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Electronics Today

July 1985

Canada's Magazine for Electronics & Computing Enthusiasts

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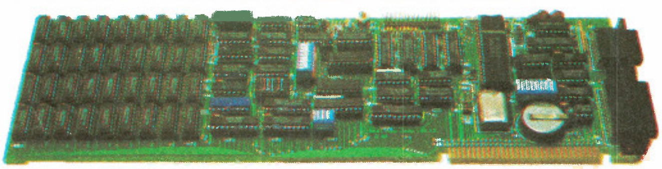

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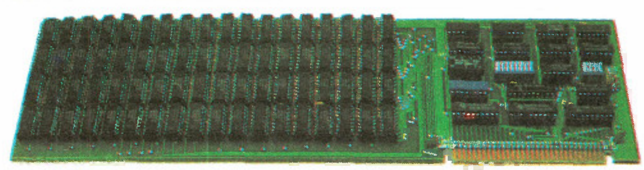

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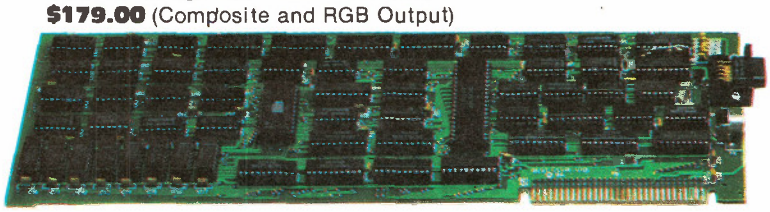

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Our Cover

Designer Dave Bedrosian returns to us with the Power Supply appearing on Page 35. The photo was by Bill Markwick; thanks for assistance to Ann, Ed, and Jim and Pat Armour.

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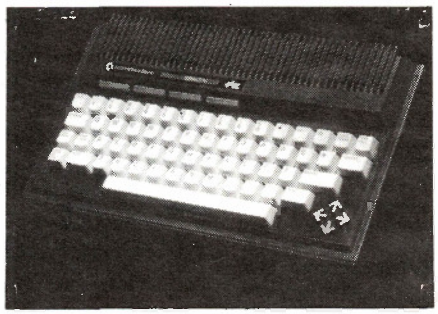

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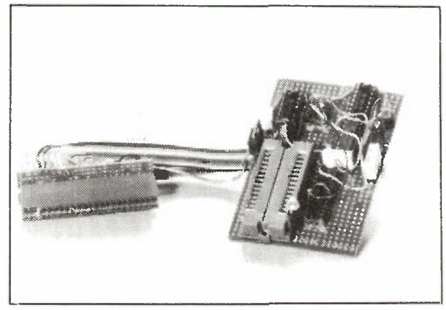

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Projects

Series

Columns, News, and Information

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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. Electronics Today has opted for sooner!
Firstly decimal points are dropped and substituted with the multiplier: thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1 uF is 100nF, 5600pF is 5n6. Other examples are 5.6pF = 5p6 and 0.5pF = 0p5.
Resistors are treated similarly: 1.8Mohms is 1M8, 56kohms is the same, 4.7kohms is 4k7, 100ohms is 100R and 5.6ohms is 5R6.

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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 PCBs and kits. Similarly do not ask PCB suppliers for help with projects.

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B—C—D Electronics, P.O. Box 6326, Stn. F., Hamilton, Ont. L9C 6L9.

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Arkon Electronics Ltd., 409 Queen Street W., Toronto, Ont., M5V 2A5.

Spectrum Electronics, 14 Knightswood Crescent, Brantford, Ontario N3R 7E6.

Now that you've sprung big dollars to get AutoCAD, the popular computer drafting system for MS-DOS, you'll be happy to know that they've improved and upgraded it with the new Version 2.1 Improvements include a 40 percent increase in speed over Version 2.0 (if you have the 8087 coprocessor), support for dot matrix printers, wire-frame drawings with obscured-line suppression, smoother curve fitting and editing, and more. Let's hope they've improved their really dumb text editor. Contact Autodesk Inc., 2320 Marinship Way, Sausalito, California 94965, (415) 331-0356.

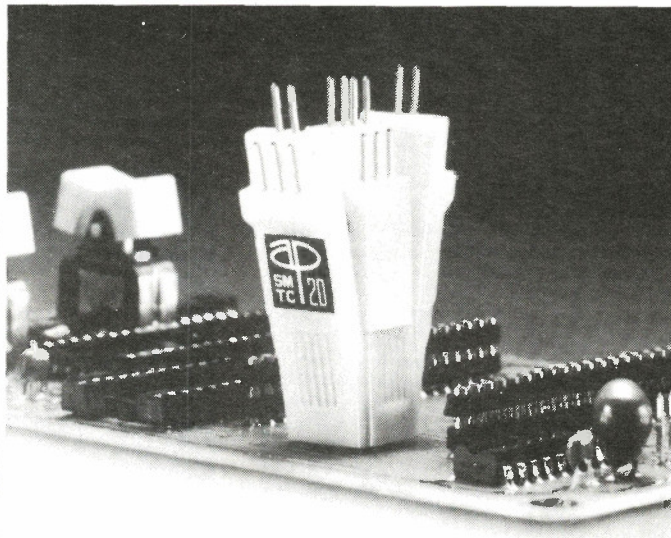
A new Howard Sams book, Electronics: Circuits and Systems by S. Madhu, is aimed at engineers and other technical people who have no background in electronics, but who need a basic grasp of the subject for dealing with specialists. Readers can see how the topics under discussion relate to their own involvement with projects; drill problems are an aid to self-study. The 976-page hardcover is $39.95 US, and available from local dealers.

Cantel Inc. of Montreal say they have signed "international roaming agreements" with US cellular telephone companies. This sounds intriguing, but what it means is that Cantel subscribers can use their cellular phones in the cities of Chicago, Milwaukee, Detroit, Gary, Flint, Cincinnati, Columbus, and Dayton. Similarly, US subscribers can use Cantel facilities in 23 Canadian markets by the end of 1986. Service begins in July, 1985. Other agreements with US networks mean extension of the Cantel network to Buffalo, Washington DC, Baltimore, Philadelphia and points east.

Users of the Radio Shack Colour Computer now have a choice of programs for assembler, text formatting, debugging, and communications. Look for the OS-9 series of assembly software, or the Color Connection III for telecommunications. Sorry, we never can get US vs Canadian spelling standards sorted out. The software packages are available from Computerware dealers, or contact them at PO Box 668, Encinitas, California 92024, (619) 436-3512.

Users of UNIX and UNIX-compatible systems can join /usr/group/cdn, a name which looks like a typo. The association encourages cooperation and assistance among suppliers and users of this popular operating system which is said to have done for multi-user computers what MS-DOS did for personal micros. Membership in the group is limited to individuals. Contact them at (416) 465-1699.

Test Clip

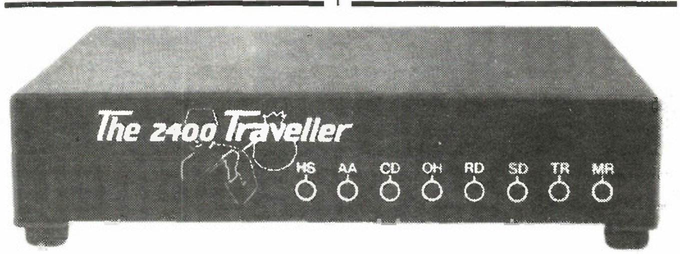


AP Products has a new surface mount test clip for connecting to plastic leaded chip carriers, not an easy thing to connect to. All four sides open simultaneously; staggered rows on 0.1" centres permit easy probe attachment and prevent shorting. The 20-conductor size will soon be available in 44- and 68-position types. Available in lavender or puce. Lenbrook Electronics, Unit 1, 111 Esna Park Drive, Markham, Ontario L3R 1H2, (416) 477-7722.

Ribbon Connectors

Available in either ribbon or PC mount, these connectors are also known as Centronics or telephone type. The Robinson Nugent IDR/RPM series Ribbon-D series come in 24, 36, and 50 positions and are compatible with all standard ribbon connectors. They terminate 28 AWG flat ribbon cable, and can be either straight or right angled. A metal front shell aids in EMI shielding. Beats using 50 jumper clips to hook up your printer. From Weber, a division of DGW Electronics, with offices in Toronto, Ottawa and Calgary, or contact them at 85 Spy Court, Markham, Ontario L3R 4Z4, (416) 475-8500.

According to the Ontario Ministry of Industry and Trade, the Province of Ontario and Jiangsu Province of China have signed a five-year agreement for scientific and technical cooperation and exchange. The pact clears the way for Ontario to establish a combination technology and trade centre in Nanjing, Jiangsu's capital. There are six areas of priority, of which fibre optics, computer software and energy conservation are the most appropriate for Canadian electronics suppliers. Funny, China was never heard from until Nancy Reagan went to see the Great Wall. Maybe she can do something about AutoCAD's text editor.



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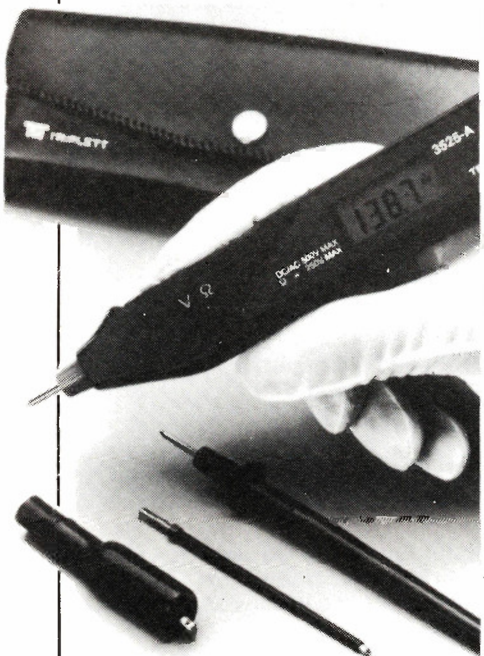
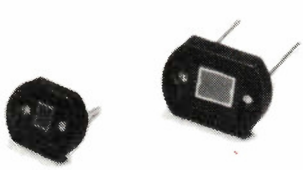
VOM Probe

The Triplett 3525A Digi-Probe now has extended resistance ranges from 200 ohms to 20 megohms, and an additional 200mV DC voltage range and improved accuracy. It also features 3 1/2 digits, a "data-hold" feature and auto-ranging. With case, batteries (wow!), test lead and manual. Contact Len Finkler and Co., 80 Alexdon Rd., Downsview, Ontario M3J 2B4 (416) 630-9103.



Photodiodes

Centronic Inc., not to be confused with the printer people of a similar name, have introduced the CBC series of photodiodes, not to be confused with a broadcasting corporation of a similar name. The selling point is that they contain a filter which provides a spectral response similar to that of the human eye. They're effective in situations where infrared and ultraviolet are present and must not be detected. For further information, write or call James McVea, Centronic Inc., 1101 Bristol Road, Mountainside, NJ 07092, (201) 233-7200.



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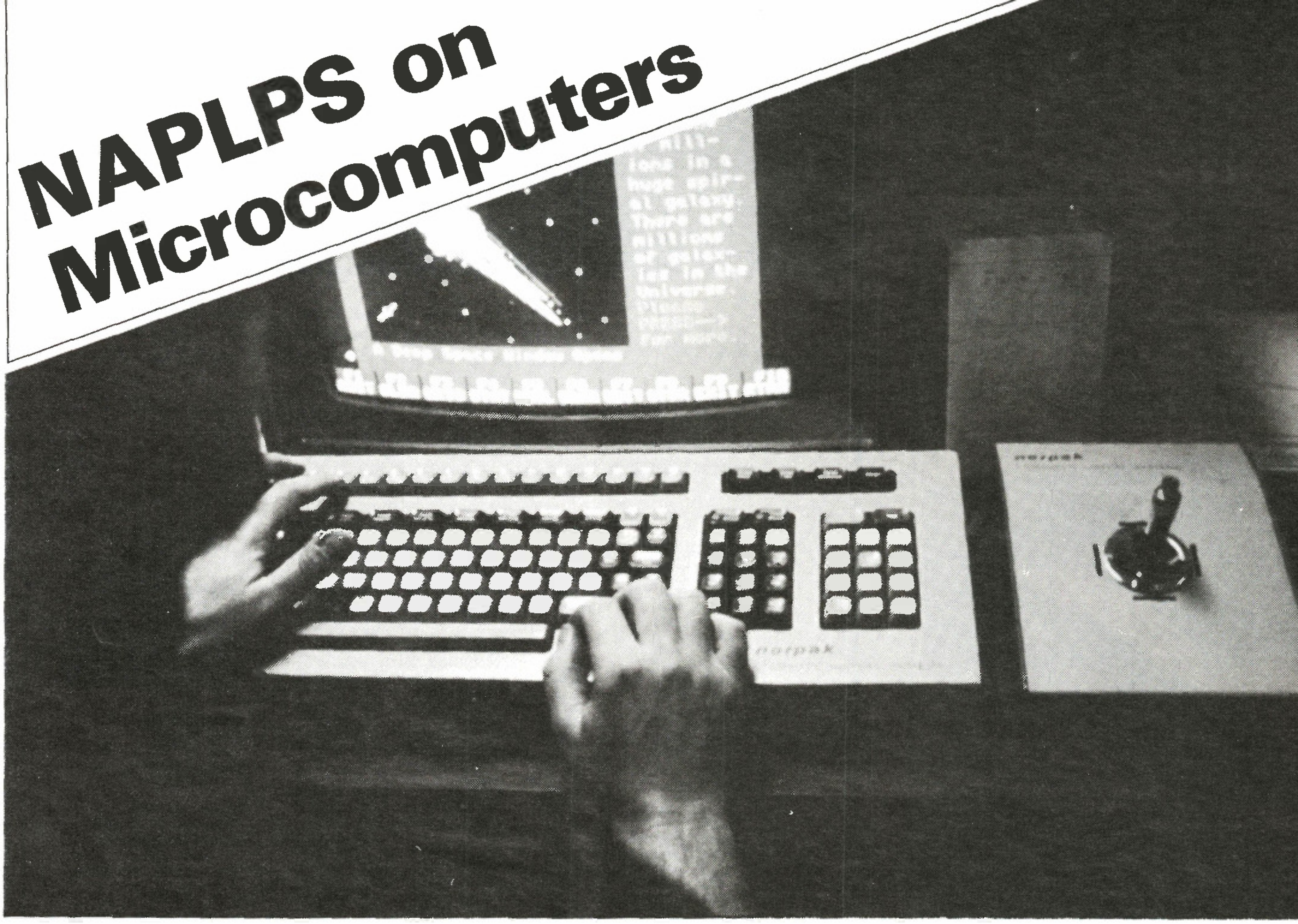
NAPLPS on Microcomputers



NAPLPS is the standard in videotex and microcomputers make ideal terminals.

By Paul Hurley

THE North American Presentation Level Protocol Syntax, or NAPLPS (pronounced nap-lips), is a new graphics protocol which has attracted considerable support throughout North America's communications and computer industries. One of the many results of this support for NAPLPS has been the development of software and plug-in cards which will permit microcomputers to generate, receive and process NAPLPS code. This article will describe the main features of the NAPLPS specification and will identify a variety of microcomputer-based NAPLPS software tools which are commercially available. Understanding some of the basic features and requirements of NAPLPS will help you to appreciate both the utility and the limitations of the computer implementation.

The term *graphic videotex* is used in this article to distinguish services like Grassroots, Teleguide and Viewtron from text or alphanumeric videotex services such as The Source, CompuServe and Dow Jones News/Retrieval. Increasingly, the communications and electronic publishing industries are accepting that both forms are videotex, and not the discreet, mutually exclusive services they were assumed to be in 1981.

Graphic videotex has generated some very emotional and entrenched attitudes within Canada's electronic engineering and computing communities. This is largely, and perhaps not unjustifiably, because of the tremendous hype, unrealistic expectations, and inordinate patronage which have surrounded Telidon since 1979. Even some videotex industry insiders now acknowledge that "Telidon left a bad taste in a lot of people's mouths", and its promotion was "a bloody mess". Fortunately, neither time nor the technology have stood still.

Telidon

In 1982 AT&T approached the federal Department of Communications (DOC), which had developed Telidon and supervised the growth of a Canadian videotex industry, with a proposal. AT&T asked the DOC to modify the Telidon 699 standard in order to create a North American graphic communication standard for videotex.

"If we hadn't been willing to change Telidon, Canada's electronics and publishing industries would have been frozen out of the US market," explains John Madden, one of the 'fathers' of Telidon. Madden is currently president of New Media Technologies Inc. of Burnaby, BC. Preserving a stake for Canadian jobs in the emerging global information economy was one of the principal rationale Madden and his colleagues used to justify the creation of a public Telidon communication system to the federal cabinet in 1975.

The hybrid offspring of Telidon and AT&T's PLP videotex format was NAPLPS. The Canadian Standards Association and the American National Standards Institute approved the NAPLPS specification in the fall of 1983. The CCITT (Comite Consultatif International Telephonique et Telegraphique) gave its blessing in 1984.

NAPLPS represents both an important stage in the evolution of videotex, and evidence of the continuing convergence of computer-communication technologies towards what two farsighted French researchers, Simon Nora and Alain Minc, termed *telematique*. The increasing number of microcomputer-based NAPLPS products demonstrate the gradual merging of microcomputer and videotex technologies. These NAPLPS tools are being used for what many purists would consider non-videotex applications in business, the audio-visual and graphics fields, and the communications industry.

NAPLPS is not without its weaknesses. Some of these will be identified in the following overview. But in several respects, some of the problems NAPLPS introduced may also prove to be a blessing in disguise. Events are not always as they appear at first glance.

A NAPLPS Primer

NAPLPS is not yet a true graphics standard. Adherence to the NAPLPS specification is still largely voluntary throughout the North American videotex industry. This has introduced countless problems, not the least significant of which is the lack of compatibility between hardware and software products. Thus images encoded by one system may not be correctly decoded by another.

NAPLPS's creators and primary advocates have been largely in the videotex industry. This has tended to confuse observers regarding its pedigree. NAPLPS should more correctly be thought of as a graphics protocol, not just a videotex specification. Its main features are hardware independence, flexible code extension, and compact encoding of complex graphics. Many of the positive attributes were inherited from the Telidon format.

NAPLPS achieves hardware independence by encoding coordinate data for the X-axis and Y-axis as fractions of each axis' resolution rather than specific pixel locations on the screen. Thus a NAPLPS image should correctly display on a 256 x 200 pixel screen, on a 512 x 400 screen, or even a 1024 x 800 screen.

NAPLPS was designed to work in either a 7-bit or 8-bit environment. Presently, NAPLPS defines roughly 600 graphics characters and codes. The code extension technique is used to map these codes into a 7-bit table by grouping them into six G-set groups for drawing, and a C-set repertoire for communications and other functions. The G- and C-set lists are mapped into the 7-bit in-use table when specific commands are sent to the interpreting software.

The minimum NAPLPS Standard Reference Model (SRM) G-set inventory consists of: 94 primary ASCII characters, 94 supplementary characters, Picture Description Instruction (PDI) geometric drawing primitives, 65 mosaic character cells, 96 macro codes, and 96 Dynamically Redefinable Character Set (DRCS) codes. Other G-sets, such as a list of sound characters or telesoftware commands, could also be implemented.

Because NAPLPS was developed for a communications environment, the need to conserve bandwidth was essential. Designers with an interest in applying NAPLPS to other tasks have inherited this feature as a saving in memory requirements. The PDI, macro and DRCS G-sets play an important role in the compactness of NAPLPS.

PDIs are opcodes which produce six basic geometric shapes. Macros are single-character code names which invoke a string of presentation codes stored in the local terminal to be displayed in their place. DRCSs are definable characters whose pattern can be transmitted from the host to the terminal or generated locally in response to macro signals.

Implementation of the NAPLPS SRM specifications places a number of requirements on the receiving terminal. The use of a 16-bit microprocessor in a NAPLPS terminal configuration equipped with highly efficient decoding algorithms requires 64 to 80K bytes of ROM. The use of a high-level language would increase the memory requirement.

NAPLPS pages are stored in a bit-plane memory. The minimal requirement is for 256 x 200 pixels resolution x 4 bits for three colour modes. Roughly 26K bytes of RAM are needed to map this data. An additional 16 to 22K bytes of RAM are needed to store DRCS characters, macro codes, blink processes, texture overlays, and other SRM functions. The terminal video display processor must also be capable of supporting the bit-plane map, colour modes, digital-to-analog conversion and interfaces for RGB/NTSC video and RF output.

Recent studies in the US have shown that videotex home and business services would proliferate if monthly subscription charges were in the $5 to $10 range. Presently these charges are running at roughly $25-$35 per month. One of the main reasons for this is that the decision to implement NAPLPS virtually doubled the cost of producing an adequate hardware decoder. This cost has been by necessity passed along to the consumer.

Until 1982-83, graphic videotex services such as Grassroots, Vista and Viewtron, which was still undergoing trials, had relied solely on dedicated user videotex terminals. Viewtron's original decision to prohibit potential users from accessing its service on equipment other than the $900 AT&T Sceptre videotex terminal was one of the main reasons the service began to faulter in mid-1984. At the recent Videotex Canada conference in Toronto, one major consensus was that what the industry really needs is an affordable decoder.

Enter the abundant and affordable personal and business microcomputer.

NAPLPS Micro Decoders

The videotex industry realized that a microcomputer NAPLPS decoder was essential to future market growth at about the same time that various small software companies, which were unbiased about videotex, began to recognize that NAPLPS was a powerful graphics tool. The result has been a steadily growing number of microcomputer NAPLPS software decoder and terminal emulation products.

The microcomputer is a logical means of accessing videotex for the business or home. There are approximately 17 million microcomputers in use in North America. Link Resources Inc., of New York, estimates that roughly 57% of these are equipped with modems. Many of the popular microcomputers have the 128K bytes of memory and the code processing power necessary to implement NAPLPS. The microcomputer is also a more versatile tool than a dedicated videotex/teletext terminal.

Most current microcomputers do have inherent limitations in colour processing and image display which prevents them from implementing the minimum SRM standard of 16 colours from a palette of 512 with a 256 x 200 resolution in three colour modes. But the addition of plug-in colour boards for some computers, such as the IBM and compatibles, provides a method of meeting and sometimes exceeding the minimum SRM requirements. The products from Conographics, Scion and Microdel will support the full SRM specifications.

Electronics industry spokesmen have predicted that 1 micron microprocessor technology presently in the labs will result in low cost hardware decoder products by 1988-89. By that time, however, the next version of microcomputers may already have integrated NAPLPS into their

designs. Presently only the Mindset microcomputer meets the SRM specifications, but industry observers are predicting that IBM, AT&T and others are likely to follow shortly. By the time this article is in print, it is expected that Cemcorp will have announced how it plans to implement NAPLPS compatibility in the ICON microcomputer it is developing for the Ontario Ministry of Education.

The NAPLPS decoder acts as a data translator, converting strings of PDI, macro and DRCS and ASCII code into a colour-mapped bit-mapped display. The development of microcomputer software decoders and software programs which work in conjunction with plug-in decoder boards has begun to have a radical impact on the graphics videotex industry. These products have also opened many doors for the use of NAPLPS for a wide range of graphic applications.

The software decoders have many advantages. They are inexpensive, averaging about $230. They are compact and much more transportable than the bulky software decoder/terminal configurations. Many of the software and plug-in decoders implement additional features, such as slide show image sequencing, page creation, system terminal emulation such as action page screens for transactions like telebanking, and ASCII terminal emulation. The products from Avcor, Micropixel, Manitoba Telephone Systems and Media Technologies also will facilitate file transfer routines called *downline loading.*

There is a noticeable absence of NAPLPS decoders for CP/M operating systems. In addition to various software, several new products will soon be available.

The microcomputer is a logical means of accessing videotex; there are 17 million in North America, 57% with modems.

Add-ons

AT&T has announced that it will release several NAPLPS microcomputer products, including a software decoder, during either the second or third quarter of 1985. Sandford Computer Systems Inc. has developed Videopro, a full SRM NAPLPS decoder. Norpak has developed a new plug-in card to challenge the Quickpel board. The Norpak decoder is based on a new microprocessor, the R6549 Colour Video Display Generator, developed jointly by Norpak and Rockwell at a cost of $2.5 million. The product employs the Mark 6 generation of Norpak video/teletext decoder architecture and will replace the outmoded TGS plug-in card.

The Quickpel plug-in card from Micropixel Inc. is a repackaging of the popular Electrohome EGT 100 hardware decoder. Based on the Intel 8088 microprocessor, Quickpel meets SRM requirements for macros, DRCS, colour mapping, logical pixel and unprotected fields, and exceeds SRM in text scaling and several other functions. Quickpel has an on-board multi-tasking executive, comes with assembler and Lattice C, and has 16K bytes of RAM for downline loading of data or programs.

New Media Technologies Ltd. of Burnaby, BC, formed in 1984 by staff who split off from Microtel Pacific Research Ltd., purchased most of the NAPLPS products marketed by AEL Microtel, the parent company of MPR. Since then, New Media has developed an enhanced version of the original Microtel 2A board decoder, named 2B and dubbed Hamlet (BC folk have an adroit sense of humour). Hamlet is reported to have achieved a speed factor of 2.6 times the speed of the 2A, which makes it presently the fastest NAPLPS decoder, bar none. Further details about Hamlet are not expected until the official release date later this year. The present 2A decoder can display 16 simultaneous colours from a palette of 4096.

Unlike the IBM PC, the Commodore 64 does not require plug-in boards in order to display NAPLPS. Limitations in the C64 design prohibit a compatible decoder from conforming to the full SRM. Version 2 of the Manitoba Telephone System Videotex Decoder for the C64 has been selling in the US for under $100. It is able to overcome some of the C64's design limitations, and displays 13 colours and 3 grey scales at a reduced resolution of 160 x 200. SRM functions which it cannot support include DRCS, the mosaicset, blink, and the supplementary character set.

Formic Videotex Systems Inc. has upgraded its Apple line of software decoders and expects to release an IBM version later this year. Sofdec "C" is a software product for the Apple IIc with 128K bytes of memory. Sofdec "E" is a plug-in card for the Apple IIe. Both products can display 16 colours with a resolution of 192 x 200, and although sub-SRM, they support the core functions.

The Ashdune Apple decoder offers an exciting range of additional features, including page creation, a slide show mode which could be used for business presentations, and hardcopy output.

DEC has been a pioneer in the graphic videotex field and has developed a wide range of NAPLPS/Telidon products for its PDP-11 series of minicomputers. The PRO/NAPLPS software decoder was DEC's first videotex offering for its Professional 350 microcomputer line. PRO/NAPLPS can display 8 colours simultaneously from a palette of 256 colours, or 8 grey scales from a range of 16 on a monochrome monitor. It will emulate the VT-100 in the ASCII mode. Although a sub-SRM product, it produces an impressive 768 pixel x 240 line resolution, and will support other operating systems such as CP/M and VENIX, a UNIX-like structure.

As could be expected, there is a lot of NAPLPS software support for the IBM PC. The PC/Videotex product from IBM implements varying degrees of the SRM, depending on the graphics board used with the PC or XT. It also offers the ability to copy frames from the communication link onto diskette, and then to display these in a continuous billboard mode. The decoder will interface with a database manager to allow routing information to be added to the captured frames.

Personality II is an enhanced version of Microstar's original software decoder with impressive credentials of its own. In addition to supporting most SRM requirements, Personality II will emulate an ASCII terminal with an 80 x 24 display. It

It is still early in 1985, and already it is apparent that many large US corporations are moving quickly to support new, specific applications of videotex. Business oriented communication services such as Grassroots and Marketfax are expanding into the US from Canada, and public access videotex systems are being introduced widely. These and other uses of videotex have become more cost-effective as a result of the development and improving quality of NAPLPS software decoders. These affordable decoders permit system operators to convert the availability of microcomputer equipment in homes and offices into videotex terminals.

It is possible that if NAPLPS had not been adopted, interest in developing low cost microcomputer software decoders might never have been fostered. As more and more microcomputer owners investigate telecommunication services in an effort to justify their hardware investments, the convergence of videotex technology with microcomputing is likely to become a reality.

Summary of NAPLPS Decoders for Micros

Apple: Integrated Information System from Avcor, requires 48K, no extra hardware.
SOFDEC C or E from Formic for Apple IIc or IIe, requires 128K and text card for IIe.
Apple Decoder from Norpak/Apple for II series, requires 48K and interface card.

Commodore 64: Jordan from Ashdune, no extra hardware.
Integrated Information System from Avcor, no extra hardware.
Videotex Decoder from Manitoba Telephone, no extra hardware.

IBM PC, XT: FBN Decoder from FBN Software, requires 128K and colour card.
PC/Videotex from IBM, requires 128K, colour card, modem.
Quickpel from Micropixel, requires 96K, no extra hardware.
Personality II+ from Microstar, requires 192K, colour card.
TELIgraph from Microtaure, requires 128K, colour card.
2A Decoder from New Media Technologies, requires 128K, colour card.
NAPLPS Decoder from Wolfdata, requires 128K, colour card. ■

Configurations

The final episode reveals the working of AND, OR, and NOT gates.

By Ian Sinclair.

For anyone who has worked with linear circuits for a long time, the first contact with digital circuits always comes as a shock because the action of digital circuits is unfamiliar, and the way in which these circuits respond to signals is equally unfamiliar. In this final part of the series we'll concentrate on the most basic of digital circuits, the gate, and how the two most common types, TTL and CMOS, carry out gate action.

Let's be clear from the start as to what we mean by digital circuits and gates. A digital circuit is one which works with signals that consist of several separate voltage levels, so that a voltage that is to be counted as a signal must be at or near one of these levels. The digital circuits that we make the most use of are binary digital circuits, meaning that the signals, into and from them, consist of only two voltage levels: which we will refer to as 0 and 1. The value of the actual voltage does not matter, the important feature is that there should only be these two levels. Most logic circuits operate with what is commonly called positive logic, in which 0 means zero volts and 1 means a positive voltage.

