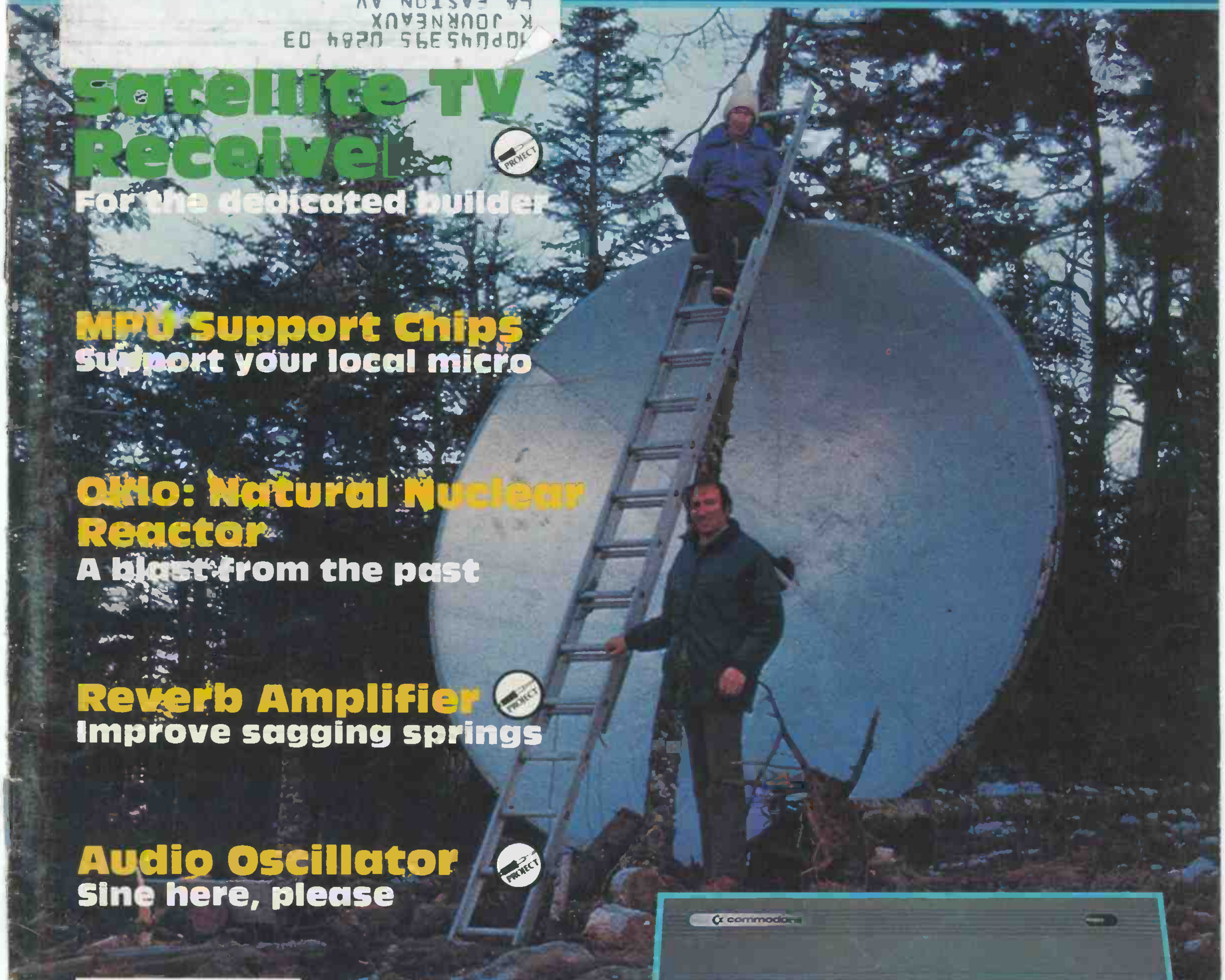
ETI for Electronics & Computing Enthusiasts

$2.25
MM70924

Bomb Drop Sound Effects

Electronics Today

July 1983



Satellite TV Receiver
PROJECT
For the dedicated builder

MPU Support Chips
Support your local micro

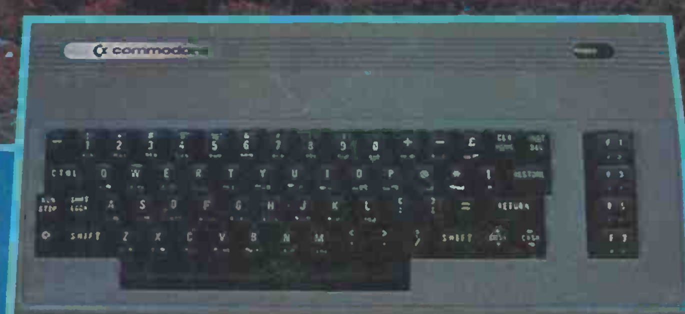
Oklo: Natural Nuclear Reactor
A blast from the past

Reverb Amplifier
PROJECT
Improve sagging springs

Audio Oscillator
PROJECT
Sine here, please

0 57438 70924 07

Commodore 64 Review
CBM's popular computer



Circle No. 7 on Reader Service Card.

The Magazine for Electronics & Computing Enthusiasts

ETI Electronics Today INTERNATIONAL

July 1983
Vol. 7 No. 7
ISSN 0703-8984

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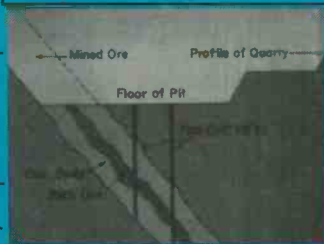
Features

Our Cover

Author Ron Coles poses in front of the antenna used in this month's Satellite TV receiver project; see page 13. Photo courtesey of Ron Coles. At the bottom of the cover, the Commodore 64. See page 43.



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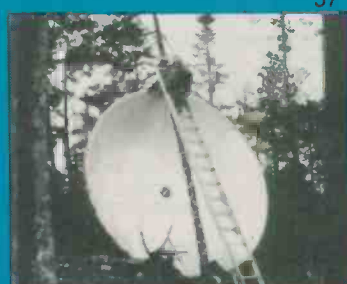
13

Projects

Columns, News and Information

ADVERTISERS' INDEX

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

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

PCB Suppliers
ETI magazine does NOT supply PCBs or kits but we do issue manufacturing permits for companies to manufacture boards and kits to our designs. Contact the following companies when ordering boards.
Please note we do not keep track of what is available from who so please don't contact us for information on PCBs and kits. Similarly do not ask PCB suppliers for help with projects.

K.S.K. Associates, P.O. Box 266, Milton, Ont. L9T 4N9.
B—C—D Electronics, P.O. Box 6326, Stn. F, Hamilton, Ont., L9C 6L9.
Wentworth Electronics, R.R.No 1, Waterdown, Ont., L0R 2H0.
Danocinths Inc., P.O. Box 261, Westland MI 48185, USA.
Arkon Electronics Ltd., 409 Queen Street W., Toronto, Ont., M5V 2A5.
Beyer & Martin Electronic Ltd., 2 Jodi Ave., Unit C, Downsview, Ontario M3N 1H1.
Spectrum Electronics, 14 Knightswood Crescent, Brantford, Ontario M3R 7E6.

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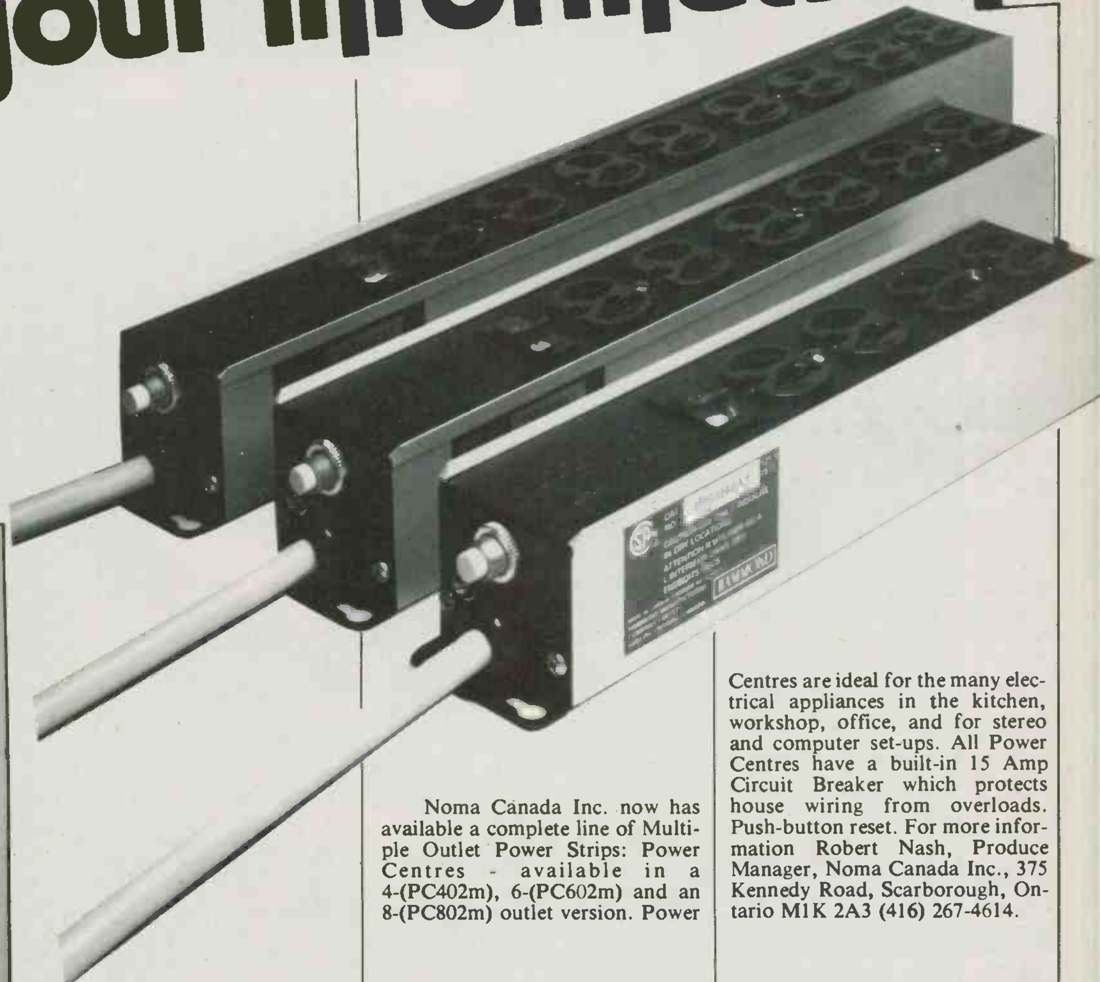
Second Class Mail Registration No.3955. Mailing address for subscription orders, undeliverable copies and change of address notice is:
Electronics Today International, Unit 6, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1.

for your information

Power Bars

Hammond Power Bars feature an attractive, contemporary, brushed-aluminum case with matte black receptacle housing. Reduced in size, 11, 14 and 17" in length, standard models are available in 4, 6 or 8 receptacle sizes, with either 6 or 15 foot cord, and with or without lighted, rocker type on/off switch. Also available are 4 and 6 foot long power bars, each with 8 receptacles. All power bars are CSA approved and are fitted with 120 VAC, 15 A circuit breaker. From Hammond Mfg., 394 Edinburgh Rd., Guelph, Ont. N1H 1E5 (519) 822-2960.



Noma Canada Inc. now has available a complete line of Multiple Outlet Power Strips: Power Centres - available in a 4-(PC402m), 6-(PC602m) and an 8-(PC802m) outlet version. Power Centres are ideal for the many electrical appliances in the kitchen, workshop, office, and for stereo and computer set-ups. All Power Centres have a built-in 15 Amp Circuit Breaker which protects house wiring from overloads. Push-button reset. For more information Robert Nash, Produce Manager, Noma Canada Inc., 375 Kennedy Road, Scarborough, Ontario M1K 2A3 (416) 267-4614.

Calibration Bath

A new calibration bath, claimed to be the first of its kind to offer the user an infinitely-variable set point reference below ambient temperature, is now available from Isothermal Technology Ltd. of Southport, Merseyside PR9 9AG, England. The new unit accommodates either 8 x 8mm diameter probes or a single 35mm diameter probe. Using the latest solid-state technology, the temperature of the metal-block calibration bath (which contains no liquids) can be set to any desired value between +10°C and −10°C with an accuracy of ±0.1°C. A 10-turn potentiometer mounted on the front panel of the unit enables the temperature of the block to be set. It is claimed that the unit reaches the set temperature within 15 minutes.

The manufacturers are also looking for a Canadian distributor of their products.

Further information from: Isothermal Technology Limited, Pine Grove, Southport, Merseyside PR9 9AG England.

Hewlett-Packard (Canada) Ltd. has reached agreement with Panacom Automation Inc. of Scarborough, Ontario to acquire the privately held industrial control products company in its entirety in a cash transaction. Terms and purchase price were not disclosed.

The acquisition, which is subject to approval by the Foreign Investment Review Agency, marks HP's first step in establishing a manufacturing operation in Canada. HP said it plans to step up its manufacturing presence in Canada significantly in the coming years.

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

Sinclair ZX81 Computer Etc . . .

Assembled $85.00

ZX81

The ZX81's advanced capability.
The ZX81 uses the same fast microprocessor (Z80A), but incorporates a new, more powerful 8K BASIC ROM — the "trained intelligence" of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays. And the ZX81 incorporates other operation refinements — the facility to load and save named programs on cassette, or to select a program off a cassette through the keyboard.

New, improved specification.
*Unique 'one-touch' key word entry: eliminates a great deal of tiresome typing. Key words (PRINT, LIST, RUN, etc.) have their own single-key entry. *Unique syntax-check and report codes identify programming errors immediately. *Full range of mathematical and scientific functions accurate to eight decimal places. *Graph-drawing and animated-display facilities. *Multi-dimensional string and numeric arrays. *Up to 26 FOR/NEXT loops. *Randomize function. *Programmable in machine code. *Cassette LOAD and SAVE with named programs. *1K-byte RAM expandable to 16K. *Full editing facilities. *Able to drive the new Sinclair ZX Printer (to be available shortly).

If you own a ZX80...
The new 8K BASIC ROM as used in the ZX81 is available as a drop-in replacement chip. (Complete with new keyboard template and operating manual). With the exception of animated graphics, all the advanced features of the ZX81 are now available on your ZX80 — including the ability to drive the Sinclair ZX Printer.

Sinclair's new 8K Extended Basic offers features found only on computers costing three or four times as much. *Continuous display, including moving graphics. *Multi-dimensional string and numerical arrays. *Math and scientific functions accurate to 8 decimals. *Unique one touch entry of "key words" (i.e. basic and system commands). *Automatic syntax error detection. *Randomize function. *Built-in interface for ZX Printer. *Connects to standard TV and cassette recorder. *164 page manual included. *Power supply (9V at 650 ma) optional for $14.95. *1K of memory is included.

$149.00

Designed exclusively for use with the ZX81 (and ZX80 with 8K basic ROM), the printer offers full alphanumerics and highly sophisticated graphics. COPY command prints out exactly what is on screen. At last you can have a hard copy of your program listing and results. Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch. Connects to rear of ZX81 — using a stackable connector so you can use a RAM pack as well. A 65 ft paper roll, instructions included. Requires 9 volts, 1.2 amp power supply (option extra).

Power Supply (500 mA) $9.95
Power Supply (650 mA) $14.95
Power Supply (1 Amp) $19.95

Etc . . .

MEMOPAK 64K MEMORY EXTENSION

The 64K Memopak extends the memory of the ZX81 by 56K, and with the ZX81 gives 64K, which is neither switched nor paged and is directly addressable. The unit is user transparent and accepts commands such as 10 DIM A(9000).
Breakdown of memory areas . . . 0-8K Sinclair ROM. 8-16K-This area can be used to hold machine code for communication between programmes or peripherals. 16-64K-A straight 48K for normal BASIC use. **$249.95**

MEMOPAK 32K $179.00 and 16K $109.50 MEMORY EXTENSIONS

These two packs extend and complete the Memotech RAM range (for the time being!) A notable feature of the 32K pack is that it will run in tandem with the Sinclair 16K memory extension to give 48K RAM total.

Memopak ...

MEMOPAK CENTRONICS TYPE PARALLEL PRINTER INTERFACE

Main Features — ● Interfaces ZX81 and parallel printers of the Centronics type ● Enables use of a range of dot matrix and daisy wheel printers with ZX81 ● Compatible with ZX81 Basic, prints from LLIST, LPRINT and COPY ● Contains firmware to convert ZX81 characters to ASCII code ● Gives lower-case characters from ZX81 inverse character set **$159.95**

POWER SUPPLY	500ma	$14.95
POWER SUPPLY	1A	$19.95 (FOR PRINTER)

MEMOPAK HIGH RES GRAPHICS PACK

HRG Main Features — ● Fully programmable Hi-Res (192 x 248 pixels) ● Video page is both memory and bit mapped and can be located anywhere in RAM ● Number of Video pages is limited only by RAM size (each takes about 6.5K RAM) ● Instant inverse video on/off gives flashing characters ● Video pages can be superimposed ● Video page access is similar to Basic plot/unplot commands ● Contains 2K EPROM monitor with full range of graphics subroutines controlled by machine code or USR function **$199.95**

Books

COMPLETE ZX81 BASIC COURSE - Inc. 2 tapes	39.95
NOT ONLY 30 PROGRAMS: 1K	16.95
MACHINE LANGUAGE MADE SIMPLE	19.95
ZX81 ROM DISASSEMBLY PART A & PART B	24.95
UNDERSTANDING ZX81 ROM	19.95
T/S 1000: PROGRAMS, GAMES and GRAPHICS	16.95
LEARNING T/S BASIC	23.95
THE BASIC HANDBOOK	29.95
49 EXPLODING GAMES	16.95
COMPUTER FOR KITS SINCLAIR EDITION	8.95
MASTERING MACHINE CODE ON YOUR ZX81	24.95
T/S 1000 USERS GUIDE (Vol 1)	16.95
EXPLORERS GUIDE TO THE ZX81	16.95
ZX81 POCKET BOOK	16.95
GETAWAY GUIDE	16.95
GETTING AQUAINTED WITH YOUR ZX81	16.95

Hardware

ZX81 Ass.	99.95
ZX Print	149.00
64K - RAM (Memotech)	249.95
32K RAM (Memotech)	179.00
16K RAM (Memotech)	89.00
16K RAM (Sinclair)	59.00
16K RAM (Kit no PC board)	49.00
Power Supply (650 M.A.)	14.95
Power Supply (1 AMP)	19.95
Keyboard (uncased) - 47 Keys, Assembled no soldering req.	119.95
Metal Case for above	29.95
Memopak High Res. Graphics Pack	199.95
Memopak Centronics Type Parallel Printer Interface	159.95
Memopak ZX81 Keyboard	119.00
Memo Calc	79.95

* Interface for any serial printer & 4 cassette recorders; Includes plugs, cords and a detailed manual.

CP-100-A Seikosha Graphic Printer

$450

- 5x7 Dot Matrix
- 8 Bit ASCII
- Parallel Printer
- 80 Columns

Interface Cards & Cable For Apple II $119.00
Memotec Interface for Sinclair $199.00 Cable $35.00

Electrohome Monitors & Accessories

EDM926/B&W 9" Black & White monitor	$159.50
EDM926/P31 9" P31 Green Monitor	$169.50
EDM1226/B&W 12" Black & White Monitor	$179.50
EDM1226/P31 12" P31 Green Monitor	$189.50
ECM1302-1 13" Color RGB Monitor	$450.00
ECM1302-2 13" Color RGB Monitor Hi Rez.	$599.00
I-1302 NTSC Interface for ECM1302 for Apple II Computers (1 year warranty from Electrohome)	$ 69.50
MP-1302-APL RGB Card for Apple II or Franklin 100	$199.00
Zenith 12" Green	$165.00
A MDEC-1 Colour 13"	$475.00

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A Professional Computer For the Price of a Personal Computer.

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- Controller card capable to handle 4 DS/DD Drives
- CP/M (North Star)
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- B/W Graphics 160 Horz. x 72 Vert.
- 256 Colours
- Full keyboard with numerical keypad
- Real Time Clock

- Runs on Z80 Based CP/M
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- Serial Paralell O/P

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Fully Assembled 100% Soft & Hardware Apple™II plus Compatible Computer . . . . . 695.00 (AMB-1 + Keyboard + Case + Power Supply and Speaker, Fully Assembled & Tested)

Same Computer with 1 Drive, 1 Controller and 12" Green Electrohome Monitor $1300.00

WOWIE! LOOK AT THIS! 6502 BOARDS & ACCESSORIES

ABB-2 $55.00
Has on-board provision for 64K RAM 80x24 Video, Floppy Controller and 6 slots.

2114L-3 Low power RAM $2.25

AMB-1 $325.00
Mother Board, APPLE II Compatible, Assembled & Tested c/w Basic ROMS, 48K RAM, Made in Japan

ABB-1 $ 45.00
APPLE II Compatible, Motherboard (no components)

6502 Board Kit $250.00
Includes all parts

PDA-232C $99.00
Serial Interface RS232C Card for APPLE II c/w Cable & Manual, Three Operating Modes: I/O, Terminal, Remote

AEB-1 $149.00
EPROM Burner Card

AIC-1 $99.00
Integer Card

AEC-1 $99.00
80 Column Card

AZC-1 $99.00
Z80A (CPM) Card

APC-1 $99.00
Parallel Printer Card

ASC-1 $99.00
Serial Printer Card

ALC-1 $79.00
16K RAM (Language) Card

AGC-1 $149.00
Graphics Parallel Printer Card

AKB-1 $109.95
Keyboard; replacement for APPLE II

AC-1 $85.00
Beige APPLE II Case (No keyboard)

APS-1 $ 99.00
Switching Power Supply for APPLE II; +5V @ 5 amps, +12V @ 1 amp, −5V @ 1 amp, −12V @ 1 amp

APS-2 $109.00
Switching Power Supply for APPLE II; +5V @ 3 amps, +12V @ 2 amps, −5V @ ½ amp, −12V @ ½ amp; c/w on-off switch & connecting wires

AAA-2
Disc Drive, 5¼", APPLE II Compatible, Excluding Controller Card $375.00
with controller $425.00

ADC-1 $75.00
Disc Drive Controller Card for two drives; Apple II Compatible

APPLE II is a registered trade mark of Apple Computer Inc.

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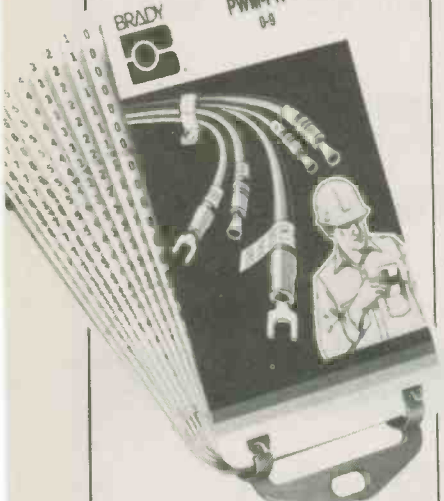
Wire Marker Book

The improved Porta-Pack II features a new comb design for instant page replacement. This extra convenience will save wasted markers. The book also offers a wide range of marker legends to meet practically all wire marking needs. Stock legends up to three digits long permit wires to be identified with a single marker, in a single wrap, instead of using three markers. The new Porta-Pack II



contains 450 full sized (38 mm) or 900 half-sized (19 mm) markers per book, plus matching terminal markers. For additional information, contact John Standish, W. H. Brady Inc., 10 Marmac Drive, Rexdale, Ontario M9W 1E6. (416) 675-2112.

Colour Computer

The TRS-80 MC-10 Micro Colour Computer (26-3011) is available at Radio Shack Computer Centres, all Radio Shack stores and participating Authorized Sales Centres (Dealers) for $199.95. The MC-10 comes with 4K bytes of RAM, a serial port for line printer or telephone modem, a cassette recorder port, built-in RF modulator for use with a standard television set, 47 key keyboard, AC power pack, and a switch that allows use of the computer or television without swapping cables.

A 16K memory module (26-3013, $69.95) can be user-installed to increase the MC-10 memory to 20K bytes. The memory module is available beginning August, 1983. The MC-10 utilitizes Microsoft Colour BASIC, similar to the Colour BASIC in Radio Shack's standard Colour Computer. Many BASIC programs available for the standard Colour Computer can be keyed into and run on the MC-10 with only minor modification. Programming can be simplified by holding down the control key, allowing single-keystroke entry of commands and low-resolution colour graphics.

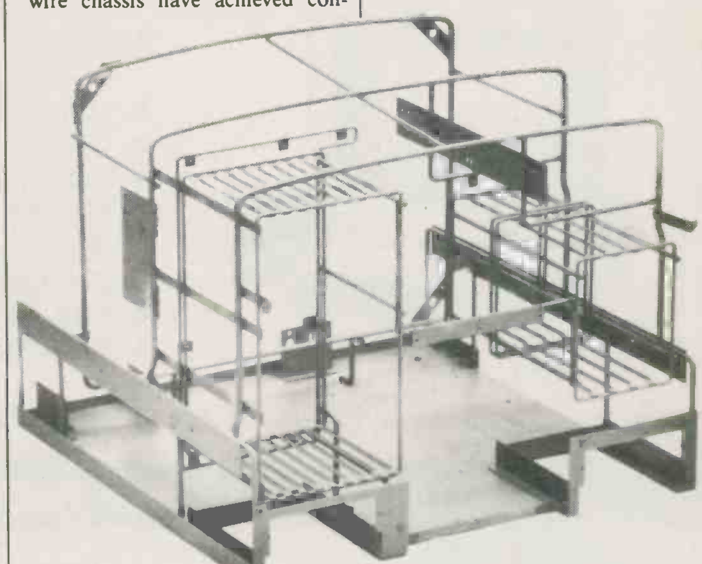
SGV Marketing Inc., Mississauga, has entered into an agreement with NCR CANADA's Independent Marketing Organization to market the *Decision Mate V* series of microcomputers and *Decision Net*, a local area network for linking personal computers from several manufacturers into a communicating and resource sharing network.

SGV has placed an initial one million dollar order with NCR. The agreement between NCR and SGV effectively opens a distribution channel for the *Decision Mate V* to SGV's large customer base of independent computer dealers across Canada. SGV will provide warehousing, distribution, dealer support and training from their Mississauga facility.

