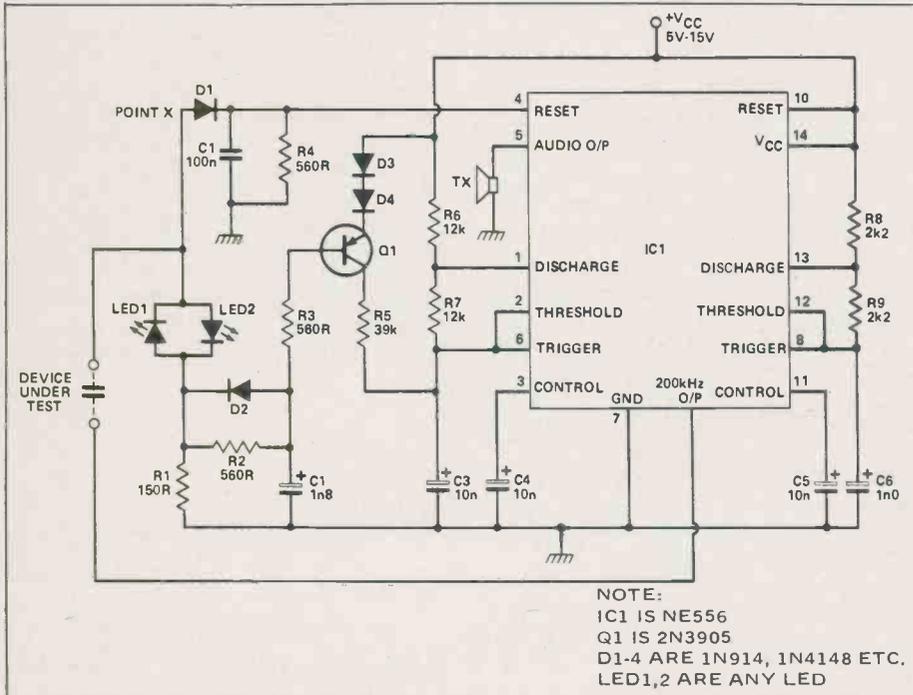
**Capacitor OK** — positive and negative pulse train at point X, both LEDs illuminated, Q1 conducts and an audio tone is produced.

**Capacitor S/C** — only a positive pulse train at point X, only one LED illuminated, C1 charges up and a lower tone produced.

**Capacitor O/C** — no pulse train, neither LED illuminated, C2 discharges and the audio oscillator is reset.

A PB2720 piezoelectric transducer was used at the output of the audio oscillator, but a high impedance speaker or earpiece should do just as well.

The tester needs the capacitor under test to be greater than 30nF to produce an audio output reliably, however the LEDs will indicate the correct condition down to 100pF at 5 V supply voltage, and 50pF at 12 V.



## Low Voltage Alarm R. Sinclair

This circuit was originally used in conjunction with an automatic mains/battery dc supply for transceiver operation. It detected the drop in dc voltage (mains supply normally 13.6 V, battery 12 V) to give visual and audio warnings of the voltage decrease.

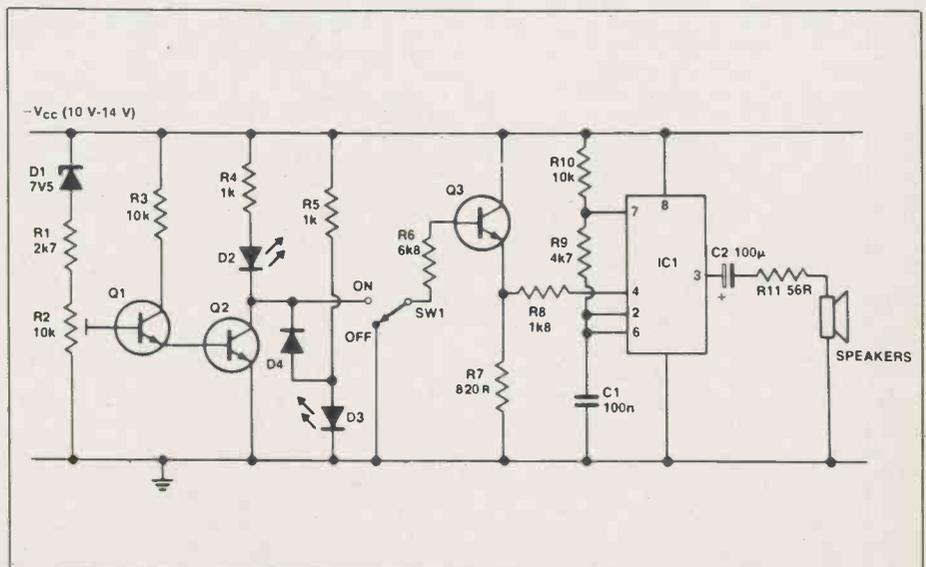
It is suitable for any application requiring detection of a drop in normal dc supply voltage with the advantage of an audio warning. This would be particularly suitable in a vehicle where a visual indicator may be easily overlooked.