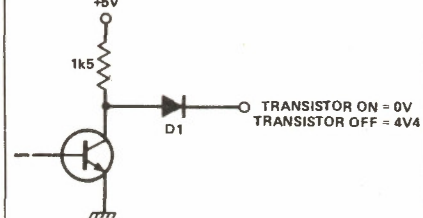


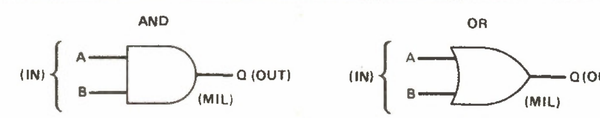
Fig. 1. Voltage levels. The presence of a diode, or transistor junction, in the path of an output can change the output level by 0V6 or so. The tolerance of voltage must be enough to make allowances for this.

The advantages of using just two voltage levels are considerable. We don't have to worry about bias, for example, in the design of circuits, provided that we arrange for each active device in a circuit to be turned on at one voltage level and off at the other. This encourages the use of ICs because bias is difficult to arrange reliably inside ICs. We don't need much in the way of voltage amplification, because with only two levels to consider, the output signals can be about the same as the input signals. The only voltage amplification we might be concerned with is that which might be required to restore the 1 level to normal when it has been reduced by, say, the 0V6 drop across a conducting diode (Fig. 1). The next major factor is that tolerances in component values have much less effect on signals than they have in linear circuits. A logic 1 voltage which is nominally 5V can drop as low as 3V6 and still be useable as a logic 1 voltage. The logic 0 voltage can rise as much as 0V8 and still be useable.

Since the normal concern of linear circuits, amplification with low distortion, is simply not necessary for digital applications, the actions that digital circuits perform are necessarily quite different. One of the fundamental actions of a digital circuit is gating, and it is gating that we will be concerned with from here on.

Digital Gates

A digital gate is a circuit which has inputs and outputs that are both digital signals. Since the output is a digital signal, it must have a voltage level at any instant which is at logic 0 or logic 1, and what the level actually is depends entirely on the combination of inputs that happens to be present at that instant. It is for this reason that the gate circuit is often referred to as a *combinational* circuit. The two most important types of gate circuit are the AND and OR gates, and we can describe their actions by a table that shows what the output will be for every possible combination of inputs. Such a table is called a "truth table", and the truth tables for the AND and OR gates are shown in Fig. 2. These tables show that for the two-input AND gate, the output will be at logic level 1 only when both inputs are at level 1: for the OR gate, the output will be at level 1 when either or both inputs are at level 1.



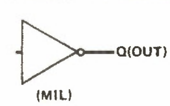
A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

Fig. 2. The two main gate types shown graphically with their respective truth tables.

Truth tables become less useful when a gate has a large number of inputs, because the number of lines needed for a truth table is 2 to the power of *n*, where n is the number of inputs to the gate. The same rules apply irrespective of the number of inputs, so that the action of the AND and the OR gates can be described in ways that are more compact than truth tables, using Boolean Algebra. But for the purposes of simplicity (and space restrictions) we'll stick to the tables.

Another circuit which is classed among gates is the inverter, sometimes called the NOT gate. Its truth table, in



A	Q
0	1
1	0

Fig. 3. The inverter or NOT gate.

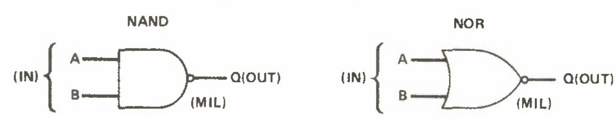
Fig. 3, is simple. The logic voltage output is the inverse of its logic input. Circuits which combine the action of the NOT gate with the action of the AND gate are called NAND gates; NOT combined with the OR gate gives a NOR result. The truth tables of these two types are given in Fig. 4. One further gate which is less important as a basic circuit, but one which is needed in arithmetic circuits, is the exclusive-OR gate, or EXOR gate (Fig. 5). The name comes from the fact that the action is like that of the OR gate but excluding the case where both inputs are 1.

Logic circuits which make use of gates are connected so that the output of one gate can pass signals to the input of the next gate in the circuit. This passing action is generally referred to as *driving* one or more inputs from another output. This usually means that the output has to be able to supply (source) or absorb (sink) current, and the number of inputs that can be driven by one output is called the *fanout* of that gate. The size of the fanout depends on the design of the input and the output stages of the gates. A fanout of 10 is generally considered to be satisfactory, meaning that 10 gate inputs can reliably be driven from one gate output.

and ground must be low enough to ensure that when this amount of current flows, the input voltage at the terminal must not rise above the maximum voltage level permitted for logic 0, usually around 0V8.

The requirement to have current flowing *out* from the input at logic 0 means that not all driving circuits are useable. In particular, the popular NPN emitter-follower, which is the choice for many purposes, is not suitable because (Fig. 7) when the input is at logic 0 the current from the gate will flow through the emmiter resistor. A PNP emitter-follower, arranged as shown in Fig. 8, can allow a satisfactory logic 0 voltage, but only if the voltage at the base of the emitter-follower can be taken low enough, preferably to a negative voltage, because of the inevitable 0V6 difference between the base and emitter. A reliable, simple driving stage is the common-emitter amplifier circuit shown in Fig. 9.

No driving problems should exist in the input of a gate is driven by the output of another gate of the same family. Fig. 10 shows the conventional circuit arrangement fro a standard TTL gate output, which uses two transistors and a diode in series. A logic 1 output corresponds to



NAND:

A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

NOR:

A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

Fig. 4. NAND and NOR gates, formed by combining AND/OR gates with inverters.

TTL Gates

The old-style 'standard' TTL gate uses bipolar transistors, but using a common-base circuit rather than the more familiar common-emitter. The inputs (Fig. 6) are to the emitters of transistors whose bases are connected through a current-limiting resistor to the supply positive voltage of 5V. A common feature of the IC construction is the creation of several emitters on to one base, so that several inputs are fed in by the same transistor. An input stage like this will draw no current when the input voltage is logic one, because such an input biases the transistor off. An input which is at logic 0, however, has the effect of grounding the input terminal, and current will flow through the base-emitter junction of the transistor to ground. Unlike our linear circuits, this input current comes *out* from the input. Standard TTL is constructed so that this current is about 1.6mA, meaning the resistance between the input terminal

having the top transistor of a pair conducting and the bottom transistor shut off, and because the base voltage of this top transistor cannot be more than the supply voltage of +5V. The emitter voltage must be no more than 4V4–4V5, which makes the output voltage (because of the diode) only around 3V8–4V0. Don't be surprised if you find that the logic 1 output from a gate is lower than the supply voltage. the logic 0 voltage from this circuit will be the voltage across the bottom transistor when it is fully conducting, which can be as low as 0V2, depending on the load.

The layout of the output stage is such that only one of the output pair will be conducting at any time during normal operation. If two gate outputs are connected together, however, it would be possible to have one output at logic 1 (top transistor conducting) and the other at logic 0 (bottom transistor conducting), so that a low resistance for current was created (Fig. 11). This would have the ef-

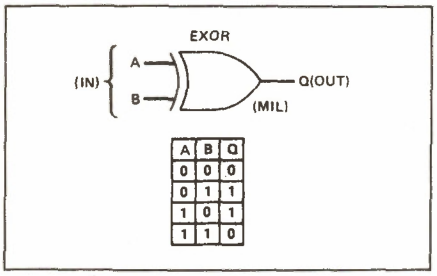


Fig. 5. The exclusive-OR (EXOR) gate and its truth table.

fect of burning out one transistor in each gate, so that for the few applications in which gate outputs have to be connected together, special gate ICs described as open-collector types are used. These have no 'top' transistor in the output stages, and are designed to work with an externally connected resistor load (Fig. 12).

Standard TTL, though still circulating in large numbers, has been replaced in production by the low-power Schottky TTL chips, distinguished by the letters LS in the type numbers. These LS chips make use of a component known as the Schottky diode. This diode uses a combination of metal (usually aluminum) and semiconductor in its junction to obtain a very low forward voltage, between 0V1 and 0V2 as compared to the 0V6 for a silicon diode. This makes these diodes ideal for use in logic circuits, as illustrated in Fig. 13, and also makes it possible to

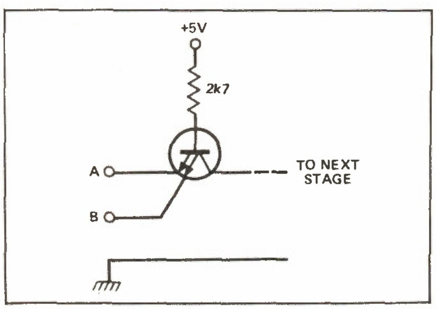


Fig. 6. (Left) TTL input. The base of the transistor is connected to +5V through a resistor, and the inputs are connected to the emitters. More than one emitter (as many as 13) can be formed on to one base.

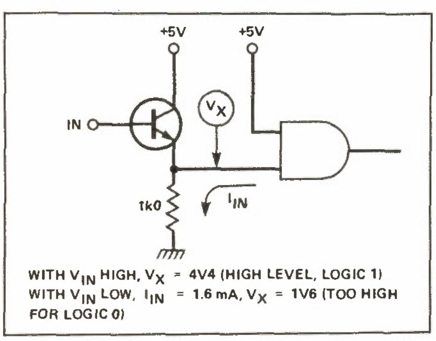


Fig. 7. (Right) Driving a TTL stage from an NPN emitter-follower. The logic 0 voltage is likely to be too high because of the current from the input of the gate.

construct transistor stages which do not saturate. Saturation occurs in a conventional transistor stage when the base current, which has a collector load, is so high that the collector voltage bottoms. The effects of saturation are to achieve a very low collector voltage, around 0V2, but also to flood the base junction with charge carriers (electrons or holes depending on the type — PNP or NPN). When the base voltage is suddenly removed from such a saturated transistor, this charge takes some time to clear, so that the transistor remains conducting; it will not switch rapidly from the conducting state to the non-conducting state. The time is usually less than a microsecond, but it limits the speed at which a gate circuit can operate reliably.

A Schottky diode placed between the collector and the base of a transistor (Fig.

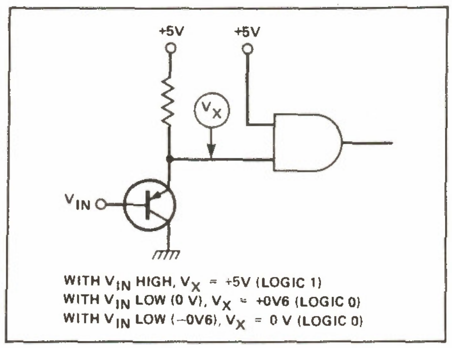


Fig. 8. (Left) Using a PNP emitter-follower as a driving stage.

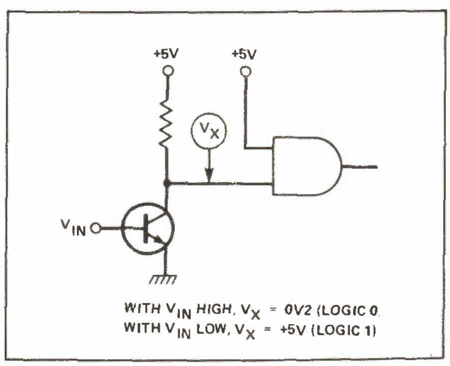


Fig. 9. (Right) Driving a gate from a common-emitter stage; this is the most satisfactory single-transistor drive stage.

14) will prevent such saturation. When the collector voltage reaches a level which is about 0V2 lower than the base voltage, the Schottky diode will conduct, connecting the base. By avoiding saturation in this way, the transistor can be made to switch very much more rapidly at the minor expense of having a collector voltage which does not reach quite so low as that of a standard TTL stage. Fig. 15 shows the internal circuitry of a typical LS type of gate circuit in which the presence of Schottky diodes is indicated by the

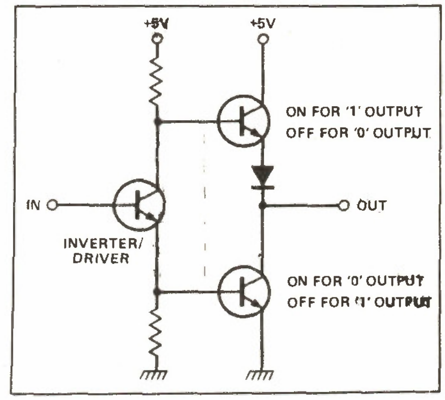


Fig. 10. The usual TTL output stage. One of the pair of output transistors will conduct to connect the output to either 0 or 1 levels.

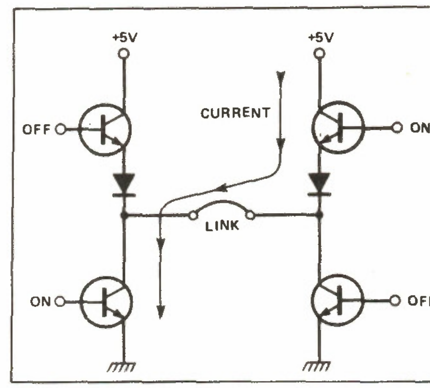


Fig. 11. Why gate outputs should not be connected together.

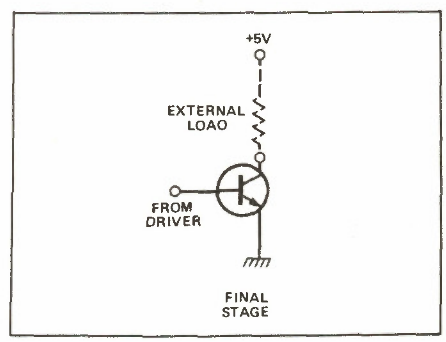


Fig. 12. (Left) The output stage of an open-collector stage. These stages need an external load resistor.

modification to the shape of the base symbol in the transistors.

CMOS

Finally, among the commonly-used logic gate circuits we have the popular CMOS types. These depend on the use of MOSFETs rather than bipolar transistors, and the inputs are invariably to the gates of the MOSFETs as compared to the emitters of the transistors in TTL stages. For this reason, no measureable current flows into or out from the input of a CMOS gate when we use low-frequency signals, and the fanout under these conditions can be very high. The size of fanout is limited

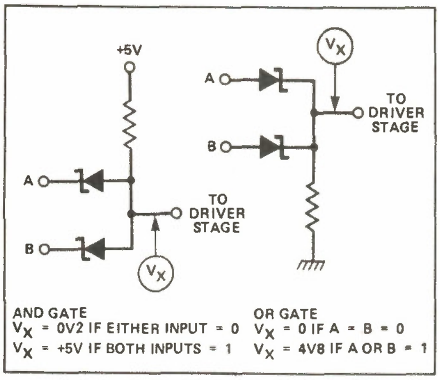


Fig. 13. (Right) Using Schottky diodes as logic elements.

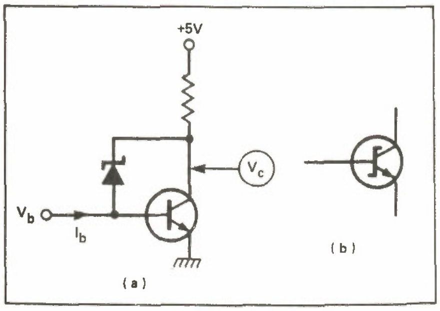


Fig. 14. (a) Using a Schottky diode to prevent transistor saturation. (b) The symbol for a transistor into which a Schottky diode has been incorporated.

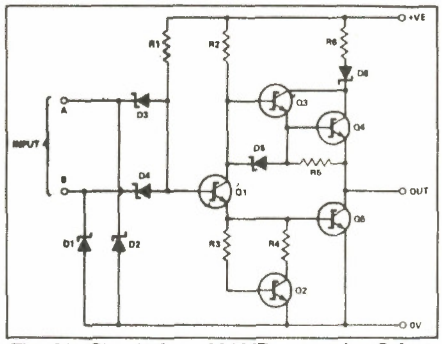


Fig. 15. Circuit for a NAND gate using Schottky diodes.

by the ability of the outputs of CMOS gates to supply currents of more than a milliamp or so, because the capacitance of each CMOS input is fairly high. In addition, rapid switching demands that each capacitance be charged and discharged rapidly, calling for current which the output of a CMOS gate may not be able to supply. The operating currents and the dissipation of a CMOS gate will therefore increase as the operating frequency is increased, and it is this factor which limits the fanout and the speed of these gates. A typical CMOS gate circuit is shown in Fig. 16.

CMOS gates have a convincing list of advantages for many purposes. The supply voltage can be in the range of +3V to +5V rather than the fixed +5V of the TTL circuits. The currents that are required by CMOS gates are very much smaller, so that CMOS is almost an automatic choice when battery operation is required.

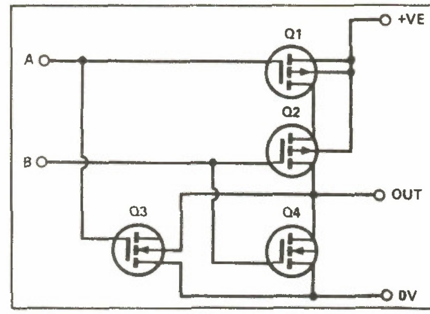


Fig. 16. Circuit of a typical CMOS gate; this one is an AND gate.

For most practical purposes, your choice of logic circuits will be between CMOS and LS TTL types, with the CMOS types probably being chosen from the standard 4000 series. For all purposes which require low consumption, lower operating speeds and small power outputs, CMOS is the more likely choice, but LS TTL chips are essential for many computing operations in which a high clock-rate is used.

continued from page 7

Gulp! We omitted two ROM listings from the May issue; one is the memory locations and source code for Designing With Microprocessors, aud the other is the ROM contents for the darkroom timer. Since the software was available in disk or IC form, we thought we could save space. Sorry about that. The proper listings follow.

Also, in the Darkroom Timer, the unlabelled line on the page 34 schematic that connects KR1-4 through resistors R7-R10 should be labelled 5V.

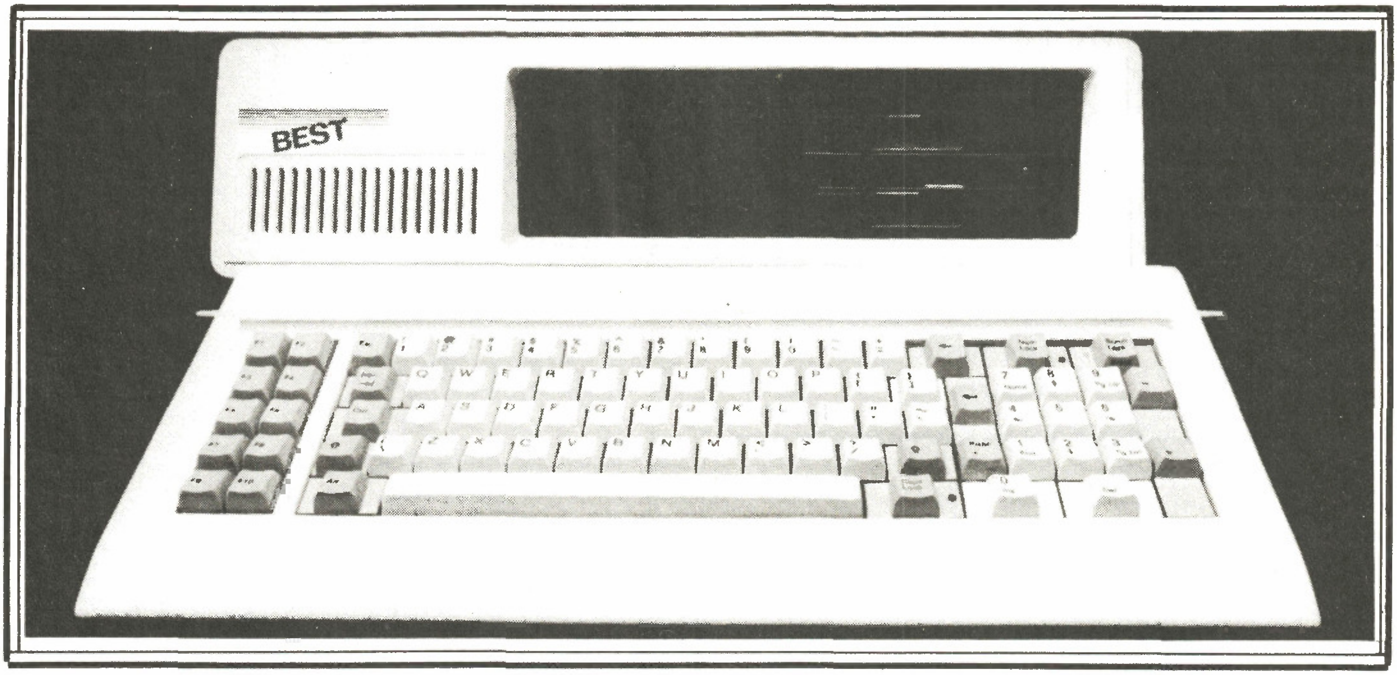
```
DEVICE                          ADDRESS
======                          =======

6532: RAM                       0000-007F
      (STACK                    0100-01FF)
      PORT A                    0200
      DDRA                      0201
      PORT B                    0202
      DDRB                      0203
      TIMER                     021X (see 6532 data sheet)
      INTERRUPT FLAG            0205
      EDGE DETECT CONTROL       020X (see 6532 data sheet)
LS244 INPUT PORT                5FFF
LS374 OUTPUT PORT               9FFF
2K RAM                          D800-DFFF
                                F800-FFFF (MODE=0)
TRANSMIT/MODE BITS              BFFF
2K EPROM                        F800-FFFF (MODE=1)
```

```
0800            ;*** LISTING 1 ***
0800            ;
0800            ;********************************
0800            ;*                              *
0800            ;*        PROTO.ROM V1.1        *
0800            ;*                              *
0800            ;*   6502 PROTOTYPING MICRO.    *
0800            ;*    SOURCE CODE LISTING       *
0800            ;*                              *
0800            ;*   OBJECT CODE WILL RESIDE IN *
0800            ;*   EPROM ON 6502 PROTOTYPING  *
0800            ;*   MICROCOMPUTER AT $F800     *
0800            ;*                              *
0800            ;*   PETER STYS        84/05/24 *
0800            ;*                              *
0800            ;********************************
0800            ;
0800            ;
0800            ;**** CONSTANTS
0800            ;
0000            TXBYTE   EPZ $00           ;LAST BYTE WRITTEN TO 'TXPORT'
BFFF            TXPORT   EQU $BFFF         ;TRANSMIT & MODE PORT
5FFF            RXPORT   EQU $5FFF         ;BIT 7 OF LS244 INPUT PORT IS
0800            ;                           RECEIVE BIT
9FFF            OUTPORT  EQU $9FFF         ;LS374 OUTPUT PORT
2580            BAUDRT   EQU 9600          ;BAUD RATE
03C0            BR       EQU BAUDRT/10     ;INTERMEDIATE STEP
0800            ;BIT TIME EQUALS 5*'FULLBIT' CYCLES
0014            FULLBIT  EQU 20000/BR      ;DELAY FOR FULL BIT TIME
000A            HALFBIT  EQU FULLBIT/2     ;HALF BIT TIME
0001            ADDRLO   EPZ $01           ;INDIRECT ADDRESS FOR DUMP
0002            ADDRHI   EPZ $02
0003            CSUM     EPZ $03           ;CHECKSUM FOR RAM DUMP
0800            ;
0800            ;
F800                     ORG $F800         ;ASSEMBLE TO RUN AT $F800
F800                     OBJ $800          ;ROUTE OBJECT TO $800
F800            ;
F800            ;
F800            ;**** MAIN RESTART SEQUENCE
F800            ;
F800            ;HARDWARE RESET FORCES JUMP HERE
F800 A2 FF      RESTART  LDX #$FF          ;SET STACK POINTER TO $FF
F802 9A                  TXS
F803 D8                  CLD               ;CLEAR DECIMAL MODE
F804 78                  SEI               ;DISABLE IRQ
F805 A9 F7               LDA #$F7          ;PUT RESTART-1 ON STACK FOR
F807 48                  PHA               ;RTS BACK TO 'RESTART'
F808 A9 FF               LDA #$FF
F80A 48                  PHA
F80B 85 00               STA TXBYTE        ;INIT. 'LAST BYTE SENT TO TXPORT'
F80D 20 1D F8            JSR RX            ;RECEIVE COMMAND BYTE
F810 20 45 F8            JSR TX8           ;ECHO TO CONFIRM
F813 AA                  TAX
F814 BD B0 F8            LDA CTABLE,X      ;GET ADDR.-1 OF SUBROUTINE
F817 48                  PHA               ;TO BE EXECUTED
F818 BD B1 F8            LDA CTABLE+1,X
F81B 48                  PHA
F81C 60                  RTS               ;EXECUTE SUBROUTINE
F81D            ;
F81D            ;
F81D            ;**** SUBROUTINE 'RX'
F81D            ;
F81D            ;WILL READ AN 8-BIT BYTE FROM SERIAL LINK AND RETURNS IN A.
F81D            ;IF C=1 => FRAMING ERROR
F81D            ;FORMAT: 1 START BIT. 1 OR 2 STOP BITS. NO PARITY BITS.
F81D            ;SERIAL INPUT IS BIT 7 OF 'RXPORT'
F81D            ;
F81D A0 08      RX       LDY #$08          ;NO. OF DATA BITS PER BYTE
F81F 2C FF 5F   RXWAIT   BIT RXPORT        ;WAIT FOR START BIT (0)
F822 30 FB               BMI RXWAIT
F824 A2 0A               LDX #HALFBIT      ;DELAY FOR HALF A BIT TIME
F826 CA         HDELAY   DEX               ;TO READ MID-BIT LEVELS
F827 D0 FD               BNE HDELAY
F829 A2 10      RXLOOP   LDX #FULLBIT-4    ;DELAY FULL BIT-TIME
F82B            ;LESS 4 TO COMPENSATE FOR OVERHEAD BELOW
F82B CA         FDELAY   DEX
F82C D0 FD               BNE FDELAY
F82E 48                  PHA               ;SAVE A
F82F AD FF 5F            LDA RXPORT        ;READ DATA BITS. LSB FIRST
F832 0A                  ASL               ;SHIFT BIT INTO CARRY FLAG
F833 68                  PLA
F834 6A                  ROR               ;SHIFT NEW BIT INTO A
F835 88                  DEY               ;REPEAT FOR ALL 8 BITS
F836 D0 F1               BNE RXLOOP
F838 A2 14               LDX #FULLBIT      ;DELAY FULL BIT-TIME
F83A            ;AND CHECK FOR STOP BIT
F83A CA         FDELAY2  DEX
F83B D0 FD               BNE FDELAY2
F83D 18                  CLC               ;CLEAR ERROR CONDITION
F83E 2C FF 5F            BIT RXPORT
F841 30 01               BMI RXEND         ;BRANCH IF STOP BIT FOUND
F843 38                  SEC               ;ELSE SET FRAMING ERROR STATUS
F844 60         RXEND    RTS
F845            ;
F845            ;
F845            ;**** SUBROUTINE 'TX8'
F845            ;
F845            ;TRANSMITS Y LEAST SIGNIFICANT BITS OF A.
F845            ;FORMAT: 1 START BIT, 2 STOP BITS, NO PARITY BITS.
F845            ;
F845 A0 08      TX8      LDY #$08          ;SET NO. OF BITS TO 8
F847 48         TX       PHA               ;ALTERNATE ENTRY
F848 18                  CLC               ;SEND START BIT IN C
F849 20 55 F8   TXLOOP   JSR TXBIT
F84C 4A                  LSR               ;SHIFT NEXT BIT INTO C FLAG
F84D 88                  DEY               ;ALL BITS DONE?
F84E 10 F9               BPL TXLOOP        ;BRANCH IF NO
F850 38                  SEC               ;SEND STOP BIT
F851 20 55 F8            JSR TXBIT
F854 68                  PLA               ;RESTORE A
F855            ;AND FALL THROUGH FOR 2ND STOP BIT
F855 48         TXBIT    PHA               ;SENDS BIT IN C FLAG
F856            ;PRESERVES A,Y,C FLAG. TRANSMIT LINE IS BIT 7 OF 'TXPORT'
F856 A5 00               LDA TXBYTE        ;LAST BYTE SENT TO 'TXPORT'
F858 29 7F               AND #$7F          ;CLEAR BIT 7, PRESERVE OTHERS
F85A 90 02               BCC TXZERO        ;IF C=0 THEN BIT 7 ALREADY=0
F85C 09 80               ORA #$80          ;SET BIT 7 TO SEND A ONE
F85E 85 00      TXZERO   STA TXBYTE        ;SAVE BYTE WRITTEN TO 'TXPORT'
F860 8D FF BF            STA TXPORT        ;SEND BIT
F863 A2 0D               LDX #FULLBIT-7    ;DELAY FULL BIT-TIME
F865 CA         TXTIME   DEX
F866 D0 FD               BNE TXTIME
F868 68                  PLA               ;RESTORE A FOR SUBSEQUENT BITS
F869 60                  RTS
F86A            ;
F86A            ;
F86A            ;**** SUBROUTINE 'RRAM'
F86A            ;
F86A            ;READ 2KBYTES AND STORE IN RAM STARTING AT $D800
F86A            ;COMPUTES AND TRANSMITS CHECKSUM
F86A            ;
F86A A9 00      RRAM     LDA #$00          ;CLEAR CHECKSUM
F86C 85 03               STA CSUM
F86E 85 01               STA ADDRLO        ;INITIALIZE ADDRESS TO $D800
F870 A9 D8               LDA #$D8
F872 85 02               STA ADDRHI
F874 20 1D F8   RDLOOP   JSR RX            ;READ A BYTE
F877 A0 00               LDY #$00
F879 91 01               STA (ADDRLO),Y    ;STORE IN RAM
F87B 45 03               EOR CSUM          ;UPDATE CHECKSUM
F87D 85 03               STA CSUM
F87F E6 01               INC ADDRLO        ;INCREMENT POINTER
F881 D0 F1               BNE RDLOOP
F883 E6 02               INC ADDRHI
F885 A9 E0               LDA #$E0          ;ALL DONE?
F887 C5 02               CMP ADDRHI
F889 D0 E9               BNE RDLOOP        ;BRANCH TO DO NEXT PAGE
F88B A5 03               LDA CSUM          ;NOW SEND CHECKSUM
F88D 4C 45 F8            JMP TX8
F890            ;
F890            ;
F890            ;**** SUBROUTINE 'SRIOT'
F890            ;
F890            ;SENDS 128 BYTES FROM 6532 RIOT CHIP RAM
F890            ;
F890 A0 00      SRIOT    LDY #$00          ;START WITH $0000
F892 98         LOOP128  TYA               ;SAVE POINTER ON STACK
F893 48                  PHA
F894 B9 00 00            LDA $0000,Y       ;READ & SEND BYTE
F897 20 45 F8            JSR TX8
F89A 68                  PLA               ;RESTORE POINTER
F89B A8                  TAY
F89C C8                  INY               ;ALL 128 BYTES SENT?
F89D C0 80               CPY #$80
F89F D0 F1               BNE LOOP128       ;BRANCH IF NO
F8A1 60                  RTS
F8A2            ;
F8A2            ;
F8A2            ;**** SUBROUTINE 'OPTEST'
F8A2            ;
F8A2            ;READS BYTE, ECHOES BACK AND WRITES TO LS374 OUTPUT PORT.
F8A2            ;RETURNS WHEN GETS AN $FF
F8A2            ;USED FOR DIRECT CONTROL OF OUTPUT PORT
F8A2            ;
F8A2 20 1D F8   OPTEST   JSR RX            ;READ A BYTE
F8A5 20 45 F8            JSR TX8           ;ECHO TO CONFIRM
```


continued on page 42

The Electronics Today Electrivia Contest

Demonstrate your knowledge of electronics trivia and win a 512K BEST computer, currently selling for $1795.