Future Electronics Inc. and Clare Division of General Instrument have signed a distributor agreement authorizing Future to inventory and market Clare's line of relays in the Canadian marketplace. Clare Division is the world's largest supplier of mercury-wetted and dry reed relays. Future has also signed a distributor agreement to stock Televideo Systems' line of CRT terminals. They have branches in Montreal, Ottawa, Toronto, Calgary, Edmonton and Vancouver.

Wire Chassis for Electronics

A major new trend in design of electronic equipment is the use of a steel wire chassis to contain all power supply components. Compared to conventional solid metal enclosures for the purpose, welded wire chassis have achieved con-



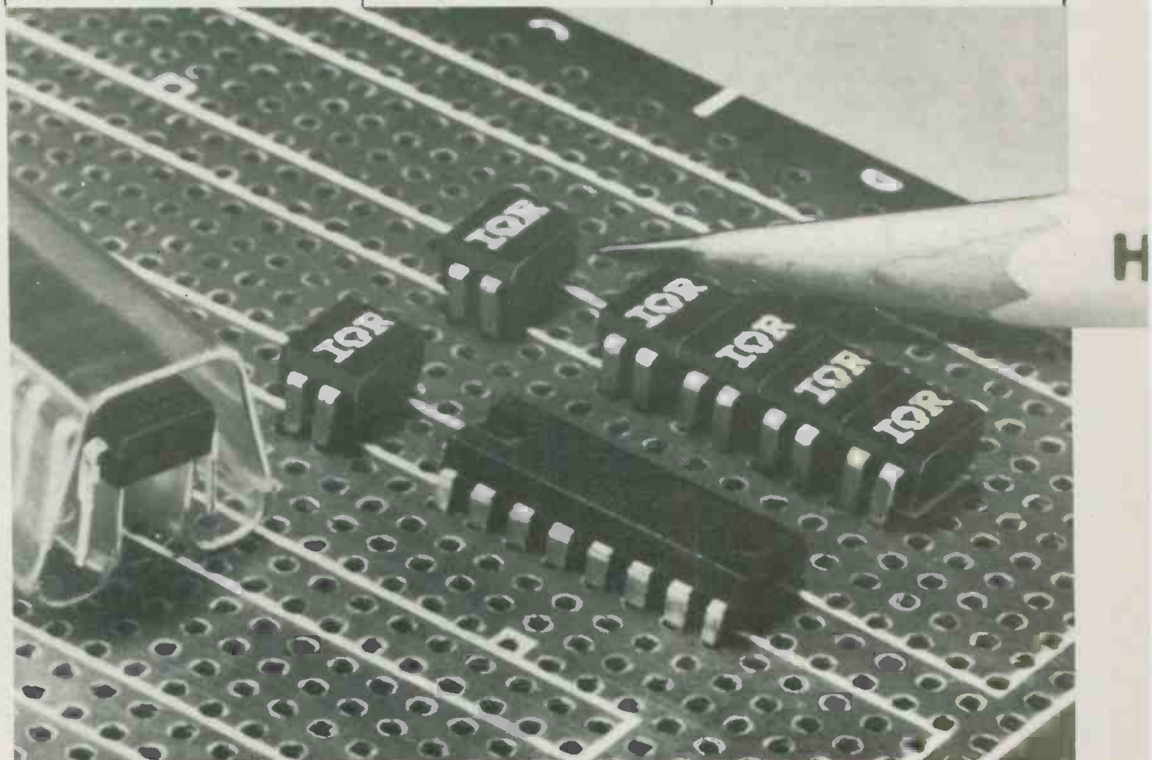
siderable savings in cost, weight, assembly time and servicing. And, in combination with perforated metal, they have eliminated electromagnetic interference (EMI) shielding problems.

Already, six large manufacturers — Burroughs, Diebold, Digital Equipment, General Signal, Perkin-Elmer and Xerox — have adopted the concept. The trend is expected to grow rapidly among other producers of office equipment: computers, copiers, word processors, cathode ray tube (CRT) terminals and other input/output devices.

For more information, contact Hill and Knowlton, Inc., 420 Lexington Ave., New York, N.Y. 0017 (212) 697-5600.

Power MOSFETs

A new series of one-watt complementary HEXFET® power MOSFETs from International Rectifier, in dual in-line packages, have a typical 15nsec rise time and 8nsec fall time, about 50 percent faster than competitive devices. The N-channel HEXFETs, designated IRFD210 and IRFD213, have a 200V and 150V drain source voltage, 0.6A and 0.45A drain-current, and a maximum on-state resistance of 1.5 Ohms and 2.4 Ohms, respectively. The P-channel devices, IRFD9210 and IRFD9213, offer a -200V and -150V drain source voltage, -0.4A and -0.3 drain current, and 3.0 Ohms and 4.5 Ohms maximum on-state resistance. The N-channel HEXFETs have a 2V maximum diode forward voltage while the P-channel units have a -5.8V drop. The switching times are an order of magnitude faster than comparable bipolar transistors. Two other P-channel MOSFETs, the IRFD9110 and IRFD9113, have -100V and -60V ratings with 1.2 and 1.6 Ohms resistance at -0.7A and -0.6A drain currents. Typical rise time is 30nsec and fall time is 20nsec. From IR dealers.



Music Shuttle

Sony Autosound announces a new car stereo with the introduction of the XRM-10 Music Shuttle, an in-dash AM/FM stereo receiver with a removeable cassette player that becomes a separate personal portable stereo with headphones. The Music Shuttle combines the security of a removeable unit with the flexibility of both car use and complete portability.

The touch of a button releases the cassette player section from the in-dash AM/FM RECEIVER. A supplied battery pack, headphones and carrying case handily convert the cassette player into an portable stereo unit. The radio continues to function after the cassette module has been removed. At Sony dealers.

The brand-new Canadian pay TV market may be worth as much as $1.15 billion (Canadian) in subscription revenue and another $150 million or so in equipment rental by 1992. According to a 134-page report from International Resource Development Inc., a Norwalk, CT market research firm, the current high rates of cable penetration in this country will greatly ease the adoption of pay services, but the single greatest stumbling block to achieving these levels of success may well be not consumer demand, but federal and provincial regulatory battles.

The regulatory problem between the federal government and the provincial bodies stems from the Canadian broadcasting system's inclusion of cable television as a "broadcasting receiving undertaking," the study states. But since a cable system is a "closed-circuit common carrier," bounded by the provincial border, shouldn't the province retain control? Already several provinces — most notably Quebec — have asserted their jurisdiction over cable, IRD reports, and since pay TV is to be a cable-based service, its future hinges on the resolution of this conflict.

Oscilloscope Probe

Model M12X10 is a miniature passive oscilloscope probe intended for use with a wide range of oscilloscopes. Specifications include dc to 250 MHz bandwidth, rise time of approx 1.4 ns, nominal input capacitance of 16 pF, compensating range of 10-60pF, input resistance of 9M ohms ± 1% (10M ohms when used with 1M ohm input oscilloscope), maximum input voltage of 600Vdc including peak ac, and derating operating frequency. The probe can be adjusted to match other combinations of input capacitance and bandwidths.

From: BCS Electronics Ltd., 980 Alness St., Unit 7, Downsview, Ont. M3J 2S2 (416) 661-5585.

Zenith Data Systems, a division of Zenith Radio Canada Limited, has appointed Dimensional Business Systems (Canada) Inc., Toronto, as a certified dealer of its desktop computer systems.

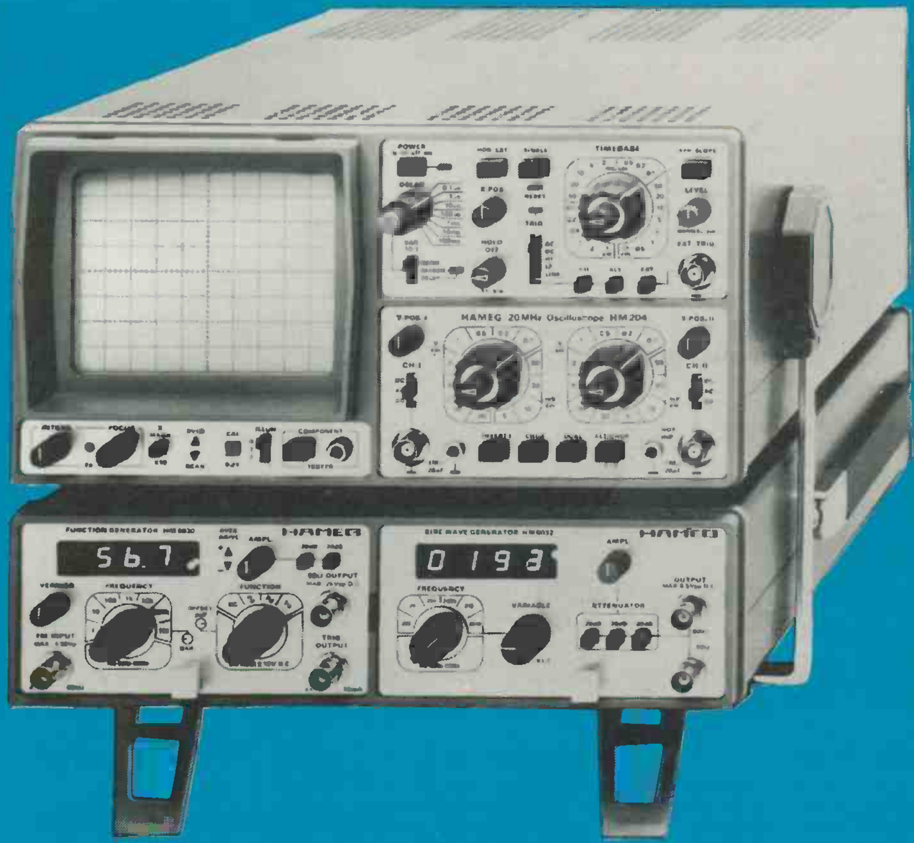
Dimensional Business Systems will be marketing microcomputers specifically to agencies and brokers in the insurance industry. Dimensional has developed a comprehensive insurance accounting package for the small to medium sized agency with annual volumes from $500,000 to $2 million.

Continued on page 42

HAMEG

New for 1983

BCS ELECTRONICS LIMITED



MS 8001 **$315.00**

HAMEG modular two hole main frame power unit. Supports 2 modules or can be used as a single support unit with blank panel.

HM 8030 **$375.00**

FUNCTION GENERATOR 0,1Hz to 1.MHz : 7 Decades with variable with 4LED display. SINE,SQUARE, SAWTOOTH with DC OFFSET +/−6.25V in 50 Ohms. FM output — 5V gives 100:1 change. Low distortion and much more.

HM 8032 **$375.00**

CONSTANT AMPLITUDE SINE GENERATOR 20 Hz to 20 MHz In 6 DECADES : 50 and 600 ohm outputs : 1.5 vRMS into 50 ohms : 3x 20 dB attenuators +/−1dB.

HM 605 **$1550.00**

Y:Bandwidth DC-60MHz (−3dB). Sensitivity 5mV-20V/cm (+/−3%) X:Timebase 1s/cm to 50ns/cm. : 5ns with x10 mag. : Trig DC to 80MHz. : Dual trace:Algebr. addition : X-Y Operation : Screen 8 x10cm : Delay line : Sweep delay : After delay triggering : Trigger filter : Single shot : reset : Overscan, Trigger, Ready, Delay indicators : Var. Hold-off : Z-Modulation : Graticule lights : HV-14kV.

HM 103 **$550.00**

Y:Bandwidth DC-10MHz (-3db) : Sensitivity 5mv-20v/cm (+/-3%) X:Timebase .2s/cm-.2us/cm : Triggering 2Hz - 30MHz : Calibrator Screen 6x7 cm internal graticule : Built in Component Tester : X-Y Operation : HV-1.8KV.

HM 705 **$1750.00**

Y:Bandwidth DC-70MHz (-3DB) . Sensitivity 5mv-20v/cm (+/-3%) X:Timebase 1s/cm to 50ns/cm. : 5ns with x 10 mag. : Trig DC to 100MHz : Dual trace : Algebr. addition : X-Y Operation : Screen 8 x 10cm Delay line : Sweep delay : After delay triggering : Trigger filter : Single shot + reset : Overscan, Trigger, Ready, Delay indicators, : Var. hold-off : Z-Modulation : Graticule lights : HV-14KV.

HM 203-4 **$835.00**

Y:Bandwidth DC-20MHz (-3db) : Sensitivity 5mv-20v/cm (+/-3%) X:Timebase .2s/cm-.5us/cm : 40ns with x5 mag : Trig DC to 40MHz : Dual trace : Algebr. addition : X-Y Operation : Screen 8 x 10 cm : Calibrator : Internal Graticule : Built in Component Tester : HV-2KV.

HM 808 **$6915.00**

Y:Bandwidth DC-80MHz (-3dB) : Sensitivity 5mV-50V/div. (±3%) X:Timebase 5s-20ns/div. Incl. x5 Magn. : Trig. DC-80MHz (0.5div.) : Dual trace analog storage with var. Persistence and Auto-Storage Algebr. addition : X-Y Operation : Screen 8x10div. (7.2x9cm) Delay line : Sweep delay : After delay triggering : Trigger filter : Single shot : Overscan, Trigger, Ready, Delay, AS indications : Var. hold-off : Z-Modulation : X-Guard circuit : Calibrator : 8.5kV.

HM 204 **$1120.00**

Y:Bandwidth DC-20MHz (-3db) .Sensitivity 5mv-20v/cm (+/-3%) X:Timebase .2s/cm-.5us/cm. : 20ns with x10mag : Trig DC to 50MHz : Dual trace : Algebr. addition : X-Y Operation : Screen 8 x 10cm : Single shot + reset : Overscan, Trigger, Ready, Delay indicators : Var. hold-off : Z-Modulation : Graticule lights : Sweep delay : Tigger Filter : Built in Component Tester : HV-2KV.

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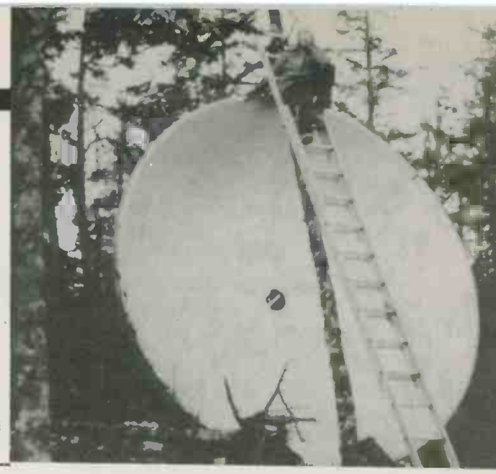
Satellite TV Receiver



The author's dish antenna. All photos by the author.

In the first of a two-part article, the story of an ambitious project builder who constructed his own dish antenna for receiving satellite TV broadcasts.

by Ron D.C. Coles

THE MINISTER of Communications made it legal earlier this year in Canada to own and operate a Satellite Television Receive Only, (T.V.R.O) Earth Station for your own personal use. The only thing stopping you now is mere money, if you are considering purchasing commercially available systems which are retailing for about $5,000 to $6,000. However, if you possess some previous experience in putting together kits, and are blessed with a lot of patience and are prepared to learn a little about the wonderful world of microwaves, you can put together the electronics of the system for less than $500. Depending upon your abilities to construct, beg, borrow, etc., you can acquire the antenna and associated hardware from as little as nothing (good at begging and borrowing) to a maximum of $1,550, resulting in your complete system costing from $500 to $2,000, which is still a lot less than $5,000.

To give you some idea of what is available in the way of television from the satellites, there are 16 satellites sitting in geostationary orbit, 22,300 miles above the equator in an arc from 79°W to 143°W, all beaming their signals towards continental North America. Each satellite has the capacity to transmit 24 simultaneous T.V. programs towards earth. Not all the 24 transponders, as they are called, are operational on all the satellites; however, there are over 100 transponders amongst the 16 satellites which regularly transmit T.V. signals to earth. The signals are beamed to earth at microwave frequencies between 3.7 GHz to 4.2 GHz, or for those who feel more comfortable in MHz, 3,700 MHz to 4,200 MHz.

The 24 transponders on each satellite are spaced 20 MHz apart with each adjacent frequency on the opposite polarization. This effectively gives a separation of 40 MHz between each transponder centre frequency on the same polarization; this is necessary because each frequency modulated video signal requires a bandwidth of 36 MHz (Fig. 1).

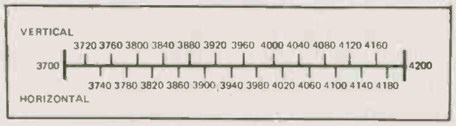


Fig. 1 Transponder center frequencies in mHz.

Let's take a look at what the T.V.R.O consists of. The basic elements of a T.V.R.O. are: The antenna and feed assembly, the low noise amplifier (L.N.A.), the down converter and the receiver (Fig. 2). Some manufacturers combine the LNA and the down converter in the same box and refer to it as a low noise converter (L.N.C.).

The antenna is a parabolic reflector or dish which should be at least 10' in diameter. The reflective surface of the dish must be metallic to reflect the electromagnetic waves into the feed assembly which is mounted at the focal point. The theory of a parabolic dish is that all parallel rays, be they light, heat or electromagnetic (radio variety) entering the aperture or open end will be focussed at the focal point (see Fig. 3).

If we then have some device at this focal point, the concentrated energy can be collected. The amount of energy collected, or gain of a given antenna, is dependent upon the diameter, the frequency of the signal it is receiving, and the illumination efficiency, that is, how well the energy is focussed and collected at the feed assembly.

For receiving 4 GHz signals from the satellites the gain of the antenna should be at least 40 dB, which means a minimum diameter of at least 10', preferably 12'. Now I know someone is just about to write to E.T.I. to tell me that his friend has an 8' dish and he gets good pictures. It's quite true that smaller dishes will provide a viewable signal if the propagation is good, the LNA is of the more expensive 100° variety, and a few other conditions are in the viewer's favour. However, this article is intended to cover all cases from Victoria, B.C., where the antenna elevation angles will be high and an 8' dish might be acceptable to St. John's, Nfld., where the antenna elevation angles will be almost horizontal and a 12 footer will almost be mandatory. Smaller antennas in the region of 3 to 4' in diameter will be used with the 12 GHz band when direct broadcast satellites (D.B.S.) are in general use later in this decade.

As far as making your own antenna, many articles have been written on this

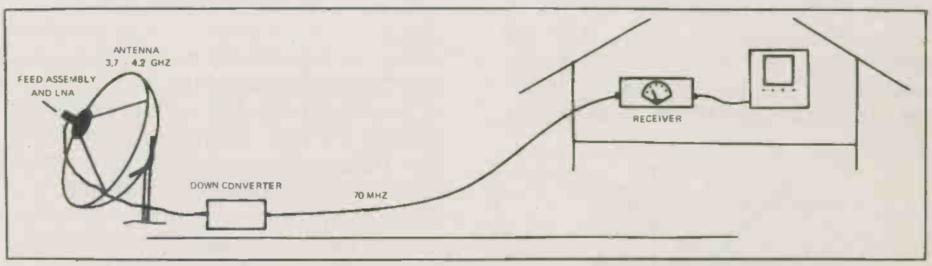


Fig. 2 The basic components of a satellite receiver system.

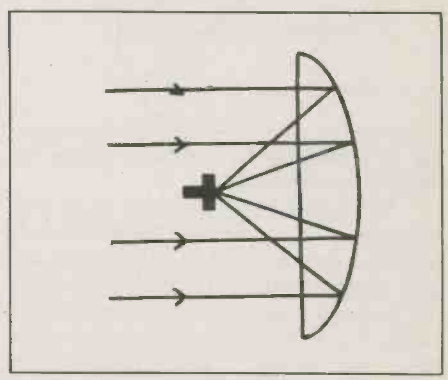


Fig. 3 Focussing of parallel rays by a parabolic reflector.

subject; one of the pioneers, Oliver Swan, made many out of wire mesh carefully laid over a framework of wood or light metal. Most of Swan's designs were spherical, i.e., the reflector surface is spherical and not true parabolic, in a 10' x 10' rectangular construction. The main problem with this type of antenna is that the focal point is usually 10' to 15' out in front of the reflector, and can be quite awkward to fix permanently unless you have a large back yard with cooperative neighbours. Also, changing from one satellite to another requires the feed assembly to be physically moved; this would necessitate an elaborate mechanical arrangement.

By far the simplest antenna is the circular parabolic, or dish, particularly if you wish to be able to move from satellite to satellite. Many dishes are being manufactured in fibreglass with a metallic reflector surface embedded in the resin, others from aluminum or steel, and in most cases they are constructed in a series of identical segments which are bolted together on site; this makes transportation easier and assembly can be carried out quite simply.

The main thing to consider if you plan to construct your own antenna is that the reflector surface is critical. The smoothness of the surface and its relationship to true parabolic are a function of the wavelength of the frequency it is receiving, i.e. at 4 GHz the wavelength is approx. 3.0" therefore any variations from the true parabolic surface should not be greater than wavelength/8 or 0.375", or to be on the safe side, 1/4". Also too many bumps and depressions of greater than ± 1/8" will have an effect of reducing the overall gain of the antenna (Fig. 4).

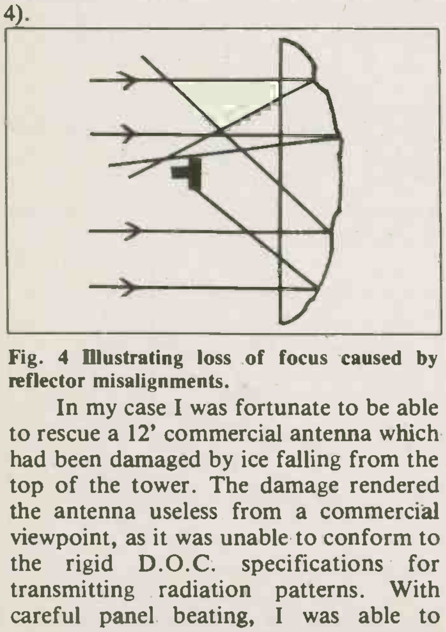
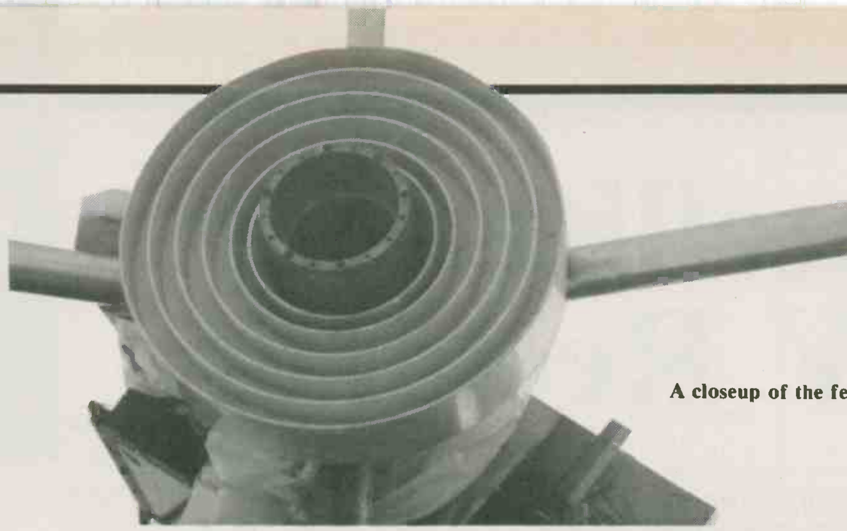


Fig. 4 Illustrating loss of focus caused by reflector misalignments.

In my case I was fortunate to be able to rescue a 12' commercial antenna which had been damaged by ice falling from the top of the tower. The damage rendered the antenna useless from a commercial viewpoint, as it was unable to conform to the rigid D.O.C. specifications for transmitting radiation patterns. With careful panel beating, I was able to recover the majority of its specified 41 dB of gain, which is quite remarkable, considering the disassembly required to move it to its final resting place in my back yard.



A closeup of the feed assembly.

The feed assembly, which looks into the reflector, sits at the focal point, or prime focus of the antenna. The most commonly used is the scalar feed, which consists of a piece of circular waveguide with a series of concentric rings to collect the energy reflecting off the dish; the rings are critically spaced and are matched to the 4 GHz frequency band (see photos). The dimensions are given (Fig. 5) for those readers whose talents abound in the plumbing area. If careful construction is carried out, the feed assembly can be made with 2" copper pipe, brass plate and a large soldering iron. I found it much simpler to acquire a commercial feed. The Chapparel scalar feed sells for approximately $30 U.S.

There are many variations and improved feed assemblies available on the market, such as electronic polarization change. This is either a ferromagnetic device or a motorized probe which permits the polarization of the received signal to be changed remotely without physically changing the feed. As we are considering a low budget approach, the inexpensive scalar feed is recommended; besides, it's fun to draw straws to see who goes out in the rain storm to change the polarization. Even with this approach the use of a simple T.V. antenna rotator and a little innovative modification to the mechanical attachments can provide you with remote polarization adjustment.

The feed is situated at the prime focus of the antenna F, which can be calculated from the formula in Fig. 6.

If you have acquired a surplus dish, the dimension C can be measured by placing a long straight edge across the face of the dish, and measuring from the straight edge to the centre of the dish; the rest is simple, as the feed can be mounted on a tripod or quadrapod arrangement, taking care to ensure that the feed is at the centre of the dish and rigidly supported, such that when the dish is pointing almost horizontally, the feed assembly does not droop. 1" aluminum conduit works well in this application. Some adjustment should be provided to fine tune the focus when the system is operating.