D1, R1 and R2 provide a stable voltage reference and the preset R2 is adjusted so that D2 lights under normal conditions. D4 is then forward biased, keeping D3 off.

When the input supply causes a voltage drop across Q2, D3 turns off and Q3 now turns on through SW1. The voltage on pin 4 (reset) of the 555 goes positive, enabling the 555 which is connected as an astable. The frequency is varied by R9.

To disable the audio alarm function, SW1 is operated cutting Q3 off, but D3 will still give visual indication.

NOTE:  
D1 IS 7V5 400mW ZENER  
D2 IS GREEN LED  
D3 IS RED LED  
D4 IS 1N914  
Q1-3 ARE 2N3904  
IC1 IS 555 TIMER  
SW1 IS SPDT TOGGLE



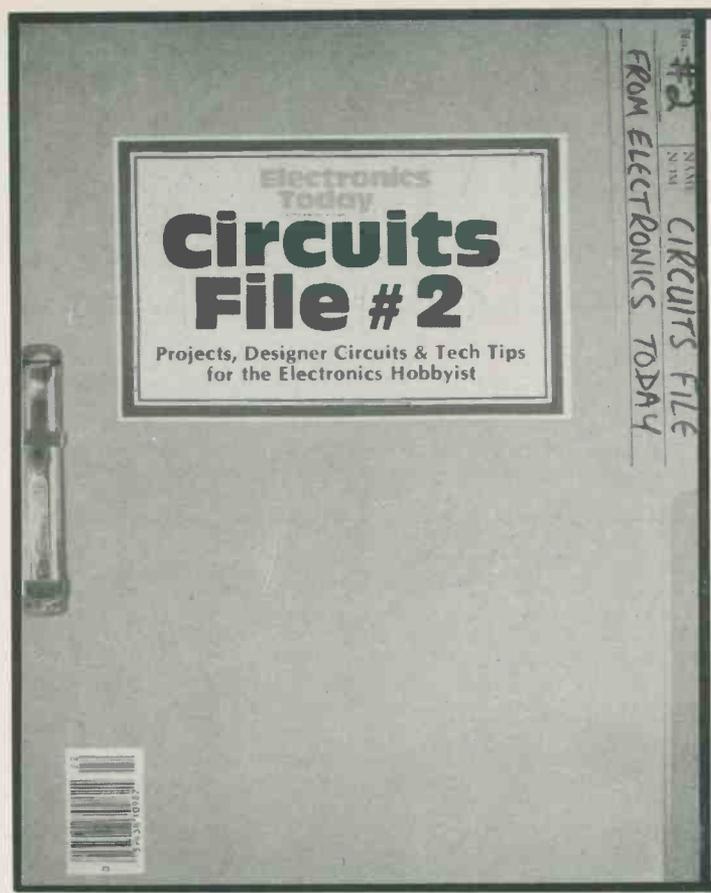
To be Published April 1984

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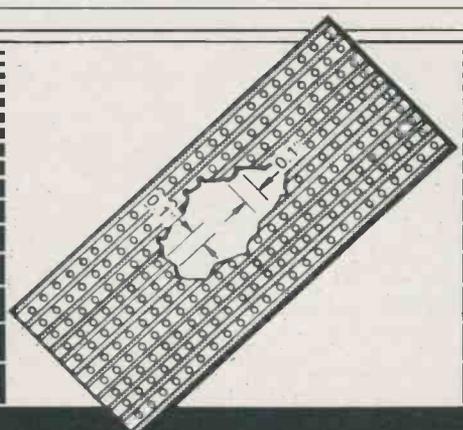
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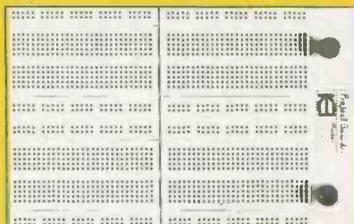