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Contest Rules:

1. The decision of the judges is final.
2. The deadline for entries is Thursday, August 15th, 1985.
3. Any person associated with the contest, including employees (and their families) of Moorshead Publications and Exceltronix Inc., are precluded from entering.
4. The prize will be awarded as described. No correspondence will be entered into regarding this contest.
5. The winner will be notified by mail or telephone within seven days of judging. The winner and the correct answers will be published in the October, 1985 issue of Electronics Today.
6. In case of multiple correct answers, the winner will be selected by drawing one of the correct entries at random.
7. In case that no totally correct entries are received, the winner will be the one with the most correct answers.

If you don't want to cut the magazine, please use a photocopy of the form, or readable facsimile.

The Electronics Today Electrivia Contest

Entries must be received by August 15, 1985. Results will be published in the October, 1985 issue; the winner will be notified by mail or telephone.

1. What law governs the relationship between distance and the intensity of a sound wave? ______
____

2. In a common-base transistor circuit, what is the equivalent of the common-emitter "beta" parameter? _______________

3. The Wheatstone bridge was invented by Charles Wheatstone. True or False? __________

4. What is the name of the oscilloscope pattern resulting from the application of signals differing only in phase to the vertical and horizontal inputs?
____

5. In transformers, the turns ratio is equal to the square root of the impedance ratio. True or False?
____

6. What unit of measurement is named after Alexander Graham Bell? _______________

7. In analog design, a buffer amplifier has a voltage gain of _______________

8. In logic circuits, an asynchronous counter is also known as a _____________ counter.

9. The algebra used in working with logic was named after _______________

10. Maximum power is transferred when the source resistance equals the load resistance. True or False? _______________

Mail your entries to:

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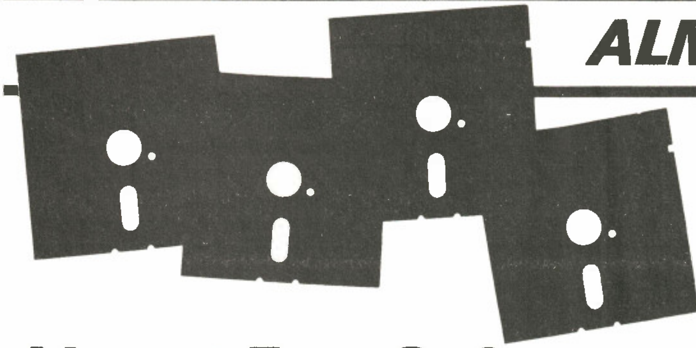


Moorshead Publications

Almost Free Software

Almost Free Software (CP/M) .... #1

Almost Free Software #1, #2 and #3 are for CP/M and are available in a variety of formats: Apple // + CP/M, 8 inch SSSD*, Access Matrix, Morrow Micro Decision, Superbrain, Xerox/Cromemco*, Epson QX-10VD, Sanyo MBC 1000, Nelma Persona, Kaypro II, Osborne and double densities, Televideo, DEC VT-180, Casio FP-1000, Zorba.

Modem 7. Allows you to communicate with any CP/M based system and download files. Complete details were in Computing Now! November 1983.

PACMAN. You can actually play PACMAN without graphics, and it works pretty fast.

FORTH. A complete up-to-date version of FIG FORTH, complete with its own internal DOS.

DUU. The ultimate disk utility allowing you to recover accidentally erased disk files, fix gorched files, rebuild and modify your system. A real gem.

D. A sorted directory program that tells you how big your files are and how much space is left on the disk.

USQ/SQ. Lets you compress and uncompress files. You can pack about 40% more stuff on a disk with this system.

Finance. A fairly sophisticated financial package written in easily understandable, modifiable Microsoft BASIC.

BADLIM. Ever had to throw out a disk with a single bad sector? This isolates bad sectors into an invisible file, making the rest of the disk useable.

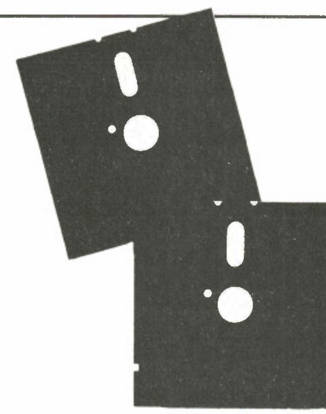
DISK. Allows you to move whole masses of files from disk to disk without having to do every one by hand, you can also view and erase files with little typing.

QUEST. A "Dungeons and Dragons" type game.

STOCKS. This is a complete stock management program in BASIC.

SEE. Also known as TYPE17, will TYPE any file, squeezed for not allowing you to keep documents in compressed form while still being able to read them.

Order as AFS #1, and specify system



$19.95 each

Except for 8" disks and those with two disks which are marked with an asterisk (*) above which are:

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*single density formats require two disks. The package cost for these formats is $22.95.

Almost Free Software (CP/M) .... #2

BISHOW The ultimate file typer, BISHOW version 3.1 will type squeezed or unsqueezed files and allow you to type files which are in libraries (see LU, below). However, it also pages in both directions, so if you miss something, you can back up and see it again.

LU Every CP/M file takes up unneccessary overhead. If you want to store lots of ata in a small space, you'll want LU, the library utility. It permits any number of individual files to be stored in one big file and cracked apart again.

MORTGAGE This is a very fancy mortgage amortization program which will produce a variety of amortization tables.

NSBASIC Large disk BASIC packages, such as MBASIC, are great . . . and very expensive. This one, however, is free . . . and every bit as powerful as many commercial programs. It's compatible with North Star BASIC, so you'll have no problem finding a manual for it.

RACQUEL Everyone should have one printer picture in their disk collection.

Z80ASM This is a complete assembler package which uses true Zilog Z80 mnemonics. It has a rich vocabulary of pseudo-ops and will allow you to use the full power of your Z80 based machine . . . much of which can't be handled by ASM or MAC.

VFILE Easily the ultimate disk utility, VFILE shows you a full screen presentation of what's on your disk and allows you to mass move and delete files using a two dimensional cursor. It has heaps of features, a built-in help file and works extremely fast.

ROMAN This is a silly little program which figures out Roman numerals for you. However, silly programs are so much fun . . .

CATCHUM If you like the fast pace and incredible realism of Pacman, you'll go quietly insane over Catchum . . . which plays basically the same game using ASCII characters. Watch little "C"'s gobble periods while you try to avoid the delay "A's" . . . it's a scream.

Order as AFS #2 and specify system

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See Order From Page 51

Almost Free Software (CP/M) ....#3

OIL. This is an interesting simulation of the workings of the oil industry. It can be approached as either a game or a fairly sophisticated model.

CHESS. This program really does play a mean game of chess. It has an on-screen display of the board, a choice of colours and selectable levels of look ahead.

DEBUG. The DDT debugger is good but this offers heaps of facilities that DDT can't and does symbolic debugging... it's almost like being able to step, trace and disasemble through your source listing.

DU87. The older DUU program does have some limitations. The version overcomes them all and adds some valuable capacities. It will adapt itself to any system. You can search map and dump disk sectors or files. It's invaluable in recovering damaged files too.

ELIZA. This classic program is a micro computer head shrinker... it runs under MBASIC, and with very little imagination, you will be able to believe that you are conversing with a real psychiatrist.

LADDER. This is... this program is weird. It's Donkey Kong in ASCII. It's fast, bizarre and good for hours of eye strain.

QUIKKEY. Programmable function keys allow you to hit one key to issue a multicharacter command. This tiny utility allows you to define as many functions as you want using infrequently used control codes and to change them at any time... even from within another program.

RESOURCE. While a debugger will allow you to disassemble small bits of code easily enough, only a true text based disassembler can take a COM file and make source out of it again. This is one of the best ones available.

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and specify system**

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Almost Free Apple DOS Software

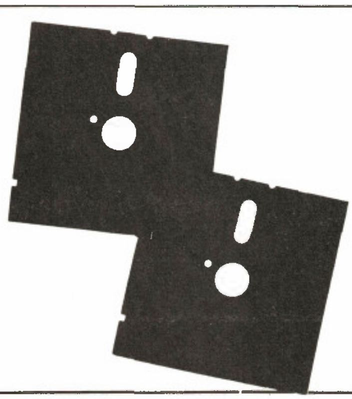
Almost Free Apple DOS Software ....#1

While CP/M is a wonderful thing in its own right, the Apple computer can also, and usually does, operate under DOS. For this reason, there's a multitude of programs available for it. Below, we offer a mini-multitude of our own.

The following programs will operate on any Apple //+, //e, //c, or true compatible operating under DOS 3.3. Apple users operating only under ProDOS may have to make alterations to some programs.

Picture Coder: All Apple HiRes pictures take up 36 sectors in their binary form. This program creates a textfile of a program in memory, squeezing out the zero bytes, that can later be EXECd into memory. The textfile often takes up less room on the disk.

DNA Tutorial: Operating under Integer BASIC, this program might appeal to 'clone' owners. In actuality, though, it's an interactive low-res graphics tutorial of DNA in its inherent forms. And you thought your Apple was only good for games...



Toad: Speaking of games, this program is an Applesoft BASIC implementation of 'Frogger' that can be controlled with either a joystick or the keyboard. The user's high scores are saved to disk.

Function Plotter: A fairly extensive Applesoft BASIC program that takes any inputted function and plots it on the HiRes Screen.

Data Disk Formatter: Apple DOS disks need not be bootable to be useful. This binary program formats a disk without setting DOS on the tracks, conserving useful disk space.

BASIC Trace: A program for the advanced Applesoft programmer, this file, when EXECd, displays the hexadecimal locations of each Applesoft line number of a program in memory.

Gemini Utility: A word processor pre-boot for Gemini printer users, this BASIC program initialises the printer's font or pitch before you boot your word processer.

Payments: This BASIC program allows you to keep track of payments and credits to and from up to 100 accounts on a single disk. A sample account is included.

Databox: A small but useful database program in Applesoft BASIC. Sample files are included to get you started.

Nullspace Invaders: A quick BASIC HiRes game testing coordination and judgement as you manipulate a monolith through mysterious gates.

Fine Print: The majority of this software has been obtained from on-line public access sources, and is therefore believed to be in the public domain. Any remaining programs were written in-house. The prices of the disks defer the cost of collecting the programs, debugging them, reproducing and mailing them, plus the cost of the media they're supplied on. The software itself is offered without charge.

Moorshead Publications warrants that the software is readable, and if there are any defects in the medium, we will replace it free of charge. While considerable efforts has been made to ensure that the programs have been thoroughly debugged, we are unable to assist you in adapting them for your own applications.

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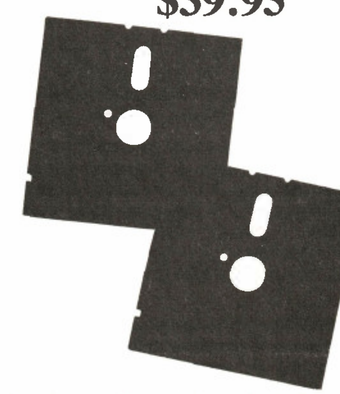

Software Services Moorshead Publications

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Moorshead Publications

Almost Free Apple DOS Software . . . . #2

Amort: A monthly amortization program that calculates monthly payments to an inputted figure, calculates principle, interest on every balance, and prints out the resulting chart.

Voiceprint: An unusual program that uses the HiRes screen to sample sounds inputted through the cassette jacks at the back of your Apple. Sampling rate and other variables can be controlled, and two sounds may be compared side-by-side.

Calc NOW!: Written in BASIC, this spreadsheet program is somewhat slower than VisiCalc, but still offers the power you expect from a spreadsheet. With sample files.

Cavern Crusader: A mix of BASIC and binary programming, winning this HiRes game is difficult, to say the least. For every wave of aliens shot in the cavern, there's always a meaner bunch in the wings.

Newcout: With source file. This binary program replaces the I/O hooks in the Apple with its own so you can operate your Apple through the HiRes screen. Comes with a character set.

Charset Editor: A utility to help you create your own character sets to use with Newcout.

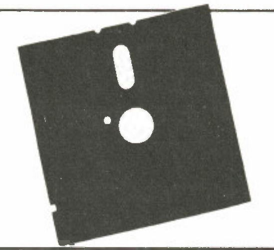
Calendar: A BASIC utility useful for finding a particular day of any inputted month and year, or for printing out any given year.

LCLODR: With source. This binary utility BLOADs any given file into the 16K language card space at $D000. The source is useful in showing how to use DOS commands through assembly language.

Cristo Rey: An animated HiRes BASIC program showing Cristo Rey by moonlight. For apartment--bound romantics.

ATOT: That's an acronym for 'Applesoft to Text'. EXEC this textfile to produce a textfile of your program.

Applesoft Deflator: This program takes a textfile made by ATOT and squeezes it, replacing PRINT statements with '?' and removing unnecessary spaces from the listing.



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Almost Free PC Software

Almost Free PC Software . . . . #1

Our Almost Free Software disks, volumes one through three, for systems running CP/M have been so thunderingly popular that we have assembled a volume for IBM PC users. The considerably greater power of a sixteen bit system, coupled with its larger capacity disk drives, have enabled us to offer a collection of programs that will knock the socks off virtually any sentient life form booting the disk. Be warned... wear sandals when you unwrap this thing.

This software will run superbly on genuine IBM PC's and compatible systems.

PC-WRITE While not quite Wordstar for nothing, this package comes extremely close to equalling the power of commercial word processors costing five or six bills. It has full screen editing, cursor movement with the cursor mover keypad, help screens and all the features of the expensive trolls.

SOLFE This is a small BASIC program that plays baroque music. While it has little practical use, it's just a kick to toodle with. It's also a fabulous tutorial on how to use BASICA's sound statements.

PC-TALK Telecommunications packages for the IBM PC are typically intricate, powerful and huge. This one is no exception. It has menus for everything and allows full control of all its parameters, even the really silly ones. It does file transfers in both ASCII dump and MODEM7/XMODEM protocols and comes with... get this... 119424 bytes of documentation.

SD This sorted directory program produces displays which are a lot more readable than those spewed out by typing DIR. It's essential to the continued maintenance of civilization as we know it.

FORTH This is a small FORTH in Microsoft BASIC. It's good if you want to get used to the ideas and concepts of FORTH... you can build on the primitives integral with the language.

LIFE This is an implementation of the classic ecology game written in 8088 assembler. While you may grow tired of watching the cells chewing on each other, in time the source will provide you with a powerful example of how to write code.

MAGDALEN This is another BASIC music program. We couldn't decide which of the two we've included here was the best trip, so we wound up putting them both on the disk. Ah... the joys of double sided drives.

CASHACC This is a fairly sophisticated cash acquisition and limited accounting package written in BASIC. It isn't exactly BPI, but it's a lot less expensive and suitable for use in most small business applications.

DATAFILE This is a simple data base manager written in... yes, trusty Microsoft BASIC.

UNWS Wordstar has this unusual propensity for setting the high order bits on some of the characters in the files it creates. Looks pretty weird when you try to do something other than Wordstar the file, doesn't it... Here's a utility to strip the bits and "unWordstar" the text. The assembler source for this one is provided.

HOST2 This is a package including the BASIC source and a DOC file to allow users with SmartModems to access their PC's remotely. It's a hacker's delight.

Moorshead Publications warrants that the software will be readable. If defects in the medium prevent this, we will replace your disk at no cost. While we have made every effort to assure that these programs are completely debugged, we are unable to assist you in adapting them for your application.

The disk also includes various support and documentation files needed to run the software.

We can provide the Almost Free PC Software Disk volume one on either one standard double sided disk or on two single sided ones.

Order as AFPC #1 and specify system.

Only

$19.95

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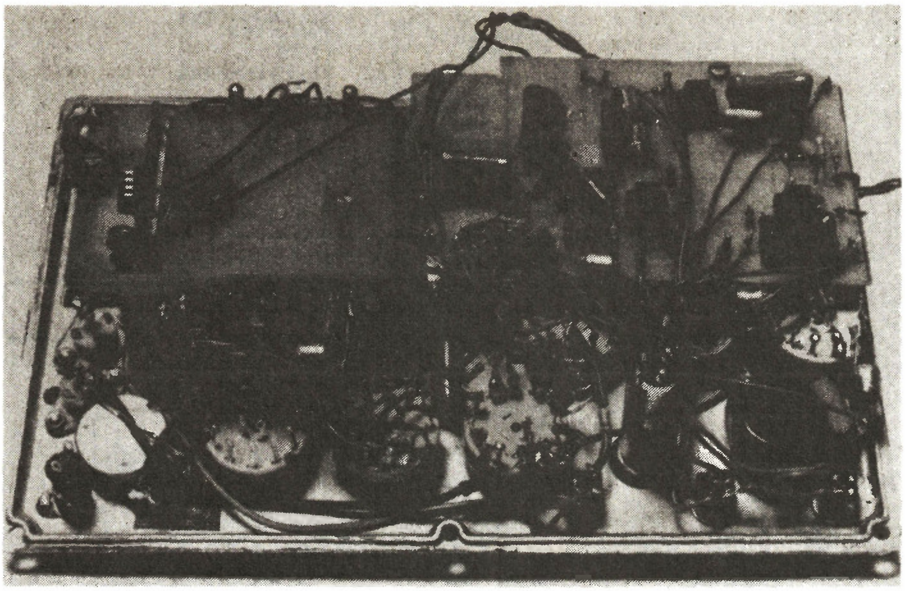

Distortion Meter Part 2

The second and final part, describing the construction and use of the distortion meter project.

By John Linsley Hood

THE THD meter is built on two PCBs, one carrying the circuitry for the distortion meter and the millivoltmeter and the other carrying the oscillator circuitry. A further PCB is required for the regulator or the dual-rail circuit if the battery supply is used. No power supply is required if twin batteries are used.

Assembly of the PCBs should present no problems if the the overlay diagrams are followed carefully, and the only points to watch are the usual ones concerning orientation of ICs, electrolytics, diodes, and any other polarity-conscious components. If you're using IC sockets, these should be soldered on first, followed by the passive components and the insertion of the ICs. If you're not using sockets, insert and solder the passive components first before soldering in the ICs.

The choice of case will be determined by the method of powering you intend to use. The single battery option will fit into a fairly small case, the twin-battery version will be slightly larger, and the AC version will be largest, requiring enough space for the transformer plus adequate clearance between this and the rest of the circuitry to prevent hum pickup. A die-cast box is preferable to a pressed-steel one, and you should not use a plastic box.

The PCBs are mounted below the front panel using stand-off pillars, and the total depth of the finished unit should be about two inches. This allows plenty of room for a metal shield and an AC power supply to be mounted in the base of a suitable box without making the completed instrument unduly deep. Leave yourself plenty of room, however; too tight a construction may lead to capacitive coupling between various parts of the cir-

Parts List — The Meter and Millivoltmeter

Resistors (all ¼W carbon or metal film)	
R1	12k
R2	3k9
R3	5k6
R4	10k
R5	470R
R6	560R
R7, 15, 18	2k2
R8	220R
R9	47R
R10, 11, 12	6k8
R13	39k
R14, 33	2k7
R16, 17	3k3 (see text for R16-32)
R19, 27	2k33
R20, 28	666R
R21, 29	R33R
R22	90R
R23, 32	10R
R24	66k6
R25	23k3
R26	6k66
R30	66R6
R31	23R
R32	10R
R34	68k
RV1	10k
RV2	10k dual gang
RV3	100R
RV4	2k2
RV5	2k7
Capacitors	
C1, 4, 7, 12, 19, 20, 21, 24, 26	470n
C2	1u0
C3	2u2 electrolytic
C5, 8, 13	47n
C6, 9	4n7
C10, 23, 25	47u electrolytic
C11	22n
C14, 15	3n3
C16	33n
C17	470p (see text)
C18	1n0 (see text)
C22	100n
Semiconductors	
IC1-4	TL072
D1-4	1N4148
Miscellaneous	
M1	100uA meter
SK1-3	co-axial socket, panel mounting
SW1	2 pole, 3 way rotary switch
SW2	2 pole, 6 way rotary switch
SW3, 4, 6	SPDT toggle switch
SW5	1 pole, 9 way rotary switch
PCB.	

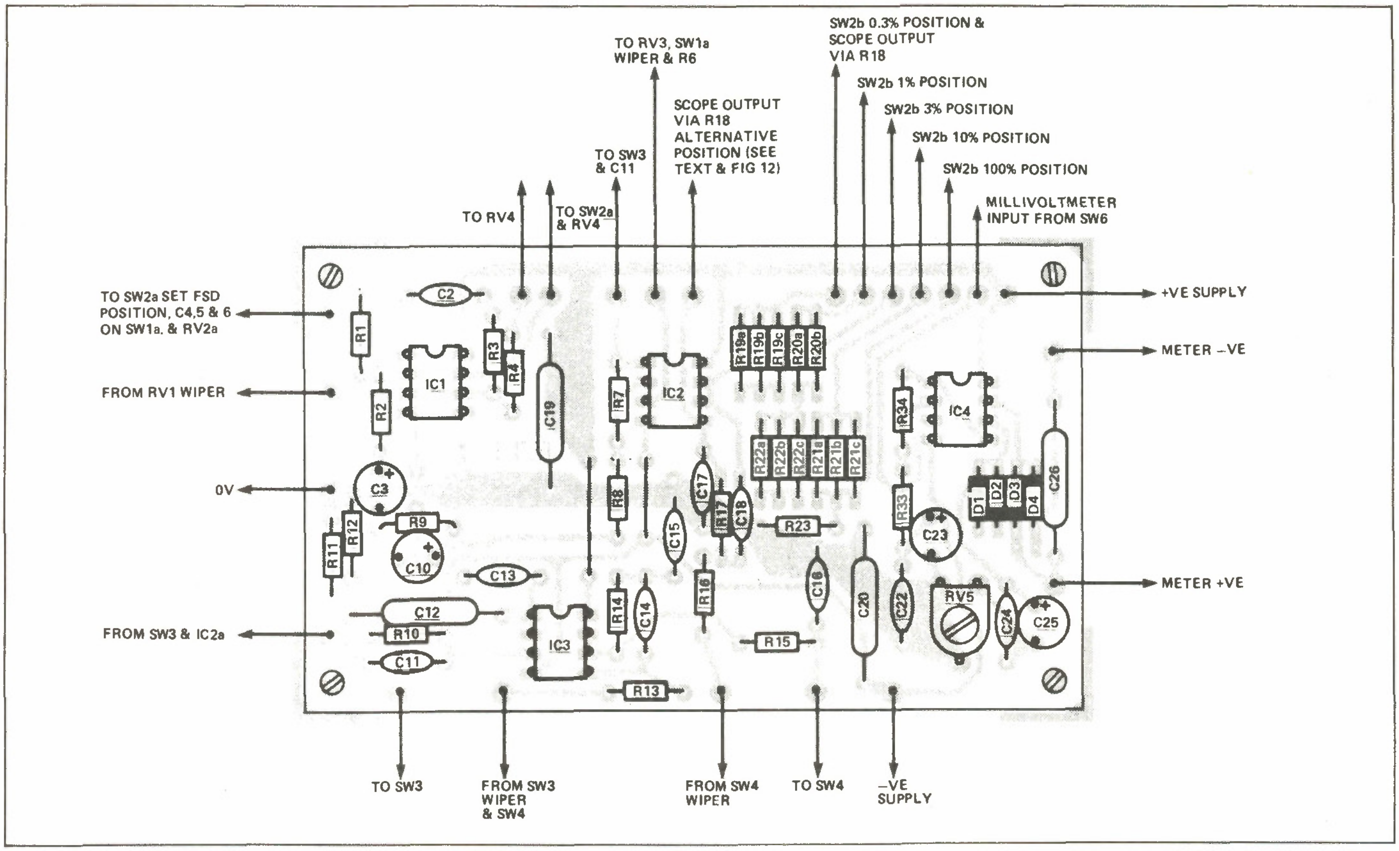

Fig 1 Component overlay of the THD and millivoltmeter PCB.

cuit. One particular example is the effect of coupling the feedback signal from the millivoltmeter into the early stages of the THD meter circuit. This gives rise to a spurious crossover distortion effect which vanishes when the instrument is nulled.

The input attenuator resistors can be mounted between the tags of the rotary switch. If you are using the specified values this arrangement is not too critical, but if you decide to use higher values to increase the input impedance, you may find it necessary to use shielding to prevent pickup. Note that a number of other components are also mounted on switches or pots rather than on PCBs. These include R5, 6, and 18 and C1, C4–9 and C21. R54 and R55 in the power supply must be mounted off the board.

Connecting up the PCBs and controls should present no problems, but don't make the wiring any longer than you have to. This is particularly important with the AC power wiring if you're building the line-powered version.

When the unit has been completed and appears to be working correctly, the sensitivity of the basic meter amplifier should be set to 10mV FSD. If calibration gear is not available, use a small power transformer in the range of 5–20V; connect it to the meter along with a multimeter and adjust RV5 and the range switch until the meter agrees with the multimeter.

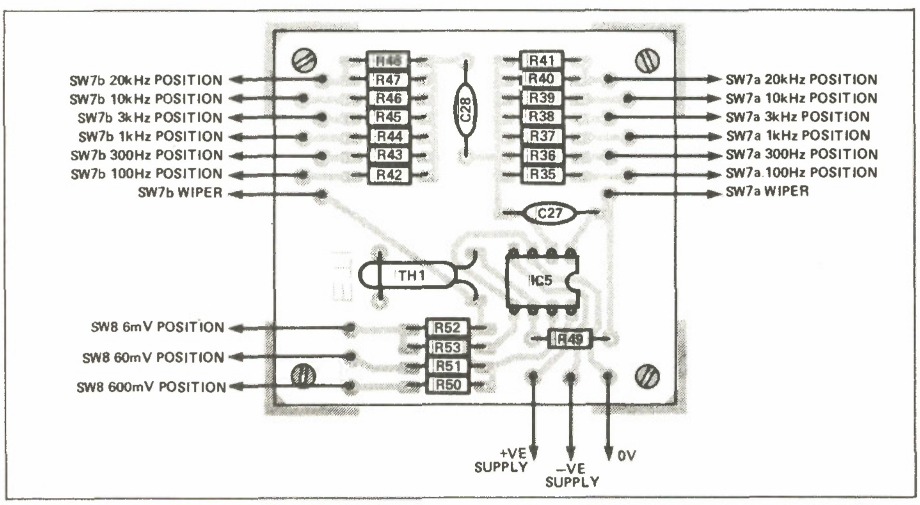

Fig. 2 Component overlay of the spot frequency oscillator PCB.

Parts List — Oscillator

Resistors (all ¼W carbon or metal film)
R35, 42 .... 330k
R36, 43 .... 100k
R37, 44 .... 33k
R38, 45, 52 .... 10k
R39, 46 .... 3k3
R40, 47 .... 1k8
R41, 48 .... 27k
R49 .... 1k5
R50 .... 220R
R51 .... 22k
R53 .... 100R
RV6 .... 2k5

Capacitor
C27, 28 .... 4n7

Semiconductors
IC5 .... TL072

Miscellaneous
Sk4 .... co-axial socket, panel mounting
SW7 .... 2 pole, 6 way rotary switch
SW8 .... 1 pole, 3 way rotary switch
TH1 .... RA53 thermistor (ITT)
PCB.

continued on page 47

See order form in this issue.

BABANI BOOKS

BP49: POPULAR ELECTRONIC PROJECTS $7.75
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.

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R.A. PENFOLD $7.60
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R.A. PENFOLD
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Computing Today

Designing with the Z80 Part 2

Give your Z80-based project some personality and memory with its own ROM and RAM

By Hagen Kornberger

READ ONLY MEMORY, more commonly known as ROM, comes in a variety of forms which give great flexibility when designing microprocessor-based projects. First there is just the plain old masked programmed ROM, that is to say that it's manufactured as an already programmed unit. The next type is the PROM which is manufactured blank, leaving the programming to the user. However, once the PROM has been programmed, that's it, it can't be erased. The last type of common ROM is the EPROM.

EPROMs

EPROM stands for Erasable Programmable Read Only Memory. An EPROM can be programmed with commercially available EPROM programmers or *blasters* as they're called in the business. They can subsequently be erased by exposing them to an ultra violet light source. This type of ROM, with its ability to be programmed and erased several times, greatly reduces the cost of project design. Once the program is perfected an opaque label is placed over the window of the EPROM to prevent accidental erasure.

Fig. 1 shows the pinouts of the most common EPROMs used by hobbyists. Each EPROM is essentially identical except for the memory capacity which varies from type to type. The 2716 type can contain 2K of program data while the 2732 and 2764s can contain 4K and 8K respectively. The layout of the address and data buses on the EPROMs are consistent making it easy to replace a 2716 with 2732 etc.

Making The Connection

Connecting an EPROM to the Z80 CPU is quite straight forward. **Fig. 2** illustrates the simplest method of connecting a 2716 EPROM to the CPU. The address of the data required is output on the Z80 address bus and decoded by the EPROM. When the MREQ signal goes low, indicating a memory operation, the EPROM outputs the correct data on the data bus and the CPU reads this data. However, with this set-up, only one memory device can be connected to the CPU.