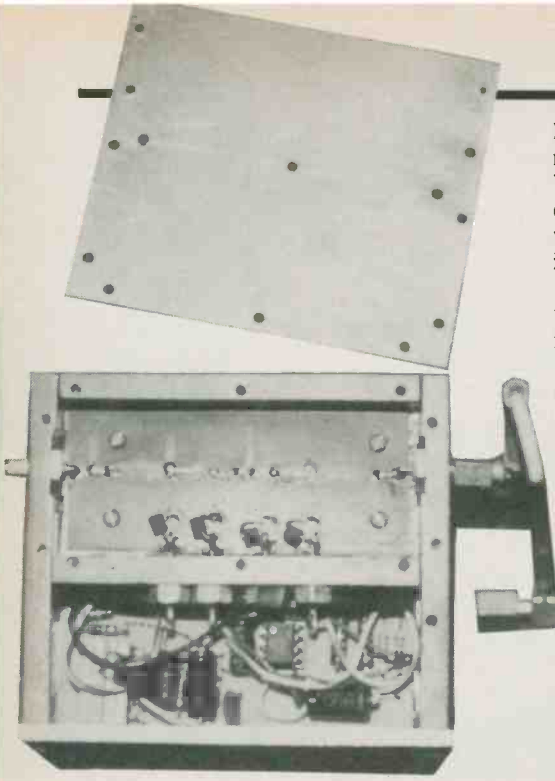
Now we are at the point where the most important part of the system electronics is situated, the LNA. The signal coming from the satellite is so small in power after travelling 22,300 miles that it is barely above the ambient noise, even after enjoying the relatively large gain of the antenna. At the point where the signal is collected at the output of the feed assembly, its level is at best barely 6 dB above the thermal noise; it is therefore imperative that the signal be amplified substantially at this point with the minimum of noise contribution from the amplifier. That's where wonderful little devices called GaAsFets come in; this stands for Gallium Arsenide Field Affect Transistors. They work at microwave frequencies and provide lots of gain with very little noise.

Table 1 Low Noise Amplifier Noise Temperature vs. Noise Power

17°K	—	0.25 dB
34°K	—	0.5 dB
75°K	—	1.0 dB
100°K	—	1.3 dB
120°K	—	1.5 dB

Most commercial LNA's provide about 50 dB of gain and contribute only 1.5 dB of noise. The noise performance of a LNA is usually referred to in °Kelvin, e.g., a 120°K LNA has a noise figure of 1.5 dB (see Table 1). This good performance of a LNA comes with a high price tag, and although the price has been dropping dramatically over the last few years, a 120°K LNA still costs in the $800 range; if you really do want a very low-low noise and adjusting to achieve the required 10mA. This current is determined by measuring the voltage drop across two 82 ohm resistors, which will be 0.82 volts when 10mA is flowing. As you are not likely to find a suitable power supply ready made, then you will have to build it yourself. The circuit is shown in Diagram 8. It is quite simple to build and was derived from a design published in 'CATJ' in 1981.

If you designed your housing as I did, you will mount the power supply in the



The LNA housing, showing the LNA and power supply.

amplifier in the 34°K range you will have to pay $3,000 to $4,000.

The major reason for this high price is the cost of GaAsFets and the manufacturing technique which requires the use of special glass-teflon printed circuit material and chip capacitors the size of a pin head. Most commercial units employ GaAsFets for the first two stages, and then produce the balance of the gain required using less expensive bipolar transistors which operate at 4 GHz. After achieving approximately 20 dB of gain in the GaAsFets, the signal is sufficiently above noise, and the relatively high noise (3 to 4 dB) of bipolar transistors is not a significant consideration.

Microwave frequencies usually like to travel inside rectangular or circular pipes known as waveguides. In order to amplify microwaves, it is necessary to make them behave more like their lower frequency cousins, and travel along printed circuit tracks. This has been accomplished by using techniques known as "stripline" and "microstrip". Stripline is a printed circuit track sandwiched between two layers of insulating dielectric material with a ground plane on either side. Microstrip is a much more manageable method; the track is on one side of the dielectric and the ground plane is on the other side. The only major difference between microstrip and regular double-sided PC board is the dielectric constant of the board material. The propagation velocity of the microwave energy is directly affected by the dielectric constant of the insulating material, and therefore a material which does not absorb moisture and which has a consistently high dielectric constant is used. Teflon reinforced with glass fibre is most commonly used in this application. Because short lengths of wire attached to microwave circuits behave like inductors and capacitors, depending on how they are bent, conventional components with wire ends cannot be used; therefore, special microwave components are employed.

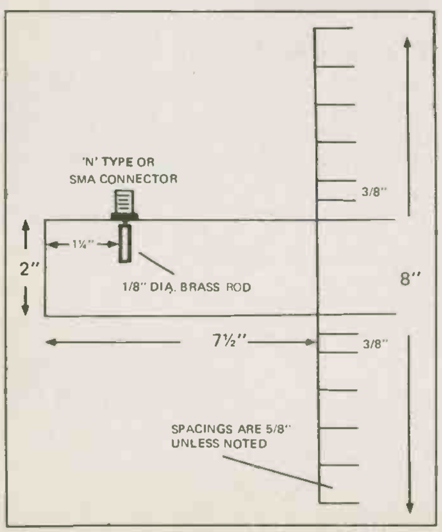


Fig. 5 Dimensions of the feed assembly.

The LNA

Fig. 7 shows a 2 stage GaAsFet LNA. This circuit was first published in a Commercial Publication 'Microwave Journal' in 1981 and was designed by an Engineer from California Eastern Labs. I have made several LNAs using this circuit which have given excellent results. I am currently using three such amplifiers in series to give me 60 dB of gain, with a noise figure which I estimate is better than 120° or 1.5 dB. The circuit dimensions are critical, as the microstrip circuit width affects the impedance match, and the length of the stubs affect the circuit match to the GaAsFets at the frequency of interest. The printed circuit board used was "Oak Laminate" .03 OAK 602 033 C 1/1, the GaAsFets are NE72089 from California Eastern Labs, and the chip capacitors are the values shown in Fig. 7.

The dimensions are given for those who wish to prepare the artwork and to etch your own board. Remember the dimensions are critical and the PC board must be double sided microwave board. Some manufacturers are:

Oak Laminates OAK 602
Oak Materials Group Inc.
Laminates Division
Franklin H.H. 03235

Rogers RT/duroid
Microwave Materials Division
Box 700
Chandler, AZ 85224

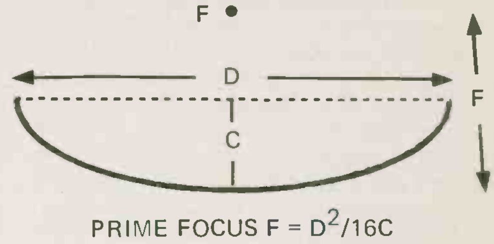


Fig. 6 Finding the focal point of a parabolic dish.

"3MM" also makes a range of microwave PC boards. Unfortunately, the above are manufacturers to the industry and do not normally supply small quantities for hobbyists, and Radio Shack as yet doesnt' supply this type of board. In order to fill this requirement I have endeavoured to acquire a supply of board directly from the manufacturer, and should be in a position to supply this item and other components by the time this article is published.

Let us assume you are going to do the whole thing from scratch, i.e. prepare you own negative, print and develop the image on your PC board, etch the pattern, assemble the components on the board and finally install the stuffed board in the housing.

If you haven't made you own PC board before then I suggest you read up on the technique. For those who have, here are some tips: You will have to sensitize your own boards as you can't, as far as I've been able to discover, buy the board pre-sensitized. A negative can be produced from your artwork by your local print shop. I found that a 12 minute exposure from a desk fluorescent lamp, 6 inches above the print frame, gave the correct exposure. Good clean etchant should be used as the fine lines of the microstrip track should be smooth and straight with no ragged edges. Remember the back side of the board, the ground plane, must not be etched. When the board is etched, drill 4 holes, as marked, for the GaAsFet source leads.

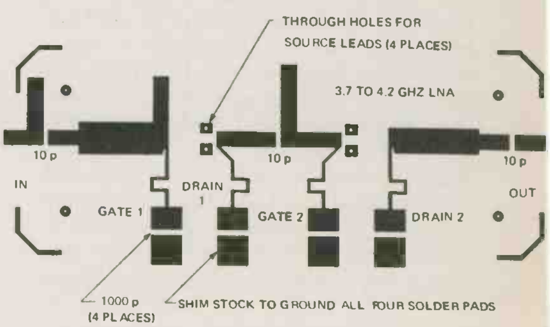


Fig. 7 The printed circuit layout for the LNA, 1:1 size.

Now you are ready to go through the strange but necessary ritual of wiring your wrist to the work surface, (metal plate of large piece of PC board), to the soldering iron and to a good ground or such as a water pipe. For the latter reason, you may wish to acquire a battery operated soldering iron, or at least ensure that the wiring on your present iron is in good condition. I would hate to think you had invented the "electric hand cuff". The reason for this strange behaviour is static electricity. Static discharges can do nasty things to your expensive GaAsFets, like making them useless. In short then, you must ensure that there is no risk of static discharge through your GaAsFets.

Now that your working surface is prepared and you are suitably grounded, first solder the chip capacitors as shown in Fig. 8. You need a steady hand to do this. I found it best to place the chip across the appropriate gap in the strip line, holding it there with a small screwdriver point, and then lightly place a small amount of solder on one side of the chip, keeping it held firmly until the iron is removed. If not, the chip will stick to the bit, and you'll be cursing. With one side soldered down, the other side can be soldered quickly. Once you have mastered the first one, the others are simple. Now solder a piece of copper foil around the lower edge of the board to extend the ground plane to the four pads on the lower edge of the board. Next solder four short lengths of 22 Ga bare wire (the surplus wire ends cut off resistors will do) to the four input bias pads; these should be long enough to connect to the feed-through capacitors when the board is installed in its housing.

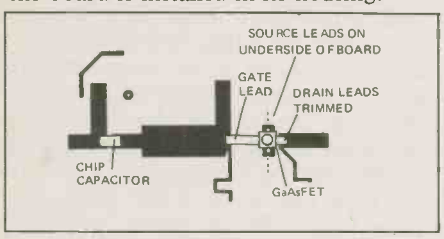
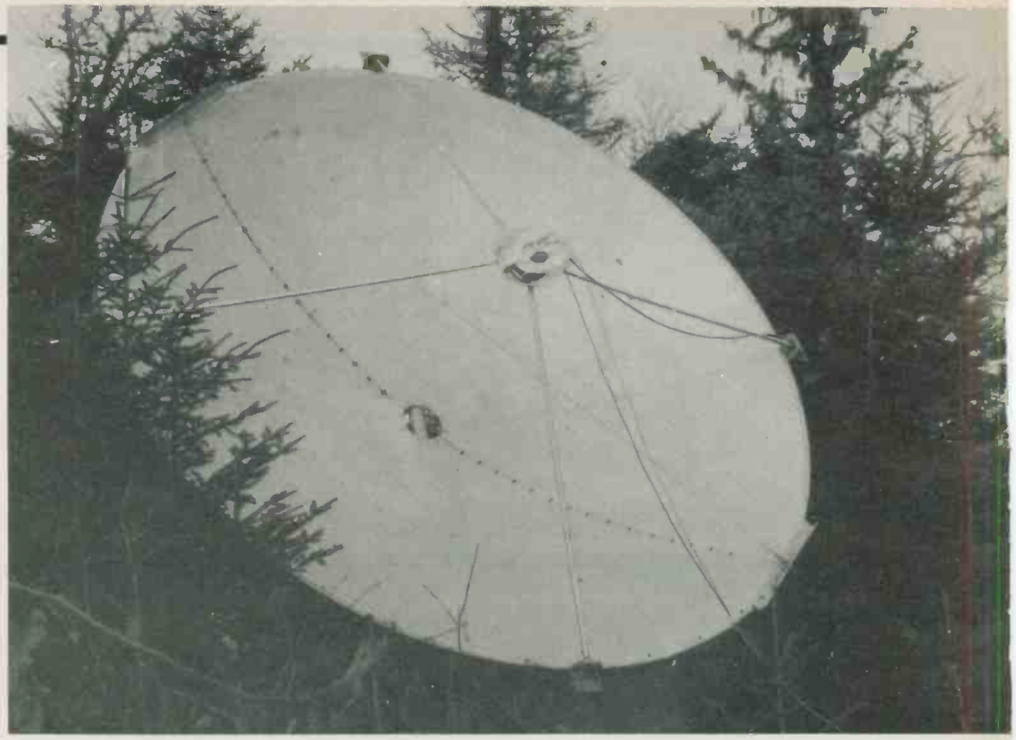


Fig. 8 Installing the GaAsFet on the printed circuit.

You are now ready to remove the GaAsFets from their static free packets. Make sure you are discharged of static first. Take the first GaAsFet, bend the two source leads downwards, and place them through the two holes you previously drilled as indicated, with the gate lead (slashed) towards the input; measure and trim the drain lead to just line up with the output strip line. Ensure the GaAsFet is held firmly to the board, flatten the source leads to the ground plane on the back of the board, and solder them in place. Next turn the board over and solder the gate and drain leads to their respective strip lines. *In all cases use a minimum of solder and a minimum of heat.* Repeat this procedure for the second GaAsFet.



The antenna, showing the mounting of the feed assembly.

Your board is now complete except for mounting it in its housing.

Making the Housing

Your choice of housing can affect the overall cost, and what is more important, can have a critical effect on the performance of your LNA. My first attempt was to mount the board in a container that was too deep, such that there was about 3/4" between the top of the PC board and the lid. I discovered by experimenting that placing a second ground plane above the circuit board improved the gain. This led to the eventual construction of a more suitable housing with the dimensions shown in Diagram 7. I used scrap 1/2" x 1/4" copper ground bar, 1/8" aluminum plate, many drill bits and a few broken taps, and a lot of swearing. The top and bottom plate could have been thinner, but I had some 1/8" aluminum plate to use up.

Your inventive genius can run amok as long as you keep the critical dimensions in mind. The critical dimensions. The input and output coaxial connectors are S.M.A., but N type can be used, depending on which connectors you have on the waveguide/co-ax transition on the output of the feed assembly.

The bias voltages are fed to the LNA via four 1500p feed-through capacitors which are screwed into the side of the housing; also, 4 ferrite beads are used on the wires previously soldered to the bias pads on the LNA PC board which connect to the four feed-through capacitors. The beads are inductors which presend a high impedance to RF spikes, and the capacitors decouple any RF to ground.

Some experimenters have used regular double sided PC board to construct enclosures for LNA's, although I have not used this personally, I see nothing wrong with this approach as long as it can be held together while being soldered. This could also be an inexpensive method of making the waveguide to coaxial transition.

L.N.A. Bias Supply

Now that you have made the LNA you will need something to power it. The drain-source voltage Vds is 3.5 volts and the drain-source current Ids is 10mA. This current is set by applying a –ve bias voltage of between 0 and –5V to the gate

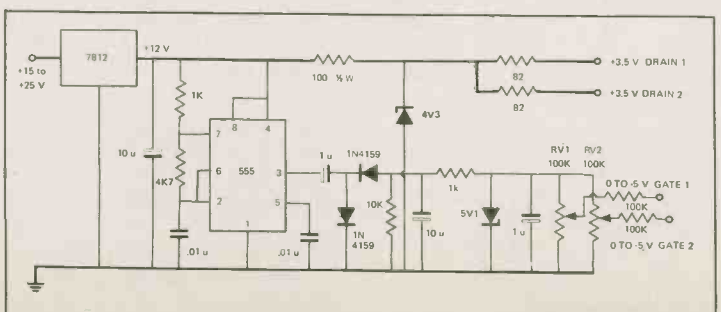
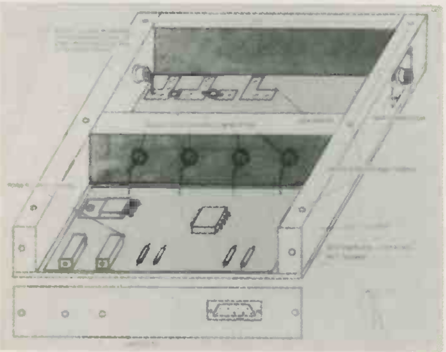


Fig. 9 The schematic of the LNA power supply.

same enclosure; in this case only a single +12 V regulated supply is required to be fed to the LNA. Also, there is a practical requirement to make the enclosure waterproof, as the LNA has to spend its life sitting at the focal point of your antenna, and you wouldn't want your antenna to suffer the indignity of having a plastic bag tied around the feed assembly, so keep this in mind when you start to package the unit.

Voltage Trimming

When you have completed the bias supply, apply a regulated 12V positive supply to the input and check for +3.5V at the



The housing of the LNA.

two drain outputs, and for 0 to −5V at the two from end to end. If this checks out, set the pots to mid range, disconnect the 12V supply, connect the two drains and the two gates (watch for static) to their respective feed-through capacitors and ensure that the LNA side of the feed throughs are connected to their respective pads. Now your ready to power up your LNA, reconnect the +12V and adjust each bias pot for 0.82V voltage drop across its corresponding 82 ohm resistor, i.e., adjust RVI for 0.82V across RDI, and RV2 for 0.82V across RD2. The voltage drop across the 82 ohm resistor should change smoothly as the potentiometer is adjusted. If any abrupt changes occur as the pot is being adjusted, the amplifier could be oscillating. If this occurs, remove the power and check your solder joints; ensure all chip capacitors are correctly soldered with no solder bridges to cause a short. With the correct voltage drop across RD1 and RD2, your LNA is now operational, and should have a gain of 20 dB with a noise figure of 120°.

Wrapping Up The LNA

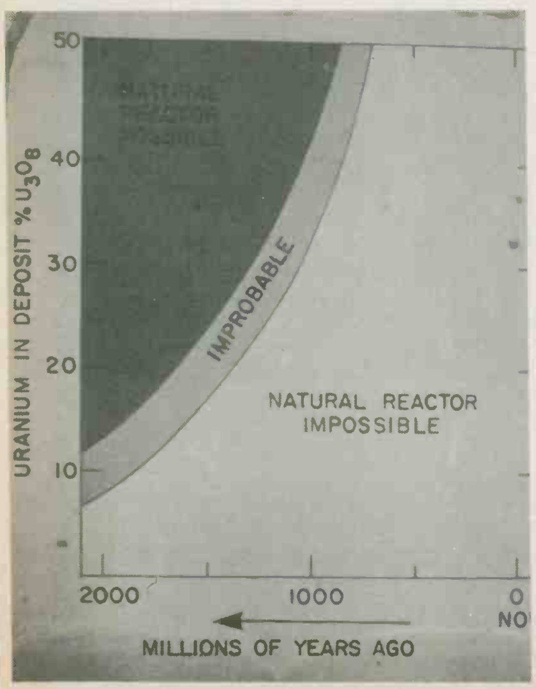
In most cases, unless you know someone with microwave test equipment, you will not be able to determine if your LNA is working, other than knowing that the bias current is behaving as it should. However, by way of reassurance, the correct packaging of the three LNA's that I have constructed all behaved perfectly with no adjustments required. Remember to take all the antistatic precautions, make sure you use a minimum of solder, use a small soldering iron of 18-27 watts, never use a soldering gun and never touch the gate connections with the meter leads. As indicated earlier, commercial LNA's have approximately 50 dB of gain, so in order to get the necessary gain from your own LNA you will require some additional stages. This can be accomplished using less expensive bipolar transistors on a suitable microstrip design matched to the particular bipolar you use. One such design can be found in Hewlett Packard application note 967 using a HXTR 6101 bipolar.

I found that the amount of savings from the bipolar stages over the GaAsFet stages were not significant when compared to the flexibility of using all GaAsFets. The advantage of making another GaAsFet amplifier is that the two can be interchanged to enable you to get optimum performance by using the lowest noise amplifier for the front end. Each two-stage amplifier has approximately 20 dB of gain; therefore, two, two-stage amps should give you 40 dB of gain, which should be sufficient as long as the cable from the LNA to the down converter is not too long, and the gain of your antenna is sufficient (40 dB).

This concludes this month's look at getting the antenna up and running. In the next issue, an explanation of the downconverter, the receiver and the TV modulator. ETI

OKLO: Natural Nuclear Reactor

Geological conditions turned a deposit of uranium into a fissioning nuclear pile about 1700 million years ago. Roger Allan investigates.



A prediction by P.K. Kuroda as to the precise conditions under which a nuclear chain reaction could occur in nature. All illustrations courtesy of Michael Tomlinson.

IN 1972, scientist Pierre Corbet, while conducting routine uranium inventories at the processing plant at Pierrelatte, France, discovered a batch which contained 0.7171 percent uranium-235. Hardly an earth shattering finding, considering that of the 200,000 samples analysed at the plant over the previous years, all had come in at 0.7202 percent, and one is expected to make the occasional error. However, on re-analysing, he found that his original determination was correct, and very privately, very quietly, a panic button was pushed. For the only way, it was thought at the time, that such an anomaly could occur in a sample was if some one had stolen some uranium and replaced it with spent material. Against a background of assasination attempts against President de Gaulle, it was not a threat to be taken lightly.

The science: naturally occurring deposits of uranium consist of a mixture of three types: uranium-238 with a half life of 4.5 thousand million years, uranium-235 with a half life of 710 million years and a small quantity of uranium-234. All uranium was created at the same time in the earth's geologic history. It is this fact which therefore provides a bench mark for determining quantity of type.

There are two ways to power a nuclear reactor. The Americans, and many others around the world, upgrade the uranium-235 content to about 3 percent. They then use ordinary water as the coolant; this absorbs a large number of neutrons (hence requiring a higher initial percentage of uranium-235). In Canada with our CANDU reactors, the uranium-235 content is kept at its natural level, with cooling provided by heavy water which does not absorb as many neutrons and hence does not require a high percentage of uranium-235 to get the reaction going. Via either method, at the end of the reaction the uranium-235 content has been lowered to below the naturally occurring 0.7202 percent found in deposits. Hence the problem with the Pierrelatte sample: it was not natural. Further, upon continued investigation it was found that some samples contained only 0.44 percent uranium-235, with very high concentrations of the rare elements

Africa and the location of Oklo.

neodymium, samarium, eropium and cerium. These rare elements were assayed in concentrations which had only previously been found as the side-products of man-made nuclear reactions.

When it had been determined that the 440 "missing" pounds of uranium-235 had not in fact been filched, the question became one as to what had happened to it, and just as importantly, why. The trail led backwards through the atomic pipeline from Pierrelatte to the uranium hexafluoride factory at Malvezi, thence to the uranium nitrate factory at Guegon, thence to Mounana in Africa where the uranium oxide comes from and finally to the Oklo, Gabon, site of the uranium mine itself. There the explanation was slowly unravelled: that there had in fact been a series of naturally occurring nuclear reactions at the site some 1700 million years ago at six sites in the Oklo deposits and one at the nearby site of Okelobondo.

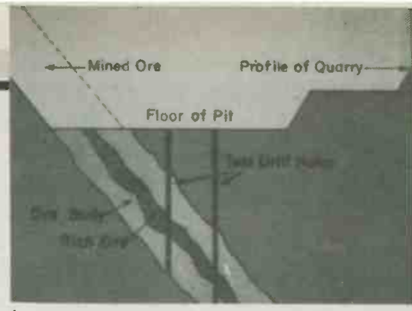
The structure of the natural nuclear reactors was surprisingly similar to the Canadian CANDU reactor's method of operation: naturally occurring quantities of uranium-235 cooled by ground water.

Essentially, this area of the world consists of a granite plateau. Erosion over the millenia created sandy sediment beds. These, in turn, have been covered and compressed by subsequent erosion. Uranium, having a density similar to lead, was concentrated at the bottom of these layers. Further, oxidative leaching, a process engenedered by the blue-green algae before the oxygen content of the atmosphere was anything like the level it is today, oxidized the black insoluble uranium oxide on the surface of the earth into yellow soluble hexavalent uranium that was carried by water down through the sediments to build up, at about 4000 meters, into the uranium ore beds that are currently mined. Subsequent crustal movements of the earth have forced these beds up at an angle so that they can now be mined. When the uranium-235 content had increased from the 0.04 percent found naturally throughout all rocks to 10-30 percent, a sustainable fission reaction occurred: a nuclear reactor.

Cooling was provided by naturally occurring ground water. Surrounded by impermeable sedimentary deposits, the reaction built up and heated the ground water to a temperature of between 400°C and 650°C, while the areas surrounding the reactor reached some 150°C. As described by M. Thomlinson of the Whiteshell Nuclear Research Establishment of Atomic Energy of Canada Ltd., "At this depth, 4 km below ground, water cannot boil — it just heats up, it just becomes less dense. At 150°C it is a little below the normal density of about 1. At 400°C it is about half the density of water, as we know it, and at 650°C it is about a tenth. As the reactor zones heated up, the water expanded out of the reactor — and the nuclear reaction slowed down. In this way the reactors were regulated at a steady power. We use exactly the same principle today in our SLOWPOKE reactors. They are self-regulating by the expansion of the water in them."

The reactors are about 0.5 to 1 meter thick and 10-20 meters across. During the course of the 500,000 years that they intermittently heated and cooled, some 800 tonnes of uranium were used up, some 6000 kilograms of uranium-235 were consumed with some 2000 kilograms of plutonium produced as a waste product. The average energy output per reactor was about 25 kilowatts (33 horsepower) with the total energy output being roughly equivalent to a CANDU reactor operating continuously for ten years.

The uranium mine as it was about 1977. The slope on the left is the bedrock, and the uranium ore has been mined away across the face of the mine. The site of the ancient nuclear reactor has been preserved for study and as a monument for posterity.



A cross-section of the mine and the ore body.

Such a natually occurring reaction requires, obviously, a very peculiar set of circumstances to be created, and cannot occur today; the uranium-235 content has, by its natural half-life, been depleted. There is some thought, however, that some ore deposits from New Mexico which show a depleted uranium-235 content may also represent the remnants of ancient nuclear reactions. Further, as the Gabon coast was once touching what is now Brazil, there is some thought that similar natural nuclear reactors may be found in Brazilian deposits.

Of concern to atomic engineers and environmentalists is that water action under ground could transport radioactive wastes to areas where they could be harmful to life. One of the more interesting, rather than novel, aspects of these reactors and the subject of many of the 200 research papers published on the Oklo deposits, is that the radioactive waste products did not move very far over a million year period, nor did the depleted uranium, even though it is readily transported by water. ETI

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We hope readers in other Provinces (which is more than half of you) will forgive this Ontario-only announcement. We only heard that ETI has been selected for this scheme on the day we went to press; there has not been time to arrange for a local announcement.

MPU Support Chips

There's no shortage of technical tomes on microprocessors, but there is a distinct dearth of texts on chips that make the MPU do its stuff. Ian Sinclair comes to the rescue.

THE FIRST ESSENTIAL for a microprocessor is a clock pulse generator. A clock pulse is simply a rectangular pulse which repeats at a high frequency, usually 1 MHz or more. All microprocessors need clock pulses, because each operation within a microprocessor is triggered by a clock pulse, so no clock pulse — no action. Each little piece of a program will take a definite number of clock pulses to carry out.

How do we generate clock pulses? A few microprocessors, notably the INS8060 (SC/MP Mk. II), can generate their own clock pulses. The INS8060 has two terminals which can be connected to external components as shown in Fig. 1. Either RC or crystal oscillator circuits can be used, providing the frequency is fairly high — the internal circuits simply won't oscillate if the time constants are too large. Keep to the values suggested by the manufacturer and you should have no problems.