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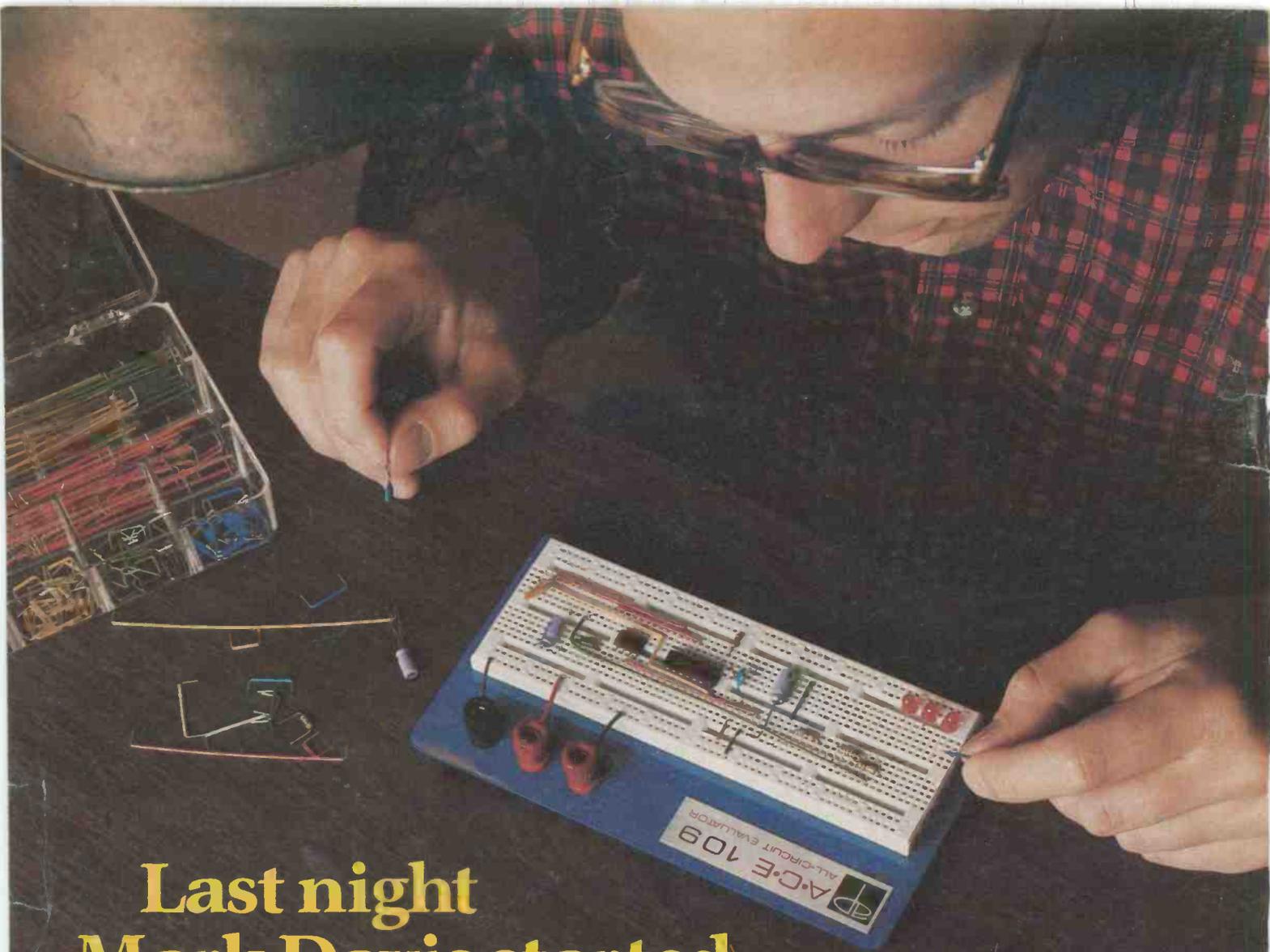
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