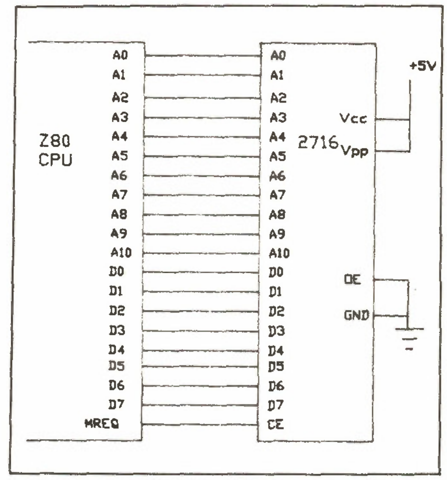

Fig. 2 Simple connection to the Z80 CPU.

In order to connect more memory devices (other ROMs and RAM) some form of address decoding must be implemented so that the CPU can sort it all out. The idea is to divide the 64K address space of the Z80 CPU into block of 2, 4, or 8K. The ROM is connected to the address and data buses in the same manner as before but will only respond when its block is addressed by the CPU. **Fig. 3** shows one way of dividing up the memory space and it should be noted that the ROM is always located at the bottom of the memory starting at location 0000H. This is because whenever the CPU is reset it jumps to location 0000H and expects to find the start of the program.

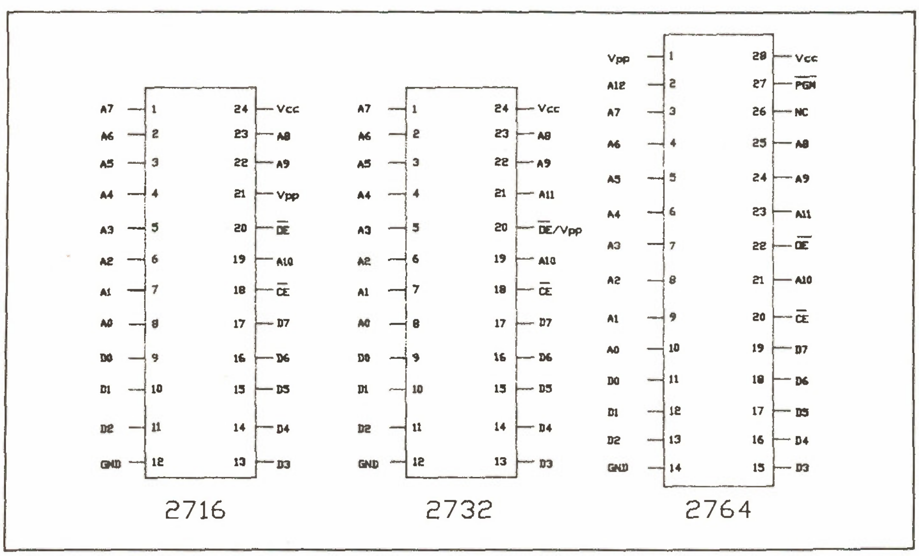

Fig. 1 Common EPROM pinouts.

Decoding

Fig. 4 shows a typical decoder circuit using a 74LS138 (3 to 8 line decoder) that

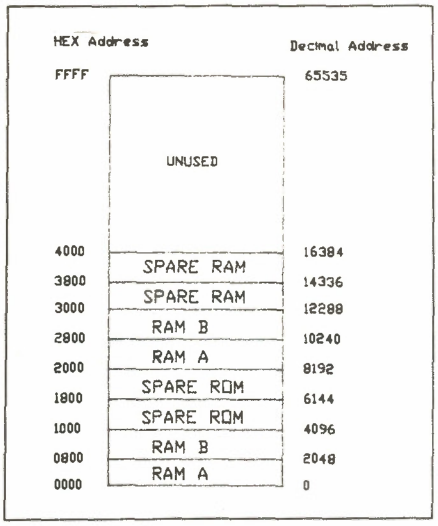

Fig. 3 A typical memory map.

divides the bottom 16K of address space into eight 2K blocks. Address lines A11-A13 are decoded into eight outputs. One of the outputs goes low while the others stay high when one of the memory blocks is addressed. The MREQ signal is connected to one of the enable inputs of the decoder so only memory cycles will be decoded.

The Chip Enable (CE) input on the EPROM is provided to turn the device on and off. When a logic level zero is placed at this input the EPROM will output data to the data bus. Since the outputs from the decoder in Fig. 4 are active low, the CE input can be directly connected to the decoder output.

The complete schematic showing the connection of four 2716 devices to the CPU is given in **Fig. 5**. Four outputs from the decoder have been left unconnected for later use with four ROM or RAM chips. The other two EPROMs, the 2732 and 2764, can be connected in a similar fashion if 4K or 8K blocks are decoded.

Fig. 6 shows an alternative to connecting multiple ROM devices. In this method, one 2764 EPROM is connected to the Z80. This provides 8K of program data which is ample enough for small projects. Minimal decoding is used here which results in the bottom 32K of the address space being dedicated to one 8K ROM. However, the top 32k is left to RAM devices which again is more than enough for most purposes.

If the full 8K of ROM space is not needed, a 2732 EPROM may be placed in the 28 pin socket. **Fig. 7** shows the placement of the 2732 and by connecting a jumper between pins 28 and 26, both devices may be inserted in the same socket. Since the 2732 is only a 24 pin device, pin 1 on the 2732 must be placed in pin 3 in the socket. The result is a project with 4K of ROM that can be upgraded to 8K without any further modification.

A RAM Always Forgets

Random Access Memory, or RAM as it is more commonly known, provides the CPU with a temporary storage area for data and programs. This type of memory can be modified by the CPU at any time but will not retain the contents after the power has been shut off. There are two types of RAM, static RAM and dynamic RAM. For the purposes of this article we will only discuss the static variety which is simpler to interface to the CPU.

Fig. 8 shows the pinouts of two of the most common RAMs which are commercially available. The 2114 chip has a capacity of 1K by 4 bits. Since this chip has only a 4 bit bus, two chips are needed to interface to the Z80 CPU. A more popular RAM chip is the 2128 which has a capacity of 2k by 8 bits. A unique feature of this chip is that the pinouts are similar to that of the 2716 EPROM.

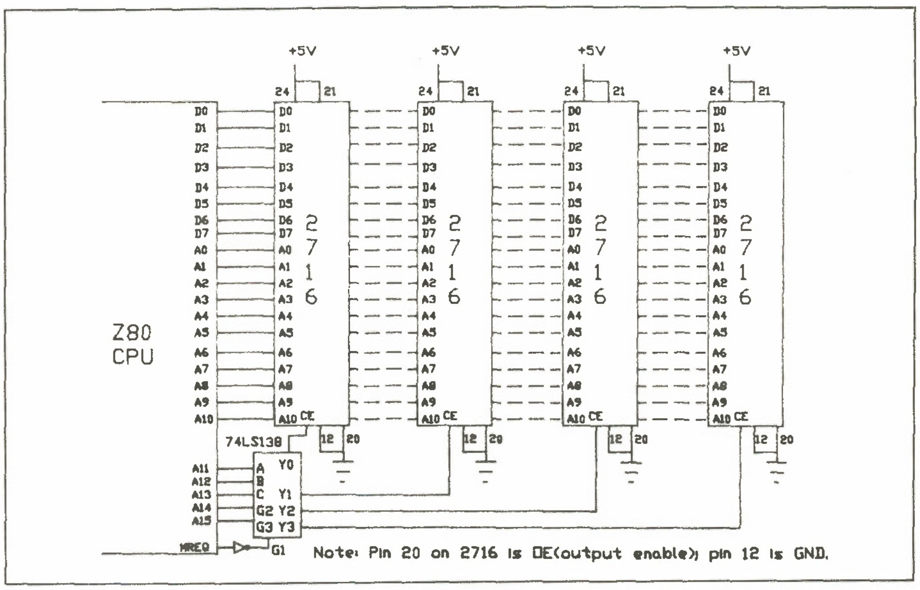

Fig. 5 Connecting multiple ROM devices to the CPU.

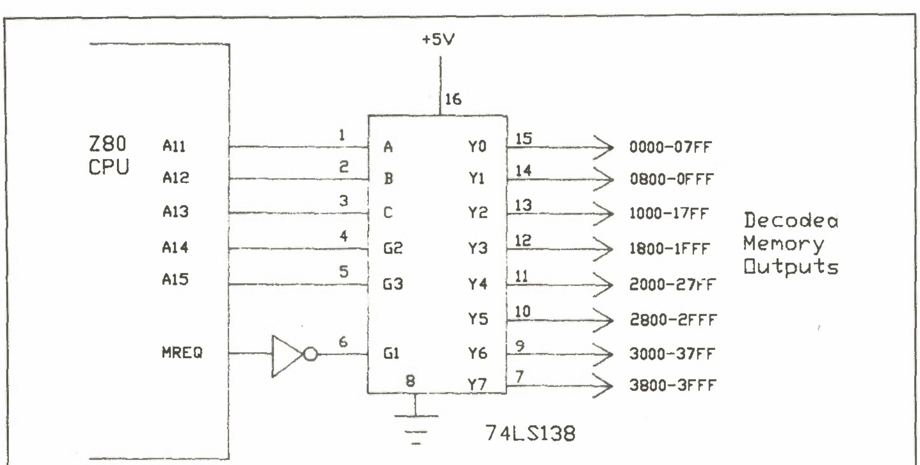

Fig. 4 Typical decoder circuit utilizing the 74LS138.

The only pin on the RAM which differs from that of the EPROM is pin 21. The programming voltage for the EPROM is replaced by the write enable on the RAM. The write enable is used to tell the RAM that the CPU wishes to write some data to it. During read operations this signal is held at a logic level one, and when data is written to the RAM this pin is pulsed to a logic level zero. The Z80 WR signal meets the requirements of the RAM write enable input.

Fig. 9 shows a simple method of connecting RAM to the Z80 CPU. The connection is made in the same manner as ROM except for the WE signal which is connected to the WR signal on the CPU. The two NAND gates provide some minimal decoding so that the RAM will

continued on page 56

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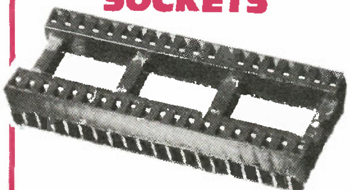

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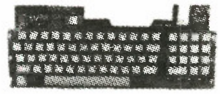

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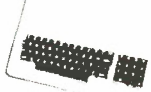

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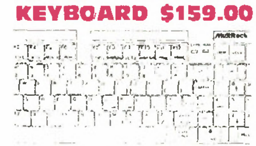

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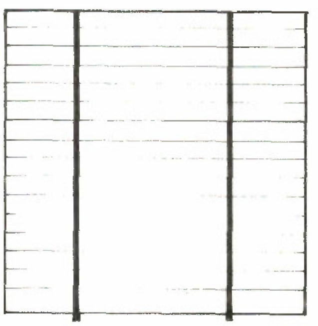

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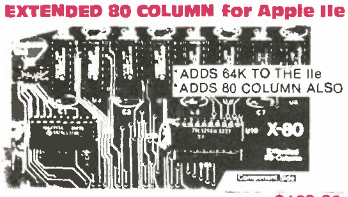

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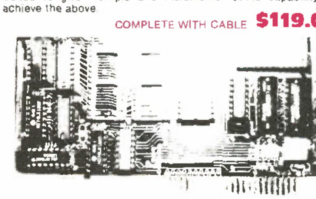
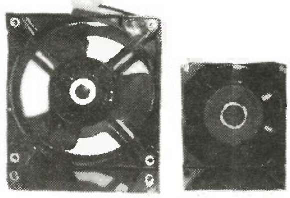


FANS FANS FANS



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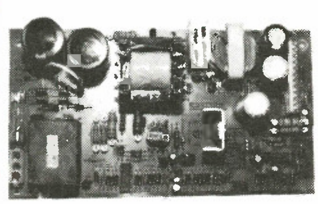

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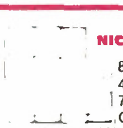

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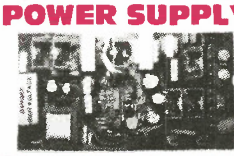

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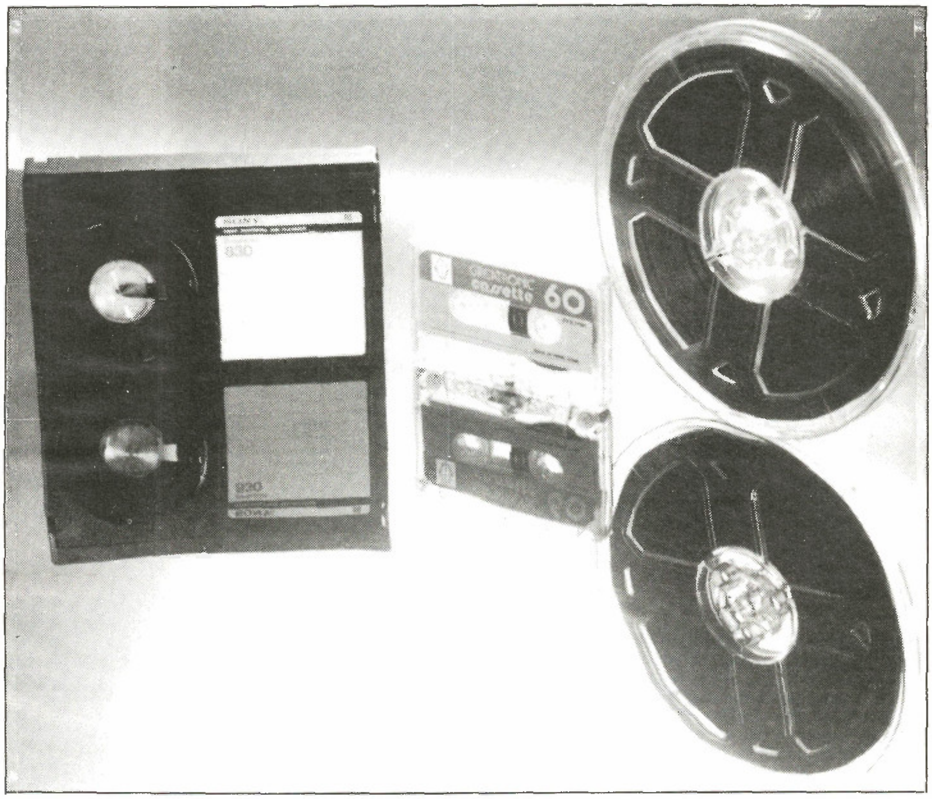
Magnetic Permanence

Audio, video and computer information is recorded on some form of magnetic storage. How permanent is it?

By Vivian Capel



Some years ago it was reported that the British Broadcasting Corporation were considering whether or not to dispose of their vast library of sound recordings on disk after dubbing them onto tapes. The decision was against, because although there would be considerable saving in space, magnetic recordings were deemed too ephemeral to trust as the medium for preserving so many historic and unrepeatable sounds.

This decision would seem to be justified by the fact that on more than one occasion broadcasts have had to be cancelled because the tape had been inadvertently wiped. Imagine if this had happened to a historic only copy. Most users of magnetic storage for sound, video and computer programs will know that this is all too easily done.

Video recordings in particular would seem to be vulnerable. Each picture field, with all its colour information and light and shade detail, is stored in a single micro-thin magnetic diagonal line much narrower than a human hair, across the width of the tape which itself is a think plastic film. Compared to that, a movie film seems positively robust.

As most readers are aware, erasure of a magnetic recording is done with a magnetic field. This is an alternating field, applied either from an erasing head or from a special bulk erasing unit. In some older cheap recorders, erasure was achieved by bringing a permanent magnet into contact with the tape.

There are fascinating and probably apocryphal stories which tell, for instance, of a credit-card company put out of business when a workman walked through the computer centre with a magnet in his toolbox, thus erasing all the magnetically stored data. An even more interesting one concerns the tax records that were wiped out by a nearby airport radar. Hope springs eternal...

Another way that the magnetization of a tape can be destroyed is by heat. Apart from the effect of heat on the plastic substrate, above a certain temperature known as the Curie point a magnetic material will lose its ability to hold magnetization. This phenomenon is made use of in some brands of thermostatic soldering irons. Here, a disk made of magnetic material is placed in the bit of the iron. In the barrel of the iron is another small magnet which, because it is attracted to the material in the bit, holds a contact shut. When the iron comes to the required temperature, which is also the Curie point of the bit, the attraction ceases, opening the contact and cutting off the heating current.

Before everyone rushes out to dispose of their video recorders and floppy disk drives, let's take a closer look at the process of demagnetization. A fully magnetized tape, like any other magnetized material, needs a certain minimum field strength applied to its surface to impress or remove magnetism. This field strength is known as the *coercivity* of the material. Some materials are much harder to magnetize (and demagnetize) than others.

For audio cassettes a figure for coercivity of about 300 to 400 oersteds (24 to 32 thousand A/m) is common; video tapes are usually somewhat higher. This means that a magnetic field of that order would be required to demagnetize a fully magnetized (saturated) tape. Of course, tapes are not recorded into saturation or the signal would suffer distortion, so a normally recorded tape would be completely erased by a lesser field than that of the specified coercivity. Even so, it would take a field of about 100 oersteds to do any damage to a recording.

What sort of fields do we find around domestic equipment? External fields depend on the current flowing in the apparatus and the number of turns if a transformer, motor winding or other inductive component is involved. It also depends on the efficiency of the internal magnetic path. For instance, a toroidal transformer is more efficient in containing the field through its core than an E-core type. Thus there is very little field external to a toroidal transformer. Equipment shielding is another factor.

A power drill running under full load has a surprisingly low external field; the field at the casing has been measured at about 10 oersteds. This is well below that which could affect a magnetic tape. House wiring and flexible power leads also generate fields, but even when carrying a heavy current these are not great. The reason is that a cable is reasonably straight and amounts to only a single turn. Further, both live and neutral are contained in the cable and this results in some degree of cancellation.

Permanent magnets are common in much equipment: loudspeakers, headphones, door catches, alarm switches, etc. Some have fields of 1,000 oersteds or more, and could certainly wipe a tape coming into direct contact.

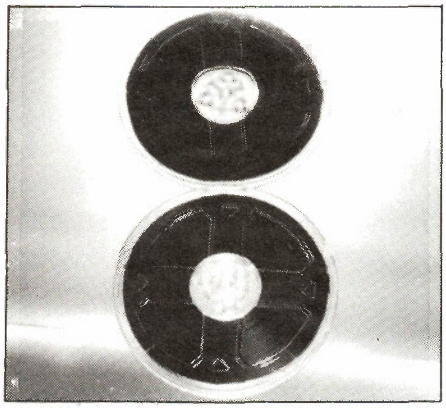
One factor that saves the endangered recordings is that magnetic fields are very strongly dependent on distance; for a single pole,the field falls off with the inverse square of the distance. However, magnets come in opposite pairs, and the field falls off even more quickly.

This has the consequence that the casing around a video cassette, for example, will be thick enough to protect it from most small magnets. The situation is somewhat different with a floppy disk, which has a much thinner case; special care is needed in the storage and handling of these.

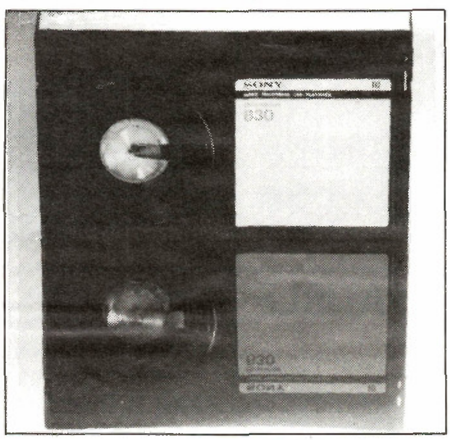
There are stories of radar installations causing erasures of magnetic recordings. The 3M Company in the US conducted some experiments to investigate this. Reels of tape were placed in a microwave oven and power applied until the reels of tape began to melt and burn. Those parts of the tape that were not physically damaged were examined and found to be unaffected. The tape had not demagnetized.

A further experiment was tried using radar. Reels of recorded tape were placed directly in front of a radar dish having a range of 250 miles. Two lots of tape were used, one at 18 feet and the other at 16 inches. These were scanned by the radar beam for 16 minutes, then removed and examined. There was no physical damage, and the recorded level was the same as before.

Next, recorded tapes were exposed to X-rays of a much higher level than those used for parcel examination. Again, the recordings were intact, with no loss of signal level.



The metal detectors at most airports do not generate a magnetic field, but measure the disturbance of the earth's magnetic field; they pose no threat to recordings. There are some detectors that are active and generate a field, but they are below 20 oersteds; in other instances, a field of up to 100 oersteds may be generated. The best answer to the metal detector problem is to request a visual inspection of recorded tapes.



Could temperature go sufficiently high to harm recordings? The Cure point for iron oxide is 450 C, or 850 F; physical damage to the tape would occur long before demagnetization. However, the Curie point for chromium dioxide is only 250 F, or 120 C; although this still seems fairly high, the tape becomes more susceptible to small magnetic fields as the Curie point is approached. One possible effect of heat is print-through from one layer to the next, especially in the presence of a stray magnetic field which in itself is not strong enough to erase the tape.

To sum up, there is not much danger to magnetic recordings in a domestic environment, provided that common sense precautions are taken, such as keeping recordings away from heat and direct contact with magnets.

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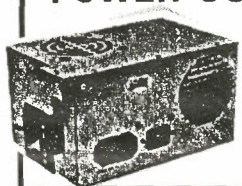

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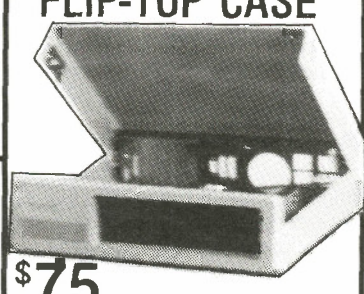

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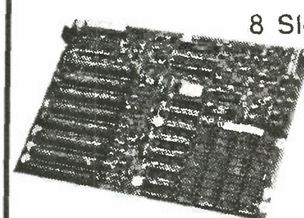

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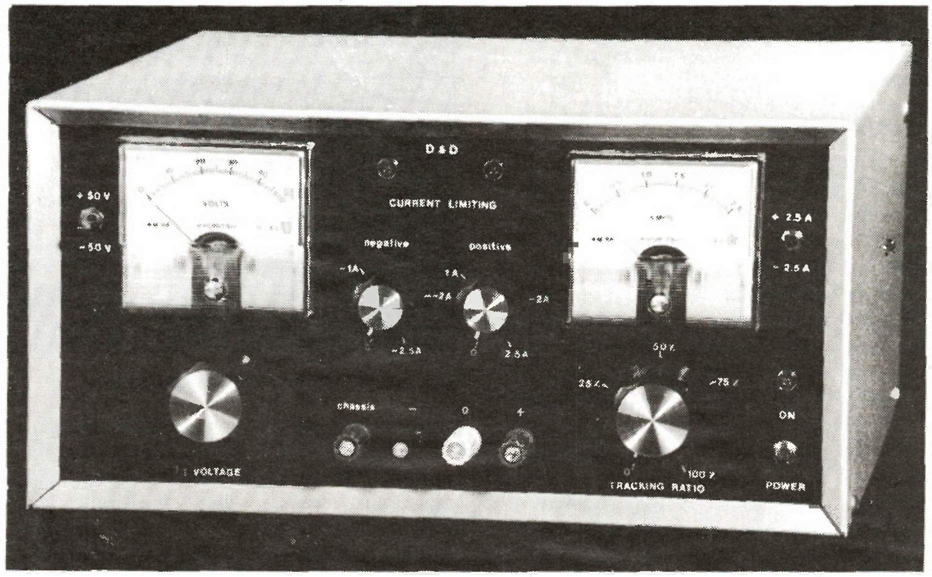
Dual Tracking Power Supply

A lab-quality power supply with one output voltage tracking the other; it features 0-50 volts and 2.5 amperes per output.

By David Bedrosian



A POWER supply is required in almost every electronic circuit, whether it is a small LED flasher or a high powered amplifier; this makes a power supply one of the most useful pieces of test equipment. To be able to fully test a circuit, the supply must put out enough voltage and current to properly run the circuit under test; as well, the supply must remain stable for all possible load conditions. To protect the circuitry under test, the supply must have a continuously variable output voltage down to zero volts, and must provide some form of current limiting. An added requirement when testing amplifiers which require dual polarity supplies (both positive and negative voltages with respect to ground) is that the supply must be capable of generating a negative voltage which tracks the positive voltage. If, for example, the output voltage is varied upward from 0 to plus 20 volts the negative supply must vary downward from 0 to minus 20 volts.

The power supply described in this article is a dual tracking supply capable of producing up to plus and minus 50 volts at an output current of up to 2.5A. The maximum current before limiting is adjustable between approximately 50mA and 2.5A for both the positive and negative outputs, using the two knobs on the front panel. The positive voltage is varied using a ten-turn potentiometer, and the negative voltage tracks the positive output with a ratio adjustable between 0 and 100 percent. Two LEDs on the front panel indicate when the supply is operating in the constant current mode, and two meters accurately monitor the output voltages and currents.

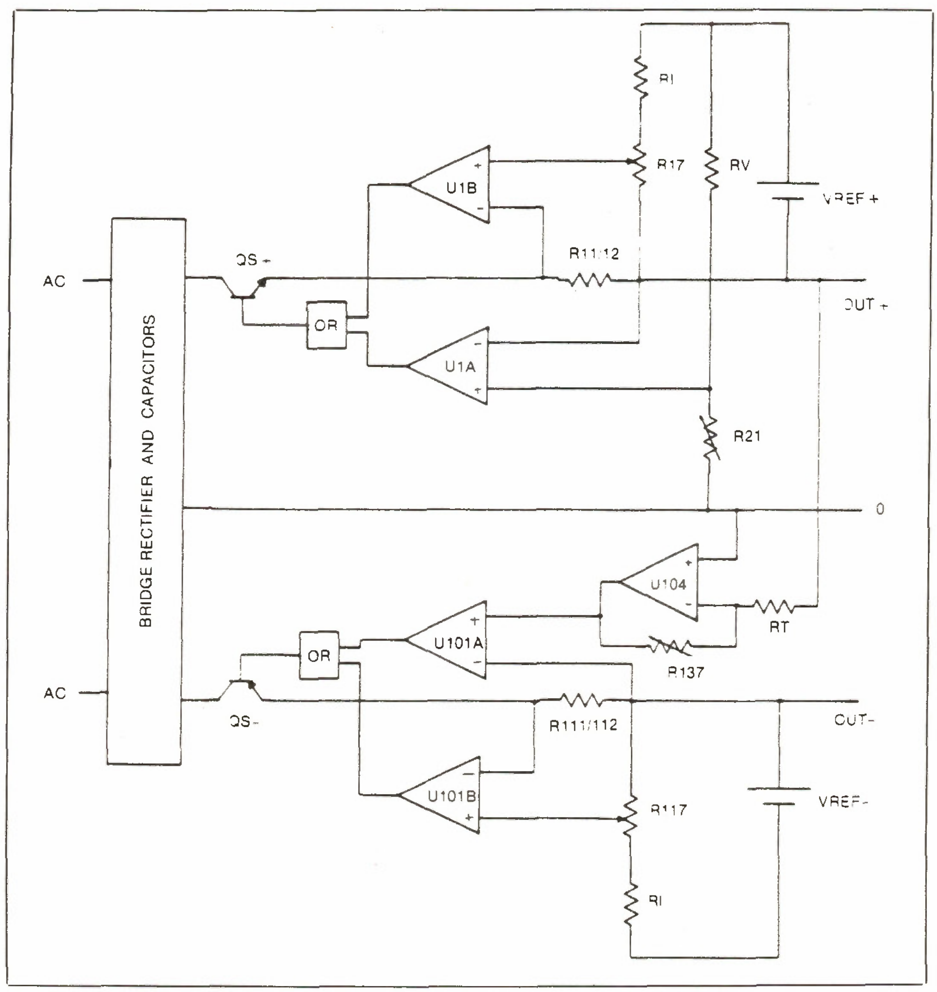


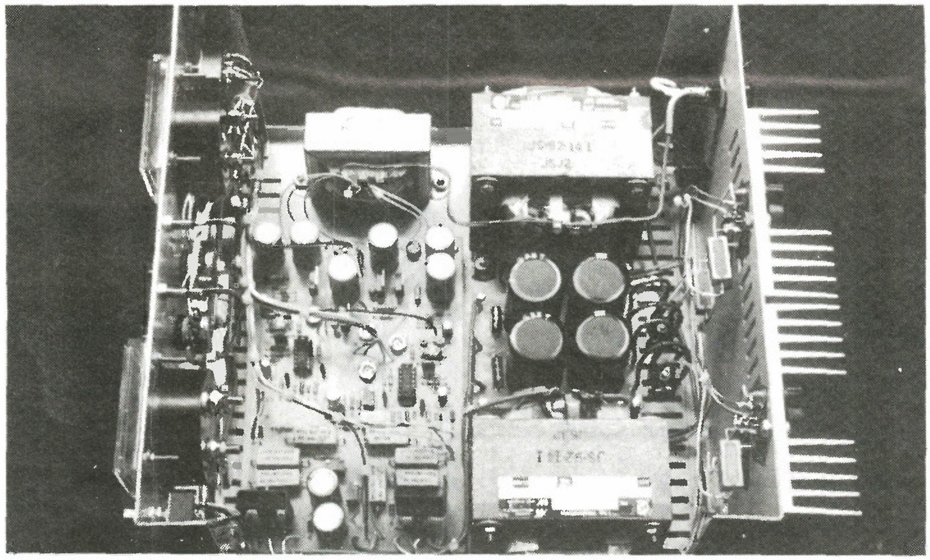
Fig. 1 The block diagram of the power supply.

The project also contains the necessary information to modify the existing circuit depending on the availability of parts and the requirements of the builder. The maximum output voltage and current values can be changed according to the transformers, transistors and heatsinks available; the negative supply can be made totally independent of the positive supply, or it can be omitted altogether.

Construction

The resistor values given in the Parts List are appropriate if the power supply is going to have the same output voltage and current as shown in this project, and if XFRMR1 and XFRMR2 put out between 50 and 60VAC under no-load conditions, and if the meters used to indicate voltage and current both require 100uA for full scale deflection. If the supply is going to be modified, refer to Parts Selection and Modification to determine the appropriate part values before beginning construction.