Phase Relations

Most microprocessors, however, can't spare the extra pin for connections to a built-in oscillator and instead use only a single pin or a pair of pins for clock pulses. When a single pin input is used, the clock is a single phase clock (a straightforward oscillator). This can be obtained from a multivibrator or by squaring the output of a sinewave oscillator, but it's very important that the waveform should be steep-sided (Fig. 2). If you use a waveform which has long rise or fall times, so that its sides appear to slope when you view the waveform on the oscilloscope, then you'll have trouble when you try to use the microprocessor. The reason is that some gate circuits will oscillate if they are switched over too slowly and that can cause chaos. Don't be tempted to economise on circuits, therefore.

One particularly useful way of ensuring that all signals entering the microprocessor have short rise and fall times is to use a type of TTL IC called a Schmitt trigger. Typical of these are the 74LS13 quad two input input Schmitt NAND. Each of these chips has a Schmitt trigger built in, so the output will always be steep-sided even if the input is not. It's often easier to use a cheap 'n' simple oscillator and a Schmitt IC than to build an elaborate transistor oscillator.

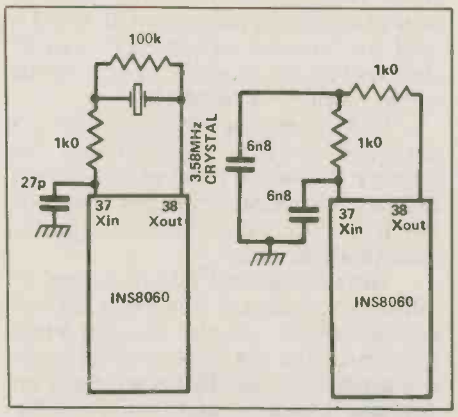


Fig. 1 Using a built-in oscillator — the INS8060 (SCMP II) can use its built-in oscillator along with a crystal or a simple R-C network.

Refreshment Is Served

Several types of microprocessors, notably the 6800 and 6502, use two pins for the clock input. This is because the clock pulses have to be two-phase. One pin is being pulsed positive at a time when the other pin is at logic 0. Just to give one example, the 6800 carries out only internal actions on the second phase of its clock, so that during the phase all outputs are isolated. This means that you can run a low-cost memory system using dynamic RAM. Dynamic RAM needs refresh pulses and these can be delivered during the second phase of the clock pulse, when the memories are not connected to the microprocessor in any case.

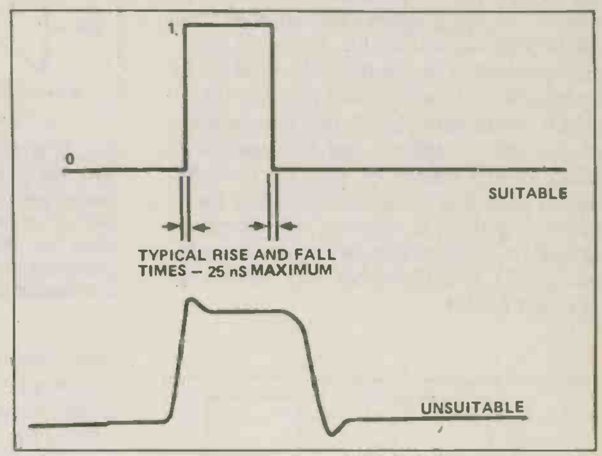


Fig. 2 Clock-pulse shapes. Most discrete-transistor oscillators and certainly all linear IC oscillators (such as 555) cannot generate sufficiently steep-sided clock pulses when driving a capacitive load. A TTL pulse generator is ideal, or a generator which is buffered by a Schmitt inverter, such as the 74LS14 or the 74LS13.

Buffers

Buffers are the next group of ICs which have to be used in practically all microprocessor circuits. A buffer is basically an amplifier circuit with a three state output — explanation coming up. There are two reasons for using buffers. One is that microprocessor circuits use PMOS, NMOS or CMOS circuits, which can't sink or source much current, usually a couple of milliamps at the most. A lot of the circuits which will be connected to the microprocessor will need quite a bit more current, so a buffer is needed — a current amplifier which can be comfortably driven by the microprocessor and which will sink or source enough current at its output to drive a lot more circuitry.

Buffers can also be used as switches. To take one example, the eight data lines of a microprocessor are used for feeding bits in and out. Since they can't do both at the same time, we need some method of switching so that input circuits are not connected at a time when the microprocessor is putting bits out on the data lines. This is another job for the buffer — in this case a three-state type of buffer.

The term three-state sometimes causes a bit of confusion. It means simply that the output of the buffer amplifier can be 0, 1 or isolated from all other circuits. In the type of output circuit shown in Fig. 7, for example, the output can be floated by connecting both the bases of the output pair to ground. This needs extra circuitry inside the IC and an extra 'state' pin on the package, but the advantages of having the floating state are enormous.

Buffers may be used unidirectionally or bidirectionally. A unidirectional buffer deals with the flow of signals in one direction only, perhaps from an input circuit to the data lines. Most of these are made in two versions, the difference being in the polarity of the three-state control pin. For example, one buffer may go open circuit at the output for a 1 at the three-state control pin and another type may go open circuit for a 0 at the control pin. When the buffer is used unidirectionally, it's purely a matter of convenience which type is used. For example, if the buffer is used to connect input signals to the data lines and the microprocessor puts out a negative pulse at the time when it is ready to take in such information, then a buffer which is open circuit on a 1 signal and operates for a 0 signal at the state pin is ideal. If the other type of buffer is used, an inverter will need to be incorporated in the control line.

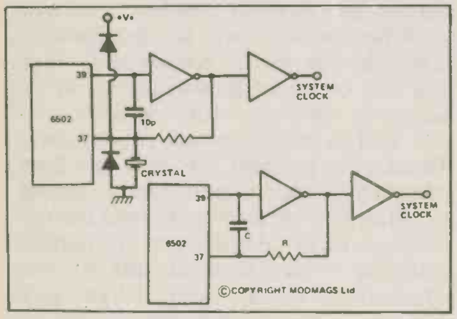


Fig. 3 The clock-pulse generator of the 6502. Either a crystal or R-C circuit can be used, but the external inverters are necessary, though they need not be Schmitt types.

Much more common is bidirectional buffering, where a buffer amplifier is needed for both inputs and outputs. One single buffer can't do this, so a very common method is to use two lots. One lot is isolated by a 1 on its state pin, the other by a 0 on its state pin, so that the outputs of one set of buffers can be connected safely to the inputs of the other set as shown in Fig. 8 with the state pins connected together. In this way, the combined buffers conduct one way when the state pin is at 1 and the other way when the state pin is at 0.

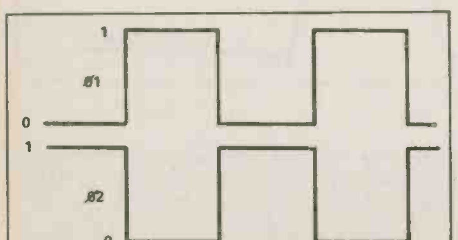


Fig. 4 Two-phase clocks. Where a two-phase clock is used, different actions are carried out in the two different phases. The sketch cannot show the correct scale; there is no overlay between the two positive phases.

Ah Yes, I Remember It Well

Most books on microprocessors assume that the readers know all about memory ICs. Assuming that you don't, point number one is that we make use of two types of memory systems, ROM and RAM. You can get bits out of ROM (Read Only Memory) but you can't, in normal operation, put any bits in. ROM is used for 'non-volatile memory', so that the data bits are still stored even when the whole system is switched off.

RAM (Random Access Memory) is misnamed, because practically all the memory ICs we use have random access, meaning that we can get at any one set of bits in the memory without having to sort through all the others.

There are several different types of technology which are used to make these memory chips, but the two important varieties are the two types of RAM (static and dynamic). Static RAMs are based on flip-flops (bipolar or MOS which will flip over one way or the other when set or reset by an input). Dynamic RAMs are based on storage of charge in capacitors and this charge is called 'refreshing'. A dynamic memory is refreshed by applying a refresh pulse to each memory cell which stores a 1.

Organisation

Apart from the question of whether to use static or dynamic RAM, the main factor we need to take into account when dealing with memory is the way in which the memory is organised. Organisation in this sense means the way in which the memory cells are grouped. For example, one very popular way of organising memory is to have 1024 cells, each using a single common data input/output pin. This is classed as a 1Kx1 memory, the 1K (K in memory size means 10^{10} (1024), not 1000) referring to the total number of groups of memory cells and the 1 meaning the number of data lines. A memory like this would (normally) need ten address lines (because $1024 = 2^{10}$) so that 1024 different address numbers can be coded in binary on the lines.

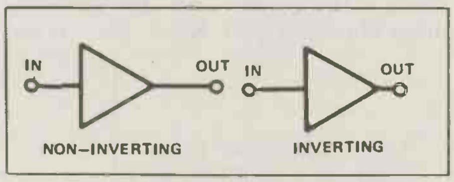


Fig. 5 Buffers, inverting and non-inverting. The MOS circuits of most microprocessors cannot provide enough current drive to activate more than one standard TTL gate and a buffer must be fitted between the MOS microprocessor and the TTL circuits if expansion is contemplated.

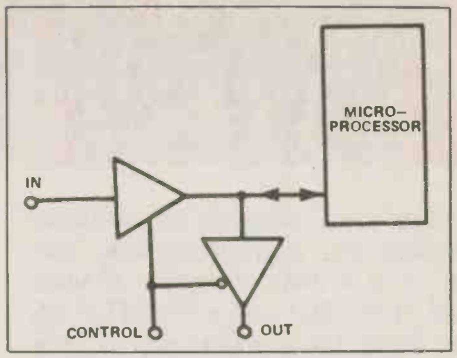


Fig. 6 Using three-state buffers. In this example, when the control signal is at logic 1, the input buffer is enabled and the output disabled. With the control signal at logic 0, the output buffer is enabled and the input disabled. The output of the disabled buffer acts like an open-circuit.

A 512 x 4 memory, on the other hand, would have 512 groups of four cells each, with four data pins for input and output signals. With only 512 groups, only nine address lines are needed ($2^9 = 512$), but at each address number, four bits are being written or read. The total number of bits stored in such a memory is 2048 (512x4).

Chip-Ability

An essential feature of all memory types is a chip-enable pin. At one logic voltage on the chip-enable, the memory can be used for reading or writing in the usual way, but with the chip-enable shut off, the memory data pins go 'floating' as if a three-state buffer were in circuit. This saves using an additional buffer chip and enables us to use large numbers of memories connected together without any other form of buffering.

How, then, do we connect memory chips to the main microprocessor (or CPU) unit? There's no simple answer, because it depends on how the memory chips are organised. Take, for example, the use of 4Kx1 chips. Each chip will provide one bit of data, so that we need eight chips to give a complete byte of memory data, 4K in this example. The data connections are simple; each data line from the CPU goes to a different memory chip. The memory lines are equally easy. 4K is 2^{12}, so that twelve address lines of the microprocessor are connected to all twelve address pins on each memory unit (Fig. 9) This would be the normal layout for a medium sized system using the INS8060, for example, which has only twelve address lines; other microprocessors which use 16 address lines would have four address lines left spare. The lines which are left spare are, of course, the higher order address lines numbered A12 to A15 (they start at A0, so the twelfth line is A11), because the lower order ones are the first to be connected.

The shape of the circuit board would have to be rather different if we were using, say 2K x 4 memories. Each memory chip would have four data pins, so that a complete data byte would need only two chips, and with only 2K to address, only 11 address lines would be needed. On the other hand, had we used 1K x 8, a single memory chip would be connected to all eight data lines and 10 of the address lines.

That's simple enough, but suppose we wanted more memory than could be supplied by a single band of memory ICs? We might, for example, find that 2K of memory obtained from two of the 2K x 4 chips was insufficient and that we needed another 2K. How do we cope with the extra? The answer is that we use one lot (two of 2K x 4) for the first 2K of memory addresses and the other lot for the second 2K of memory — but how? When we have two identical lots of memory chips they will all use the same address lines and the same data lines. In our example using 2K x 4 chips, we want to use the first two chips for the first 2K of memory and the second two for the next 2K. Each chip, being a 2K chip, has 11 address lines and four data lines, and all the address lines will be paralleled. In other words, the A0 pin of each chip is joined and connected to the A0 pin on the CPU, and A1 pins of the RAM are similarly connected to the A1 pin of the CPU and so on. The data pins 0 to 3 of chips 1 and 3 are connected to data pins D0 to D3 of the CPU and the data pins 0 to 3 of chips 2 and 4 are connected to data pins D4 to D7 of the CPU.

Bits Of Memory

If these were the only connections, we wouldn't have a workable system, because a given address, say 10010110110, would fetch data from (assuming that we're reading memory) both lots of chips and something would end up frying tonight. 'Address decoding' solves the problem. The simplest method is linear address decoding. The highest address for chips 1 and 2 is 11111111111. The next number above this is 100000000000. The lower address lines are now all at 0, so that both lots of memories 1 and 2 along with 3 and 4 are fetching from address 0.

This is where the chip-enable pin comes into the picture. Suppose line A11 is connected to the chip-enable pin of memory chips 1 and 2, and an inverter, whose output is connected to the chip-enable pins of memory chips 3 and 4.

Consider what happens if the chip-enable is active, allowing the chip to operate, when it is at zero. Addresses 0000 up to 07FF (that's all zeros up to all 1s) will be fetched from chips 1 and 2 only, because line A11 is low, activating the chip-enable of those two chips. Because of the inverter, the chip-enable of memory chips 3 and 4 is high, putting their data outputs into the floating state. The data bytes for the first 2K of addresses are, therefore, read from memory chips 1 and 2 only. When the address number reaches 100000000000 (0800 in hexadecimal), the A11 line goes to 1, so that the chip-enable pin of memory chips 1 and 2 goes high, putting the data oututs of those chips into the floating state. The inverter action ensures that the chip-enable pin of memory chips 3 and 4 will be low, so that the next 2K of address numbers are read from these chips only.

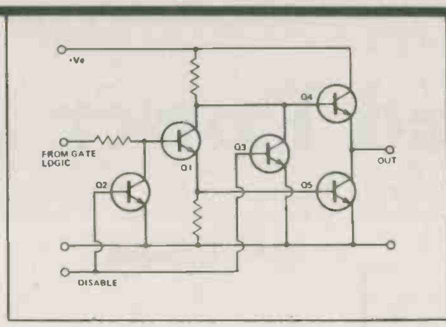


Fig. 7 A simplified form of three-state control. The normal gate output circuit consists of Q1, 4 and 5. When the disable pin is high, Q2 and Q3 conduct, shorting the bases of Q1 and Q4, so that both transistors are cut off. This isolates the output completely.

Partial Control

This system is only a partial solution, though, because the decoding does nothing about lines A12 to A15. As the program count proceeds, these lines will be activated and if nothing is attached to them, the memory chips will be controlled purely by the lower lines.

Since the upper four lines can have $2^4 = 16$ possible addresses on them for any given address on the lines which we're using, the sequence of use of memory can be repeated 16 times.

All this address decoding business, incidentally, applies equally to ROM or RAM. The only extra complication which is present in RAM chips is the read/write pin which has to be taken to one logic voltage for writing data from the microprocessor to memory and to the other logic voltage for reading data from the memory to the microprocessor. The microprocessor CPU will control such pins directly from its read/write control pin, or pins, which will be indicated on the pinout diagram.

Any Port In A Storm

Most microprocessor systems need nothing like the 64K of memory which could be addressed by sixteen address lines. Even a computer with fairly extensive capabilities may use only 16K of RAM, though its ROM and other use of memory addresses can bring the total up to 32K. All in all, then, there are several address lines floating about if we want to load data into the CPU directly or feed data out. An address-decoded or memory-mapped input/output system makes use of buffers and latches which are controlled by a signal gated out from the address lines.

For example, suppose the ROM and RAM that we use in a system take up a total of 8K. 8K memory needs addresses up to 2^{13}, so that it uses 13 of the 16 memory lines and there are three left. Now three lines can be used in $2^3 = 8$ different sets of addresses, of which we have used one set in the 8K of memory addresses. That leaves seven sets of 8K (56K) of addresses which are spare if the top lines are fully decoded!

We can, for example, choose to use an address such as 36D6, which involves decoding all the address lines, or more simply, use any address which has line A13 high. Normally this would activate the memory, but we can easily arrange things so that when A13 is high, a gate circuit will disable all the memory chips, making use of the chip-enable inputs. That way, any memory address which has line A13 high can be used to activate a buffer and so connect the data lines to a connecting strip. The buffer would also be controlled by the read/write signals to ensure that signals were going in the right direction. A more common type of interface is an eight-bit latch, which holds data temporarily stored until either the CPU or any external circuits can deal with the bits.

Map Reading

Memory-mapping is a very common method of making use of the address lines to control inputs and outputs; porting is another. A port is usually a separate IC

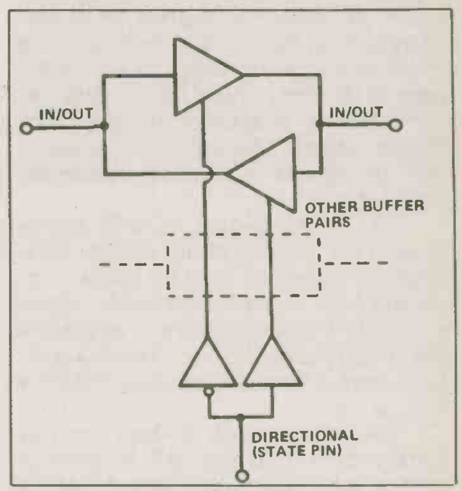


Fig. 8 The bidirectional buffer. The buffer stages are connected input-to-output with the enable lines driven so that the two buffers of a pair cannot be enabled at the same time. This arrangement is sometimes described as a 'transceiver' — an example is the quad transceiver 74LS243. An octal buffer such as the 74LS241 can also be used in this way by connecting the enable inputs together.

Continued on page 78

Light and Power from DC

Generating line-independent light and power from batteries is fraught with many unrealised difficulties. Whether you want dc back-up to operate equipment when the line goes 'off the air' or a wholly independent 120 Vac supply, you should know the problems up front.

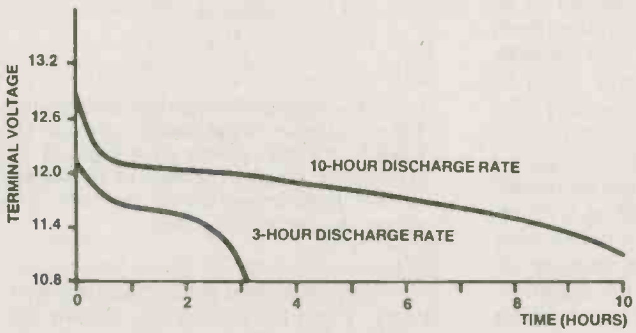


Fig. 1 Typical discharge characteristics of a 12 V (nominal) lead-acid battery.

THAT'S THE TROUBLE with power companies — they've insidiously crept into our lives and made us quite dependent on them. For those occasions when we cannot avail ourselves of their 'services', we have to rely on other sources to provide light and power. The old kerosene pressure lamp has its advantages — and disadvantages — but how on earth do you keep a disk drive running when the ac line 'browns out'? As storage batteries are ubiquitous, the 12 V car battery in particular, it's natural that we turn on them to provide back-up and line-independent supplies.

Back-up supplies

For equipment designed to be powered directly from a nominal 12 Vdc source or from either 12 Vdc or 120 Vac, back-up supplies are employed to maintain continuity of supply, the battery being kept charged from the line, but the battery acts to maintain power supply to the equipment in the event of line failure. This sort of system is commonly installed with burglar alarms, amateur radio repeaters and geophysical monitoring equipment, for example.

The 'power budget' of such systems is carefully considered to provide maximum service period from the battery supply when line power is unavailable. Hence a single 12 V storage battery — generally a low maintenance type — is employed. Let's learn a bit about lead-acid batteries first.

The fully-charged, no-load terminal voltage of a lead-acid cell is between 2.3-2.4 volts. This drops under load to about 2.0-2.2 volts. When discharged, the cell voltage is typically 1.85 volts. The amp-hour capacity is determined from a 10-hour discharge rate. The current required to discharge the battery to its endpoint voltage of 1.85 V/cell is multiplied by this time; e.g: a 40 Ah battery will provide four amps for 10 hours before requiring recharge. Note, however, that the amp-hour capacity varies with the discharge current. The same battery discharged at a rate of 10 amps will not last four hours; on the other hand if it is discharged at 1 amp it will last somewhat longer than 40 hours. The typical discharge characteristics of a (nominal) 12 V battery are shown in Figure 1.

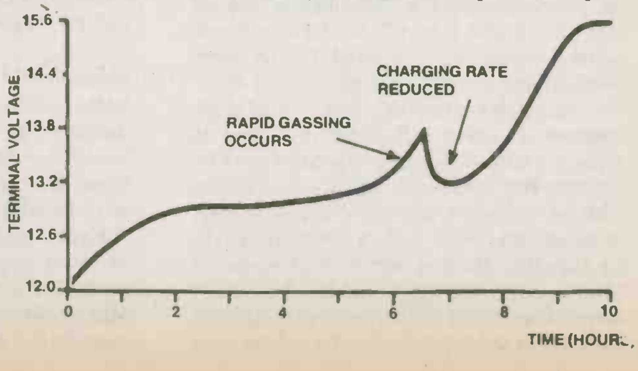
The ideal initial charging current for the fully discharged battery (cell voltage under 2.0V) should be about 20 amps per 100 amp-hours of capacity (i.e: 8 amps for a 40 Ah battery). Once the electrolyte begins to gas rapidly, the terminal voltage will be around 13.8 volts and rising rapidly. At this point, the charging current should be reduced to somewhere between 4-8 amps per 100 Ah until charging is complete.

At the end of charging, terminal voltage may rise to about 15.6 volts or more, but this decreases slowly after the charger is removed, the terminal voltage then usually reading around 14.0 to 14.4 volts (see Figure 2).

Back-up supplies are generally of the 'trickle-charge' type or the 'battery condition' sensing type. The example in Figure 5 is of the former type and trickle charges a 12 V battery when the mains is on and provides automatic switchover when the power drops out. It's cheap and simple, but needs to be used for the batteries to stay in condition so that they deliver their rated capacity when needed. Back-up supplies of this sort are only practical where the load on the supply is not too heavy — generally 20W or so.

To drive a heavier load, upwards of 50 W for example, it's best to power the equipment from the battery all the time and have a charger which senses the battery terminal voltage, charging the battery when the terminal voltage falls to a preset level and turning off when the terminal voltage rises to the desired operating level again. There is a slight element of luck involved as to how charged the battery will be at any one time, but the lower limit is usually set so that the equipment will operate for a specified period. A 100 Ah battery can drive a 10 A load at the 10-hour discharge rate — which effectively means it's a good back-up supply for equipment with a power budget of up to 120 W mean consumption. This means that actual consumption can be greater than that from time to time provided that consumption falls below the mean level for an equivalent period. An amateur VHF or UHF repeater is a good example. Whilst 'listening' only — no stations active on the input channel — consumption is quite low. When 'activated' by a station or stations, the repeater spends most of its time transmitting, and consumption can be four to ten times that during inactive periods, depending on the power output

Fig. 2 Charging characteristics of a 12 V (nominal) lead-acid battery. The 'kink' in the curve near six hours is explained in the text.



of the transmitter employed in the repeater.

As stated earlier, the major consideration with back-up supplies is the power budget of the equipment being supplied. If you anticipate the necessity of operating the equipment for periods exceeding, say, eight hours, then a battery of adequate ampere-hour capacity needs to be used. It is always prudent to choose a battery with 20-50% more capacity than strictly necessary.

dc-ac inverters

Like storage batteries, 120 Vac mains-operated equipment is ubiquitous! The huge variety of products have been designed to be convenient, thus making themselves necessary. Or so it seems. Why on earth anyone would want to take an electric razor on a camping expedition and expect to power it from an ersatz 120 Vac supply is beyond this writer — but then I haven't had a shave in more than 15 years except when my appendix was removed and then they didn't shave my face!

There are two common approaches to providing 60 Hz ac power for mains operated appliances: provide square wave drive of the appropriate amplitude, or derive a sinewave (or pseudo sinewave) supply of appropriate amplitude. Both are fraught with hidden difficulties. If you want any substantial amount of power output — like 200 W — you're in hot water — and probably unable to boil a kettle, to boot!

A square wave dc-ac inverter has the advantage of simplicity and efficiency — depending somewhat on the design. Inverters generally take two forms: self-excited, usually employing a feedback winding on the transformer, and driven, where an oscillator drives a switching circuit, generally with transformer output. Where the precise frequency of the ac output is unimportant, self-excited inverters are employed. Where a stable 60 Hz output is required, a driven inverter is necessary.

Lighting is one area where self-excited dc-ac inverters find application. The common tungsten filament incandescent light globe is a poor choice for lighting where a dc supply is employed. They have an efficiency of less than a fifth of that of a fluorescent light of the same power rating — viz: around 12 lumens/watt for the tungsten filament lamp versus better than 60 lumens/watt for a fluorescent tube. A 20 W fluorescent tube would provide as much light output as a 100 W incandescent globe! Those figures are based on 60 Hz ac supply. Fluorescent tubes actually improve in efficiency when driven from a higher frequency supply. Figure 3 shows how the light output of a fluorescent tube increases with increasing supply frequency. Driving the tube from a supply frequency of 10 kHz or more will result in a 20% increase in light output.

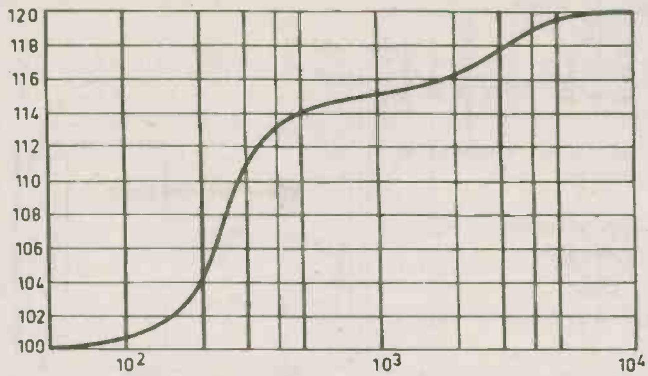


Fig. 3 The light output of a fluorescent tube increases with increasing supply frequency in the manner shown in this graph. This property is exploited in dc-ac square wave inverters for lighting.