The circuit board designs shown are recommended to speed construction and minimize wiring errors. It is also recommended that resistors, diodes and transistors be tested before being soldered into place; this may seem time-consuming, but can actually save a considerable amount of time later if troubleshooting is required. Diodes will have a very high resistance in one direction and low in the other; transistors should have a high resistance between both the base and emitter leads and the base and collector leads in one direction, and a low resistance in the other. The resistance between collector and emitter will be high in both directions.



The interior of the power supply unit.

Construction begins with the main circuit board. First solder in the three jumpers and the IC sockets; the long jumper should be insulated. Next install all of the quarter and half watt resistors. The capacitors and power resistors can now be soldered in place; be sure to check

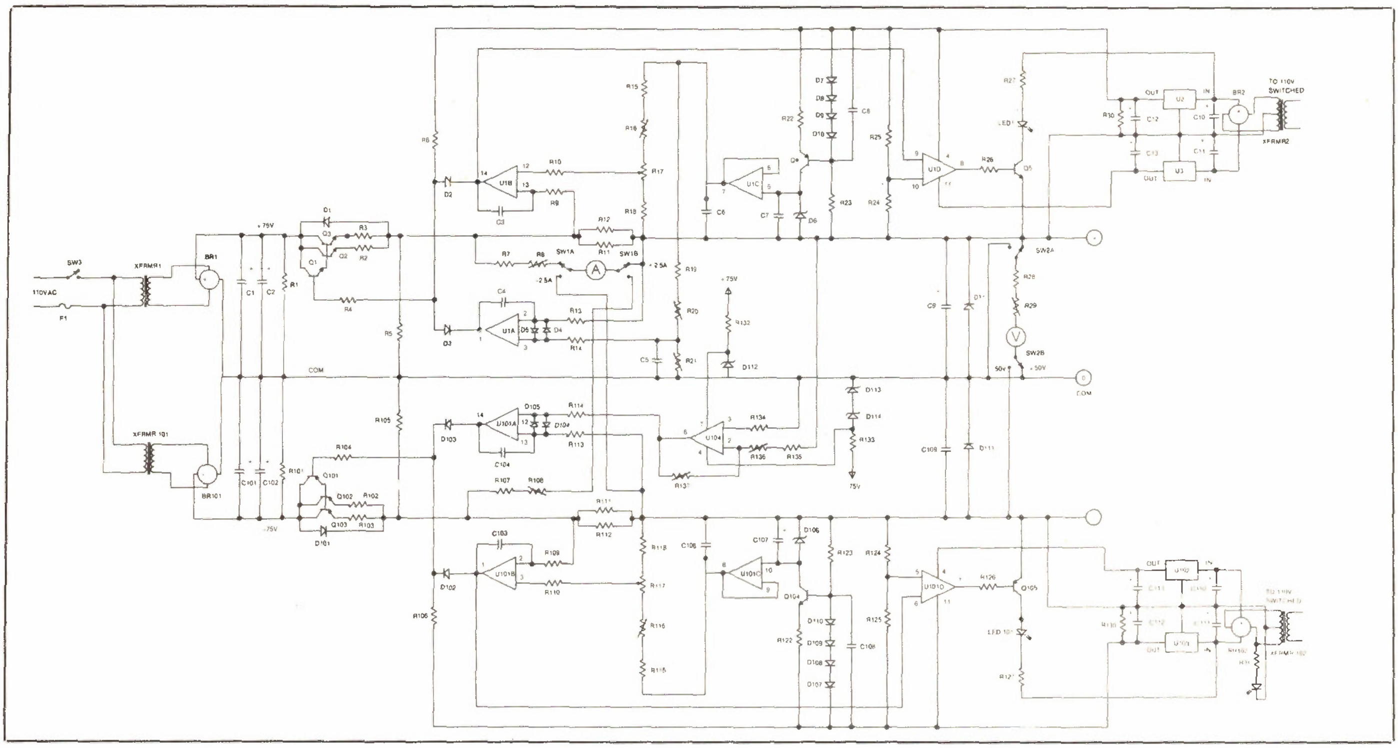


Fig. 2 The schematic of the power supply

the orientation of the electrolytic capacitors, as a reversal can cause serious circuit damage when power is applied. The 5W resistors should not have to dissipate more than one or two watts, and can therefore be mounted directly on the PCB. The seven trimpots are next soldered onto the board; provision has been made for both the upright and the flat types. If 25-turn upright trimpots are available (Bourns series 3299W) they can be used to allow for finer adjustment. The bridge rectifiers, diodes, and transistors can now be soldered into place. Note that the two bridges are oriented differently; look for the plus signs on the circuit board overlay to ensure correct insertion. Be sure to differentiate between zener diodes and the rectifiers. Before soldering in Q1 and Q101, attach a small heatsink to each device; silicone grease is not necessary and the heatsinks need not be insulated from the collectors as long as they don't touch any other metallic object (each heatsink is at the full input voltage of 75V, so beware). The op amps (U1, U101, and U104) should not be inserted yet; however, the voltage regulators (U2, U102, U3, and U103) can be soldered in place without heatsinks. This completes the assembly of the main circuit board.

The small circuit board should be completed next. This board may need to be modified if different sized capacitors are used for C1, C2, C101 and C102; otherwise assembly should be straightforward. After completing both boards, they should be thoroughly inspected for poor solder joints or bridges.

Construction now begins on the cabinet; the following description assumes the recommended Hammond cabinet is being used. Start with the back panel; drill holes for the fuseholder, the power cord (or connector), and the heatsinks. Temporarily mount the heatsinks and mark on the back panel where the power transistors will come through. The four power

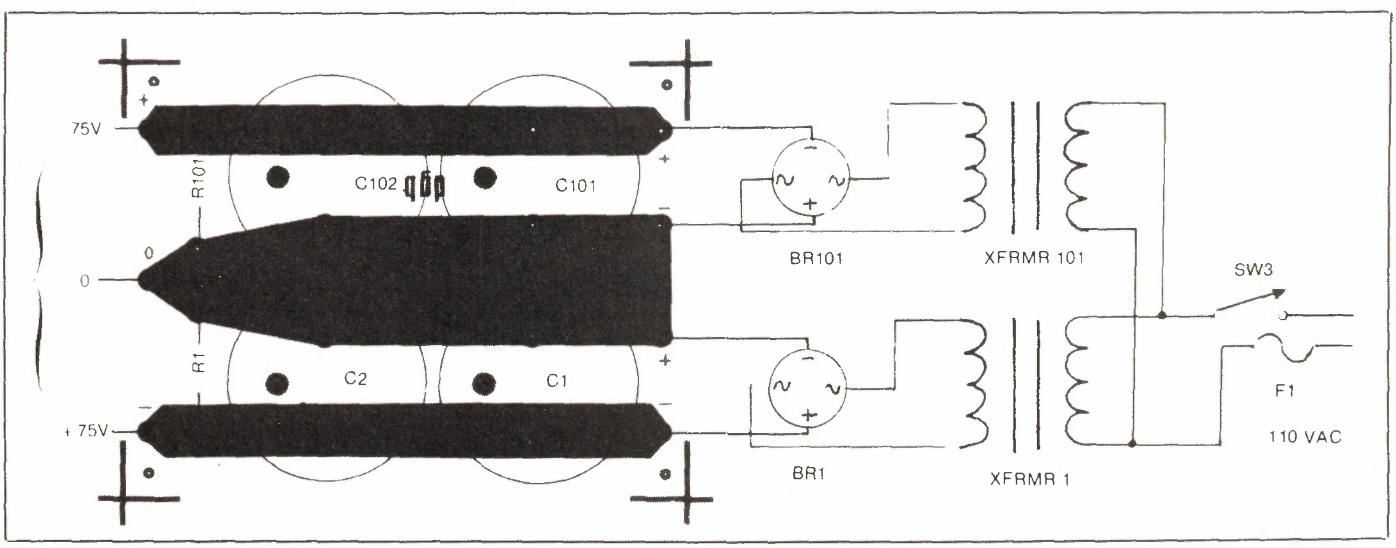
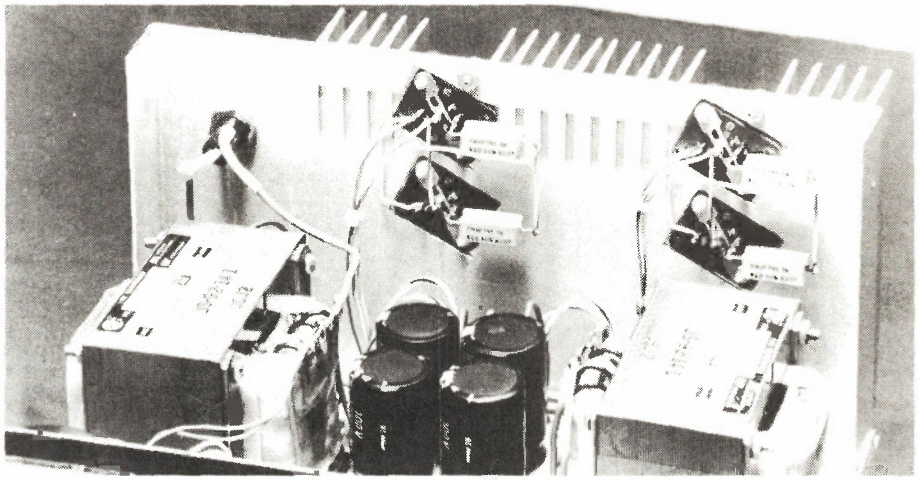


Fig. 3 Component location for the small printed circuit.

transistors should then be mounted; each transistor should then be isolated from the heatsink using a mica insulator with silicone grease on both sides. If transistor sockets are not used, the bolts holding the transistor must be insulated with a plastic sleeve and shoulder washer. The heatsinks can now be permanently fastened to the case, and the power transistors should be tested with an ohmmeter for possible shorts to the heatsink or cabinet.

The main power transformers, the large bridge rectifiers, and the small circuit board should be bolted to the bottom of the cabinet and wired with at least 18 gauge wire. The power cord ground lead should be attached directly to the cabinet with a ground lug between a bolt and the cabinet. The bridge rectifiers should be mounted directly on the cabinet, which will act as a heatsink; silicone grease is not required. Do not wire in the power switch yet; instead run two wires to the front cabinet of sufficient length to reach the power switch. The three wires to the main circuit board should not be soldered in place yet. The wiring in this section is critical, so be sure that all wires are mechanically sturdy and connected to the proper location.

The front panel can now be drilled and all parts should be mounted. Only the power switch should be wired at this time to allow for testing of the main power supply. With a 3A slo-blo fuse installed, apply power to the supply and measure the voltage at the output of the small circuit board (the voltmeter leads can be clipped across R1 and R101). If no voltage is present or it is very low, measure the AC voltage to the input of each bridge; they



The rear panel, showing the transistor and emitter resistor mounting.

should have about 55VAC each to their inputs, depending on which transformer is used. If there's a problem, check the wiring and fuse.

With approximately plus and minus 75VDC at the output of the small board, the power supplies on the main board can be tested. Mount XFRMR2 and XFRMR102 in the cabinet and wire their primary windings to the switched 115VAC connected to XFRMR1 and XFRMR 101. Temporarily connect the secondary windings to the main circuit board and run three wires from the small circuit board to the main board for 0, plus 75, and minus 75V. Apply power to the circuit and measure the voltages at U1, U101, and U104. The voltage at pin 4 of U1 with respect to the positive output (clip onto the outside end of R11 or R12) should read 12V plus or minus 0.5V, the voltage at pin 11 should read -12V plus or minus 0.5V, and the voltage at pin 5 should be 6.2V. The voltage at pin 4 of U101 with respect to the negative output should be (clip onto the outside end of R111 or R112) should read 12V, the voltage at pin 11 should be -12V, and the voltage at pin 10 should be -6.2V. Pin 7 of U104 should be at about 4V with respect to ground (clip onto the inside lead of R1 or R101) and pin 4 should be at -55V, again with respect to ground.

The main board should be removed from the cabinet and the ICs inserted. Suitable length wires should be soldered to the main circuit board for connection later to all of the front panel parts, the power transistors, the small circuit board, and the low voltage transformers. The wires to the power transistors, the small circuit board, and the output binding

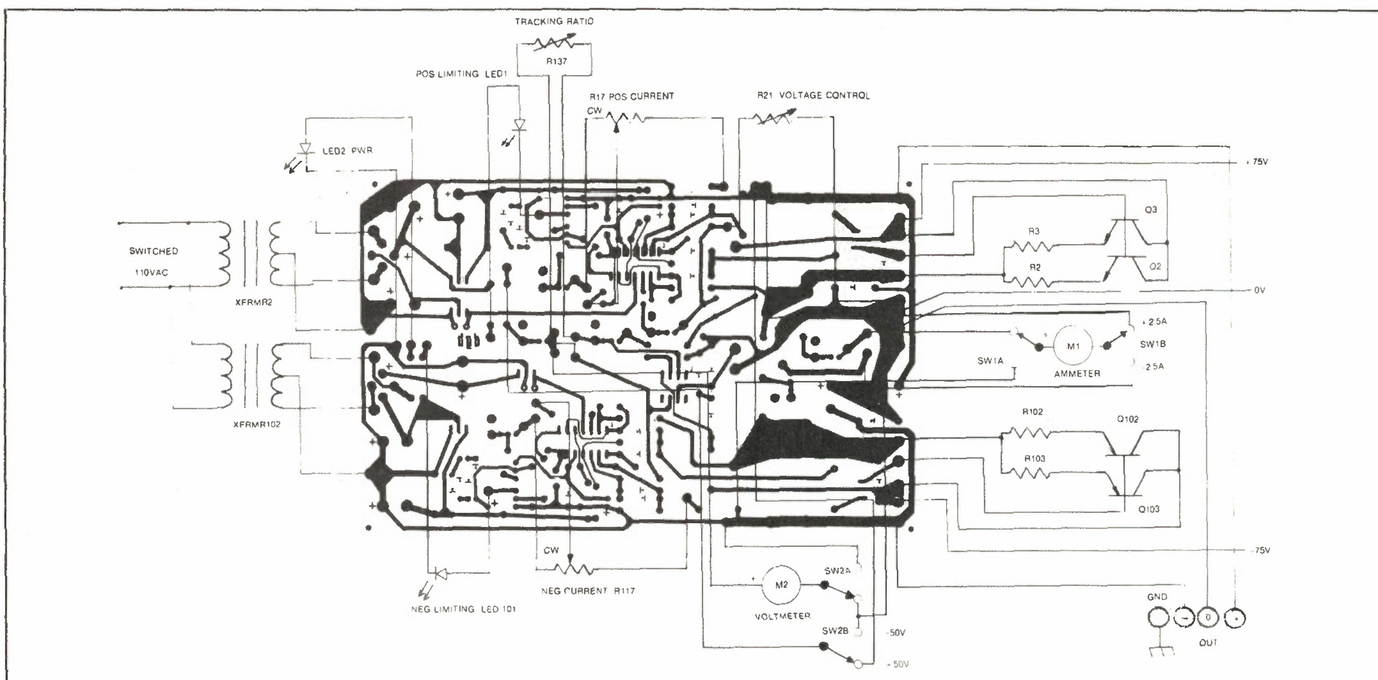


Fig. 4 The wiring points for the main printed circuit.

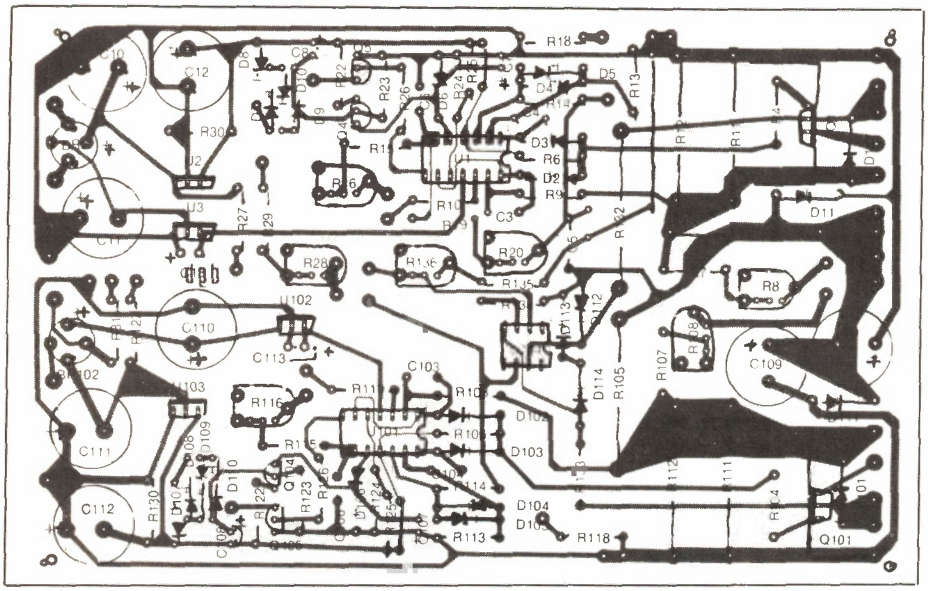


Fig. 5 The component location for the large printed circuit.

posts should be 18 gauge or larger; all other wires can be a lighter gauge. The main circuit board can now be fastened to the cabinet and the wiring can be completed. The chassis ground binding post is wired directly to the cabinet using a ground lug. The 0R2 5W resistors (R2, R3, R102, and R103) can be attached directly to the emitter terminals of Q2, Q3, Q102, and Q103. The voltage control pot, R21, and the tracking ratio pot, R137, should both be wired so that clockwise rotation gives maximum resistance.

The final step in constructing the power supply is to replace the voltmeter and ammeter scales with the ones shown; these scales should work well for most 2.5" meters.

Testing and Adjustments

Before turning the supply on, check that both M1 and M2 are zeroed, and then connect an external voltmeter between the positive and the ground binding posts. Switch on the power supply and turn the voltage control pot clockwise; the output voltage should increase. Set the output voltage to exactly 25V and adjust R29 until M2 reads 25V; be sure SW2 is in the +50V position when making this adjustment. Turn the output voltage up to 50V and see that M2 also shows 50V. If the output voltage will not go up to 50V, adjust R20 until it does; this trimpot should be set to give an output voltage about 1 or 2 volts above 50V with the voltage control pot fully clockwise. Turn the voltage back down to 25V and connect the external voltmeter to display the negative output voltage; also switch SW2 to the -50V position. Turn the tracking pot clockwise; the output voltage should become more negative. With the tracking pot set fully clockwise, adjust R136 until the output voltage is exactly 25 percent (100 per cent tracking). Turn the positive output up to 50V and check that the negative voltage goes down to -50V; if the output will not go this low, the negative supply to U104 is not negative enough and D114 must be changed; refer to the Part Selection section. The tracking ratios can be adjusted to 25, 50, 75, and 100 percent and appropriate markings added to the front panel.

To set the current limiting, adjust the positive output to about 2V and connect a ammeter between the positive output binding post and the ground binding post; be sure the ammeter is set to a current range greater than 2.5A. The positive output current limiting LED should be on. Turn the positive current limiting pot clockwise; the current should increase; set the pot at 1/2 rotation and adjust R16 until the output current is approximately 1.3A. Also adjust R8 until M1 reads the same value as the ammeter (SW1 must be in the +50V position). Turn the current limiting pot fully clockwise and adjust R16 for a current output of 2.5A. The same procedure should be followed for the negative supply, adjusting R116 for a maximum output current of -2.5A and adjusting R108 so that M1 displays the correct current. Lines can be added to the front panel for both current control pots to indicate plus and minus 1, 2, and 2.5 amperes. This completes the testing and adjustment of the power supply.

Troubleshooting

If the op amp supply voltages or the reference voltages are not present, refer to Table 1 for assistance in locating the problem. If all of the required voltages are present but the supply does not function properly, use the schematic and carefully measure the voltages around the circuit. The voltage between the inverting and non-inverting terminals of each op amp should be 0V within a few millivolts unless the output of the amp is saturated to + 12 or -12V. The output voltages of U1C and U101C should be equal to the collector voltages of Q4 and Q104 respectively. The output voltages of U1A and U101A should be within 1 or 2 volts of the positive and negative outputs respectively when the supply is operating in the constant voltage mode. The outputs of U1B and U101B should be approximately equal to the respective output voltages when operating in the constant current mode. The voltage across R21 should be the same as the positive output voltage, and the output of U104 should be the negative of this voltage. The base voltages of Q2 and Q102 should be within 1 volt of the respective output voltages.

Part Selection and Modification

If some of the recommended parts are not available, or if the supply does not fulfill the requirements of the builder, the existing circuit can be modified quite easily.

The most expensive components are the transformers and are the most likely to be substituted; the transformers selected, however, will greatly affect the available output voltage and current. Choose a transformer that has an AC output current approximately 1.5 times the required DC output current, and an AC voltage several volts above the required DC output voltage. Operating a transformer above its maximum rating for long periods of time will cause the transformer to overheat, and is not recommended.

The selection of the power transistors and the heatsinks should be based on the output rating of the supply. The MJ15003 and MJ15004 transistors used will work well for most configurations with currents up to 10A and voltages up to 100V; however, as the current and voltage ratings are increased, the size of the heatsinks must be increased. The maximum power dissipated by each pair of transistors is equal to the product of the maximum output current and the collector voltage. For this supply, the maximum power dissipation is about 200W (75V x 2.5A) for each pair of power transistors. If the temperature rise is to be kept to 100 degrees C, the heatsinks must have an efficiency of 0.5W/deg C in free air convection; alternatively, smaller heatsinks could be used with a cooling fan. Instead of the MJ15000 series transistors, a pair of 2N3055s and a pair of MJ2955s can be used for Q2, Q3, Q102, and Q103 respectively if the input voltage to these transistors is kept below 50V.

If the power supply's voltage or current ratings are changed, the formulas

HOW IT WORKS

It's best to refer to the block diagram. The AC input is converted to plus and minus 75V by the bridge rectifiers and the filter capacitors, and applied to the collectors of Qs + 1 and Qs – . Ignoring the negative supply, the base of Qs + is driven by U1a if the supply is operating in the constant voltage mode, or U1b if it is in the constant current mode. Vref sets up a constant current through RI and R17 and through RV and R21; the current through R21 produces a voltage directly proportional to the resistance of R21. U1a attempts to keep this voltage and Vref equal by generating an error signal proportional to the difference between the voltages. If the load resistance decreases and the output voltage drops, U1a increases the conductance of Qs+, causing the output voltage to return to its previous level. Similarly, an increase in output voltage causes U1a to reduce the drive to the base of Qs+. The output regulation is very good because the high gain of U1a produces a large error signal for even very small input voltage differences.

Op amp U1b compares the voltage at the wiper of R17 to the voltage across R17/R12, the latter voltage being proportional to the output current. If the output current increases past a certain point, the output of U1b goes negative and reduces the drive to Qs+, reducing the output current. The OR circuit selects the lower of the two output voltages from U1a and U1b to drive the base of Qs + . This causes the supply to operate in the constant voltage mode until the output current exceeds the value set by R17, at which time U1b will take over and switch the supply to constant current.

To provide the negative supply with tracking, the positive supply voltage is inverted by U104 and applied to U101a. The gain of U104 can be varied between 0 and -1 by adjusting R137, thus giving a tracking range of 0 to 100 percent. The output of U101a is an error signal which tries to maintain a constant voltage. The current limiting operates in the same way as the positive supply, except that the OR circuit now selects the higher of the output voltages from U101a and U101b.

The operation of the negative half is much the same as the positive. Referring to the schematic, Q2 and Q3 are the pass transistors and Q1 is the driver; resistors R2 and R3 help compensate for differences between transistors. The base current for Q1 comes from the OR circuit, D2, D3, and R6; this circuit selects either U1a or U1b as controller, depending on which has the lower output voltage. The high gain of the op amps ensures a sudden transition; the drive current actually comes from R6.

The reference voltage is provided by D6 and constant current source Q4, which is biased by D7-D10 and R22. C8 provides a soft start when the supply is switched on. The reference voltage is buffered by U1c.

The reference voltage generates a constant current through R21; the developed voltage is compared to the output and any difference controls U1a. R20 allows adjustment of the current through R21 and C5 stabilizes the voltage; C4 provides extra compensation against oscillation.

The voltage at the non-inverting input of U1b is taken from the wiper of R17; when the voltage across resistors R11/R12 exceeds the voltage set by R17, the output of U1b will drop from 12V to a voltage which will maintain the current at the limiting value.

The plus and minus 12V for the bias circuitry is provided by XFRMR2, U2 and U3. This voltage is referenced to the positive output because the outputs from the op amps must swing around the power supply output voltage. C13 prevents oscillation, and C12 and R30 are included to prevent the supply from putting out its full voltage when first switched on. The negative supply requires that the positive 12V come on first, so C112 and R130 are added to the negative regulator.

C9 and C109 improve the overall stability of the power supply. D11 and D111 protect the supply from an accidental connection of another power supply wth the opposite polarity. D1 and D101 protect the supply if it is turned off with another power supply of the same polarity still connected.

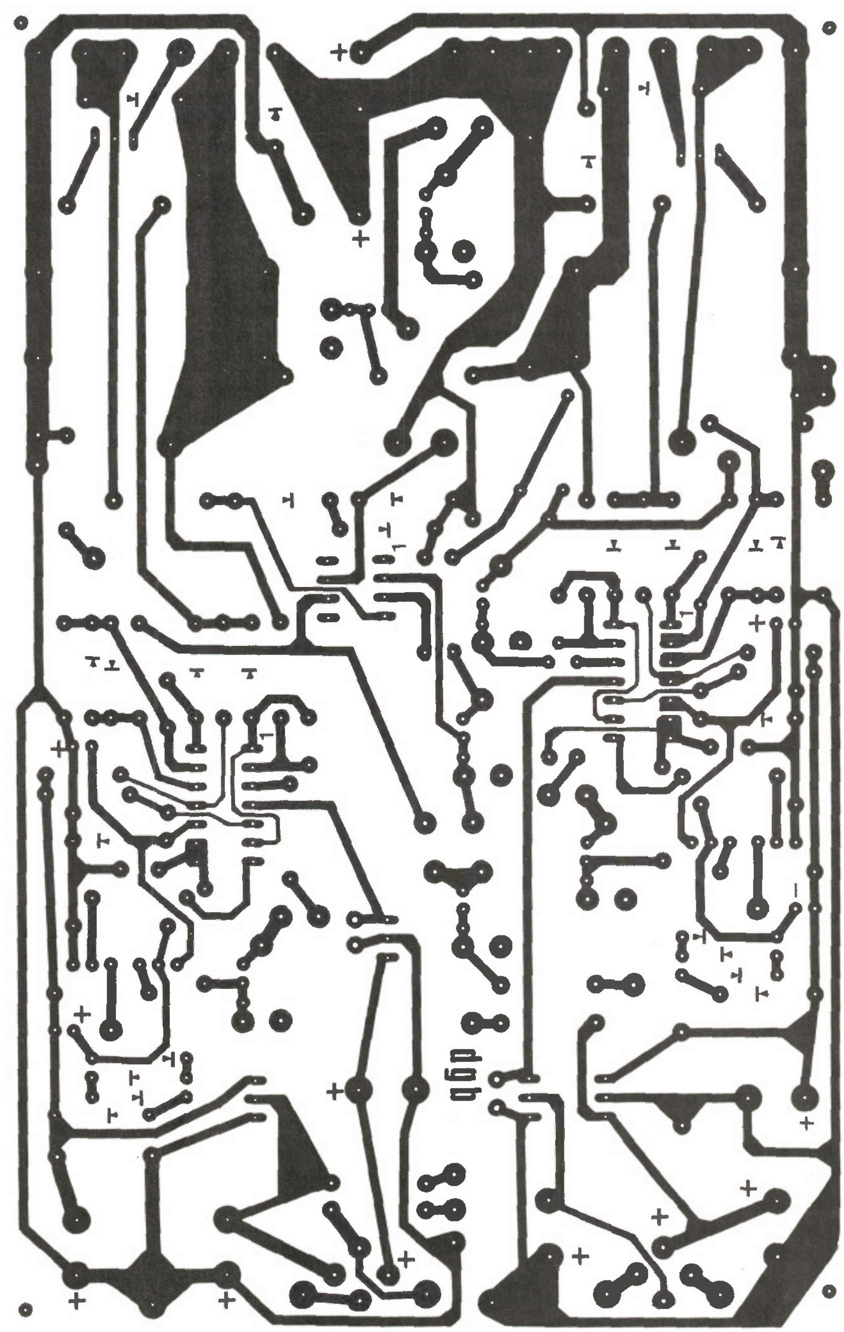
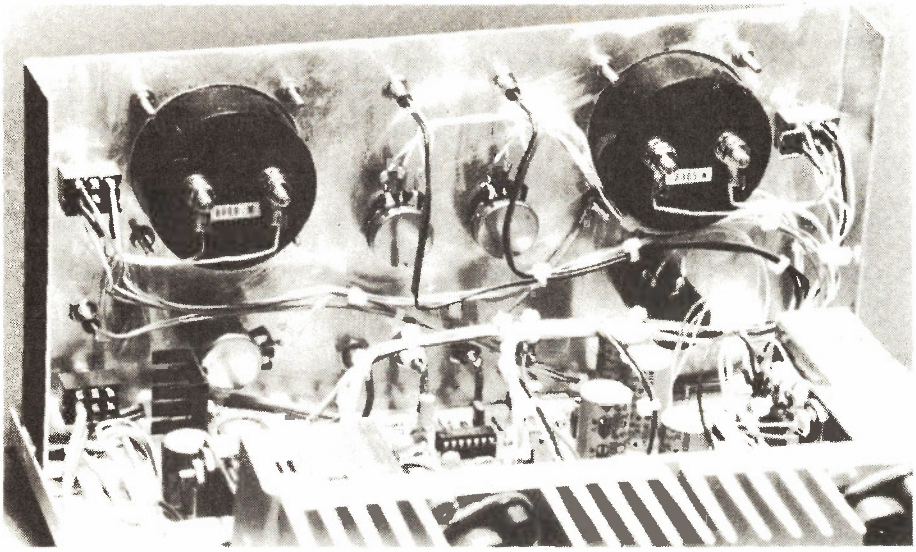


Fig. 6 The main printed circuit.



The front panel, showing the meter and control wiring.

given in Table 2 can be used to calculate the new resistor values. This table also includes the formula to calculate new series resistors for the meters if the recommended ones are not used. In the table, Vmax and Imax are the maximum output voltage and current of the supply, respectively. Imeter is the current required for the full-scale-deflection of the appropriate meter.

A change in the output voltage also requires a change in the zener diodes D113 and D114. Choose two 1W zeners that sum to approximately 5V more than the maximum output voltage. Note that the MC1436 has a maximum supply voltage of 60V. R133 must also be changed in order that each zener diode dissipates about 200mW.

R133 = 4 x Vz x (Vsupply - Vz)
where Vsupply is the magnitude of the negative input voltage from C101 and C102, and Vz is the sum of the zener diode voltages of D113 and D114.

The voltage reference diodes D6 and D106 are temperature compensated zener diodes; however, ordinary 6.2V (1N4735) zener diodes can be used with some loss of temperature stability. The current through these diodes should be increased by decreasing R22 and R122 to 75R.

If the negative supply is to be fully independent of the positive supply, U104 and its associated circuitry can be replaced with a duplicate of R19, R20, R21 and C5 off pin 8 of U101. If the negative supply is not required, all the 100-series parts can be deleted.

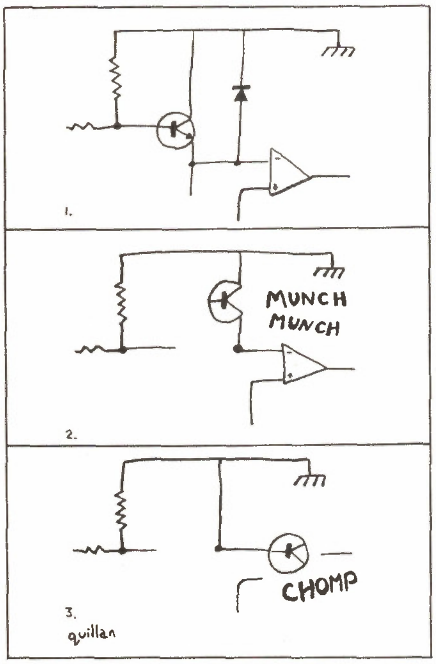
The 10-turn potentiometer (R21) can be replaced with one or two single-turn pots; if two pots are used, one should have a value of 50k for coarse voltage adjustment, and the other in series should be 1k for fine adjustment.

There are many other options available to the user, such as providing terminals for remote sensing when long leads are used, or replacing XFRMR1 and XFRMR101 with one larger transformer; however, these are left to the ambitious builder.

Use

Using the power supply is very easy; the maximum output currents are set on the current limiting pots (this can be done by shorting the output of the supply and adjusting the current limiting pot until the desired current is reached). If there is a problem with either load, assuming both positive and negative supplies are being used, the current limiting circuit will override the voltage control pot and keep the current constant. As the output voltage is increased, the output current also increases until the limiting current is reached. At this point the output voltage will not go any higher because the current would not remain constant. If the resistance of the load decreases, the output voltage will also decrease to keep the output current constant. With a short circuit, the output voltageis zero.

When the positive supply is current limiting, the negative supply will be limited to the output voltage of the positive supply regardless of the operating mode of the negative supply (the negative supply voltage can go below this voltage, of course). In other words, the magnitude of the negative supply can never exceed the magnitude of the positive supply.



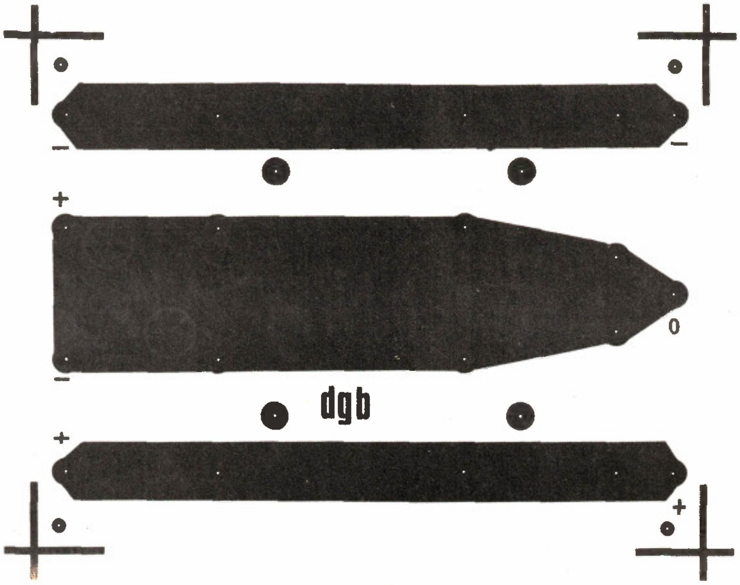


Fig. 7 The small printed circuit for the capacitors.

PARTS LIST

Resistors (All resistors 1/4W unless otherwise noted)
R1, R101 .... 10K 1W
R2, R102, R3, R103, R11, R111,
R12, R112 .... 0R2 5W
R4, R104 .... 47R
R5, R105 .... 2K7 5W
R6, R106 .... 2K7
R7, R107 .... 680R
R8, R108 .... 5K trimpot
R9, R109, R13, R113, R134 .... 1K
R10, R110, R14, R114, R26
R126, R135 .... 10K
R15, R115 .... 10K
R16, R116 .... 50K trimpot
R17, R117 .... 1K pot
R18, R118 .... 10R
R19 .... 4K7
R20 .... 5k trimpot
R21 .... 50K ten turn pot
Bourns # 3540S-1-503
R22, R122 .... 270R
R23, R123 .... 2K2
R24, R124, R25, R125 .... 47K
R27, R127 .... 470R 0.5W
R28 .... 270K
R29 .... 500K trimpot
R30, R130 .... 1K 0.5W
R31 .... 200R 0.5W
R132 .... 3K3 5W
R133 .... 4K3 0.5W
R136 .... 50K trimpot
R137 .... 50K pot

Capacitors
C1, C101, C2, C102 .... 2200*u* 100V
C3, C103, C4, C104 .... 470p
C5 .... 470n
C6, C106 .... 100n
C7, C107 .... 1*u* 25V
C8, C108 .... 47*u* 25V
C9, C109 .... 100*u* 100V
C10, C110, C11, C111,
C12, C112 .... ~~100*u*~~ 25V
C13, C113 .... 4*u*7 tant.

Transistors
Q1 .... TIP31C
Q101 .... TIP32C
Q2, Q3 .... MJ15003
Q102, Q103 .... MJ15004
Q4, Q105 .... 2N3906
Q5, Q104 .... 2N3904

Diodes
D1, D101, D11, D111 .... 1N4004
D2 - D5, D102 - D105,
D7 - D10, D107 - D110 .... 1N914
D6, D106 .... 1N821A
D112 .... 1N4731 (4.3V 1W)
D113 .... 1N4757 (51V 1W)
D114 .... 1N4731 (4.3V 1W)

Integrated Circuits
U1, U101 .... LM324
U2, U102 .... LM7812
U3, U103 .... LM7912
U104 .... MC1436

Miscellaneous
BR1, BR101 .... KBPC602 (6A 200V)
BR2, BR102 .... WO2M (1A 200V)
XFMR1, XFMR101 .... 50V @ 3-4A
Hammond # 167-P50
XFMR2, XFMR102 ...... 20VCT @ 0.3A
Hammond # 166-F20
LED1, LED101 ... green panel mount LED
LED2 .... red panel mount LED
M1, M2 .... 100uA 2.5" panel meter
SW1, SW2 .... DPDT switch
SW3 .... SPST switch
Cabinet .... Hammond # 1426Q
4 binding posts
4 knobs
2 small TO-220 heatsinks
2 large TO-3 heatsinks
2 14 pin IC sockets
1 8 pin IC socket
4 TO-3 transistor sockets
1 panel mount fuse holder
1 5A slo-blow fuse

■

continued from page 17

For Your Information

```
F8A8 8D FF 9F          STA OUTPORT
F8AB C9 FF             CMP #$FF              ;QUIT IF BYTE IS $FF
F8AD D0 F3             BNE OPTEST
F8AF 60                RTS
F8B0             ;**** COMMAND TABLE 'CTABLE'
F8B0             ;
F8B0             ;SUBROUTINE INDICATED WILL BE EXECUTED WHEN CORRESPONDING
F8B0             ;COMMAND BYTE IS RECEIVED:
F8B0             ;(NOTE: ALL COMMAND BYTES MUST BE EVEN)
F8B0             ;
F8B0 FF E2       CTABLE DBY EXEC-1           ;$00
F8B2 F8 69             DBY RRAM-1            ;$02
F8B4 F8 8F             DBY SRIOT-1           ;$04
F8B6 F8 A1             DBY OPTEST-1          ;$06
F8B8             ;
F8B8             ;
F8B8             ;**** SUBROUTINE 'EXEC'
F8B8             ;
F8B8             ;MAPS RAM ADDRESS SPACE TO $F800-$FFFF AND PERFORMS
F8B8             ;INDIRECT JUMP TO ($FFFC) I.E. HARDWARE RESET VECTOR
F8B8             ;LOCS. $DFF7-9 OVERWRITTEN IN RAM
F8B8             ;
FFE3                   ORG $FFE3
FFE3                   OBJ $0FE3
FFE3 A9 6C       EXEC   LDA #$6C              ;OP-CODE FOR 'JMP ($FFFC)'
FFE5 8D F7 DF          STA $DFF7             ;TO END OF RAM AT $DFF7
FFE8 A9 FC             LDA #$FC
FFEA 8D F8 DF          STA $DFF8
FFED A9 FF             LDA #$FF
FFEF 8D F9 DF          STA $DFF9
FFF2 A9 80             LDA #$80              ;CLEAR MODE BIT THEREBY
FFF4 8D FF 8F          STA TXPORT            ;MAPPING 2K RAM
FFF7             ;INTO $F800-$FFFF, AND DISABLING ROM
FFF7             ;AT THIS POINT ROM IS DISABLED AND INDIRECT JUMP IN RAM
FFF7             ;WILL BE EXECUTED
FFFA                   ORG $FFFA
FFFA                   OBJ $0FFA
FFFA             ;SET NMI,RESET & IRQ VECTORS TO 'RESTART'
FFFA 00 F8 00          ADR RESTART,RESTART,RESTART
FFFD F8 00 F8
0000                   END
```

```
DARK ROOM TIMER ROM
0000: 3E CF D3 03 3E 80 D3 03 3E CF D3 02 3E 0F D3 02
0010: 0E 30 79 E6 0F 59 57 CB 3A CB 3A CB 3A CB 3A 06
0020: 3C 3E 00 D3 00 DD 21 21 00 DB 00 E6 0F FE 0F 20
0030: 03 C3 FA 00 DD 21 7A 00 3E 60 D3 00 DB 00 E6 0F
0040: FE 0F 28 0B FE 07 CA D0 00 F6 60 08 C3 FA 00 3E
0050: 50 D3 00 DB 00 E6 0F FE 0F 28 06 F6 50 08 C3 FA
0060: 00 3E 30 D3 00 DB 00 E6 0F FE 0F 28 06 F6 30 08
0070: C3 FA 00 DD 21 21 00 C3 FA 00 08 D9 4F D3 00 E6
0080: 0F 47 DB 00 E6 0F B8 28 08 DD 21 21 00 D9 C3 FA
0090: 00 06 00 21 C5 00 7E FE FF 28 07 B9 28 0C 23 04
00A0: 18 F4 DD 21 21 00 D9 C3 FA 00 78 D9 CB 21 CB 21
00B0: CB 21 CB 21 B1 4F 3E 00 D3 00 DB 00 E6 0F FE 0F
00C0: 20 F8 C3 12 00 57 6E 5E 3E 6D 5D 3D 6B 5B 3B FF
00D0: 3E B0 D3 00 AF B9 20 02 16 0A 05 20 0F 06 3C 1D
00E0: 7B B2 CA 12 00 FE FF 20 03 1E 09 15 DD 21 DA 00
00F0: DB 00 E6 08 CA 21 00 C3 FA 00 21 1A 01 7A 85 6F
0100: 7E D3 01 DB 01 E6 80 28 FA 21 1A 01 7B 85 6F 7E
0110: D3 01 DB 01 E6 80 20 FA DD E9 3F 06 5B 4F 66 6D
0120: 7D 07 7F 6F 3F 29
```

Probotics, Toronto's personal robot user's association, will hold its first robot contest in the afternoon of Saturday, October 26, 1985. The contest will be open to robots which will have been designed and built by members of the club, and prizes will be awarded in each of two categories. The first category is for robots that can learn their way through a maze; the robot making a second pass in the shortest time wins. The second is for speech-recognition systems. Robots are required to be able to tell left from right when one of the words is spoken, which is more than some people can do. Robots must be home-built; anyone who feels that their robot has too little design and too many commercial parts should contact Probotics prior to the contest. A third category, that of robots which must negotiate the Don Valley Parkway at rush hour, has been eliminated. Write to Probotics, 38 Arlene Crescent, Scarborough, Ontario M1P 3L9.

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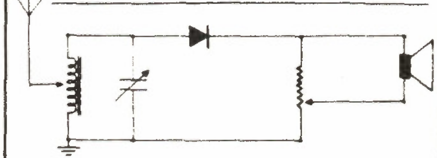

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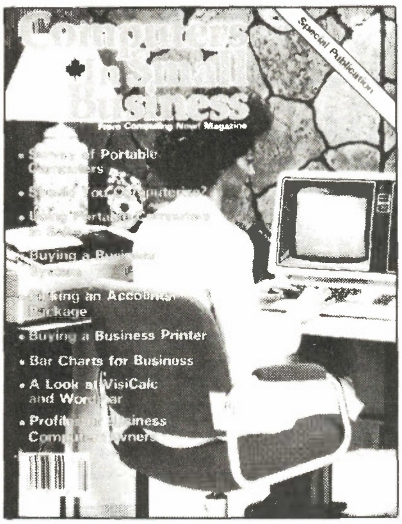

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Circuit Ideas

FET Grid-Dip Oscillator

G.C. Mellor

This relatively up-to-date version of the popular triode tube grid-dip oscillator can be constructed very inexpensively by replacing the RF triode by a FET such as the 2N3819 or preferably, the MPF106 in the Hartley circuit. Although the physics of a triode and a FET are obviously different, they seem to operate in a similar way.

A non-mathematical explanation of the oscillation assumes an alternating RF potential on the source of Q1 which, due to the autotransformer action of L1, gets amplified without any phase change (making up for circuit losses). This voltage is fed to the gate of Q1. Since we are using it in the source follower mode, FET action maintains the amplitude of the alternating RF we first assumed. The tank circuit, L1 and C1, will provide the initial RF we require for this explanation on power-up.

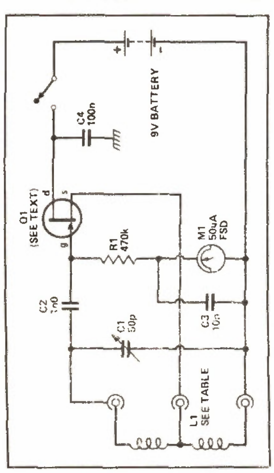
The GDO must be calibrated and this can be done in one of two ways:

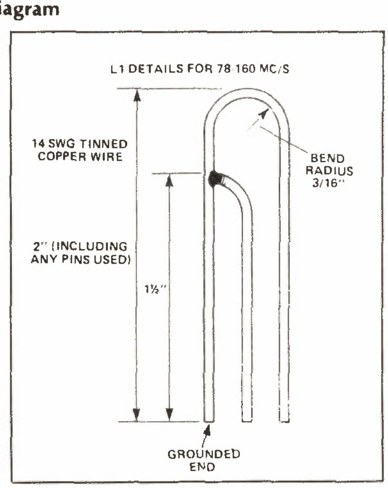
i) Listen for the GDO frequency on a good communications receiver and, using spot frequencies, calibrate the C1 scale.

ii) Measure the GDO frequency with a meter using a high impedance probe on the source of Q1.

Using the GDO is simple; the appropriate coil for L1 is plugged in and the GDO is switched on. L1 (which is mounted on a 3 pin DIN plug external to the circuit) is brought in the vicinity of the tuned circuit under test (TCUT). C1 is adjusted for a local minimum in the meter reading and the frequency read off the scale. This dip in the reading occurs because some of the RF feedback in the GDO is absorbed by the TCUT, consequently making the natural potential on the gate of Q1 less negative. It should be noted that loose coupling to the TCUT is essential to avoid the GDO frequency being "pulled" away from the value indicated on the scale. A dip can also occur when the GDO frequency is an integral sub-multiple of the TCUT frequency. However, practice in using the GDO will soon remedy this.

Coil	Frequency Range (MHz)	Number Of Turns	Tap	Wire Gauge (SWG)	Number of Turns Per Inch	Coil Diameter
A	1.6-3.5	139	32	36ENA	Close Wound	¾"
B	3.45-7.8	40	12	36ENA	Close Wound	¾"
C	7.6-17.5	40	14	24Tinned	32	½"
D	17.2-40	15	5	20Tinned	16	½"
E	37-85	4	1½	20Tinned	16	½"
F	78-160	See Diagram				





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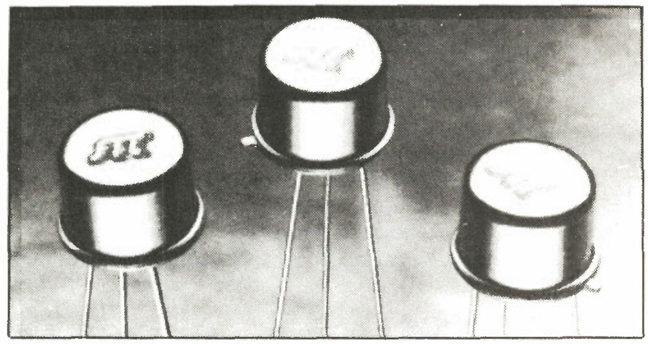
Electronics Today's Guide To Parts Substitution

BUILDING one of our projects and stumped on parts? Because our projects come from a wide variety of sources, the Parts Lists often specify components that aren't easily available in your area. Our readers also often keep issues for years and years; the specific part may be long gone when construction is attempted.

Not to worry. We make every effort to select projects which use general-purpose parts, and you can usually substitute for the unobtainables. Occasionally, you're out of luck; we'll keep making efforts to see if that can't be prevented.



Capacitors

Capacitors generally have one of two purposes: smoothing or frequency-selecting. Smoothing (or decoupling) capacitors are always large electrolytics, and the rule is that you can go larger in both capacitance and voltage ratings by as much as 100 percent or even more. Frequency-selecting or timing capacitors, however, are generally non-electrolytics and should be within about 10 percent of the stated value. You can usually mix polystyrenes, polycarbonates, ceramics, etc., unless the author has pointed out a special reason for his selection of type.

Transformers

Transformer voltages are sometimes specified as 15-0-15, which is the same as 30V centre-tapped. If the supply produces both positive and negative outputs, you must have a centre-tapped transformer and a four-diode bridge. If only one output voltage is produced, you can use either an untapped winding with four diodes, or a centre-tapped two-diode version (which should have twice the voltage rating of the single winding version).

"VA", or volt-ampere, can be considered the same as a watt. You can always make the transformer current or power rating much larger than specified (if it fits in the box). We try to avoid PC-mount transformers because of the wide variety available; if you can't locate one to fit, we suggest running wires to the PCB.

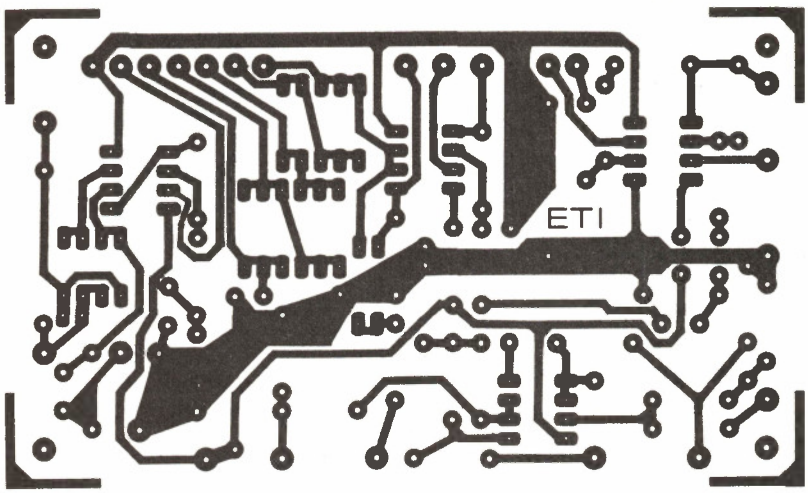
Transistors

If you're not building touchy test equipment or hi-tech audio gear, then a transistor is pretty much a transistor for low-power stuff. Usually, a general-purpose small-signal transistor such as the 2N3904 NPN wil substitute for any other small-signal NPN, such as the BC107, BC108, BC109, etc. Similarly, the 2N3905 PNP replaces the BC177, etc.

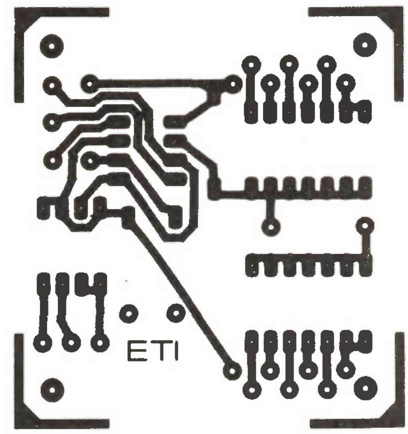
We hesitate to suggest substituting large power transistors unless you have some skill at figuring out spec sheets, because they may be fussy about dissipation or high-frequency performance.

Say, now...

This short guide only touches on the many components that may need substitution. It looks like we should get to work on that complete article; we'll warm up the word processor and see you in a future issue. ■



The THD and millivoltmeter board for the Distortion Meter



The Distortion Meter spot frequency oscillator board.

Use

While the major application will be audio amplifiers, for instance setting the quiescent current correctly, there are other uses.

There are three particular applications that are particularly valuable. One is to check that the alignment of a phono cartridge is correct. For this, you need a test record with a track of 1kHz or 3kHz (the higher, the harder for the cartridge) recorded at, say, 5cm/sec. If the cartridge is properly aligned, the THD will probably be in the range of 0.4 to 1.2 percent depending on cartridge quality. A worn stylus will increase these readings rapidly, so a check from time to time can monitor the health of the stylus.

A second useful application is to check the correct recording and bias levels on a tape or cassette recorder. With the latter, on a reasonable machine, the THD should be on the order of 0.3 percent at -5VU. This will worsen with increasing level, becoming perhaps 3 percent just below the recording overload level. This allows the overload level to be determined for a particular tape/machine combination. A reel-to-reel at 7.5 in/sec should have about half these values.

Since the bias level settings on a tape recorder are a compromise between flatness of frequency response and THD, the combination of oscillator, millivoltmeter and THD meter should allow you to check or reset this level if it not ideally chosen.

The final additional use for the meter is in setting up FM tuners. The THD of these depends on the alignment of the IF coils and also upon the setting of the quadrature coil on the demodulator IC. Needless to say, you should have some experience with tuners before twiddling with the coils.

In all of these operations, the method of operation is the same:

1. Set the THD meter input sensitivity to zero and switch out both filter stages.
2. Set the mV/THD switch to THD and set the Mode switch to Set FSD.
3. Connect the input of the meter to the output of the system under test, and gradually increase the sensitivity until the output meter reads full scale.
4. Switch the Mode switch to 100 percent and alter the settings of the Coarse and Fine tune at an appropriate choice of frequency range, set by SW1. Adjust until the best practical notch is obtained with the mode settings adjusted to the 10 and 3 percent settings.
5. Progressively increase the sensitivity given by the mode switch until the highest practical value is obtained, with the fine tune and trim pots adjusted alternately until no lower value of reading can be obtained. Although the use of a single gang pot as RV3 is practicable, it does mean that it is necessary to try trim settings on either side of the apparent minimum position before adjusting the fine tune pot.

PARTS LIST

Resistors

R54	470R
R55	1k0

Capacitors

C29, 31	100u 16V electrolytic
C30, 32	1000u 25V electrolytic

Semiconductors

IC6	7815
IC7	7915
LED1	panel mounting LED
D5-8	1N4001

Miscellaneous

SW9	toggle switch
T1	15-0-15V 3VA transformer
PCB.	

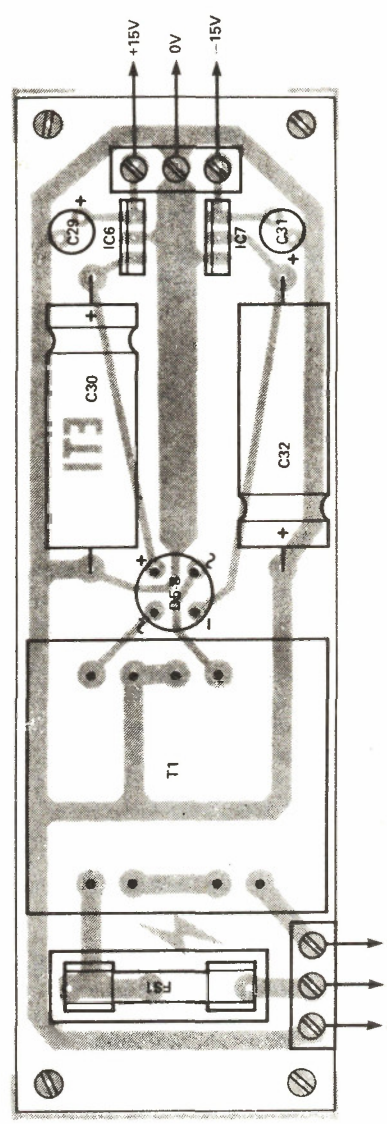
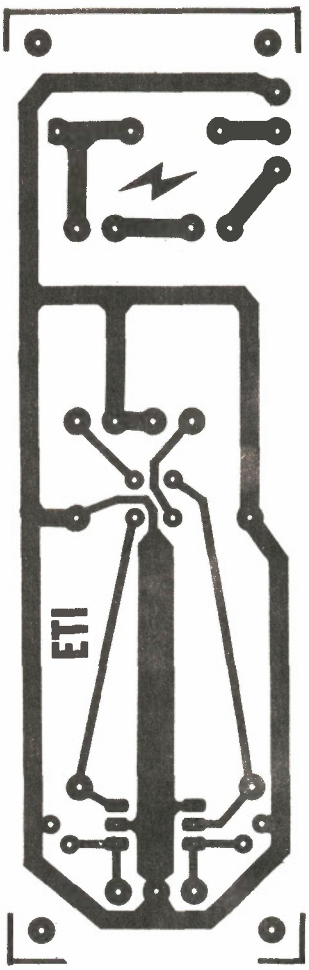


Fig. 3 Component overlay of the AC power supply PCB.



The Distortion Meter AC power supply board.

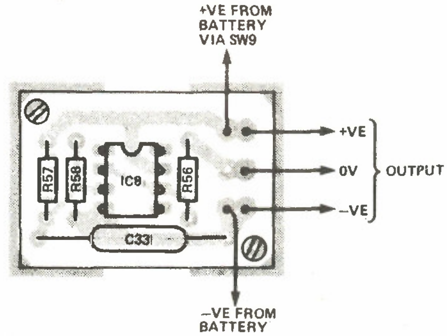
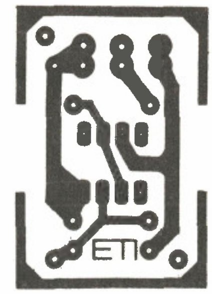


Fig. 4 Component overlay of the single battery supply PCB.



The Distortion Meter single battery supply board.

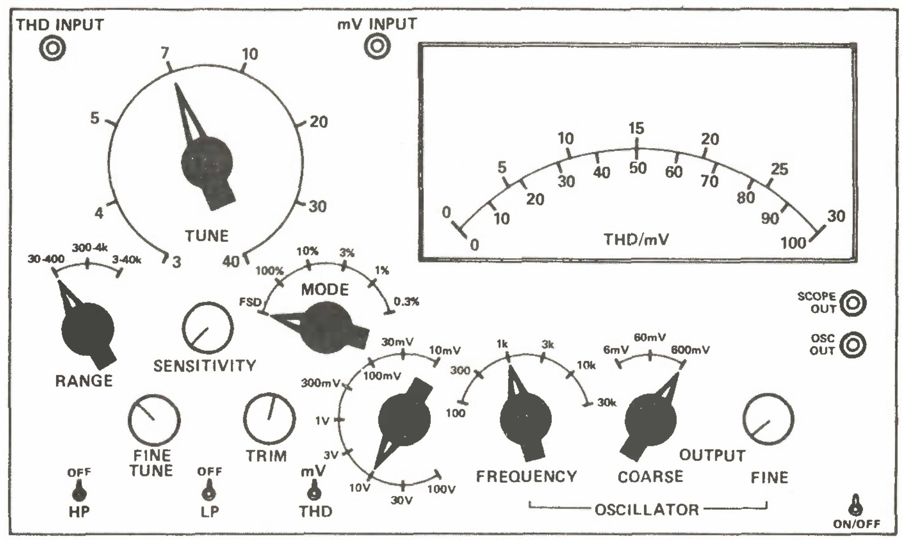


Fig. 5 The front panel layout used in the prototype.

Interpreting

In spite of all the publicity which attends the introduction of new, very high quality audio amplifiers, and in spite of all the efforts of designers to produce very low distortion systems, I think a lot of effort devoted to getting more zeros after the decimal point is of small value to the user. I do not believe it is possible to hear the difference between nil and 0.05 percent. For myself, I am convinced that if an amplifier doesn't sound good and the THD is less than 0.05 percent, then the problem lies elsewhere, perhaps in its transient response or in incipient stability or overload hangup effects.

I say this to save users from needless anxiety if, in testing a well loved unit, they find it has, say, 0.04 percent or maybe even more. Most of that could be low order distortion which isn't really audible, or even hum and noise. The corollary is also true, that an instrument with a lower THD limit of, say, 0.03 percent will still be a valuable amplifier.

Parts List — Single Battery PSU

Resistors
R56 .... 100R
R57, 58 .... 1M0

Capacitor
C33 .... 1u0

Semiconductor
IC8 .... TL071

Miscellaneous
SW9 .... SPST toggle switch

■

Commodore Plus 4

Integrated software is becoming more popular, so Commodore is offering the compact Plus 4.