The circuit of a self-excited inverter driving a fluorescent tube is shown in Figure 4. It ran at around 2 kHz and employed a ferrite-cored transformer. Consumption was 2.5 amps. An incandescent globe to provide a similar light output would draw around 10 amps! Such inverters have one drawback — the transformer core 'sings' owing to the magnetostrictive forces on the core pieces (which generally come in two pieces). That can be solved in two ways — put the inverter in a 'soundproof' box or operate the inverter at a frequency above audibility.

When it come to powering 120 Vac-operated equipment or appliances a number of considerations have to be looked at. First, will the equipment operate from a square wave supply? Many appliances employing an ac or ac/dc motor will operate quite happily from a square wave supply. One of ETI's correspondents employed battery back-up for his computer's disc drives, supplying these with 120 V, 60 Hz square wave ac from a driven inverter. The general arrangement is shown in Figure 6. A 120 Hz oscillator drives a flip-flop, which drives a pair of HEXFETs connected in push-pull across the secondary of a toroidal transformer. Battery supply was 24 V. The transformer is operated 'back-to-front' here, where input is applied to the secondary and the load connected across the primary. Toroidal transformers perform much better in this application than conventional types as core losses are lower and primary-to-secondary coupling is generally better. Some losses are involved, the saturation voltage of the HEXFETs generally being the greatest source. Hence the use of a 20-0-20 V winding and not a 24-0-24 V winding.

The saturation voltage loss in switching devices driving a transformer is an important consideration. One or two volts lost from a 24 V supply represent only about 4% to 8% loss, but at 12 V it's twice that! Any further losses only magnify the problem.

A square wave ac supply is inherently rich in harmonics. These can play havoc with audio and digital equipment and it's often difficult to suppress interference generated by the supply. Then again, some equipment — particularly anything containing a transformer and rectifier, will produce entirely different performance from when it's operated from a sine wave supply. The problem arises because the peak and RMS values of a square wave are the same, whereas the peak/RMS ratio for a sinewave is 1.414. To deliver the same work value as a sine wave supply, the peak output voltage of a square wave dc-ac inverter is generally set at 120 V. When driving a motor or resistive load, the square wave supply will deliver the same amount of power as a sine wave supply; i.e.: the same amount of work will be done (all else being equal). But, where the load or equipment expects a peak voltage of 170 V (as we have with the ordinary line), then a square wave supply of a nominal 120 V output will not 'deliver the goods' as its peak voltage is only 120 V.

Once you get a small inverter going, it's only natural that you will want one that can drive an electric kettle or hotplate from a 12 V battery. This, unfortunately, is impractical, for the following reasons.

Consider this: a sinewave dc-ac inverter needs to be of the driven type. Hence it generally consists of an oscillator driving a class B power amplifier — usually a push-pull type. The theoretical maximum efficiency obtainable with a class B power amplifier is 78%. With losses and power consumption of drive circuitry taken into account the dc power input to ac power output efficiency of an inverter of this type is generally around 65-70%. Thus a 1 kW dc-ac inverter to run from a 12 V battery would draw in excess of 120 amps at full load! Few batteries available would supply that sort of current for long. With currents of that magnitude, special arrangements have to be made for primary circuit conductors. A resistance of 5 milliohms (0.005 ohms) will result in a power loss of more than 70 watts. Then again, special consideration has to be

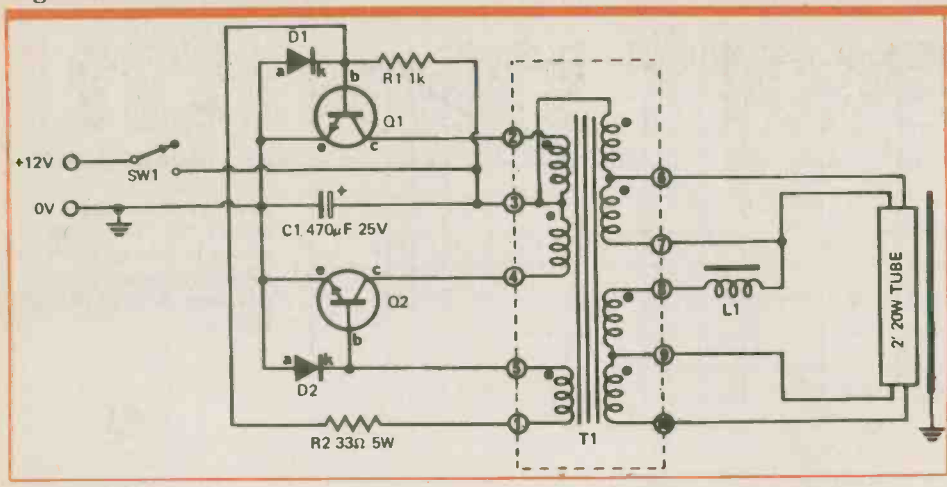


Fig. 4 A self-excited dc-ac square wave inverter operating at 2 kHz to drive a 20 W fluorescent tube — an efficient solution to providing light from a dc supply.

given to heat dissipation in the power output stage. The devices used would dissipate something over 400 W at peak load. No load dissipation would probably be in the vicinity of 40-50 W, which is no mean amount to get rid of.

Apart from the weight of a heatsink, consider the weight of a 1 kVA (or 1000 W) transformer (assuming a single transformer is used). We'll leave the expense to your imagination.

The problems are reduced somewhat when a much higher dc supply voltage is available. However, in the latter case other techniques of dc to ac conversion present themselves — but that should be the subject of another article as it's a whole new ballgame.

Where a 12 V battery supply only is available, there is a practical limit to the maximum power of a dc-ac inverter, and that's probably around 300 W output. At typical efficiencies, the dc input power is around 450 W, or close to 35-40 amps current from the battery.

As you would already appreciate, this brings its own special problems. A battery to supply that sort of power for any ap-

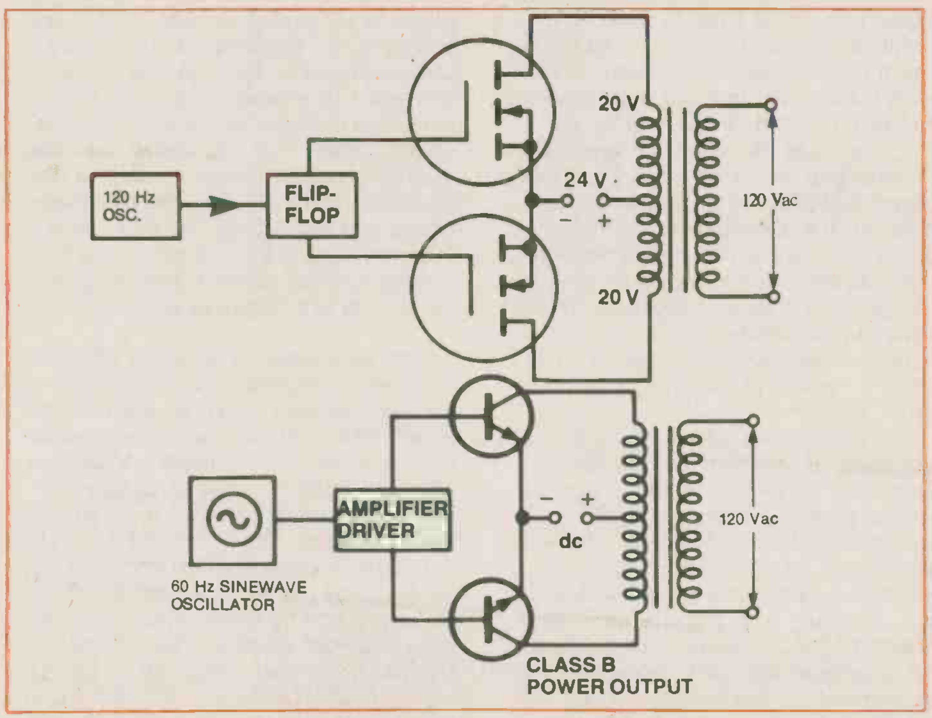


Fig. 6 Class B driven sinewave inverter technique for providing 120 Vac from a dc supply.

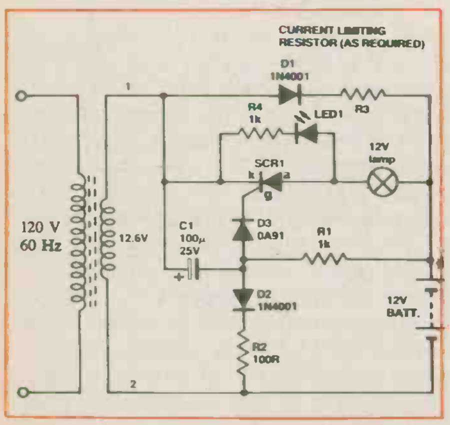


Fig. 5 Circuit of an 'Emergency Lighting Unit', a simple back-up supply that can be used for other than lighting applications.

preciable or worthwhile period would need to have a considerable ampere-hour capacity. Your typical 40-60 Ah car battery would barely deliver an hour's worth of power. If the inverter is installed within the vehicle, or close by, and you are willing to keep the engine running during operation, then the battery will deliver the goods for quite a period, provided you can 'set' the throttle to suit so that battery charge is maintained. At this stage, I might point out that an alternator coupled to the motor would provide a more efficient energy conversion.

To gain, say, four to six hours of operation for a 300 W inverter, you would need a battery system of more than 200 Ah capacity.

A more practicable power level for a sinewave dc-ac inverter would be around 120 W. Such an inverter would pull 12 to 15 amps from the battery, a much more manageable figure.

Having seen the primary side of the problem, let's consider the secondary side — the load. How many appliances do you have rated at less than 300 watts? Very few. The humble electric kettle is rated from 1 kW to 1.5 kW. Monochrome TV sets, particularly portables, may only consume 100 W, but a colour TV may draw three times that or more. A 'low power' (say, 30 W/ch.) domestic hi-fi will draw around 100 W, depending on how much equipment is in use and how loud you like it. Anything more ambitious has a proportionately larger consumption. A 300 W dc-ac inverter is best considered where the full output is only required intermittently.

Conclusion

As can be seen, many factors have to be taken into account when considering obtaining light and power from a battery supply — whether it be in a back-up application, for lighting or 120 Vac substitution. The ubiquitous 12 V battery is not up to the job in some instances — in which case higher voltage dc systems are better considered.

Readers wishing to experiment with practical circuits for converting 12 Vdc to 115 Vac, 60 Hz, should contact Hammond Manufacturing, 394 Edinburgh Rd., Guelph, Ontario N1H 1E5. Ask for information on the 513 series switching transformers. ETI

ETI next month

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

The Canadian Amateur Radio Astronomy Society

Eric McMillan looks into Computer Assisted Design/Computer Assisted Manufacturing in Canada. He's getting a word processor, and will be a CAA (Computer Assisted Author).

Satellite TV Receiver Part 2

Ron Coles continues with the easy part, now that he's wrestled a 12 foot dish into position; a look at the receiver and converter.

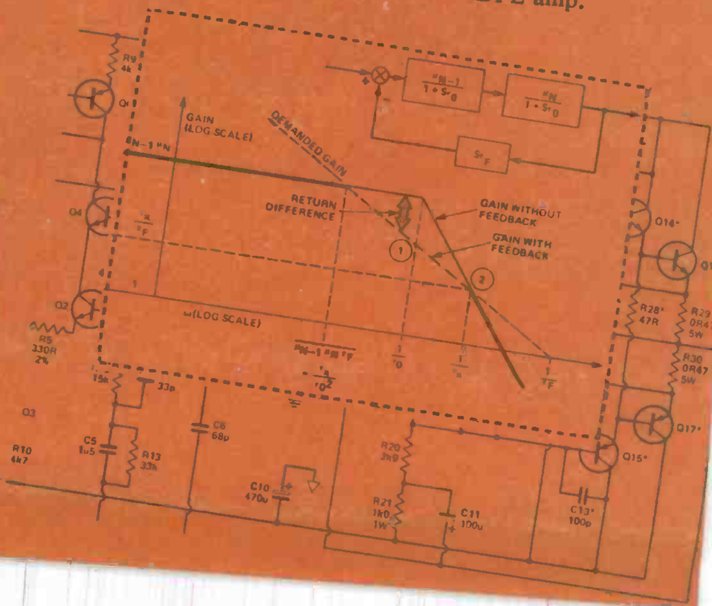
PLUS!
The Lowdown on Pay TV Piracy!
Auto Sprinkler Project!
Sound Switch Project!
Memory Systems!

CAD/CAM

Roger Allan writes up one of the most dedicated amateur groups you'll find.

NDFL Amplifiers

A doubleheader - an article on how to design Nested Differentiating Feedback Loop Amplifiers (whew!), plus a complete project for an ultra-low distortion 60 w NDFL amp.



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Reverb Amplifier

PROJECT

A spring line for professional audio? Don't sneer - those inexpensive springs have remarkable potential when used with the right electronics. By Bill Markwick.

IF YOU'VE listened to the average guitar reverberation, you're probably creasing over giggling with the idea of using the familiar Gibbs or Accutronics springs for home or studio recordings. They bring to mind that hollow boingy twang, like yelling down a pipeline. But wait: it isn't so much the fault of the line as the electronics driving it. Here are the major drawbacks.

1. Some driver amps are low impedance voltage sources such as op amps or emitter followers; this approach neglects the fact that the spring's input coil looks like a pure inductance, and, for good treble response, needs a rising voltage response to match its increase in impedance with increasing frequency.

2. This rising impedance means that the amplifier must supply whole bunches of voltage at the high end; if it isn't a constant voltage source, the output climbs to follow the line impedance, and if it is, the operator is tempted to crank the input level to make it sound brighter. Most amplifiers run out of headroom very quickly.

3. Under the pressures of recording in a studio, the operator can't always monitor the signal level carefully, and too much signal is usually the cause of the springy sound we all know and hate.

Here's an amplifier that goes a long way towards curing the reverb spring blues. It features a constant-current type of drive to allow for the spring's rising impedance, a bridge configuration to provide a extra 6 dB of headroom, and an optional limiter circuit to prevent overload distortion in case you nod out during the session.

To begin at the beginning: the input signal can come from either balanced or unbalanced sources; IC1 and the three-conductor input jack form a balanced amplifier for rejection of any noise induced on the line, and if you're using an unbalanced source with regular two-conductor phone plugs, it just acts as a 47K buffer amp.

IC2 is the drive circuit for the line. It's a voltage-controlled current-source, which means that the current through the line will be constant for a constant input; the circuit automatically follows varia-

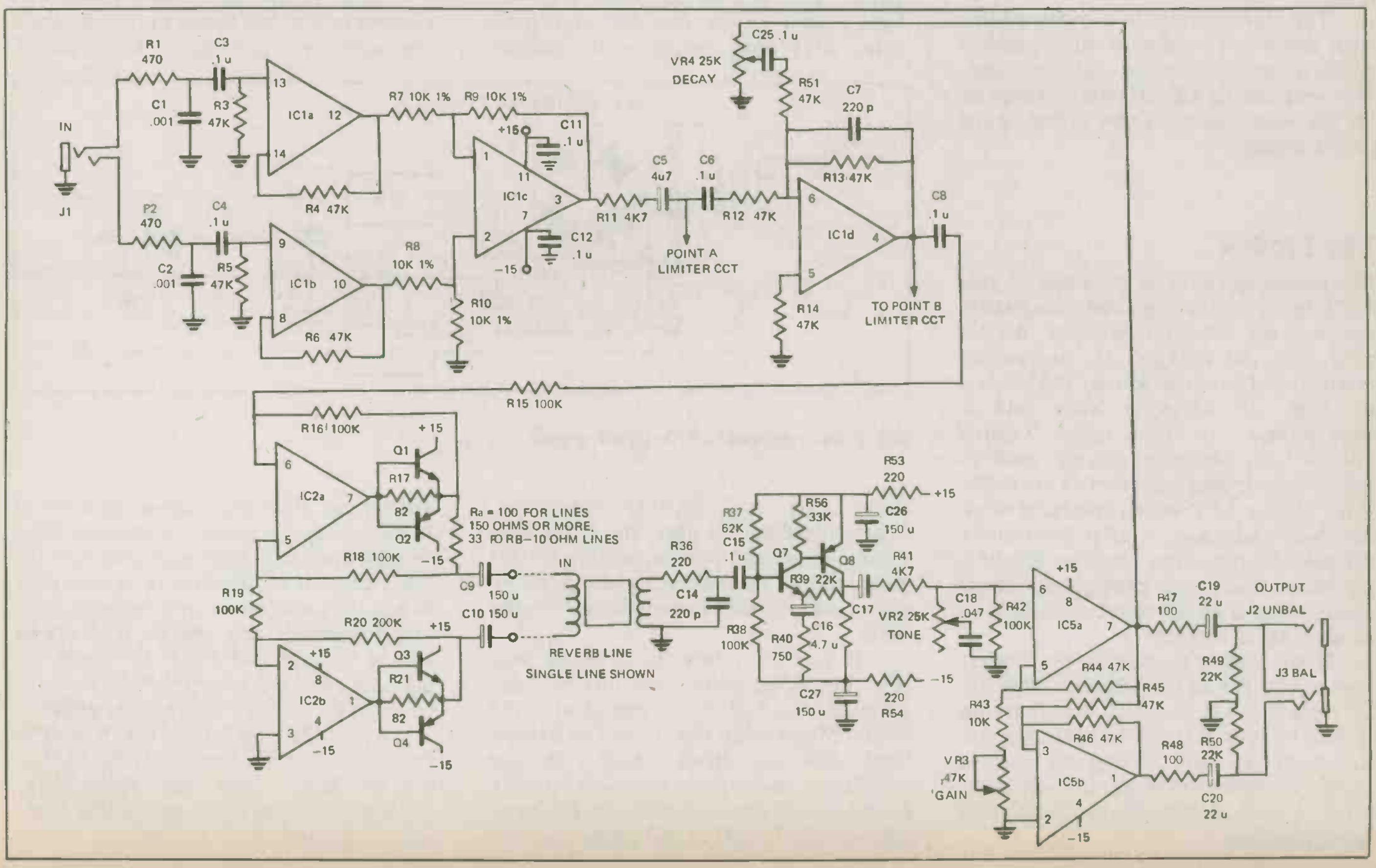


Fig. 1 The schematic of the input and output circuits.

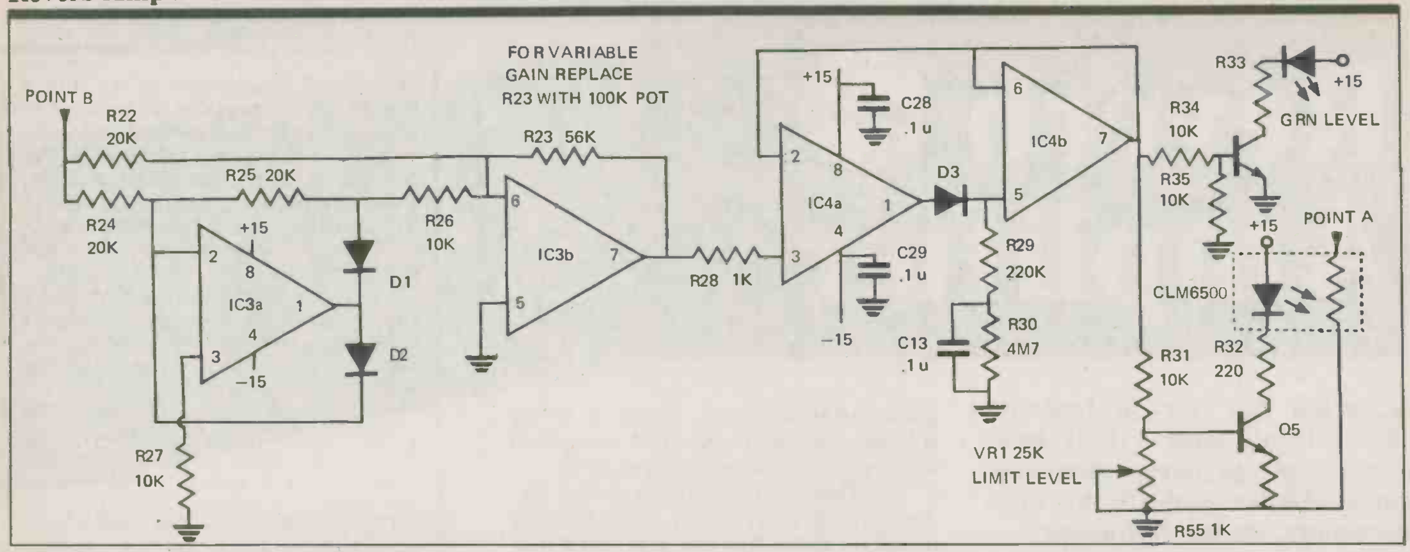


Fig. 2 The schematic of the limiter circuit.

tions in line impedance. IC2b is out-of-phase with IC2a; this effectively doubles the signal swing across the line - it's equivalent to using a 60 V supply.

The loss through the line itself is about 40 dB. This loss is restored by the output amplifier Q7, Q8 and IC5. The sound of the line tends to be rather bright because of the excellent HF response of the current source drive, and a tone control is added after Q8 to allow you to set the treble to suit; cutting the treble also improves the signal-to-noise ratio considerably, without seriously muffling the sound.

The final output is a balanced-line type, and a two-conductor output jack is added in case your system is unbalanced. The level can be adjusted to compensate for the wide variations you'll find in the reverb springs.

The Limiter

The limiter circuitry is optional; if you don't feel into the cost and complexity, just omit the circuitry. However, it does have the advantage of preventing overload distortion if you set the levels a bit high, or someone leans into a microphone. It also helps reduce "flutter" on percussive sounds such as kick drums. In addition, there's the facility for a green LED which comes on when the level is adequate; a drive level that's too low will mean that you'll be amplifying noise, hum, and people's footsteps when you hoist up the reverb return pot to get acceptable volume.

If you decide to build in the limiter, you'll have to find the Clairex CLM6500 LED/photocell. I know it's a bore trying to hunt up special parts, but this one has the advantage of not causing any increase in noise or distortion levels; it's worth the effort. The CLM6000 should also work in this application.

The Line

Now as to the line itself: the real piece de resistance in the way of spring lines is the Accutronics 99 system. It consists of two lines for a total of six springs; the delay and decay times are chosen for a realistically full reverb sound, and they aren't quite as plagued with mechanical whistles and pops when the signal goes through. You can bug your local music store about getting you one of these systems; most places that repair guitar amps should have access to Accutronics parts. These are special order lines, and here's what to ask for: 240 ohm input coils, 2575 ohm output coils, medium decay time, and floating connectors. When installing the lines, the input coils should be wired in series, and so should the outputs. This seems to give a richer sound, as one coil's impedance affects the other.

If you can't face the ordering process, any large guitar-type line will do, although the higher the impedance, the better. Many guitar lines have 8 or 10 ohm lines, and the driver circuitry in the amplifier may be restricted in its headroom. If you have a choice, the input coils should be 200 to 800 ohms, and the output coils 600 to 3000 ohms.

Mounting

The reverb lines and the amplifier will fit nicely into a standard 19 inch rackmount box, as shown in the photograph. This reverb amp had an amazingly wonderful idea incorporated into it: the two sets of output coils from the Type 99 each had their own amplifier; this gave a "stereo" output from a mono input. The trouble was, nobody could hear difference as the switch was changed back and forth from stereo to mono. Such is life.

There is one small hassle involved in rackmounting, and that is the reverb line's obsession with picking up every bit of hum it can find; this may mean a lot of fiddling with the power transformer location to prevent it from radiating into the line's coils. If all else fails, you may have to put the transformer in a separate mini-box. Remember, too, that the audio jacks should be insulated from the chassis — the only connection to the chassis should be the power supply's zero-volts point.

Also, the regulator IC's 6 and 7 should either be mounted on the chassis with insulating washers and nylon screws, or they should be fitted with a tiny heat-sink; a square inch or two will do.

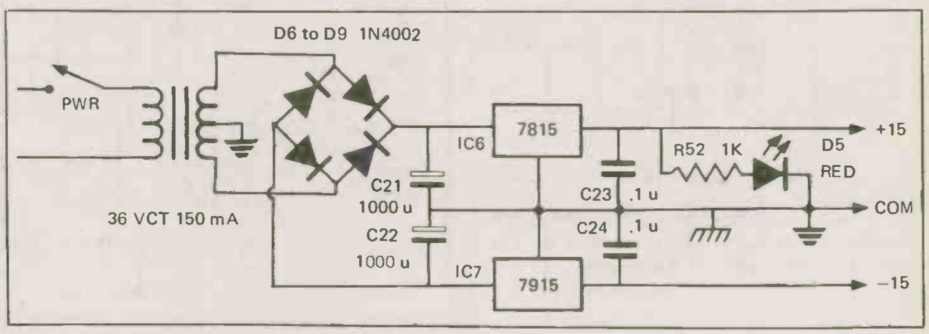


Fig. 3 The schematic of the power supply.

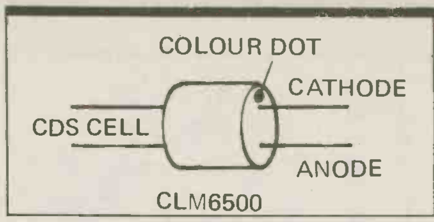


Fig. 4 The CLM6500 case outline.

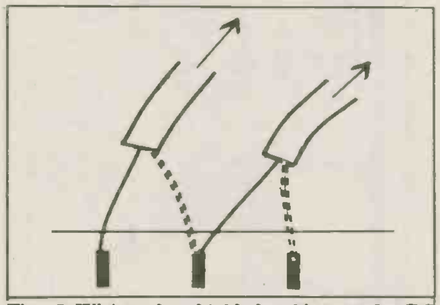


Fig. 5 Wiring the shielded cables to the PC board when two lines are used; inputs and outputs are wired in the same way.