By Bill Markwick

LIKE a fly's eye, software these days is supposed to be multi-faceted. The idea is to integrate the most commonly used programs, such as word processors, databases and spreadsheets, so that they can transfer data among themselves painlessly. Commodore has provided this for us in the new Plus 4 model. It also features 64K, but with a difference: from BASIC you actually get all of 60K as opposed to the C64's 38K or the Model 16's 12K. It lists for $529.95, but may be discounted by local dealers.

Unwrapping

Despite the general resemblance to the C64 in size and keyboard style, the Plus 4 has a new look; it's an angular wedge sporting decorative plastic fins on top that you might associate with a large power amp heatsink. The usual vertical row of function keys is replaced by four small horizontal bars, and the cursor keys are now plastic arrows on the bottom right corner of the body. The keyboard is otherwise almost identical to the 64 and 16; another Control key has been added at the right, a repeat of the one on the left and a nice touch, and some of the keys have been moved slightly as a result. Alternate key functions such as colour and graphics remain the same.

On the right end is a power switch and a Reset button to clear the memory and reboot the computer; at the left end is an RCA jack for the television RF output, switchable to channels 3 or 4. The rear panel has the full complement of C64 connectors: power, serial port, cassette port, user port, memory expansion, joysticks and video/audio. It's worth noting that the power connector is new; it's now a square 4-pin instead of the round DIN-type. Since the power supply is identical to the 64's, the reason for the change remains a mystery. Maybe people are trying to jam the power plug into the video output or something. Also note that the new cassette machines (datasettes) no longer have an edge connector that slides onto the printed circuit card edge; it's now a tiny round 7-pin. It's worth pointing out right away that the datasette seems to work only in BASIC and doesn't respond to the integrated software; you'll need a disk drive.

Boot it up with either a colour or monochrome monitor, and you'll see BASIC, version 3.5 with 60,671 bytes free. You'll also see a message saying "3-plus-1 on key F1".

3-plus-1

The unusual amount of memory freed up

for the user is no doubt due to the internal software which saves you the bother of loading the most-used programs in via disk or cassette. Press F1 and you'll get a command written to the screen, SYS1525, which calls the word processor when you press Return. It comes on in monochrome with the Line and Column number displayed at the bottom. The display is 37 characters by 22 lines, and the text window scrolls over an area 77 characters wide by 99 lines deep; that's the maximum size for each document. This means that documents print out in the usual 80-column format, with a page being defined as 66 lines. It also means that half your text is hidden. There are various commands for tinkering with the margin settings and the justification and so forth, but they're cumbersome to use and the formatted text only appears on a paper printout; the screen display remains the same. The auto- repeat cursor is also a bit slow for this sort of thing: it took about seven seconds to toddle over 77 characters. The formatting commands must be embedded in the text by typing them in reverse video, which is Control-9. Bothersome.

There is no auto-insert; to insert text you have to press the insert key the required number of times to move the text over for the new addition, or you can insert whole lines, except that if you wrap around the edge you'll overwrite the next line. Bothersome.

Another oddity occurs when you type a Return in the middle of your text under the illusion that this will insert a line. It does that all right, but it does it by deleting the text on that line. You can get it back by typing the "at" symbol along with the Commodore logo key, but what you should have done is type Commodore-C to get into the command mode and then "il" to insert a line. They must be kidding.

Well, no, they're not. Bothersome. Now, I know what you're thinking: here's this guy with a whizbang word processor provided by the company, and he's knocking a five-hundred-dollar computer complete with software. You have a point. Still, I've never been able to fathom why computer makers think that all of us out here are crazy into long control codes. They aren't necessary.

There are the usual search-and-replace and block moving functions, plus commands for merging files.

Spreadsheeting

The word processor comes up as the main control for the 3-plus-1 integration; Commodore feels that this is the most often used software, and the other two programs are called from it. To enter the spreadsheet, you type Commodore-C for the command mode, and then "TC" for "To the Calculations". Were you expecting "SS" for "spreadsheet"? No way. CBM is still one of those outfits that programs the user to suit the computer instead of the other way around.

Anyway, after TCing, the word processor is instantly replaced by a spreadsheet showing three columns and 12 rows. The full sheet extends to 17 columns by 50 rows. To go up and down the rows, you use the cursor up and down keys, but to move along the columns, you must use F1 and F2; oddly, the left and right cursor works only for corrections within the selected cell. The cursor bar is generated by graphics, and lags slightly behind the keypress; you can get ahead of it easily.

You can enter numeric values or text and then add the formula relating the cells; the formulas can be any of the mathematical functions available in BASIC. The Fit command will adjust the formula in one cell to make it work in another. The calculated values can then be saved to the disk.

Integrating

To go from the spreadsheet to the word processor, you type "TW" ("To Word"); the processor appears on the top half of the screen, and seven rows of the spreadsheet appear on the bottom half. The command BLKMAP will then map a previously defined block of the spreadsheet into the word processor area. There is also a MAP function to transfer all 36 characters of a cell into the word processor.

There are lots more commands available for the spreadsheet, including labelling, editing and formatting; the formulas can also use logical operators such as Equal To, Less Than, etc. Various background colours can be set.

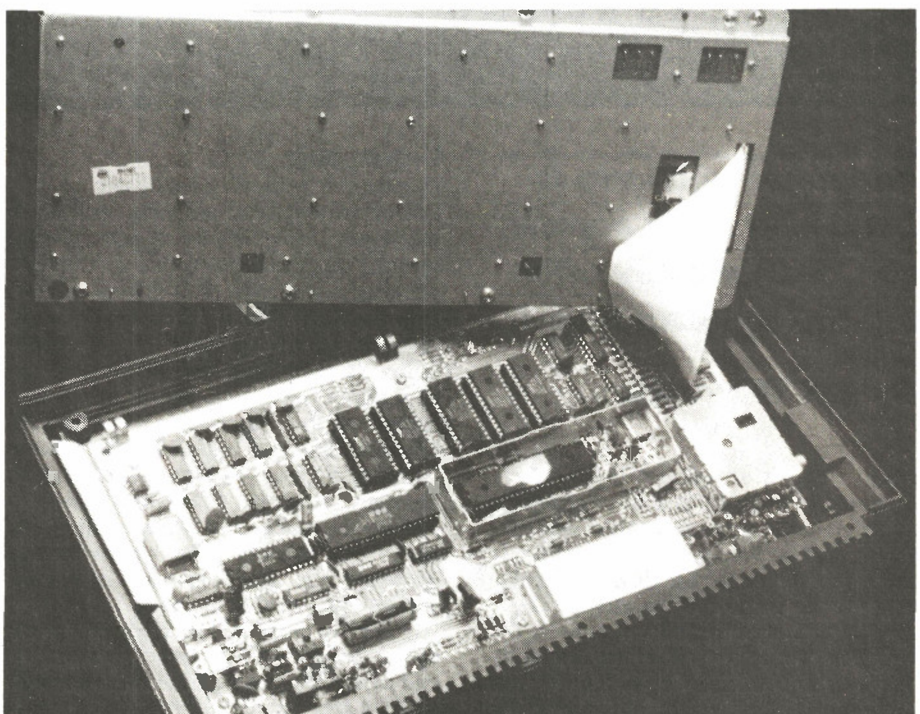
Graphs

This is an impressive function. After a row of numbers is entered into the spreadsheet, the command GR will cause a bar graph to be generated. It has a vertical axis of 20 units (which you can't modify), and a horizontal axis of however many numbers you entered. Each coordinate is marked with a number symbol (hash mark). It's a bit coarse, since it uses punctuation marks rather than hi-res, but it's a quick way to see the relationship between entered numbers, and also a way to quickly check for gross errors in number entry. In cell 50,16 lives the scaling factor; you can have a peek there to determine the value of each of the 20 vertical divisions.

The Database

CBM prefers to call it a file manager. It can hold 17 pieces of information, or fields, in each of 999 records. Each field can hold up to 38 characters. This seems like bunches, but you'll quickly use up fields since they recommend a separate field for the first name, last name, address, postal code, etc.

The File Manager is accessed by typing TF ("To File" — I can live with that one), but you'll need a blank disk in your drive, because the database overwrites it



The Plus 4's top lifts off for remarkably good serviceability. The neatsink has been removed from the CPU.

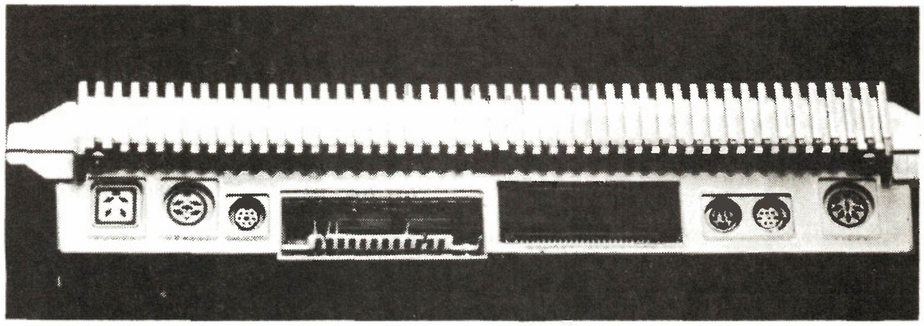
during its manipulations.

You can edit entries, sort, search, list and print, pick the number of records to be searched, save it to disk, and so on. All in all, a very comprehensive and useful database.

BASIC

The Plus 4 supports the usual Commodore BASIC, version 3.5. It has all the bells and whistles of the 64, including hi-res graphics. It also has the considerable advantage of presenting you with 60K worth of RAM to play with. This lets you write huge BASIC programs with graphics and still have elbow room. BASIC programs can be saved to the datasette, unlike the integrated software, which insists on having one of the CBM disk drives.

The CPU is an 8501, which is an upgrade of the 6502 and uses the same assembler mnemonics.



The rear panel of the Plus 4; note that the power and cassette jacks (at left) are a new type.

Summary

I'm not exactly sure who's going to buy the Plus 4. Presumably CBM has done a market survey and found ready and willing buyers out there. Or did they just jump on the integrated software bandwagon? The word processor is too cumbersome for anything but occasional business use, especially with the 38-character width; that leaves the database and spreadsheet. They're limited by the narrow screen width and the slowness of the usual 1541 disk drive. Perhaps a lot of people want a sort of business computer at home. For about $500 or so, plus drive and monitor, you do indeed have a usable computer without having to load software, though you'll soon be past its limited capabilities and tired of its cumbersome operating codes.

Still, it's reasonably priced and very well made, and does everything it says it will. The 234-page manual is comprehensive and easy to use. If you haven't got your feet wet in basic business computing, this might be a good way to start.

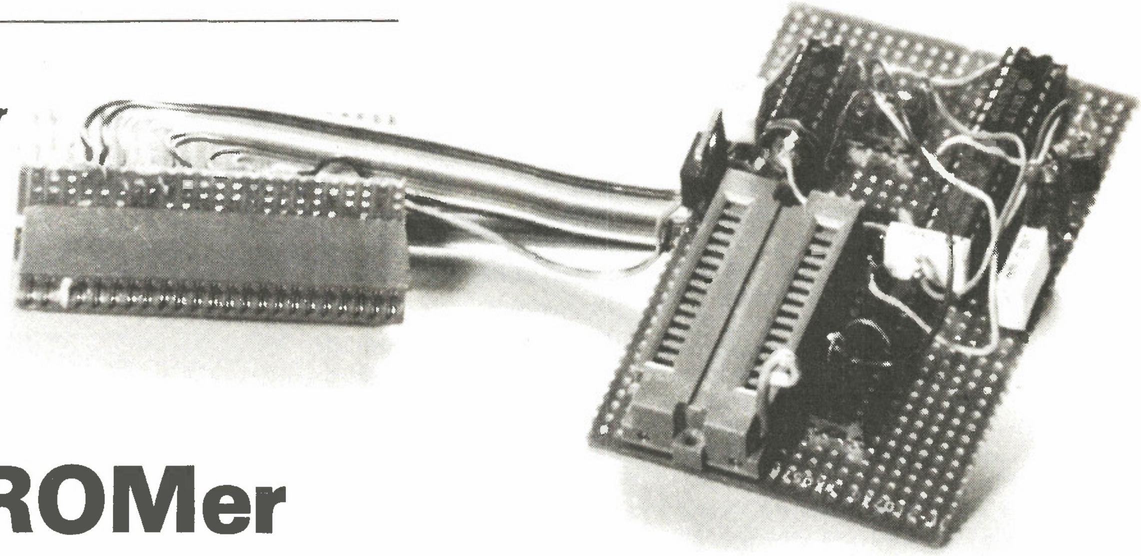
Quick Reference

Commodore Plus 4

Application:	home, small business
RAM:	64K, 60K user RAM
CPU:	8501
Software:	BASIC, word processor, spreadsheet, database
List Price:	$529.95

A low-cost EPROMer to put your ZX81 to use.

By Nick Dennis and David Turner



ZX-EPROMer

EPROMS are powerful, inexpensive and familiar components that are found in many circuits popular today. A stand-alone programmer can cost over $1000. A card for your fruit is cheaper, but then you must have a machine to put that card in. Stop using your ZX-81 as a doorstop and cash in on its hidden potential; build this "full-feature" EPROMer and enjoy freedom over EPROMs. The circuit described here will program the popular 2764 type EPROMs; these are under $10 and store 8K, making them a good choice for many applications. Some uses of this device could be:

1. Program any compatible EPROM.(i.e., 2716).
2. Read any ROM, PROM, or EPROM.
3. Static RAM in any unoccupied memory block.
4. A games cartridge system for the ZX-81.
5. An EPROM copier.

How It Works

While we will be looking at programming the 2764, the theory of operation is much the same for other types. It is well worth your while to consult the proper manual before trying a different memory chip. The programming voltages, for example, vary from type to type. When programming the 2764 it needs:

1. Stable data and address lines for the duration of the write.
2. A stable 21 voltsat 50mA at the Vpp pin.
3. The PGM and CS held low for 50mS after 1 and 2 are met.

The OE pin can be tied to CS to allow for verification of each write. Vpp can be either 5 or 21 volts while reading; PGM should be held high when reading. In this circuit we are slipping our 8K EPROM into the memory map in the "never bothered by BASIC" 8-16K block. As such, PEEK and POKE can give us direct access to all locations. This means that all software can be written in slow but friendly BASIC.

IC 1 is a block decoder. It looks at the top three address lines and decodes all memory requests into 8K wide Block Selects (8 outputs x 8K ^{5} 64K). The Y0 BS de-echoes the ROM (familiar ZX stuff) while its neighbour Y1 delivers the BS where our EPROM lives.

IC 2 is the trap circuit. If BS is low and RD is high (this can only mean a write to the EPROM) and if the timer output is high, then a WAIT is issued to the Z80. This has the unadvertised effect of freezing the Z80's lines until released. The WAIT is also inverted and after a slight delay (C3) passed to the first timer's + ve trigger. Each timer has two outputs, Qbar and + Q. Because the 2764 is programmed with a high-low-high sequence PGM is connected to Qbar. The Q output is applied to the second timer's -ve trigger. After 50 milliseconds these outputs both flip, thus ending the programming and triggering the second timer. The second timer prevents the LS10 from retrapping this same write. But what about REFRESHing the dynamic RAMs? Even though D-RAM is usually REFRESHed every few milliseconds, experience has shown that good data integrity is maintained with occasional periods much longer than 50mS.

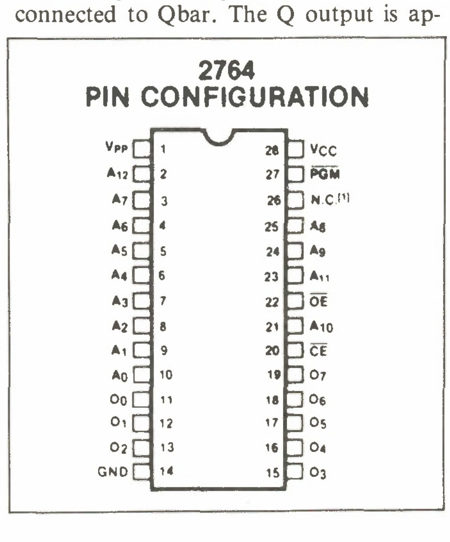


Fig. 1 The pinouts of the 2764 EPROM.

Hooking'er Up

This project is fairly straightforward and does not require a printed circuit board. Veroboard is a good choice for most projects like this. Connecting the veroboard to a ZX-connect with coloured ribbon cable will keep wiring simple. As a bonus, not every edge-connect line has to be brought out to the board.

A ZX-connect can be made by cutting a 50 pin 1/10 inch standard edge-connect to length. The key-way tab is made from veroboard. The expansion strip can also be made from two pieces of veroboard sanded to half thickness and glued back to back. An easier approach is to cut the strip from an existing circuit board. Our strip came from Zebra systems but we have seen many ideal bits of fibreglass in our favorite surplus store. The 1/10 inch spacing is very common.

All this is necessary because the EPROMer must be the first device plugged into the expansion port. The Memory Packs alter the high order address lines (to be stackable) and this definitely won't do. Many peripherals are memory mapped in the 8-16 K range and as such are not compatible with this gadget. To be able to use a 64K pack with the EPROMer you must be able to de-select the 8-16 K range. Most have this feature. Any I/O mapped device (e.g., the ZX printer) is cool.

If the expansion strip is not possible for some reason then bring any altered address line (typically A14) directly from inside the computer to IC1. This is low-tech and not too neat, but will still do the trick.

Personality The use of several IC sockets as "personality" strips is recommended but not vital. The idea here is to be able to make modifications to control hookups without soldering. A look at the pinouts for most popular ICs reveals that many lines always connect to the same pins while others change from type to type. Having the top few address lines and most of the control lines jumpered through a row of IC sockets will allow a lot of scope for testing, adjustment and hacking.

The Data lines and A0 to A10 are wired directly to the socket. Solder the control lines as the circuit comes together. WAIT, RD, MREQ go directly from the circuit to the ZX-connect. A good "personality" candidate is WR . While not used in the circuit, it allows the use of static RAMs in the socket.

It is worth noting that no points are awarded for a cramped, tiny board. While keeping all wire lengths as short as possible is always a good idea, never paint yourself into a corner when building around a flexible circuit like this.

Testing and Adjustment

When your board is all assembled and well-checked over for solder bridges, it is time to power it up. Connect it directly to the ZX edge-connect and (with no EPROM) apply the power. If the cursor does not appear re-recheck all wiring.

If it does, try a POKE to anywhere in the block, e.g., POKE 10000,0. A screen flicker at this time tells you that all is well. This is the Z80 "freezing".

If you are unable to get a screen flicker, test the trap by momentarily grounding 3, 4, and 5 of the LS 10 (disconnect them from LS 138 first). A screen flicker now means that the problem is in the block decoding. If you are still having problems, read the section "Gotcha".

But you were careful and you got the screen flicker right away. Centre Rl and R2 and enter the program, except for line 120. The idea here is simple: while 50 milliseconds is hard to time with a stopwatch, 50 seconds is pretty easy. Disconnect the LS138 from the LS10 and (no flicker) RUN the program. This is approximately 70 seconds in SLOW mode. Reconnect the LS138 to the LS10 and re-RUN the program. For 1000 loops the "flicker" should add 50 seconds to the "no flicker" RUN time, giving a total time of 120 seconds. Adjust Rl until this is

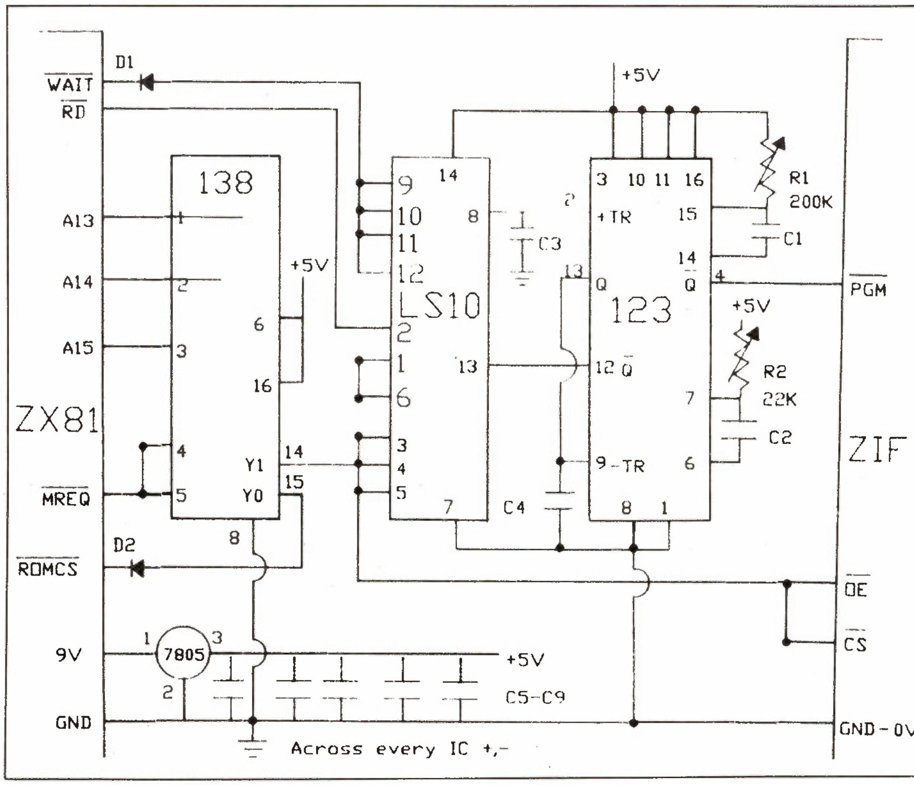


Fig. 2 The complete circuit of the ZX EPROMer

exactly right. Now put a drop of your favourite nail polish on Rl's arm. By now the use of the "personality" strip should be apparent. Without it this setup stage can be a hassle.

R2 is not too critical. If the system "hangs" on the first write, then increase its value. Add line 120, delete line 30, CLEAR the variable area and SAVE the program to tape. DEST and the number of LOOPs will change for different applications, but the theory of operation and the timing set by Rl will remain the same.

Programming

To simplify programming we will be using BASIC. Because the socket is "memory-mapped", PEEK and POKE will give us access to the EPROM. PEEK behaves normally, while POKE is extended by the circuit to meet the 50 millisecond requirement. Remember, POKEs are permanent! To erase any one location you must erase the entire EPROM.

The EPROM can be programmed in many ways or in any order. Most assemblers have a Block Transfer or MOVE function, but usually without verification. The easy solution is to move the object code into a string variable and then type in the minimum BASIC program. With 16K of memory there is still ample room for most assemblers (4K-7K), a few lines of BASIC, and 8K of data in a variable.

To copy an existing EPROM, for example, transfer its contents to an array, save everything to tape, power down, install the blank, reload and then program.

The BASIC given here is only to show how simple it is to program an EPROM. Feel free to include Menus, features, bells and whistles if you like. Your program should:

1. Verify that all locations to be programmed are 255 ($FF) before writing. You can make a one into a zero but not vice versa.
2. Verify all start/finish values with the user.
3. Verify that the correct value has been written. If an error occurs it is not likely that the machine can correct itself.

Vpp drifting or poor socket contacts are the initial suspects so STOP if even one write will not verify.

Mods

A look at the pinouts of these common chips reveals how similar they all are. For example, even if we can't program a 2732 type, it is still possible to READ its contents. The contents of the 2732 can then be put in half of a 2764. When installing the "double 32" connect the highest address line to either 0 or 5 volts depending on which half you want to use. These devices are cheap enough to make this method the easiest way to get around some tricky circuit construction.

```
  5 REM THE ZX EPROMER
        BY D.TURNER + N.DENNIS

 10 REM THIS ASSUMES THAT THE
        CODE TO BE PROGRAMMED
        IS ALREADY STORED IN A
        VARIABLE CALLED D$.

 15 REM IT SHOULD TAKE 50 SEC
        LONGER TO EXECUTE 1000
        LOOPS WITH THE EPROMER
        ACTIVE (SCREEN FLICKER)
        THEN WITHOUT.
 20 REM TYPICAL TIME FOR 1000
        LOOPS OF THE PROGRAM
        IS 70 SECONDS.
        THIS TIME DOES NOT
        INCLUDE LINE 120 WHICH
        WOULD STOP THE TEST.

 25 REM LINE 30 IS A DUMMY FOR
        TESTING ONLY. DELETE IT
        AFTER TIMING OR IT WILL
        DESTROY THE DATA IN D$.

 30 DIM D$(1000)
 50 REM
 90 LET DEST=8192
 99 SLOW
100 FOR I=1 TO 1000
110 POKE DEST+I,CODE D$(I)
120 IF PEEK (DEST+I)<>CODE D$(I
) THEN GOTO 999
150 NEXT I
200 STOP
999 PRINT "VERIFICATION ERROR A
T ";I
```

Fig. 3 A simple BASIC listing for programming and compatible EPROM.

Gotcha

The most common problem with project or kit failure is faulty soldering. Before powering up, go over the entire board with a magnifying glass. Tiny wisps of solder, while barely visible to the eye, can cause expensive damage. Going over the board thoroughly is time well spent. If your project will not work, examine each section independently. Remove the other ICs from the board, and using the "How it Works" section, trace the circuit's operation. With only the LS138 installed, PEEKing 10000 should return 255. Any other result means that the ROM echo is not suppressed; therefore, re-check the 138. The trap and the timer can be checked statically, making them much simpler to debug.

The next most likely trouble source is the ZIF socket. A good socket will cost half of the total cost of the project, and is worth every cent. The cheapies do not guarantee the good connection that must be maintained.

When programming, bear several things in mind. The 21 volts needed to program an EPROM is *fatal* to all other TTL circuits. If this voltage varies by more than a half a volt either way, the write may not take. It is important that the chosen supply can deliver at least 50mA with good regulation. An on-card 5 volt regulator and a decoupling capacitor across every IC also helps maintain the accuracy needed for programming. These capacitors must not be eliminated or you will be plagued with unpredictable results.

PARTS LIST

I.C.s

I.C.1 ....74LS 138 block decoder
I.C.2 ....74LS 10 triple Nand
I.C.3 ....74LS 123 dual timer
I.C.4 ....7805 voltage regulator

Resistors, Capacitors

R1 ....200K 10 turn mini-trim type pot.
R2 ....22K trim pot.
C1 ....1.0 uF tantalum cap.
C2 ....500 pF cap.
C3, C4 ....005 uF cap
C5-C9 ....1 uF (decoupling)

Misc.

D1, D2 .....1N4009 or approx. equivalent diodes
ZX edge connect and expansion strip
I.C. sockets (4-5 with personality)
Veroboard, Ribbon cable
A GOOD ZIP (Zero Insertion Force) Socket
21 Volt power supply.........2 9 Volt and 2 1.5 Volt (AA) batteries will work just fine if fresh.

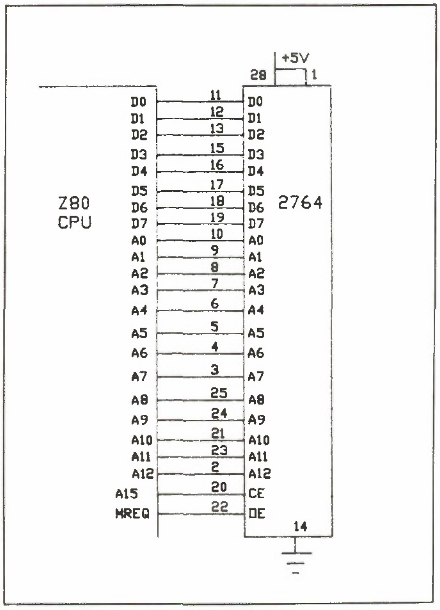


Fig. 6 Connection of a 2764 ROM provides 8K of program data.

only be accessed in the 8000H-87FFH address range.

More Memory

To connect more than one RAM device to the CPU, some form of address decoding is required. Fig. 10 shows a complete circuit diagram for connecting four 2716 EPROMs and four 2128 RAM chips. This circuit provides the CPU with 8K of ROM and 8K of RAM; ample storage for most small projects. The ROM is decoded between the 0000H-1FFFH address range and the RAM is decoded between 2000H-3FFFH.

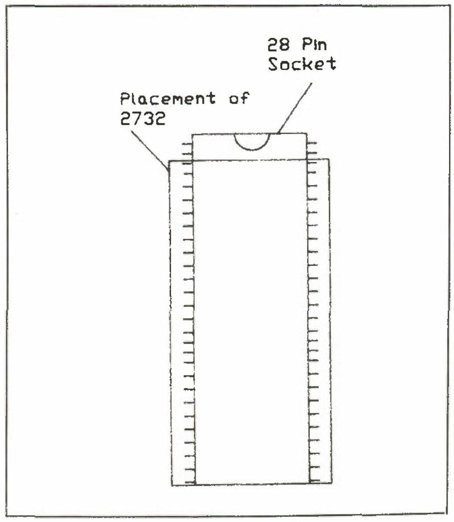


Fig. 7 A 28 pin socket can be used to house either a 2732 or a 2764 EPROM device without any further modification.

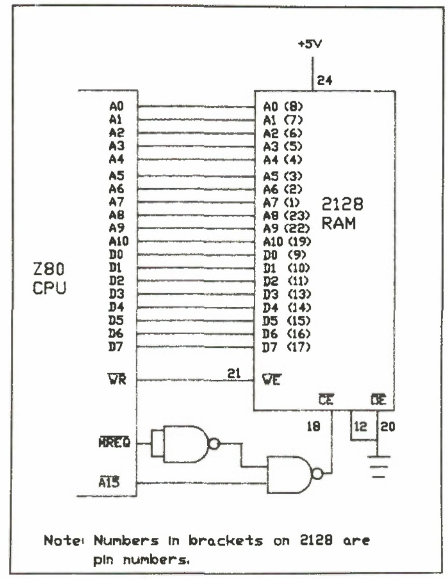


Fig. 9 Simple connection of the 2128 RAM to the Z80.

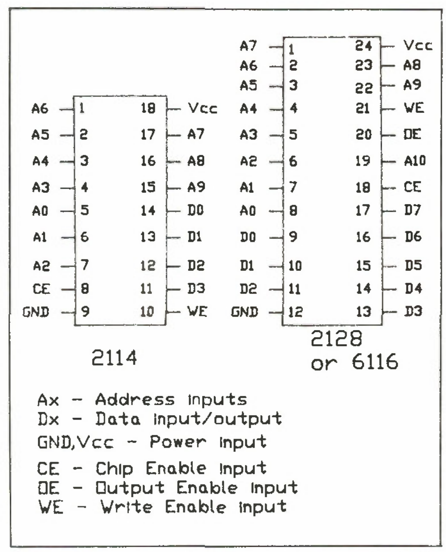


Fig. 8 Pinouts for two types of static RAM.

If a jumper is used on pin 21 of each IC to select either 5V or the Z80 WR signal, the circuit in Fig. 10 is not limited to 4 ROMs and 4 RAMs. By selecting a 5V connection, an EPROM can be used in the socket. Or, by selecting a Z80 WR signal connection, a RAM can be placed in the socket. When using this method, 8 sockets are provided on the PCB for either ROM or RAM devices. If more or less RAM is required, this can be done just by selecting the proper jumper for the socket. *To be continued next month.*

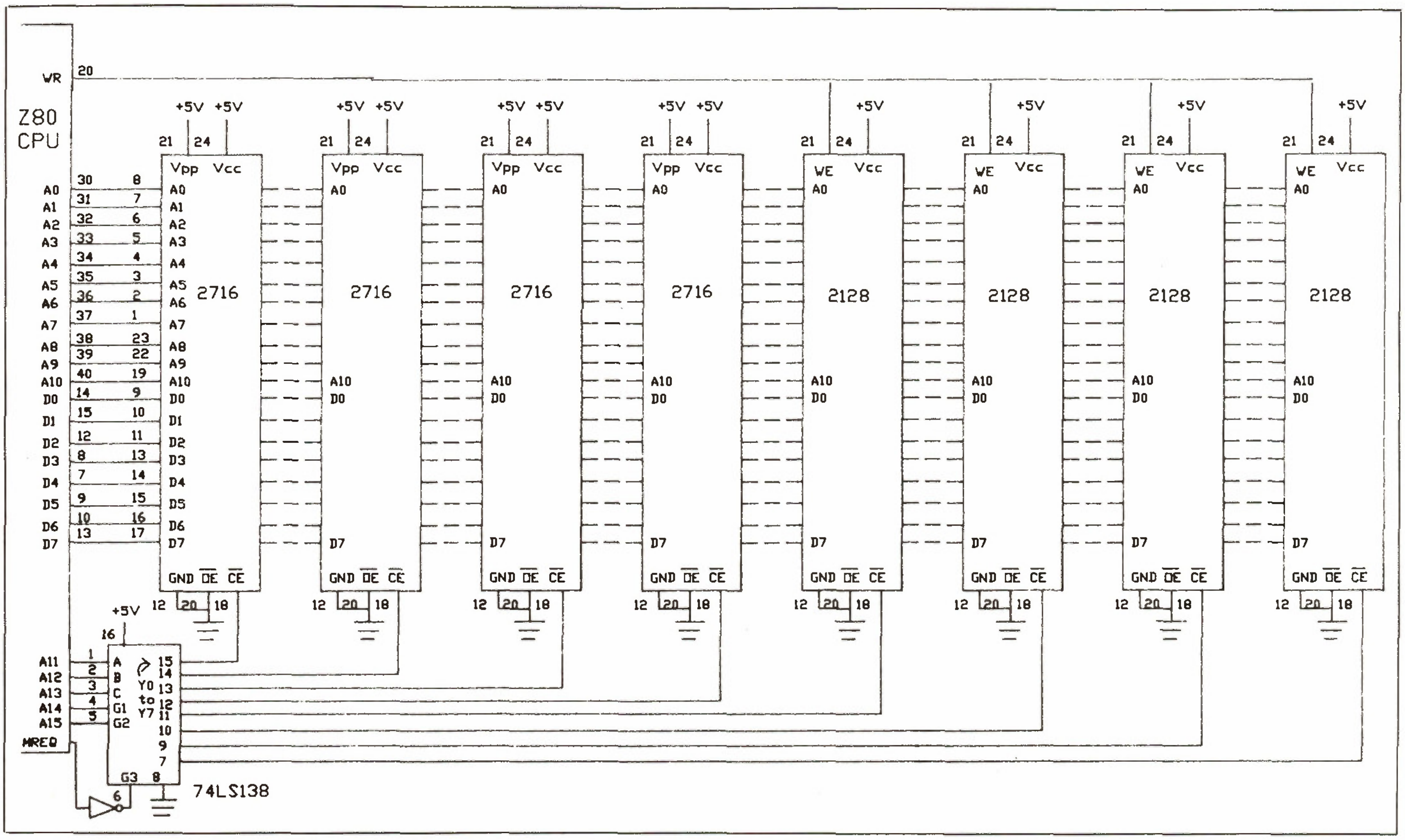


Fig. 10 Complete diagram to connect 4 ROM and 4 RAM devices to the Z80.

■

Designer's Notebook

Using Fibre Optics

Copper wire may become extinct as a conductor as new techniques simplify working with fibre optics.

By L.N. Owen

It's common knowledge that the phone company and similar organizations now use optical fibres as a transmission medium instead of conventional wiring. This comparatively new technology has been refined to provide a highly efficient system for long-distance telecommunications, but as yet has not been used widely by the experimenter and hobbyist. This is almost certainly because of the high cost and the scale of typical applications (10km + transmission lines), but like most new technologies it has produced a number of spin-offs, some of which do fall within the scope of the humble experimenter.

The main reason for the high cost of transmission systems is the need to use coherent light; that is, light which is of a specific phase and wavelength. To achieve this, and because of the need for a concentration of high energy to overcome long-distance transmission losses, lasers are used. Obviously, if we can do without the laser, things become much less expensive. Using a much lower energy source, and one which produces incoherent (random) light, causes a loss in the ability to transmit over distances greater that 50m, but we open a very broad field of applications.

In all the sample circuits given here, the incoherent light source is a narrow-beam, high-intensity, red LED. These can be purchased ready-mounted into fibre optic hardware, or bought separately and then mounted and polished for a specific application. The first method is recommended for the less-experienced.

Techniques

Optical fibres can be used in one of three ways: illumination, data transmission, and sensing.

Taking the simplest case first, fibres can be used very effectively as illuminators, the principle being that of providing a light source that can be channeled where you will. Any form of optical fibre can be used for this purpose; in fact, several types of heavy-gauge fishing line have been used for this purpose for short distances. Many cables can be used from the same source, providing an efficient means of illumination. Typical examples are instrument panels, microscopes, meters, switches, logos, etc.

One of the simplest applications of fibres as sensory devices is in position detection (Fig. 1a). A similar system using reflected light could be equally well employed (Fig. 1b). The same system can be extended easily to counting applications, using pulse counting circuitry, and also to some forms of quality control. In the reflective mode, there is a threshold of surface finish in order for the light to be reflected at sufficient intensity, and in the direct mode, there are intensity thresholds depending on the colour density or opacity of the moving object (e.g., testing paper quality).

Taking the principle a stage further, we can apply it to a shaft encoder in both reflective and direct modes (Fig. 2). Encoders are also being mechanically coupled to measure pressure. Attach fins to another encoded disk, and you have a form of flow measurement.

Circuits

The purpose of this section is to simply present a few tested emitter/detector circuits as a guide to further experimentation. Design usually revolves around input sensitivity and speed of serial transmis-

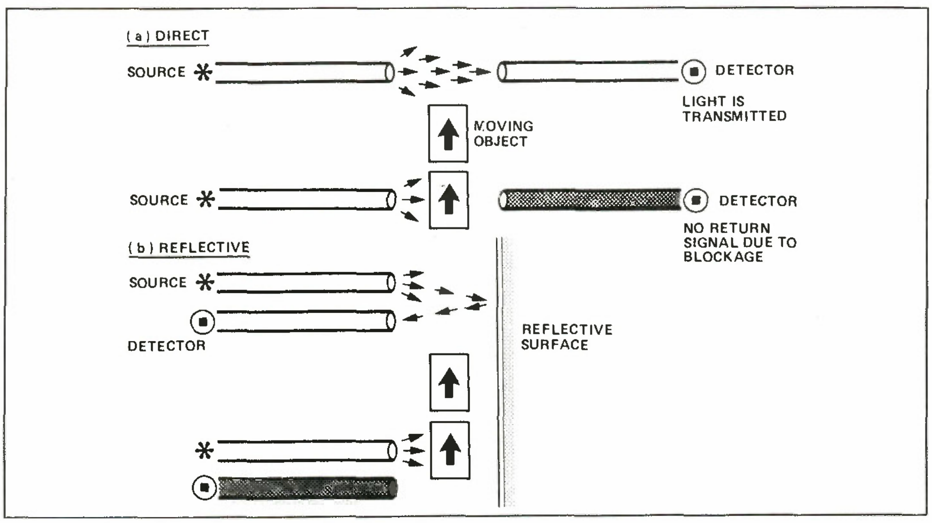


Fig. 1 Position detection using optical fibres.

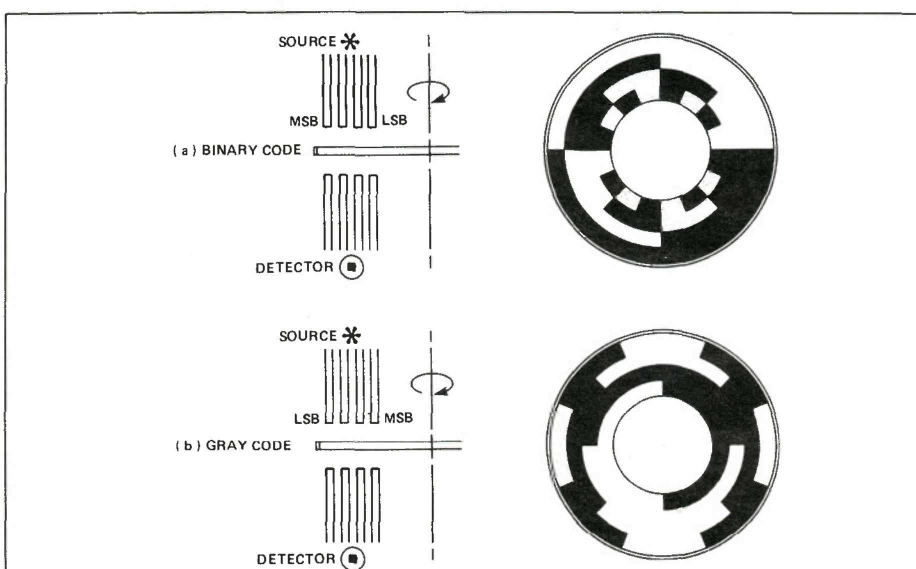


Fig. 2 Shaft encoders and flow meters.

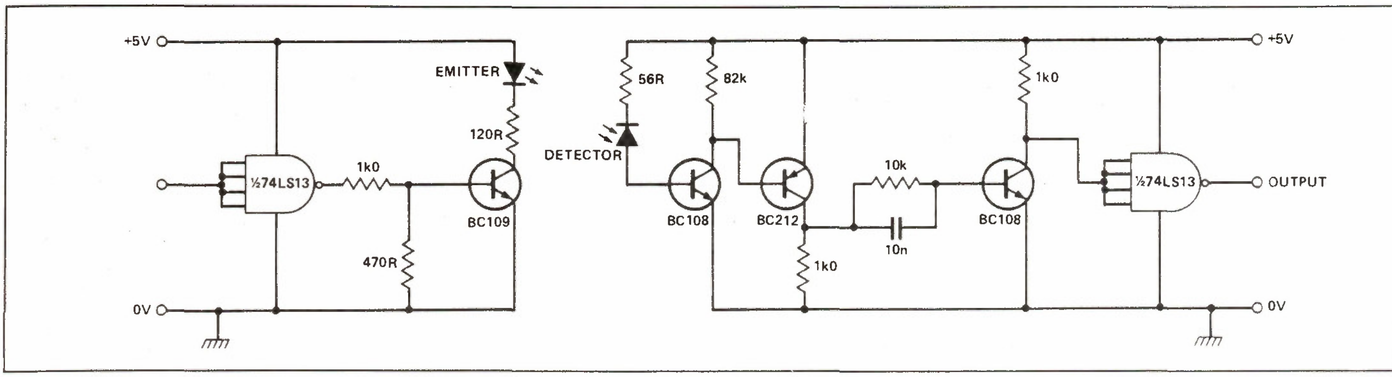


Fig. 3 TTL compatible link.

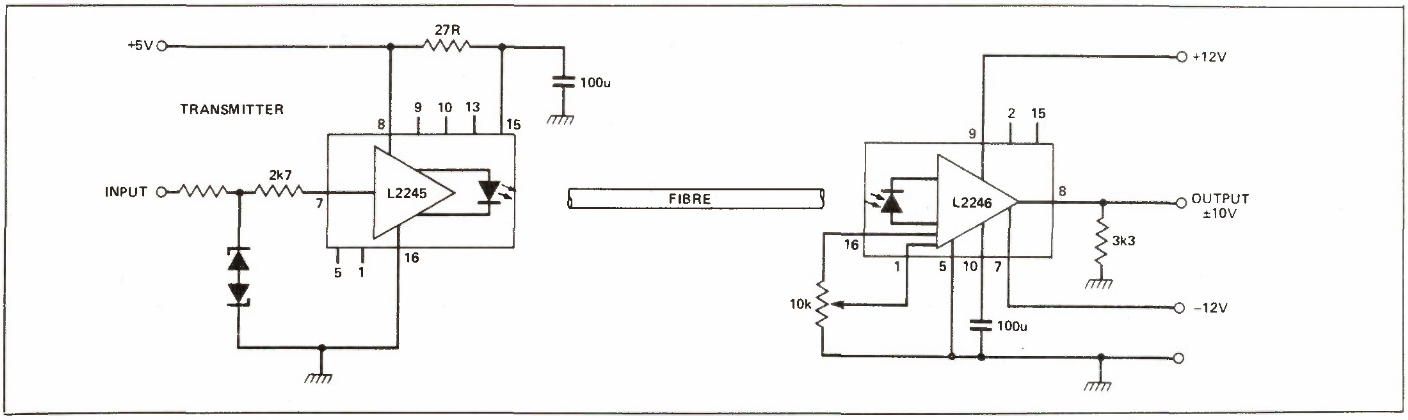


Fig. 4 RS232 replacement link.

sion; however, various other factors such as analog linearity, fitting, etc., do creep in.

The first circuit, Fig. 3, is one of the most useful, since it provides a medium-distance TTL-compatible link. Using standard polymer cable, this circuit can transmit up to 200Kbits/sec over a distance of 10m.

Fig. 4 is a standard transmission line, the RS232. The use of fibres eliminates all the noise problems, twisted pairs, and emitting loops. The modules can be PCB mounted, providing convenient computer links up to 200m.

The circuit of Fig. 4 can be modified to become a TTL or CMOS transmission system. A 1489 IC (Motorola, etc) acts as a current buffer and also interfaces the RS232 signal to TTL.

An audio frequency transmitter can be made using a simple op amp circuit with a gain of about 60 driving an NPN transistor with the LED in its collector circuit. A 100k pot may be used in series with the NPN base to adjust offset.

If power consumption is a problem with transmitters, then a series-driven emitter circuit is required (Fig. 5a). This configuration is TTL compatible and gives high brightness. If the current step is so high that supply line modulation is occurring, then a shunt-driven emitter can be used (Fig. 5b). The power consumption is greater, but the current step is reduced.

Receiver design depends on which parameter you want to measure, and whether the signal is digital or analog.

Fig. 6 is an audio frequency receiver compatible with the transmitter of Fig. 5. In its basic form it is a simple one transistor amplifier driven by a photodiode.. Obviously there are many variations on this theme: DC/AC amplifiers, A/D converters, log amps, etc.

Finally, for the keen and wealthy, there are several optical communications receiver hybrid circuits available. These provide most of the reception functions on the chip, the user being able to control the sensitivity and operating speed. One such chip is the LH0082 (National). This requires only a photodiode and a stable operating supply (Fig. 7a). Add a few minor components and the device can function over a range of 3nW input sensitivity at 100Kbits/sec to 300nW at 15Mbits/sec. Additionally, it can operate in an analog mode (Fig. 7b).

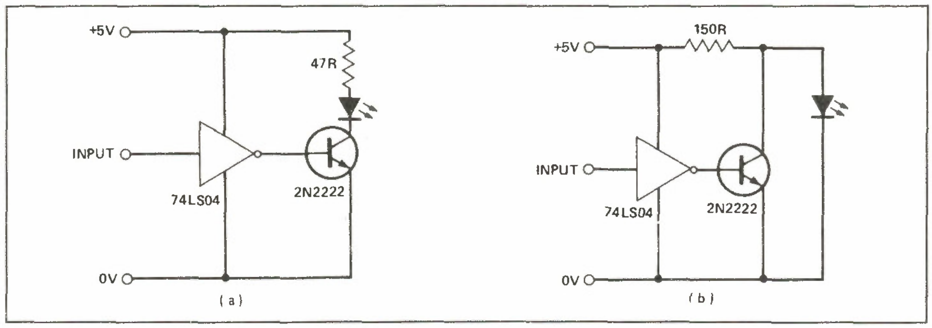


Fig. 5 Series and shunt driven transmitters.

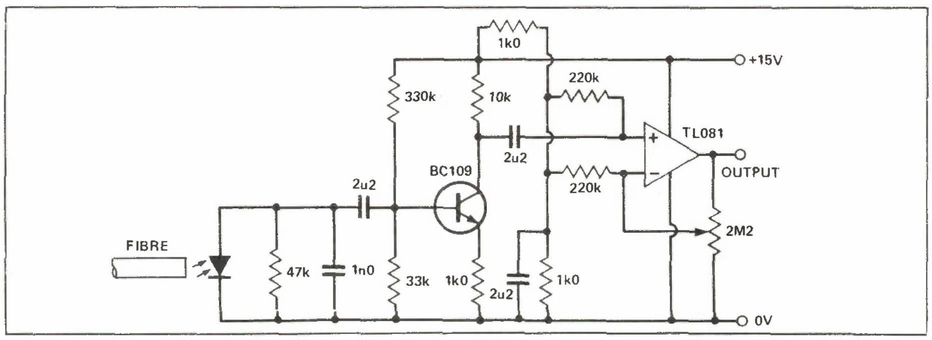


Fig. 6 Audio frequency receiver.

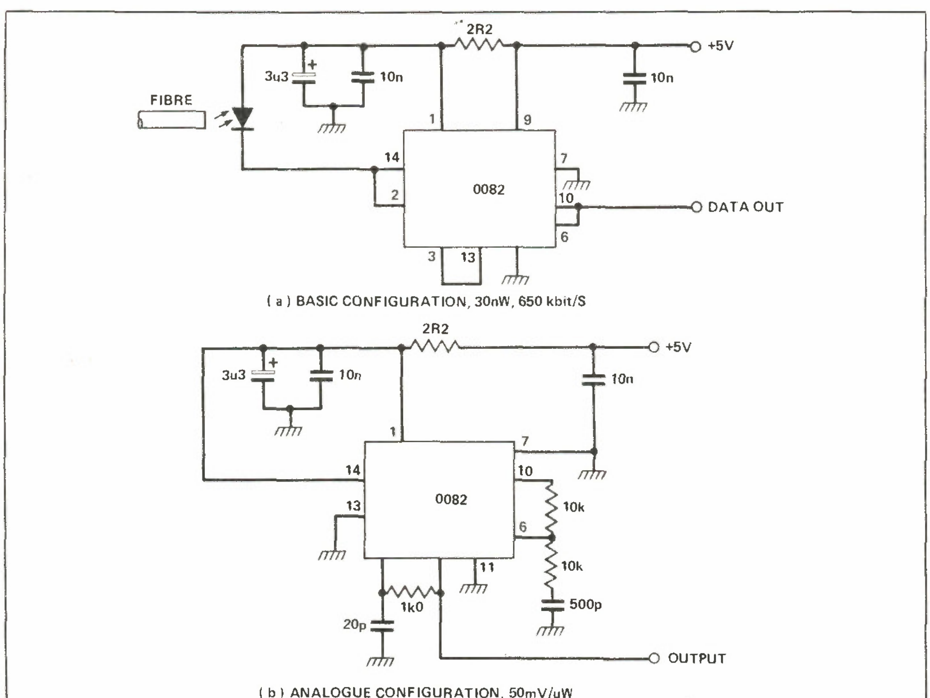
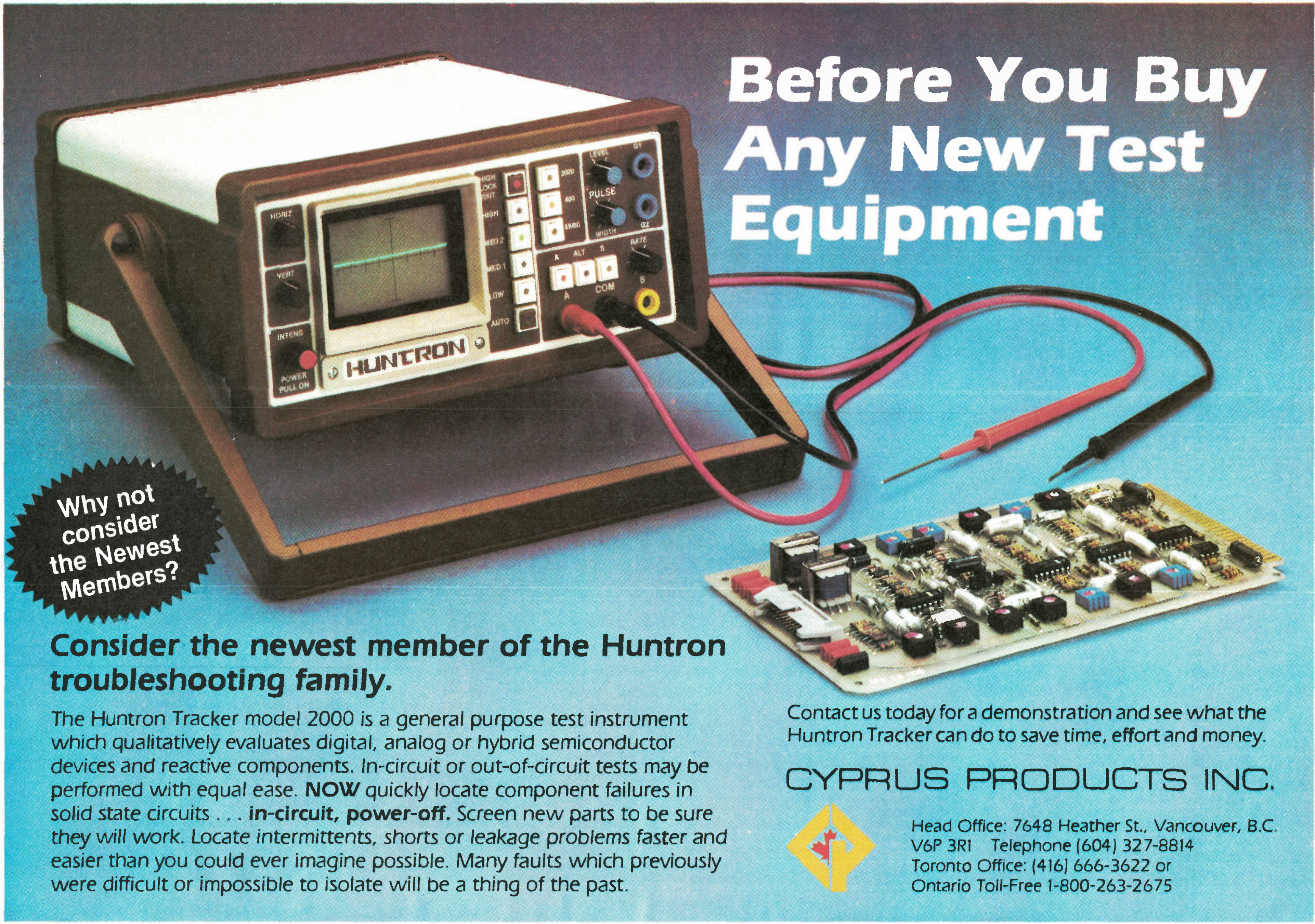
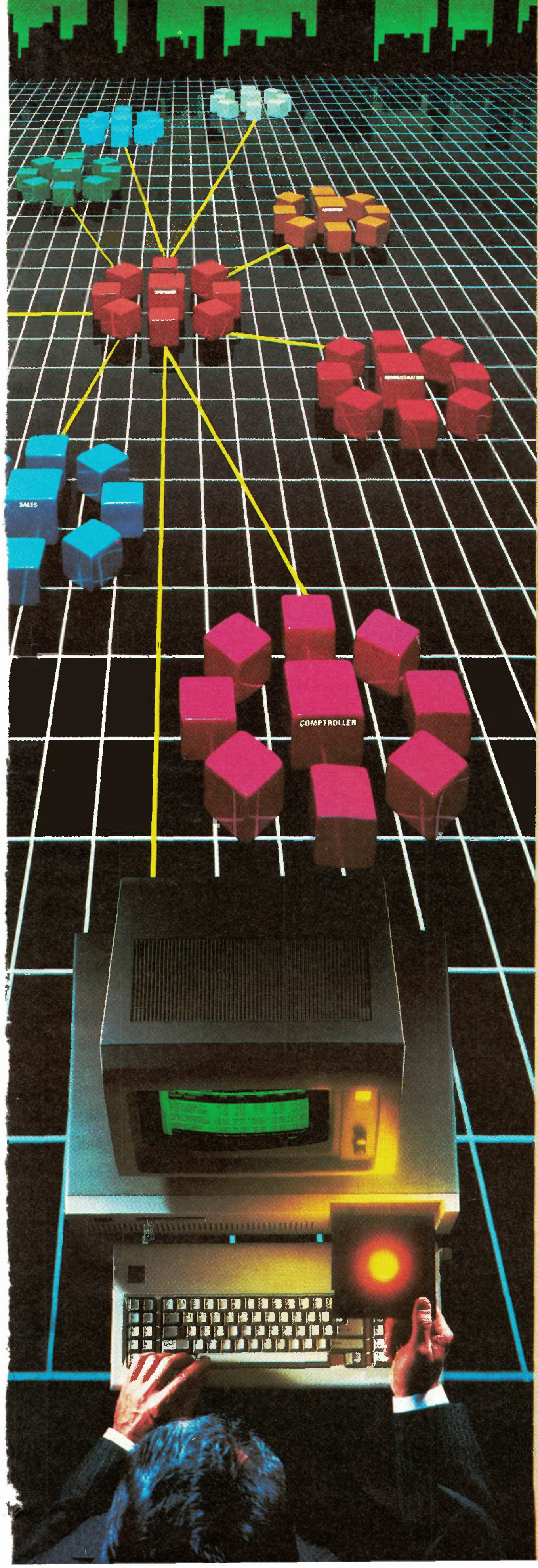


Fig. 7 Optical communication receiver.



Circle No. 30 on Reader Service Card



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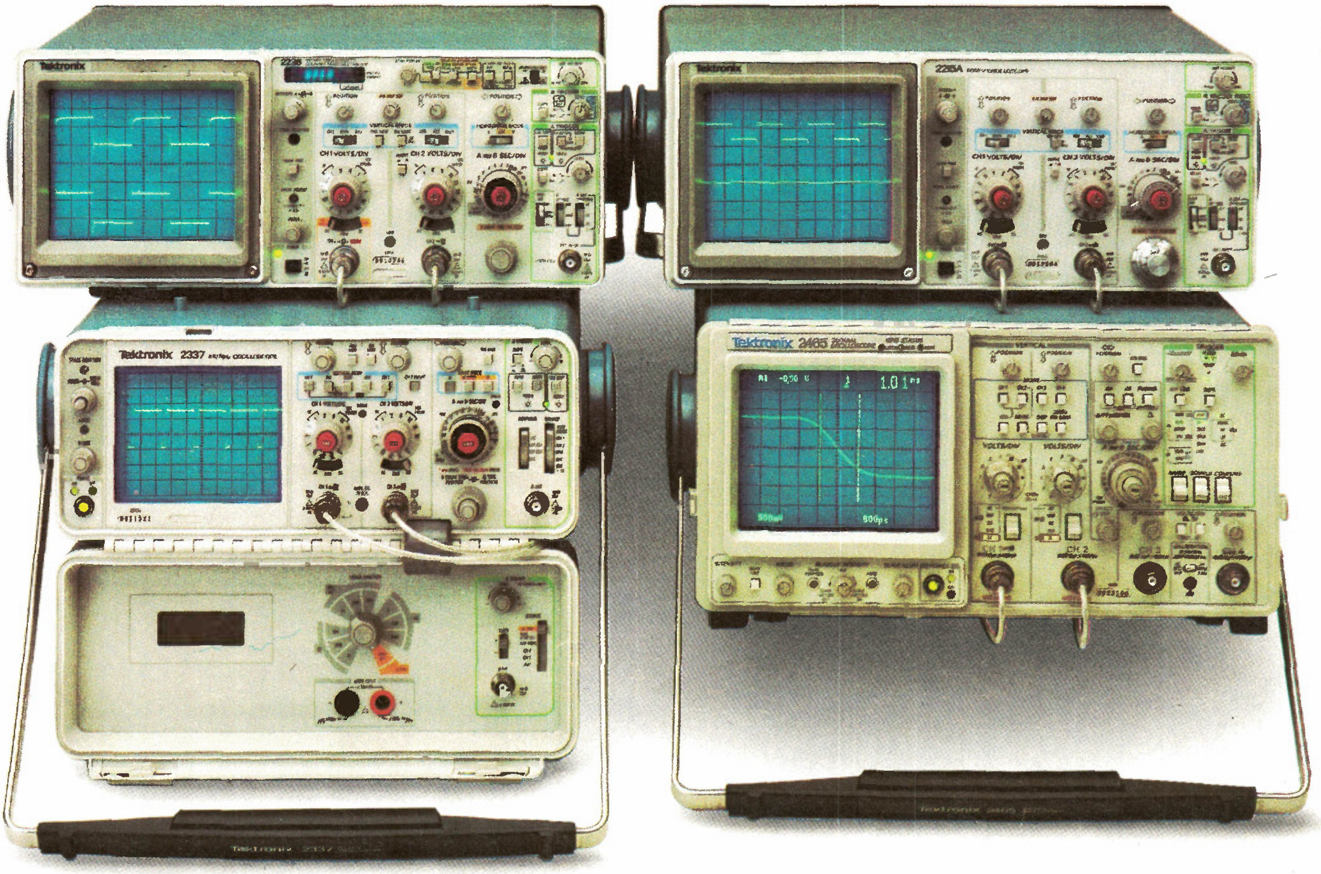

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