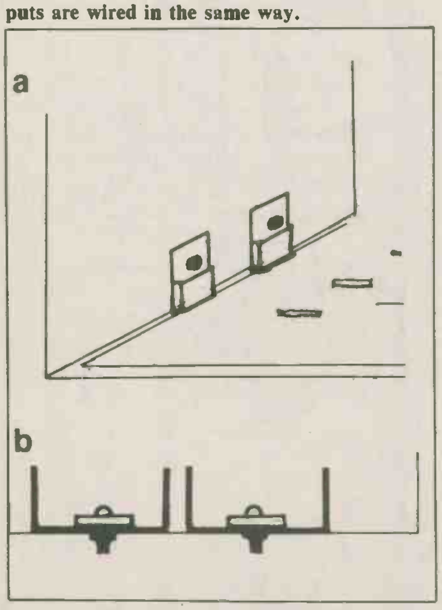


Fig. 6 In (a) the regulators are mounted to the chassis with insulating kits; (b) shows the top view when using two small heatsinks.

Calibration

You can't calibrate the level with a sine wave! There are so many resonances in any reverb system that the output sine amplitude can vary 20 dB within a few Hertz. The easiest way is to send it program material at a level consistently near 0 VU, and adjust the output trim pot to get the same level out. If you're a fanatic about level-setting, you'll need a white noise source such as an FM tuner set off-station. This will give a good relative indication of input/output levels.

Operation

Operation is straightforward. The green LED should flash every now and then, say, once every one or two seconds. If it stays on consistently, the level is set too high. Incidentally, you can delete this LED entirely if you prefer watching a VU meter on your mixer.

The limiter control takes a bit of experimenting to find the point where limiting begins; an audio source with loud peaks is good for this. You can then leave the control in this position forever, if you like.

The tone control is just set to suit your idea of good treble. It certainly isn't meant to be as good as returning the reverb back through an equaliser, but it'll do in a pinch.

How Does it Sound?

Well, it won't sound like an EMT plate or an AKG spring. There are limits to the El Cheapo route, you know. On the other hand, it sounds remarkably better than the average spring line that you find in

PARTS LIST

Resistors, ¼ W 5%

R1,2	470
R3,4,5,6,44,45,46,51	47K
R11,41	4K7
R15,16,18,19,38,42	100K
R17,21	82
R20	200K
R22,24,25	20K
R23	56K
R26,27,31,34,35,43	10K
R28,52,55	1K
R29	220K
R30	4M7
R32,36,53,54	220
R33	1K2
R37	62K
R39,49,50	22K
R40	750
R47,48	100
R56	33K

Ra is 100 ohms for lines 150 ohms or greater, 33 ohms for 8 to 10 ohm lines.

¼ W, 1%

R7,8,9,10	10K
VR1,2,4	25K potentiometer
VR3	47K trim pot such as Philips 411 series.

Capacitors

C1,2	.001 *u* ceramic
C3,4,6,8,11,12,13,15,23,24,25,28,29	.1 *u* film
C5,16,17	4*u*7 electro.
C7,14	220 p
C9,10,26,27	150 *u*, 16V electro
C18	.047 film
C19,20	22 *u* 16V electro
C22,25	1000 *u*, 35V electro

Semiconductors

IC1	4136 low noise quad op amp
IC2,3,4,5	TL 072 dual FET op amp
IC6	15 V regulator
IC7	-15 V regulator
IC8	Clairex CLM6500 opto-isolator
Q1,3,5,6,7	2N3904 NPN transistor or equiv.
Q2,4,8	2N3905 PNP transistor or equiv.
D1,2,3	1N4148 silicon diode or similar
D4	any green LED
D5	any red LED
D6,7,8,9	1N4002 silcon power diode or equiv.

Hardware

J1,3	three-conductor phone jack
J2	two-conductor phone jack

Insulators for above, if necessary
Mounting kits or heatsinks for regulators

Miscellaneous

Rackmount box or similar, 36 V 150 mA transformer such as Hammond 166E36, line cord, power switch, knobs, RCA phono cords for connecting reverb lines, PC terminals.

HOW IT WORKS

THE FIRST three sections of IC1 form a true differential amplifier. IC1a and IC1b are unity-gain buffers, and feed the balanced signal to difference amplifier IC1c. The common mode rejection of this amplifier, which is set largely by the matching of R7 to R10, drops out any noise which has been induced on the incoming line; the CMR should be about 40 dB.

IC1d functions as both a mixer and a buffer; it mixes the output signal back into the reverb line, with R51 preventing oscillations, and also buffers the signal after the limiting resistors R11/IC8.

IC2 is a constant-current source. The current is set by Ra, and the feedback loops set by R16 and R18 maintain the output current at the proper level regardless of load impedance changes. Q1 and Q2 increase the output current capability; if it rises beyond a few milliamps, the voltage drop across R17 will turn on one of the transistors. IC2b is an inverting amplifier; the resultant out-of-phase signal across the load means an increase in maximum output of 6 dB, or twice.

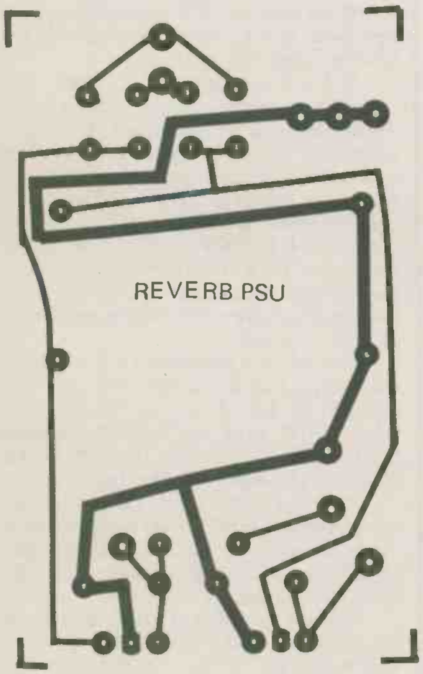
The recovery amplifier is a straightforward compound connection with a gain of about 30 dB. Low frequency rolloff is provided by C15, (and also by C6 in the drive amp) and prevents the line from producing distortion on large bass amplitudes.

After the tone control, a balanced output is provided by IC5, with an unbalanced output available at J2. This output is adjustable for up to 15 dB gain unbalanced, or 21 dB balanced.

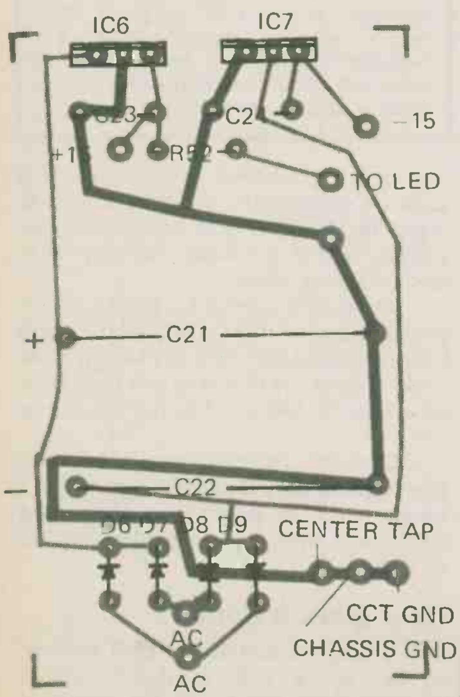
IC3 is a full wave rectifier, and sends the rectified signal to peak detector IC4. This IC charges C13 to the peak level of the input signal, and this charge is buffered by IC4b and sent to control transistors Q5 and Q6. If Q5 turns on, the LED in the opto-isolator is turned on, and reduces the resistance of the CDS photocell. This shunts the input signal at R11. The minimum resistance of the photocell is about 270 ohms, and results in a control range of 25 dB when combined with R11.

small mixers and instrument amps. The only objection usually raised relates to the little bit of ping and flutter you'll hear on very loud percussive drum sounds. This seems to be inherent in the line, and I've never heard any limiters or envelope followers that would take it out. The objections can be reduced if not stilled by minimizing the input level as best you can.

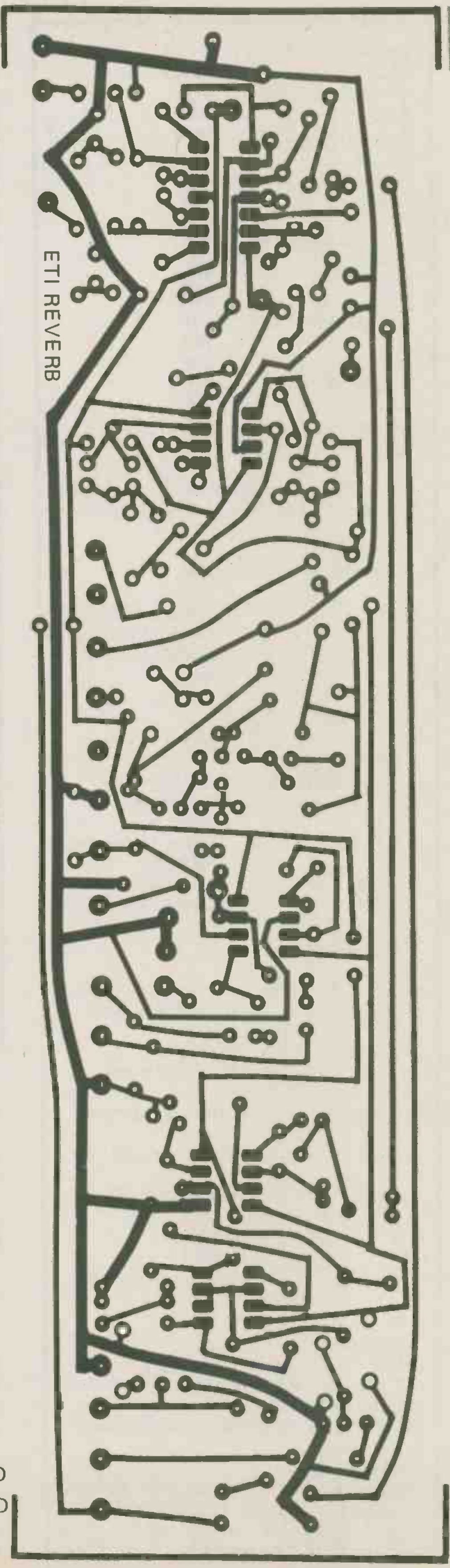
Happy reverbing!



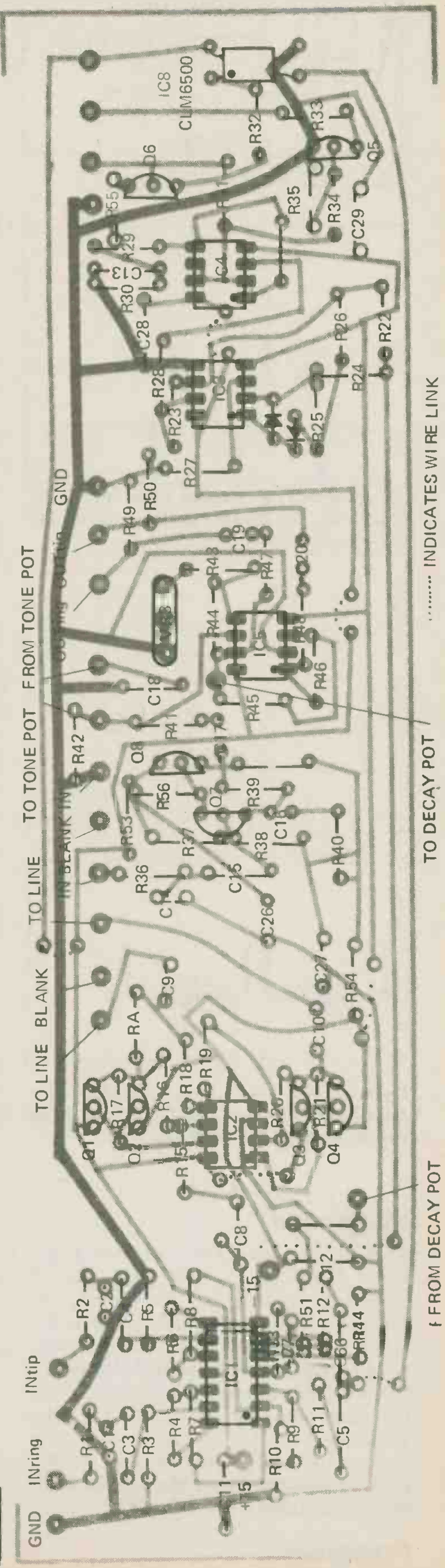
The printed circuit for the power supply.



10 The power supply component location.



The printed circuit for the amplifier.



The amplifier component location.

Selecting a Computer System

Last month, Robert Traub gave a basic introduction to microcomputers. In this issue, he presents a general guide to choosing the necessary peripherals.

by R.G. Traub

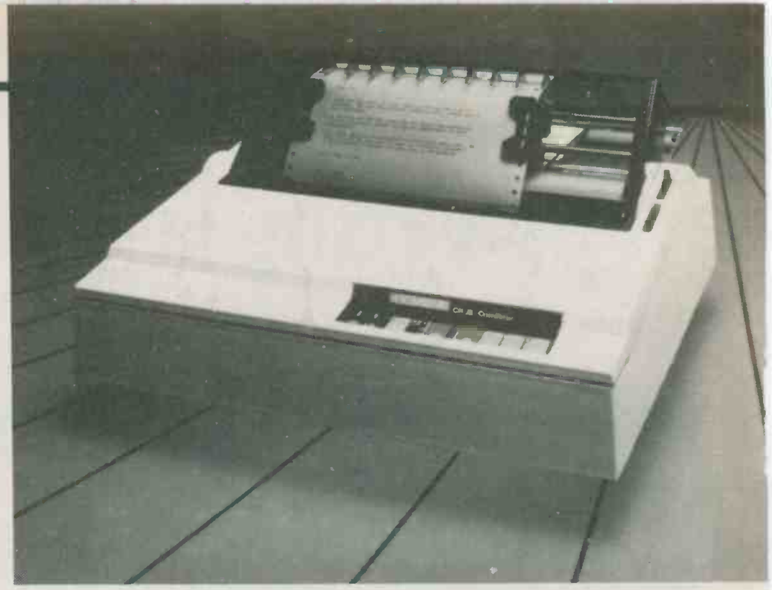
The microcomputer is an extremely versatile tool capable of an infinite number of personal and business applications. To some people the microcomputer may signify a great word processing system, to others a professional accounting system. Some may see a data base management or telecommunications system, to name only a few. The microcomputer can of course be used in all of these areas, but by itself it is nothing more than a collection of sophisticated micro-electronic components. In order to utilize this microelectronic collection, some external equipment, known as "peripherals" will be required along with programs known as "software".

Before the microcomputer can communicate with the outside world, and thereby perform some functions, there must be some way to feed information into the computer (input) and some way to get the processed information out of the computer (output). Each different type of input or output device will require a software routine known as a 'drive' in order to function. With some systems each 'drive' will have to be written by the user. With other systems the 'drivers' are included as part of the overall operating system software. If the microcomputer uses diskettes for data storage, a special program called the Disk Operating System or DOS is required. The DOS will look after such things as copying a diskette, copy a file from one diskette onto another, deleting a file from the diskette directory, displaying the diskette directory, and so on. With cassette storage the operating software is known as COS, or Cassette Operating System. Generally the operating system software is provided with the purchase of a microcomputer.

Input and Output Needs

The operating system and the functions it can perform will have to be totally understood in order for successful operation to occur. The degree to which the end user understands the basic operating system and its functions, will determine the ease and speed of operation. A total understanding of the operating system is required before any "user software" can be successfully maintained and operated on the system. User software are the programs, either written or purchased, designed for a particular application such as word processing, data base management, general ledger etc. All of the user programs will have to communicate with the outside world at one point or another. This communication will occur through the microcomputer's input and output ports to the particular device attached.

An input device can be almost anything, depending totally on the application. A few of the more common input devices include a keyboard, an analogue to digital converter, a modem, a group of environmental sensors, or a point of entry terminal, such as a cash register. Also, there are a great variety of output devices that can be utilized, again depending on the application. Some of the more common output devices include a video display, digital to analogue converter, printer, modem, robot or Light Emitting Diodes (LED's). The job for which the microcomputer will ultimately be utilized will determine the peripheral equipment required to satisfy the project. It is the user's responsibility to know the task required of the microcomputer, and what peripheral (input/output) devices will be needed. As the peripherals constitute the greatest expense in any system and are necessary to obtain the desired result, it is important to know exactly what type of peripheral is required. If this first basic step is not clearly understood and strictly adhered to, the chance of obtaining even a fraction of the desired result, is at best, poor. For example, when a printer is required, it is desirable to know exactly what features in a printer are the most important. It could be speed, the letter quality, the cost, graphics, form size, or paper feed type, to name a few.



A myriad of printers are available; choice is determinted by requirements such as speed, print quality, and interface type.

Printers

Printers range from simple dot matrix, to sophisticated word processing printers, to large high speed units. For example, where cost is the main factor, there are inexpensive 5 x 7 dot matrix printers that offer a limited but definite use. These printers have poor letter quality, and do not allow for descenders. Descenders are the lower part of letters such as 'g' or 'j' that drop slightly below the base line. A simple function such as underlining text cannot be performed without the ability of the printer to descend below the line. However, these printers are still adequate for computer program printouts and non-critical in-house documentation. Some of the newer and more expensive dot matrix printers offer very fine graphics and near letter-quality print. This is done by increasing the number of dots in the matrix. For true letter-quality print used in word processing, there are very sophisticated daisy wheel printers. These units offer bi-directional printing, proportional spacing, half line up, and half line down, for superscript and subscript, variable form width, many different letter styles (print wheels), and so on. Where high speed is required, there are a number of specialized jet ink spray or laser printers available. Each printer will offer special features depending on the job they were designed to do. Some printers are known as character printers; that is, they print a character at a time while others are known as line printers. A line printer will wait until its local buffer has one complete line of text, then print that complete line at one time. No matter what type of printer is decided upon, close examination of the print type and quality will be required to ensure it will meet the requirements of the job. A dot matrix printer offering good graphics may not have the letter quality required for reports or correspondence. Which of these areas is the most important, the graphics, or the correspondence will determine the final choice. Good letter quality printers are very expensive and require expensive, sophisticated software in order to utilize all the features inherent in the printer. Other criteria might include the speed at which a document can be printed rather than the quality of the print.

As "speed" is a relative term, a short explanation may assist. If a printer is said to print 45 characters per second, this would represent a full page of print every 1.46 minutes. To elaborate, there are, with margins, approximately 72 characters on each full line of print. One full page, again with margins, consists of 55 lines; 72 characters per line, times 55 lines, equals 3960 characters for each full page of text. Divide this number by the number of characters per second that the printer can produce, in this case 45, to arrive at 88 seconds per page; 88 seconds is 1.46 minutes. A word of caution here: some printers will accept characters from the computer at a high speed, but actually print the characters onto the paper at a slower speed. The reason for this lies in the fact they they have what is called a "buffer'. A buffer is a bank of memory cells that can take in the information from the computer at a high speed and then feed the characters to the print mechanism at the lower print speed of the unit. When talking about printers and speed, the term BAUD RATE will come up. The baud rate is the rate at which each bit of the character is transferred from the computer to the printer. With a printer that has a serial interface, each bit is transferred one after the other; there is 1 start bit, 8 bits to make up one printable character, and 1 stop bit for a total of 10 bits for each character to be printed. If the baud rate was said to be 300 baud, then simply divide this number by 10 bits to arrive at the approximate "characters per second" number.

When selecting a printer, other areas to consider include the type of paper feed system available, and the maximum paper width the printer can process. The availability of service and a service contract is an important aspect in the purchase of any equipment including a printer. All these points must be considered, fully examined and the correct determination made before the proper printer can be obtained for the job at hand.

Data Storage

As with the printers, the area of data storage also has many areas that need consideration. Some common methods of data storage include the use of either an audio or a digital cassette system, the floppy disk system, the hard disk system, or punch cards. For the beginner, in a non-business environment, an audio cassette storage system may be adequate. In a business environment, however, they are not recommended. These systems are inherently slow since the information is stored serially along the length of the tape. Therefore, if the required program were near the far end of a 60 minute tape, a great deal of time would be wasted waiting for it to arrive at the tape head. The audio cassette systems have no directory of the information recorded onto them and are therefore hard to maintain as files. They are not always reliable and the data may or may not be recorded as required or loaded back into the system consistently. In the field of floppy disk drives, there are 3.5 inch systems, 5.25 inch systems, and 8 inch systems. The floppy disk drives can be either single sided or double sided. For double sided recording, the drive must be equipped with two read/ write heads, while single sided recording only requires one read/write head. The recording format can be either single density or double density; double density will allow about twice as much data storage per diskette than single density. Again, the job at hand will determine if a floppy disk storage system will be required. If a great deal of data or information has to be stored and maintained, the hard disk storage system might be the most cost efficient purchase.

Capacities

As a rule of thumb, a 5.25 inch single sided, single density diskette can hold

100,000 bytes or characters. As each full page of text holds 3960 characters, the total number of pages that can be stored on a single diskette is only 25. This is true providing the diskette contains only the pages of text and no other programs. If other programs are being stored on the same diskette, such as the operating software, the amount of storage area available would be reduced. The double sided, double density 8-inch diskettes, on the other hand, can hold over 1,000,000 bytes or characters, while the hard disk systems can store in the tens of millions.

Recently, with the newer microcomputers, there has been a trend to supply certain peripherals and operating software to form a system. These include such things as a built-in video unit, a built-in keyboard, and one or two floppy disk drives or cassette recorders. This can be a benefit, but can also restrict the potential of the system. The keyboard may not offer all the functions required by the user software, or the video unit may not have the full 80 character lines with 24 lines per screen. In the area of storage, the disk drives may only be 5.25 inch single sided, single density types. This may fall well short of the required storage space and external storage devices may still have to be purchased.

Software

Once the microcomputer and peripherals have been decided upon, the next step, and perhaps the hardest, is to determine the type of software or programs required. Of all the areas in microcomputing, this one is the most difficult to visualize. Software can hide a great number of shortcomings while appearing at first glance to be just the required program. It generally takes a few days of working with a program to find any limitations or operating inadequacy inherent in the software. In order to produce good programs, a great deal of knowledge is required about the given software subject. A knowledgeable programmer is not only required to have a good understanding of microcomputer programming, but must also be well educated in the subject matter of the program, be that accounting, data base management, word processing, graphics or whatever. Currently there are a great number of word processing programs available; however, few if any were written by someone with a degree in the field. Upon close inspection, any shortcomings inherent in the software will become apparent. Most software is written in order to be as general as possible in hopes of covering as many related applications as possible. Even if a program has been tested and loved by some users, it still may not be satisfactory for the given job. With word processing software for example, there are a number of programs that will allow the operator to see on the screen exactly how the print will appear on the printed page. This sytem has some major drawbacks in as much as the video screen is a fixed pitched device. With video units, there are 10 characters to the inch. This of course means that the system can not produce documents with proportional spaced print. Special features such as bold striking of letters are difficult to see on a view screen. Postscript and subscripts are impossible and complex tab combinations are restricted. These may or may not be important, but if the system is purchased for the sole purpose of word processing, there is no reason to be restricted in these crucial areas. With any software package, the user is the ultimate expert and must demand his/her requirements be met completely. Therefore, as a general rule, first examine each potential piece of software very carefully. Be sure that it will fulfill all requirements as determined by the application. It is not important that each function of the software is carried out in the manner that you are personally accustomed to; only that the required function is indeed performed. Unless the software is custom written for your own application, it cannot be expected to perform to your individual preference. Software can be and often is custom written for a particular application; however this is an expensive method requiring a sound and unique reason for such development.

Cassette machines are a popular low-cost method of data storage. Their slow speed is a disadvantage.

Time FLies

The next consideration is that of time. It will take time to fully understand the basic operating system. Each software program purchased will also require time to master. There is a fair investment in time when the purchase of a microcomputer system has been completed. More often than not, the manuals provided with the software and operating system will leave the user asking more questions than they are able to answer. Many hours will have to be spent at the keyboard in order to produce even a basic output or result. This investment in time is one that should be considered, as it will have to be done for each new piece of software purchased, and for each different system used. In an office environment, the end user is not likely to be conversant in the field for which the microcomputer was purchased. In the area of telecommunications for instance, the end user is not expected to know all of the buzz words associated with the field and may find difficulty in operating the system. This will require not only the end user's time being spent in learning the system, but also that of a supervisor or other knowledge-able personnel. This learning time can be reduced significantly if the manuals for the software and hardware are reviewed with the vendor and understood prior to the actual purchase.

Some microcomputers are offered as complete dedicated systems. This is especially true in the word processing field. The purchase of such a unit will by necessity restrict the buyer to that operating system. The user will also be restricted to the peripherals, and programs provided. There is no option to purchase software from other vendors, nor to add specialized input and output devices. With these systems the user must compromise and adapt to the system as it currently exists. Many of these units are based on the "what you see on the video screen is what you get on the paper" philosopy. This has been done in order to reduce the learning time required by the end user. These systems are by no means bad, as they are generally well thought out and provided with tested software which can be readily mastered. These systems are usually backed by a good service department and supplies such as ribbons, diskettes, and paper are readily available. This method offers the user the quickest and easiest way to get a fully tested and proven system.

The microcomputer system will have to last for a few years at least. The cost of these units can vary, but no matter what the cost, it must do the job as required. If the system is carefully thought out, and all the required hardware and software obtained, then ultimately the product will pay for itself. A good system can never go obsolete. The microcomputer and the associated equipment and software allow for an almost infinite variety of applications. Whatever the job, the microcomputer can be designed to handle the application providing you know exactly what the job is.

ETI

Electronics in Fine Art

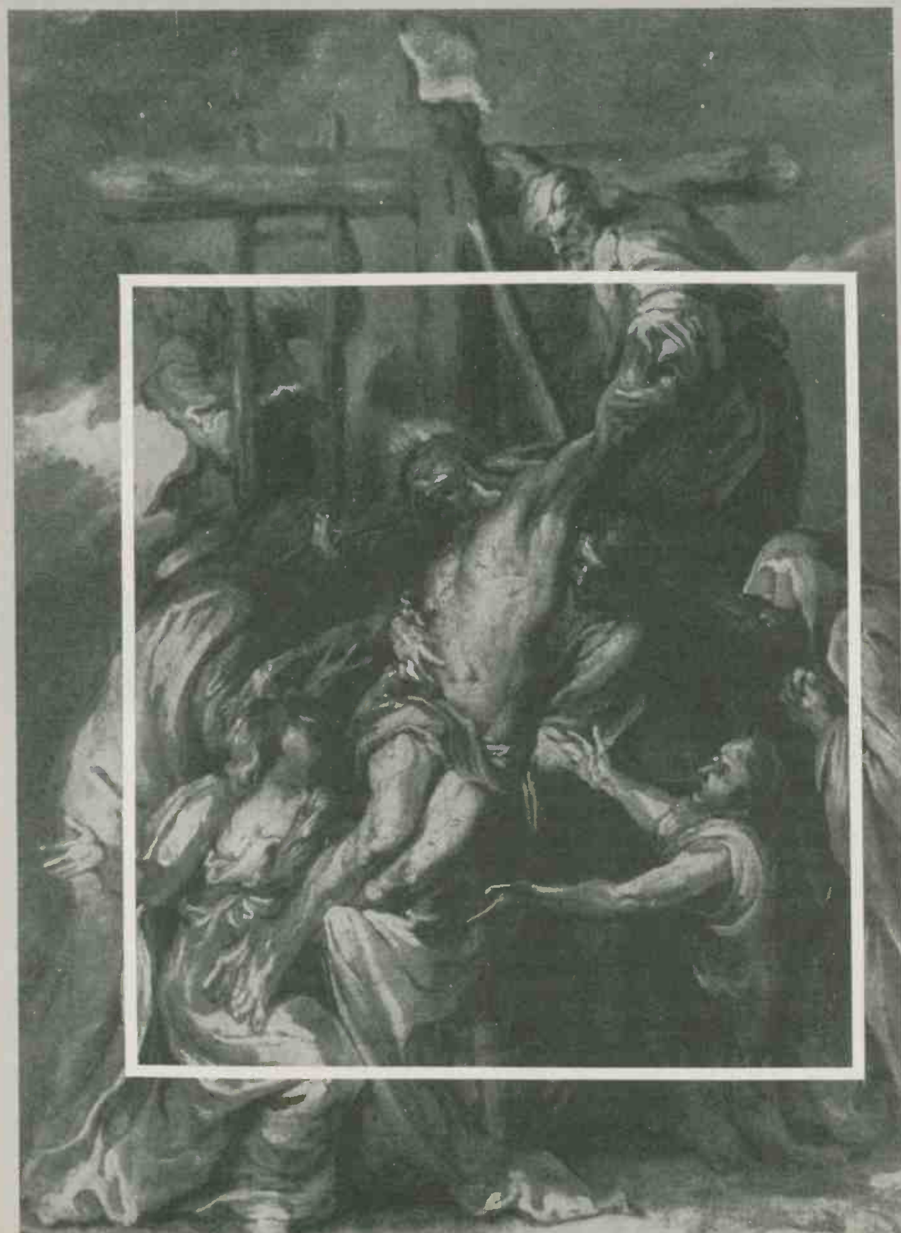
Radiographic scanning and computer analysis have made it possible for art experts to not only detect forgeries, but reveal the artist's step-by-step painting methods, even after centuries. By Roger Allan.

FOR MILLENIA, the study of fine art was limited to specialists using their eyes to visually examine and judge a painting by its color and style, pentimenti (painting over an original), brush stroke characteristics, contemporary documentation and the artist's preparatory sketches. With the discovery of x-ray radiography, the subjective element in fine art studies, both curatorial and historical, found a new and very useful tool. As the years have passed, the interface between art and science, specifically electronics in all its manifestations, has broadened until today no art museum can be considered as being modern without an electronics laboratory stuck somewhere in the building studying the works' chemistry and physics by means of x-ray analysis, spectrophotography, infrared photography and the like.

There are two process which represent the state of the art, in the study of art as it were, one for historical reasons and one for conservational: neutron activation autoradiography and the digitizing of x-ray radiographs.

Autoradiography is a non-destructive technique used for the examination of underlying paint layers. A light transient radioactivity is generated by placing the painting in a beam of thermal neutrons for a short period of time. Immediately following the activation procedure, a series of photographic films is placed in contact with the surface of the painting. This work has been done at the Brookhaven Medical Research Reactor facility outside New York City.

More technically, a neutron beam, screened of energetic and epithermal neutrons by initially passing the beam through heavy water and bismuth metal layers — leaving only low-energy thermal neutrons — is passed through a foot



"The Crucifixion", a 17th century oil painting by an unknown Flemish artist, was painted over another, completely different work. The area bordered in white is shown on the opposite page after radiographic photography and computer processing by Jet Propulsion Laboratories and the Los Angeles County Museum of Art.

square port. The painting, wrapped in polyethylene to prevent contamination with radioactive dust, is irradiated by the beam. Immediately after activation, the painting is removed from the irradiation facility and the radiation intensity from the painting measured. The polyethylene is removed and a sheet of photographic film is placed in close contact with the surface of the painting, aided by a vacuum arrangement. Since the largest photographic film available for the purpose is only 14 x 17 inches, a number of such sheets must customarily be used to cover a decent sized painting.

After a predetermined exposure time, the film is removed and developed and the painting secured, and another photographic film is placed in contact with the painting's surface. This is repeated nine times over a period of fifty days. Each autoradiographic exposure shows the distribution of those painting materials that contain the most intensely radioactive elements at the time of exposure. Because of the differences in the decay times of the radioactive elements, different images are generally observed among the series of nine autoradiographs.

At three different times after activation, gamma-ray energy spectra measurements of the painting are taken. These measurements allow identification of most of the radioactive elements present in the painting. Only those elements with decay constants of less than thirty minutes or those that do not emit gamma rays remain undetected by this technique.

However, not all elements present in a painting form radioactive products suitable for autoradiography, for example lead and iron, even though they are among the most abundant in paints (ie. lead in lead white and iron in ochers and umbers). The distribution of lead white, however, can be accurately observed in x-ray radiography. Further, this technique will not demonstrate the presence of oxygen, carbon or hydrogen in the pigments (they do not form radioactive elements). As such, the process will not show the presence and distribution of organic pigments.

As the distribution of pigments on a canvas results from the process of painting, autoradiography may recapture unique evidence of working methods: from the application of the ground layers, to the underpainted sketch, to blocking out, and the addition of multiple paint layers in the working up of the image. The unique "handwriting" of an artist, their brushstrokes, can be studied more carefully. Brushstrokes, illegible through aging, can be made apparent, producing the subtle tonal transitions characteristic of backgrounds.

Because autoradiography can distinguish fine details of paint application, it is useful in questions of attribution and authenticity. An earlier work may be found underneath the visible surface picture; it can be determined that a forger used a paint which (chemically) hadn't been invented at the date attributed to the painting.

Further, as x-ray radiography really only shows lead based pigments which are durable, the x-ray radiograph usually will not tell much about the painting's condition. Deterioration in paintings customarily commences with the browns and blacks which are not detectable with x-rays. Such pigments are recordable with autoradiography, and protective measures or restorative work can be done to maintain or enhance the work, bringing it back to its original composition.

The effects on painting materials from exposure to radiation, particularly with regard to discoloration, increased brittleness and decreased solubility of varnish and paint layers, have been studied and found to be all but non-existent — discernable changes require some 1,000,000 rads while this process uses only about 1,740 rads.

X-ray analysis of art is one of the oldest of scientific study methods, but it

This image, separated from "The Crucifixion" by radiography, depicts a man and woman in 17th century clothing. Photos courtesy of JPL.

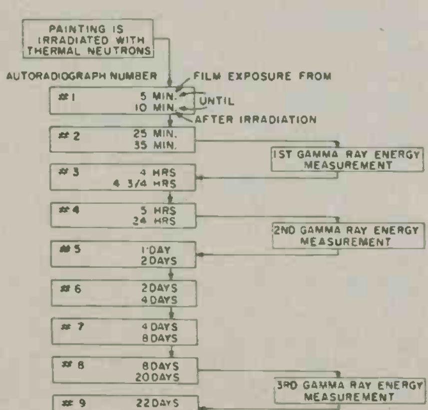
The Codex Hammer, a treatise by da Vinci on the nature of water, was examined for premature deterioration by computer scanning techniques. Photo courtesy of the Armand Hammer Foundation.

has a drawback: since it registers predominantly iron and lead, another, original, image beneath the externally visible picture (eg. a hidden picture), will merely cause the x-ray analysis to show a blurred image consisting of both pictures.

In order to separate the two images, conservators at the Los Angeles County Museum of Art (LACMA) teamed up with scientists from the Jet Propulsion Laboratory (JPL) and, drawing on their expertise in computer enhancement processes developed for the Voyager space probes, tried to overcome the problem.

The picture studied so far over a period of two years is *The Crucifixion (Deposition from the Cross)* originally attributed to Anthony van Dyck, but now believed to be by an unknown Flemish painter. Painted on paper, it shows Jesus Christ being lowered from the Cross by a group of followers. It had been suspected, via x-ray radiography, that there was a second picture underneath the first, but its details were unknown. X-ray radiographs merely showed a blurred image, compounded by the wood striations.

Essentially, the enhancement process depends on a computer's ability to electronically add or subtract coded information. In the LACMA/JPL process, a



The series of film exposures required for examining art by radiography.

cameralike apparatus called a microdensitometer used a light beam to scan the negative of the radiograph. The beam divided the negative into a million pixels, or picture elements, which were assigned a shade of grey numbering 1 to 256 (greater then the range of the human eye within the restrictions of any printing or painting process). The result is an infinitesimally small graytone checkerboard of the original negative, making the image susceptible to calculation and therefore analysis of change, enhancement and suppression.

With the data now in the computer's memory, the JPL scientists designed computer programs to minimize the appearance of the grain pattern of the wood on which the original work was painted. Once that was completed, a photograph of the top painting was matched with the x-ray image, permitting any brushstrokes from the x-ray version that matched the top painting to be subtracted. Subsequent subtractions removed most traces of the top painting while the remaining bottom painting was further computer enhanced to bring out detail.

The final result, that is, the underlying picture, has nothing to do with Jesus Christ being lowered from the Cross, but rather shows a buxom wench lolling at a table, her male companion sitting across from her, one hand on her forearm and the other pointing upwards, with light streaming through a window.

A follow up study, currently underway by LACMA/JPL and funded by the Armand Hammer Foundation, involves the digitizing of surface features of a painting in an attempt to determine deterioration before such deterioration becomes discernable to the human eye.

The specific item to be studied is the **Codex Hammer**, a Leonardo da Vinci treatise on the nature of water. It had been encapsulated in plexiglass such that both sides of it could be viewed during a recent international tour, a process which has been used by the Royal Collection at Windsor Castle for twenty-five years in protecting the world's largest collection of da Vinci's written works. Microcurrents of air internally to the encapsulated sheet of paper along with air pollutants and ultra-violet light were thought to be resulting in as yet undiscernable deterioration of the paper's surface.

The first step in the process was to take a sheet of 18th century paper and photograph it in the same manner as in the **Crucifixion** process. The sheets were then encapsulated and for five months put through the most extreme changes in environment possible: a daily 60°F temperature range and rapid humidity fluctuations. At the end of five months, a second optical reading was taken and digitized. The two readings are compared with deterioration being determined by changes in the readings.

Further, a fast Fourier transform technique is to be used which will provide a plot of the frequency of occurrence of features of different sizes. Because surface features are altered over time, these plots can highlight subtle changes. A further refinement is to start using a new electronic digital camera being developed for the Galileo mission to Jupiter (currently on hold). The advantage of this charge-coupled device (CCD) is that the images come out in digital form without having to go through the intermediate step of taking and digitizing pictures, which results in some deterioration.

A further application of digitizing art work's images is being undertaken by the National Gallery in London, where they are using image processing as an objective color measurement method to document the fading of paintings.

Fig. A. The original Rembrandt

Fig. B. The artist's rough sketch

Fig. C. Blocking-out and the background.

Fig. D. Establishing the costume.

Rembrandt and Radiographs

THE NEUTRON activation process in the study of art was first used on an investigation of nineteenth-century American paintings at the Heckscher Museum at Huntington, N.Y., but the bulk of the work has been done by the Metropolitan Museum of Art, New York City, in association with the Brookhaven National Laboratory. Of the 40 pictures he studied, some 28 are by Rembrandt Harmensz. van Rijn. While his work, Bellona, Fig. A, does not demonstrate all of the things that autoradiography can determine, it is perhaps the most useful example for the purposes of this publication and the size of photographs that can be printed.

This picture was altered many times, alterations which were not suspected until the autoradiographic examination. The identity of the goddess was established in the early stages of the painting when Rembrandt placed the shield on the left, carried on the right arm so that the inside would show. The sword was held in the left hand.

Previously hidden is Rembrandt's rough sketch for this composition. In the autoradiographs, it is visible in the Medusa head on the shield, Fig. B, in Bellona's face and right hand, and in a summary indication of the background hair. Fig. C appears to be increased in fullness, indicating the blocking-out stage when the background was painted up to the contours of the figure. Fig. D demonstrates how, in establishing the costume of the figure, Rembrandt clearly painted the Bellona's decorative skirt with its deep slits first, and then added the armour on top of it. He also sketched the right hand before adding the glove. Changes were made in the upper part of the costume where a sash fell over the shoulders, bosom and right arm, in the size of the plume of the helmet, and in the contour of the skirt hem.

ETI

for your information

Continued from page 11

A report from Ontario's electrical industry projects the creation of 21,000 jobs without the need for large investments of new capital by Ontario Hydro or the Province. Job creation would result from initiating a series of recommendations listed in the report called "Electricity; Ontario's Economic Power Source."

Immediate recommendations deal with electrical heating conversions in residential, industrial and commercial markets and in government facilities. They also call for developing information programs on electricity, supporting the marketing programs of Ontario Hydro and the municipal utilities, promoting electric heat and accelerating engineering consulting services on several industrial projects where the intentions are to use electricity in various processes.

EAPROM Waveform Storage

An EAPROM is now an available option on Krohn-Hite's Model 5910 0.0001Hz to 5MHz Arbitrary Waveform/Function Generator. This option now allows the storage and retrieval of the instrument's arbitrary waveforms, auto-programmer programs and operating parameters in user transparent non-volatile memory. Up to 89 user programmed waveforms and programs may now be loaded into EAPROM manually via the front keyboard or the standard IEEE-488 bus. Modifying various waveform parameters, programs, and inserting or deleting arbitrary waveform points on specific waveforms is performed without PROM programmers, since all EAPROM programming is accomplished through the front panel or the IEEE-488 bus.

For further information on this and other Webster products please contact: Mr. Roger Webster, President, WEBSTER INSTRUMENTS LTD., 1134 Aerowood Drive, Mississauga, Ontario L4W 1Y5 (416) 625-0600.

Ground Resistance Tester

The "Vibroground" from Associated Research measures ground system resistance and soil sensitivity. This device is contained in an all metal cabinetry for rugged field use. The accurate resistance readings are not affected by lengths of stray AC or DC earth currents. Measuring ranges up to 10,000 ohms. Units available from the exclusive Canadian representative: Brunelle Instruments, 826 Belvedere, Sherbrooke, Quebec J1H 4B8, (819) 569-1408.

The electronic chip is already being used to give a sense of smell.

Scientists at Warwick University in Coventry, in the English midlands, have built a primitive "electronic nose" that is capable of distinguishing reliably between different odours. The researchers are working on the principle that individual sensing cells in the human nose respond with relatively little discrimination to the molecules of a wide variety of odours. However, the collective response of millions of cells, each slightly different, creates a distinctive pattern for every smell.

So far, the experiments have involved a simple system based on three semi-conductor gas sensors. This has to be able consistently to identify smells and determine their strengths.

 Circle No. 1 on Reader Service Card.

Commodore 64 Review

Does it live up to its reputation for being a powerful computer, or is it a glorified VIC-20? Steve Rimmer looks into the 64's workings.

IF YOU DON'T own a computer, you are probably beginning to feel a bit like a rally driver in a Volkswagen beetle. This is intentional . . . a lot of money has been given over to the drooling minions of TV and magazine advertising to bring Western civilization to the realization that a computer is a good thing to own, even if it isn't quite sure why just yet. Some would say that this is because the age of the microprocessor is upon us. Others would counter that it's all happening because people weren't buying enough stereos to keep Japan in business. I feel it's a plot by Martians, myself, but I realize that this thinking is in the minority.

The Commodore 64, unlike many of its less familiar antecedents, is a mass market computer. It lacks many of the professional touches of the PETs and CBMs from which it hath sprung, but it has filled the void with all manner of stuff designed to make it really a lot of fun. Unlike the VIC 20, which it resembles quite a lot, it has useably large chunk of RAM available without dangling teetering memory expansion packs off it. It sports sophisticated, if a mite unusual, on-board graphics capabilities and a screen of practical dimensions. (The VIC 20, on the other hand, as many users have come to realize, has among the smallest number of characters on its screen of any home system . . . one of its fundamental limitations.)

If you are just starting out, the 64 is a splendid system. It incorporates the legendary PET BASIC, a language never rivaled for its ease of use. It has few inherent software bugs, none of which are particularly troublesome and it's so crammed with features as to seriously trouble the mind in grasping their scope.

On top of this, you wind up with a computer than looks like a pop art sculpture of a doorstop. It's almost as if it were handed down from on high.

Chip or Slice

The 64 is a marvel of new chips . . . there is a lot of dedicated LSI technology inside its sleazy injection moulded case. The first thing that comes to mind is the 6510 microprocessor. This is a trendier version of the faithful 6502 . . . the latter of which is getting to be a bit of a dinosaur, harkening back to the mid seventies. The 6510 is very similar to the 6502, with the same instruction set and architecture. As such, if you are up for writing machine code for the 64, you won't have to unlearn anything, and there will be plenty of reference materials available.

The enhancements in the 6510, however, do a lot to give the 64 so much of its power. For one thing, it's speedy. While you can scare quite a lot of speed out of a 6502 by using the selected B chips and faster clocks, the 6410 represents a quantum leap forward, as it utilizes pipeline architecture to improve the way it handles instructions. Basically, this means that it can fetch an instruction while it's executing the previous one. In fact, it can queue up several.

The problem with large operating systems, like that of the 64, is that they tend to take a lot of processor activity to do their stuff. This faster processor, then, is more than just an enhancement . . . it's kind of essential that the 64 be able to cope with real time to handle all its bells and whistles.

There are two chips in the 64 which relate directly to the human staring at the tube . . . it's these two little trolls that give the system so much of its power. The first is the 6566 video controller. It is a custom made chip for the 64, and has power just oozing out from under its pins.

The screen of the 64, the sole province of this chip, is able to display twenty-four lines of forty characters. While this is not as good as a professional system . . . which would have eighty characters per line . . . it's the best that can be done with a standard TV as a monitor. The characters and background can be any of sixteen colours. This is handled in software, and rather neatly. You can choose the background by POKEing values into a register of the chip, and the colours of the characters by PRINTing (or typing) control codes.

While the system wants to have a specific colour for the characters being printed . . . this does seem to be essential . . . the screen is not limited to having a single colour up at any one time. You can PRINT something in one colour, go for the appropriate control code and PRINT in something else. There are no restrictions as to what colours print where, and so on.

The CRT controller chip supports high resolution colour graphics. This means that you can "draw" video game type graphics on the screen. There are a number of ways this, in turn, can be handled by BASIC . . . the 64 comes equipped with a rather unusual one. It has sprites.

Now, in the normal course of the epic of reality, when one has a computer with high resolution graphics, one can draw lines and shapes, fill in solids and so on. This is to say, one can produce static pictures. To animate the pictures one must write software to redraw and erase the images on the screen. This is quite difficult to do in BASIC because BASIC is pretty slow, and you wind up with very ginchy looking images that flicker a lot.

Sprite graphics, on the other hand, allow you to create shapes that move. While you can't draw lines and circles on an unadorned Commodore 64, you can define shapes and vectors. This doesn't sound like a lot of fun, but, when you get down to it, it's kind of a gas. You can create an image, such as a space ship or a killer gnu, and then have it move around the screen without having to redraw it.

However, there's more. It's easy to envision sprites as being paper cutouts moving around on a series of glass planes one above the other. As such, you can have multiple sprites happening at any one time, and, if a sprite on a "closer" plane passes over one on a more rearward plane, the former will obscure the latter, all without any prodding from your program.

If you are up for creating animated graphics this will be like rediscovering pencils.

Sound Off

The other profound chip in the 64 is the 6581 sound interface device . . . or SID. It's neat the way they give human sounding names to silicon these days. When I get around to it I want to devise a Write Only Memory Bus Activity Timer, or WOMBAT.

It isn't proper to call the SID chip a synthesiser . . . it has relatively limited waveform control compared to a true analog synthesiser, or a sophisticated sound system like the Mountain Music card for the Apple. However, it is decidedly more than just a fancy control G beep. It can produce three voices of music in the range of zero to four kilohertz. Each voice can be defined as wailing in square waves, triangle waves, variable duty pulse waves . . . recycled square waves, really . . . or white noise for percussive or aspirative sound effects. Each voice has its own voltage controlled amplifier and envelope generator. As such, sounds with specific attack and decay characters can be created without having to POKE lots of data into amplitude registers from BASIC. The VCAs have 48 deciBels of headroom which, while not great, is passable for computer-generated sound.

Programming the sound chip from BASIC is not particularly difficult. There are no higher level functions dedicated to its operation. You just POKE numbers into it to turn on the voices, adjust the pitch, set the characteristics of the envelopes, and so on. While a bit tedious at first . . . you can't just say SOUND and start toodling . . . this does give you a great deal of control over the chip without having to learn to relate to some esoteric specialized commands and functions.

BASICally

Working with the 64 is quite an agreeable experience. It is, to be sure, user-friendliness taken to a fine art. The keyboard is passable and the display is fairly crisp. Unlike most low cost computers, the 64 features full screen editing. If you want to change a line of your program you just cursor up to it and do what you want. This beats EDIT functions hands down. The cursor movement keys have auto repeat.

The 64 has a full 64K of RAM in the form of eight 4164 chips. However, you can only access this if you disable BASIC, as the BASIC ROM firmware overlays about half of it. Properly designed machine code programs, on the other hand, can utilize the whole RAM range. This is a good trip if you are contemplating tromping the kids away from the system at nights and dabbling in spreadsheets and little word processors.

The 64 is happy with most of the peripheral doodahs available for the VIC 20 . . . many of the games will also run without freaking. As such, even though it's still fairly new to the planet, there's plenty of support kicking around for it. In addition, Commodore expects to have various splendid nifties out for the thing by and by. Splendidest and niftiest of the lot promises to be a Z-80 card, which will let the 64 behave like a latter day Apple and run CP/M as well as its inherent BASIC cum non-disk operating system.

Commodore is plugging the 64 as a home computer that is also happy at work. This is true . . . providing they let you play video games at work. Otherwise, it's probably best regarded as a very sophisticated fun system. While you can do business things on it to a limited degree, its fun aspects tend to hamper serious endeavours . . . probably as it should be. A system with sprites and three voice music should not be perverted into file systems and other similar heavies.

As a home computer, the 64 is a really nice trip, and one well worth considering if you are planning to succumb to the media barrage and buy a machine. Imagine being able to walk onto the subway, look up at the ads and smile in the security of knowing that you are now part of the elite. That alone is almost worth the price.

Argh, Billy . . . help me plane off the bottom o' this door here'n so's the computer'll fit underneath . . .

ETI

TV Stereo Sound

The U.S. and Japan are working on multichannel sound standards for TV. By Brian Dance.

THE US ELECTRONIC Industries Association (EIA) has spent the past three years or so discussing future television sound standards for use in that country, and it is expected to recommend a multichannel television sound standard to the FCC very soon.

Not only will the new standard provide for stereo sound, but it will also involve a secondary audio programme system which can be used for the transmission of sound in a second language.

In addition, two proprietary signals for broadcasting station use are proposed for inclusion in the transmitted signal at a lower level.

One of these low-level signals will be used for electronic news gathering (ENG) purposes so that reporters in the field can carry receivers which will monitor this narrow band, over which programme directors in broadcasting studios can issue instructions.

The second low-level sub-channel will carry an FSK signal which can be remotely monitored so that unmanned broadcasting stations can satisfy FCC requirements.

Current Japanese proposals for stereo television sound standards do not include any proposals for the inclusion of the ENG or remote signal monitoring channels.

The American proposals take into account the fact that compatibility with existing television receivers is to be regarded as essential. The additional audio transmissions must not be allowed to degrade the picture or sound quality of the huge numbers of receivers now in use, although the reception of stereo sound and possibly of the second sound channel will require the purchase of a suitable decoder, additional audio amplifier and a second loudspeaker.

In order that users shall be able to upgrade their systems when they so wish, the new stereo television system must employ some multiplexing scheme similar to that employed in FM stereo broadcasts.

Thus there will be a (left + right) signal channel and a (left − right) channel covering the full 5 kHz audio bandwidth, the left - right signal being modulated onto a suitable subcarrier. The secondary audio programme for other languages will probably offer a 10 kHz to 12 kHz audio bandwidth and will be modulated onto a subcarrier of higher frequency.

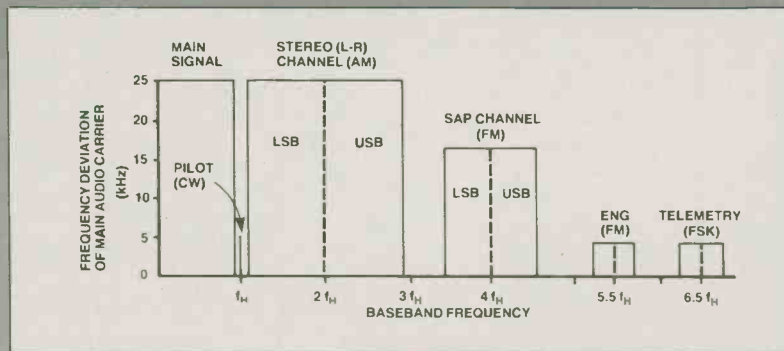


Figure 1. The Zenith multichannel system.

The two proprietary channels will be modulated onto still higher frequency subcarriers, but their bandwidth can be quite low—probably about 3.5 kHz. Thus the audio spectrum of the transmitted signal may be like that proposed by the Zenith Company (Figure 1) or by the Telesonic Company (Figure 2).

A constraint imposed by the US National Television System Committee (NTSC—often humourously remembered as "Never Twice the Same Colour') is that the 6 MHz interchannel frequency spacing is unalterable and therefore the total bandwidth required by the improved radio transmissions cannot exceed that of the conventional transmissions.

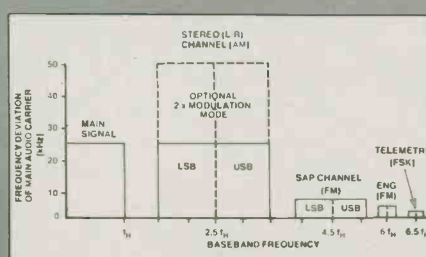


Figure 2. The Telesonic system.

When one remembers that the television signal already has a chroma subcarrier, the number of subcarriers required becomes quite large. As the frequency of the ultrasonic subcarrier is increased, the signal-to-noise ratio in that channel becomes smaller. Thus a decoded stereo signal will have a signal-to-noise ratio some 16 to 20 dB lower than that of the monaural left-plus-right signal, whereas the secondary audio signal, where the highest possible fidelity is not so vital, will contribute perhaps 10 dB more noise than the stereo signals. The least critical ENG and telemetry signals will operate at still higher noise levels, but this is acceptable.

The US systems prefer to employ AM for the stereo subcarrier, since this technique appears to provide less distortion than in systems using FM for both the main signal and for the subcarrier. The two systems (Figures 1 and 2) employ different subcarrier frequencies, each claiming specific reasons for the choice of these frequencies.

The Japanese-proposed system for stereo television sound has an audio spectrum similar to that of Figure 3. The control tone at 3.5 f_H indicates whether the subcarrier contains stereo difference signals or whether it contains a second language soundtrack. If desired, the left-minus-right signal could be transmitted on the 2 f_H subcarrier and a further channel could be added on a subcarrier of 5 f_H (for example, for a second language).

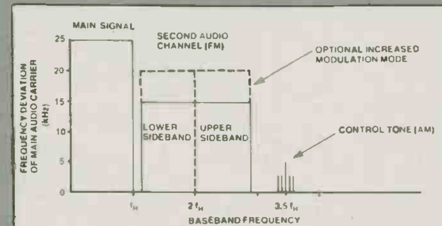


Figure 3. The Japanese system.

Although these systems are, at the moment, only proposals, it seems likely that it will be only a matter of time before television sound becomes available at least in stereo, if not also in multilingual sound. ETI

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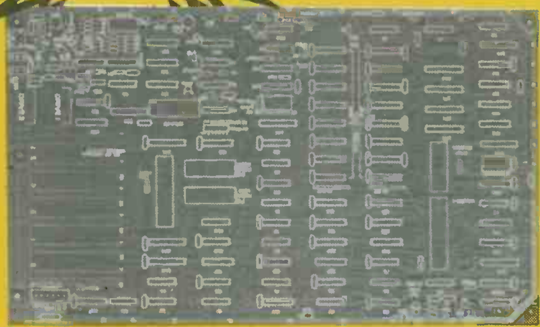

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Instrumentation Techniques Part 2

In the first part of our instrumentation techniques, we looked at making and using a digital multimeter; in this part we look at decibel and noise measurements.

by Bill Markwick and Tim Orr

THE FOLLOWING SECTIONS describe several electronic measurement techniques, and by adopting a modular approach it will be possible to construct a wide range of electronic measurement systems. First of all though, we'll look at some of the units involved and try to clear up some of the confusion about them.

The decibel

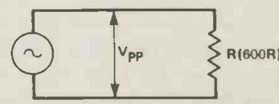
The decibel is a convenient way of expressing signal gain or loss in a system. You may say that volts are okay, too, and we've been using voltage levels for a long time, but consider: if a chain of amplifiers takes in a signal at one microvolt and jazzes it up to ten volts, we're dealing with ratios like 0.000001 to 10. Furthermore, as the signal climbs in level from stage to stage, we need a convenient way to specify both the level and the change in gain, and these monstrous numbers just serve to confuse. Finally, if we want to compare our amplifier with another one, we're forced to start specifying a whole lot of voltage levels to find the relative gains — "amp A has 1.8 microvolts in and 10.2 volts out, while amp B has . . . ." — and so on.

The cure to this proliferation of numbers is to take the logarithm to the base 10 of the voltage gain; this sort of overdoes it, because it reads out in Bels, a rather inconveniently small unit. Multiplying by 20 will change the Bel to a decibel. (Why 20? Because 1 Bel = 10 decibels, and this is properly a power ratio. If we're dealing with voltage levels, the power increases as the square of the voltage — twinkle, twinkle, little star, power equals I squared R — and twice the log of a number is the same as squaring the original number. Presto: 20 log E ratio.)

Table 1 lists voltage ratios and the decibel equivalent, as well as a rounded-off rule of thumb for remembering some of them. Another handy rule is that 20 dB is 10 times the voltage, so 20, 40, 60 dB will be 10, 100, 1000 and so on.

0dBm IS USED AS A VOLTAGE MEASUF

0dBm IS A SINEWAVE LEVEL THAT DI
1 MILLIWATT OF POWER INTO A 600F



THE POWER DISSIPATED = $\frac{V_{PP}^2}{8 \times R}$

∴ FOR 1mW, $V_{PP}^2 = 8 \times R \times 10^{-3}$

$V_{PP} = \sqrt{8 \times 600 \times 10^{-3}} = \sqrt{4.8}$

$V_{PP} = 2.1909V$

∴ 0dB IS EQUIVALENT TO 2.1909 V_{PP} or 0.7746 V_{RMS}
THIS IS USUALLY ROUNDED OFF TO 2.2 V_{PP} or 0.775 V_{RMS}

Fig.1 Everything you ever wanted to know about the dBm!

TABLE 1

dB	MULTIPLIER	RULE OF THUMB MULTIPLIER
+80	×10,000	10,000
+70	×3162	3,000
+60	×1000	1,000
+50	×316.2	300
+40	×100	100
+30	×31.6	30
+20	×10	10
+18	×7.94	8
+12	×3.98	4
+10	×3.16	3
+ 6	×1.99	2
+ 3	×1.41	1.4
0	×1.00	1.0
− 3	×0.708	0.7
− 6	×0.501	0.5
−10	×0.316	0.3
−12	×0.251	0.25
−18	×0.126	0.125
−20	×0.100	0.10
−30	×0.032	0.03
−40	×0.010	0.01
−50	×0.0032	0.003
−60	×0.001	0.001
−70	×0.00032	0.0003
−80	×0.0001	0.0001

$A_V = \frac{V_{OUT}}{V_{IN}}$, OR IN dBs = 20LOG $(\frac{V_{OUT}}{V_{IN}})$

TABLE 2

dBm	V RMS	V_{p-p}
+20	7V75	22V
+18	6V16	17V47
+12	3V08	8V76
+10	2V45	6V95
+6	1V55	4V39
+3	1V094	3V11
0	775 mV	2V2
−3	549 mV	1V56
−6	388 mV	1V1
−10	245 mV	695 mV
−12	197 mV	553 mV
−18	97.6 mV	277 mV
−20	77.5 mV	220 mV
−30	24.5 mV	69.5 mV
−40	7.75 mV	22 mV
−50	2.45 mV	6.95 mV
−60	775 uV	2.2 mV
−70	245 uV	695 uV
−80	77.5 uV	220 uV
−90	24.5 uV	69.5 uV
−100	7.75 uV	22 uV
−110	2.45 uV	6.95 uV
−120	775 nV	2.2 uV
−130	245 nV	695 nV

The dBm

Here we come to the creme-de-la-creme of decibel confusion: the dBm. Strictly speaking, the dBm is an absolute, rather than relative, signal level. The starting point, or reference level, is 0 dBm. This is defined as a *power* level of one milliwatt across 600 ohms, and comes from way back in the Dark Ages when everybody used real 600 ohm lines. Now the tendency in professional audio is to use very low source impedances with very high load impedances; a typical recording studio might use 50 ohm outputs driving 10K loads. The confusion begins with the fact that people still use the dBm power level to describe the signal voltage on an audio line. The reading itself isn't wrong, only the terminology. To further garble things up, various alternative labels have been suggested: dBU, dBV7 and so on. In any case, generally speaking, you can safely assume that a signal level in dBm is referred to a zero level of 775 mV regardless of line impedances. Table 2 converts dBm to voltages.

The VU

The VU, or Volume Unit, is derived from telecommunications practices, and further muddies the picture because it's the same as a dB to all intents and purposes. The reason it exists at all is that it allows you to easily specify an audio meter reading without worrying about the absolute value of the signal level. For instance, professional studio VU meters have an internal loss of 4 dB; our 0 dBm level will then read -4 VU. Cranking the level up to +4 dBm will restore the meter to 0 VU, and also explains why +4 dBm is the studio standard across North America.

On home tape recorders and stereos, it isn't unusual for the maker to set 0 VU as any arbitrary level that keeps him happy, though there's a tendency now to standardize zero level as 775 mV.

By the way, the Volume Unit is a misnomer; it doesn't measure volume at all, but signal level. You could put in 0 VU worth of 10 Hz, for instance, and the volume would be pretty much zip.

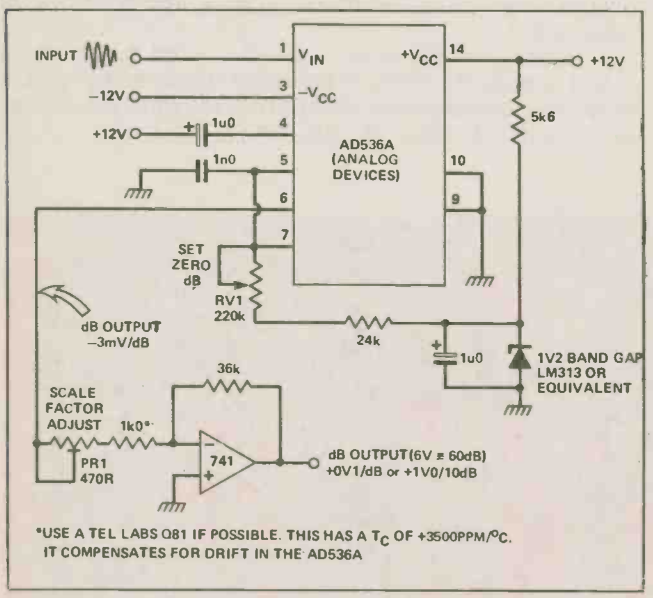


Fig. 2 Circuit for a dB meter using an Analog Devices IC.

Measuring Decibels

The AD536A is an RMS-to-DC converter chip, which is made by Analog Devices. It contains an absolute value circuit, a squarer/divider and a current mirror. With these elements it can compute a true RMS value or a log (dB) equivalent of the input signal. The circuit in Fig. 2 has a useful operating range of 60 dB. PR1 sets the scale factor of the meter. Insert a 1V peak-to-peak sine wave and then change it to 100 mV peak-to-peak; this is to a change of 20 dB and so the preset PR1 should be adjusted for a 2V change in the output voltage. RV1 sets 0 dB by inserting a current that cancels the log output current from the squarer/divider. This can be used to measure absolute voltage in dBm by setting zero at an input voltage of 775 mV RMS. Alternatively, it can be used to compute a dB ratio. Insert a signal, set zero and then change the input signal level — the resulting output change will represent the dB change in input level. Note that the input of the AD536A can accept DC signals, but a small DC offset on the input signal will add a large error to low level readings. For the computation of dBs for AC signals, it is best to AC-couple the input with a 4*u*7 capacitor.

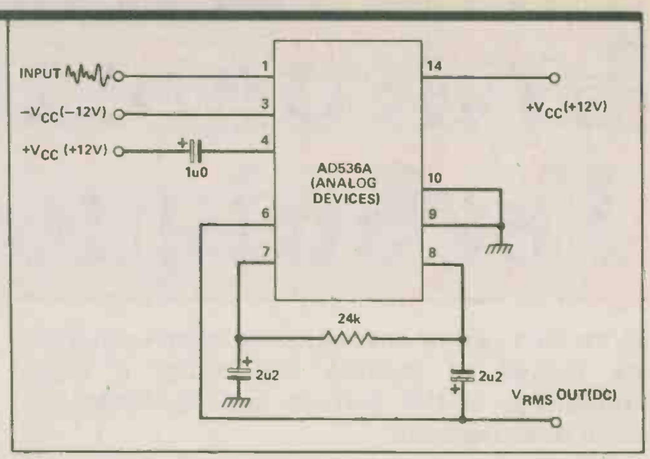


Fig. 3 The same chip can be used for an RMS to DC converter.

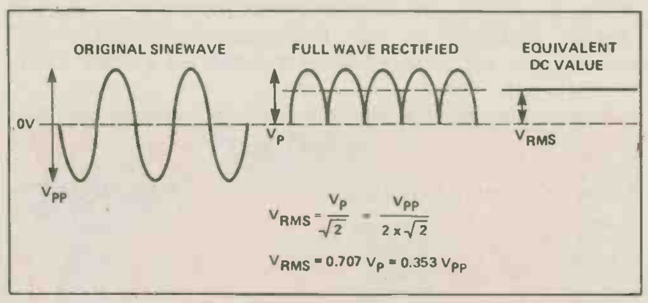


Fig. 4 Sine wave level measurement.

RMS To DC Conversion

The AD536A, in Fig. 3, calculates the true RMS (Root of the Means Squared) value of the input signal and converts it to a DC output; this is the definition of RMS: the heating or DC value that is the equivalent of a complex waveform. If we wrestle RMS to the ground and pull it apart, it looks like this:

1. Convert the input signal to an absolute value; i.e., rectify it.
2. Square these voltage samples by putting them through a logarithmic amplifier and a gain of two. (2log = square, remember?
3. Average these values in a capacitor storage circuit.
4. Take half this value and find its antilog with an antilogarithmic amplifier (½log, then antilog = root.)

Thank goodness for microchips; you could fill your bathtub with the components required to do this with transistors.

WAVEFORM	RMS	CREST FACTOR*
SINEWAVE (V_P)	$0.707\ V_P$	$\sqrt{2} = 1.414$
SYMMETRICAL SQUAREWAVE (V_P)	$1.0\ V_P$	1.0
TRIANGLE WAVE (V_P)	$\frac{V_P}{\sqrt{3}} = 0.577\ V_P$	$\sqrt{3} = 1.732$
NOISE ($2\ V_P$)	TRUE RMS	3.0 TO 4.0 DEPENDS ON THE SPECTRUM
SPIKE (V_P)	TRUE RMS	10.0 DEPENDS ON SHAPE!

*THE CREST FACTOR = $\frac{V_P}{V_{RMS}}$

Fig. 5 Measuring different waveforms.

Most moving coil meters are calibrated for sine waves only; their mechanical inertia makes them respond to the *average* value of a complex waveform. Since we know the characteristics of a well-behaved sine wave, we can then print the meter face to give the RMS value. Put in any other waveform and you'll have a meaningless voltage reading, although you can use it for comparison with a similarly-shaped wave.

Noise Annoys

All electronic components generate noise, and the combined effect of all the noise components in a system gives rise to the phenomena of a noise floor. This is a background noise signal that is forever present. The measurement that is often used to describe the noise performance of a system is called the signal-to-noise ratio, which is expressed in dB. This is the ratio between the normal operating signal level, and the residual noise level with the signal removed. Measurement of the signal is relatively straightforward; a sine wave signal can easily be measured with an AC voltmeter, to give the RMS value. The noise measurement is more difficult. First, the noise level will probably be very low and so it will need amplification. Second, we will only be interested in noise within a certain bandwidth. Noise outside our selected bandwidth will make the noise reading seem larger than it really is. Therefore we will need to band-limit our amplifier. For audio applications, a bandwidth from 20 Hz to 20 kHz is often used.

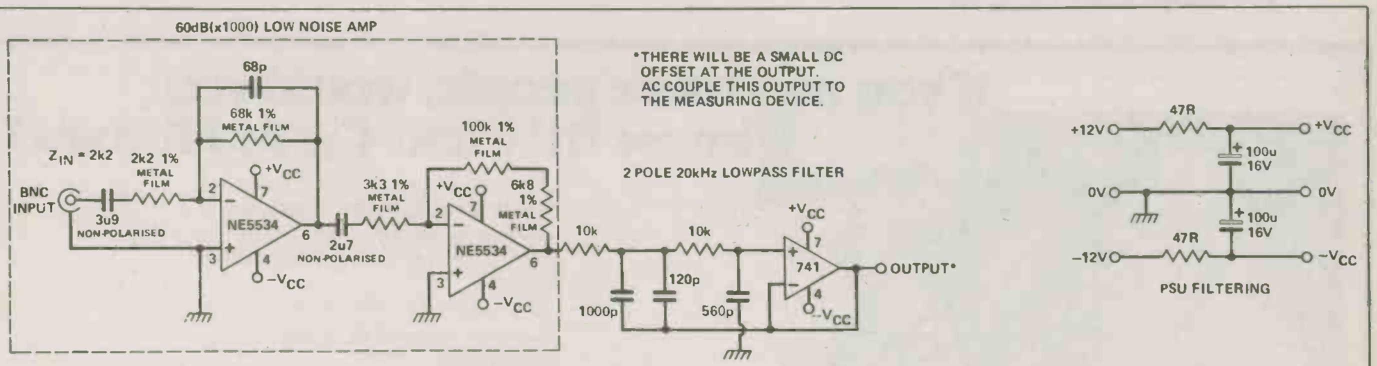
Finally, noise is a random process and it has a constantly varying ratio between its peak and RMS voltage. A simple rectifying and smoothing process will give an erroneous reading and a *true* RMS-to-DC converter is needed for correct readings. Thus by using a band-limited amplifier with a true RMS converter, it is possible to accurately measure the residual noise level. A suitable amplifier and filter for audio work is shown in Fig. 6. The NE5534 op-amps are low noise devices, so they will contribute very little noise to the output signal. The amplifier has a voltage gain of 60 dB and so the output reading must be divided by the same amount; Table 1 shows the equivalent is x1000, so millivolts turn into microvolts. This calculation assumes a flat noise spectrum. Note that the input impedance is equal to the 2K2 resistor near the input jack. This means that you will have to drive the circuit from a source of less than 200 ohms in order to maintain the 60 dB gain figure. If you're measuring high impedance sources, the first stage should be twisted around into the non-inverting mode.

You may also find that the reading tends to flicker; this is due to energy in the subsonic region of the signal. You can minimize this by lifting the 10K filter resistor off Pin 6 of the 5534, inserting a .1 *u* capacitor between Pin 6 and the 10K, and putting an 82K resistor from the right-hand end of the .1 to ground. This will give a single-pole rolloff at about 20 Hz.

A slight error is introduced by using one- or two-pole filters for restricting the noise bandwidth; ideally, we should have filters with an infinitely sharp slope. However, it's only a dB or so, and won't matter for the majority of measurements you'll be doing.

Figure 7 is a circuit that measures the equivalent input noise of op-amps. The circuit has an overall gain of 100 dB (x100,000) and so the DVM reading must be divided by this factor; additional filtering may be included to remove hum or to produce an A-weighting.

You may find to your surprise that Fig. 7 gives you a signal-to-noise reading of 2 or 3 dB! This is usually due to the



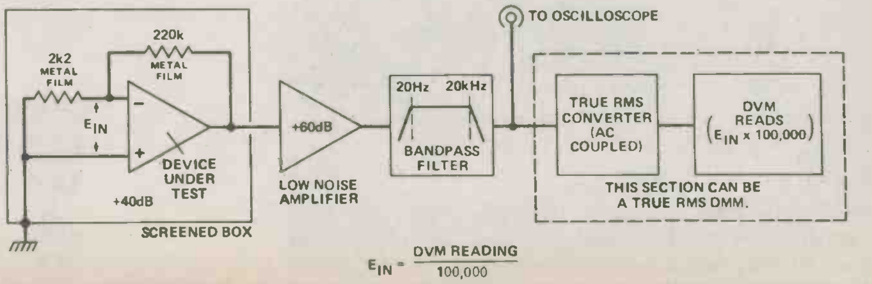


Fig. 6 (Above) A low noise 60 dB amplifier and 20 Hz to 20 kHz filter.

Fig. 7 (Right) Measuring noise in op-amps.

digital gadgetry used in the DVM; there are clocking signals whizzing around in there at many megaHertz, and they may be getting out into the circuit under test. If this should happen, the cure is usually to use an analog meter.

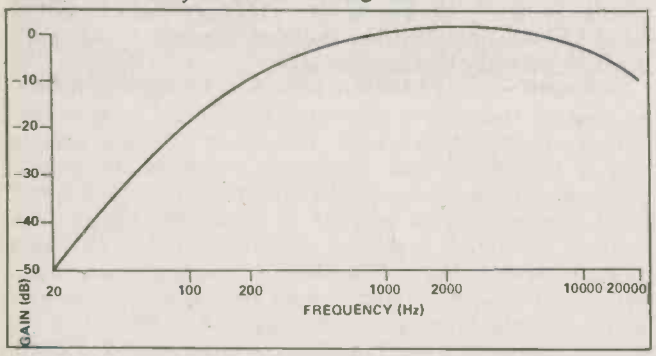


Fig. 8 The IEC 'A' weighted curve.

The noise often has an A-weighting frequency response applied to it before measurement (Fig. 8). This curve is similar to the frequency sensitivity of the human ear and so by A-weighting the noise measurement, it becomes a subjective quantity. It also improves the apparent noise performance figure. Usually when you make a noise reading, there is a line

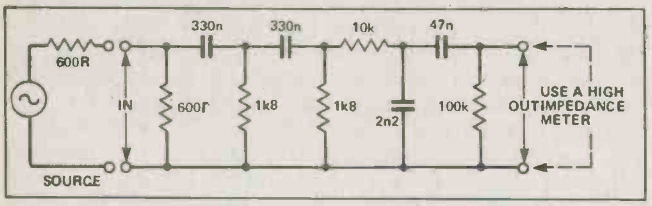


Fig. 9 An IEC 'A' weighting circuit.

Noise in op-amps is specified in nV/√Hz. The equivalent input noise voltage is:

$E_{IN} = E_n \times$ BANDWIDTH
$= (E_n \times 141)$ nV for a 20 kHz bandwidth

where: E_{IN} is the equivalent input noise voltage in V_{RMS}
E_n is the input noise in nV/ √Hz.

hum component that is actually bigger than the noise. This can be removed with a 400 Hz high pass filter as in Fig. 10. This filter also removes some of the energy of the noise below 400 Hz, but even so, the noise reading is still useful. Sophisticated digital multimeters often give you the choice of 400 Hz high-pass, 30 kHz and 80 kHz low-pass and A-weighting filters; sometimes they also have the facility for true RMS, dBm and dB ratio measurements.

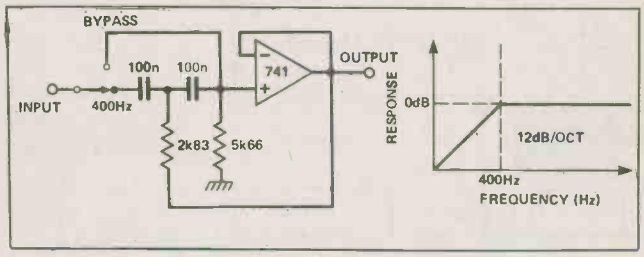


Fig. 10 A 400 Hz two pole high pass filter.

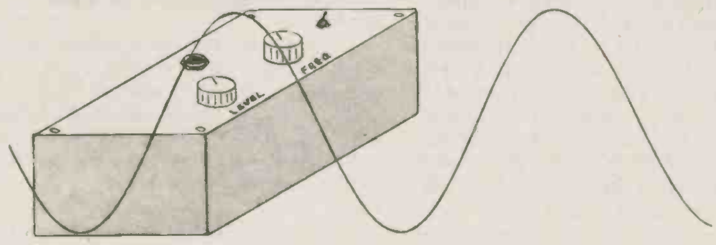
The calculation assumes a flat noise spectrum. Here's an example of using the EIN to give you some idea of the noise voltage you can expect at the output of an op amp.

1. Find the manufacturer's input noise figure if they list it. You'll usually find it for low-noise types but not for general purpose amps. The 5534 from Texas Instruments or Signetics for instance, is listed at 3.5 nV per root Hertz.
2. Multiply this by the root of the bandwidth in Hertz; 141 in the case of 20 kHz.
3. Multiply this by the gain of the op amp circuit under test; if the gain is in dB, convert it to a ratio using Table 1. If you have a calculator handy, it's antilog dB/20.
4. Now you have the RMS noise voltage at the output of the op amp circuit. You can convert it back to dBm using Table 2, or if you're game, it's 20log Eout/.775.

ETI

Audio Oscillator

A portable, battery powered oscillator for toolbox or test bench; compact and easy to assemble with low-distortion output. By Bill Markwick.



HERE'S A handy project if you do service calls, or if you want a compact oscillator for the test bench. It features battery power, selected frequencies for repeatability, and a five-position output attenuator in 10 dB steps. The distortion can be trimmed to 0.1% or less, which is more than adequate for anything but critical measurements.

Most oscillators you've seen have probably used a thermistor in the feedback loop to stabilise the output amplitude. These thermistors are very hard to find, so this one uses a precision bridge and a zener diode instead; the bridge is available from RCA dealers as the CA3019, or National Semiconductor dealers as the LM3019. You can substitute any diode bridge, but the distortion will be much higher.

The circuit is designed to cover the audio band of frequencies by changing two resistors; the frequencies given are the ones usually found on audio alignment tapes for setting up tape recorders. You can change these values to any others you prefer using the formula given in Table 1. If you'd prefer using a dual potentiometer for continuous frequency adjustment, the hookup is shown in Fig. 1. There's a catch, though: if you use a linear pot, the higher frequencies will all be crammed into the last few degrees of rotation. The cure for this is to use an anti-log pot; this gives a reasonable approximation of change vs. rotation. These pots are available in the Mod-Pot series from Allen-Bradley dealers, but be prepared to wait for a long time for them. Another cure, should you be persistent about this, is to use a dual log or audio pot to stretch out the dial markings. Naturally, you'll have to wire the pot backwards, so that counterclockwise rotation increases the frequency.

The pot resistances shown give a range of about 15:1. Next you'll have to install a switch to change C1 and C2 to extend the audio range; a value of .01 u for C1 and C2 covers about 16 Hz to 240 Hz, .001 to 2400 Hz, and 100 pF to about 24 KHz.

The output impedance has been chosen as 150 ohms; this will suit almost all input requirements - it can drive low impedance microphone lines, high impedance amplfiiers inputs, console line inputs, and what have you. If you use it with any sort of equipment which absolutely must have a 600 ohm source, you'll have to insert a 430 ohm resistor in series with the output. You could use a switch and wire this resistor into the box permanently, but it's a rarely-used feature.

The output attenuator can be set in 10 dB steps to suit the level to whatever sort of input you're testing; in the 0 dB position, the voltage can be varied up to 4½ volts or so, and in the other positions, resistive attenuation suits the level control's range to microphone inputs, as well as reducing the inherent noise from the amplifiers. Table 2 gives the approximate output levels for the attenuator settings.

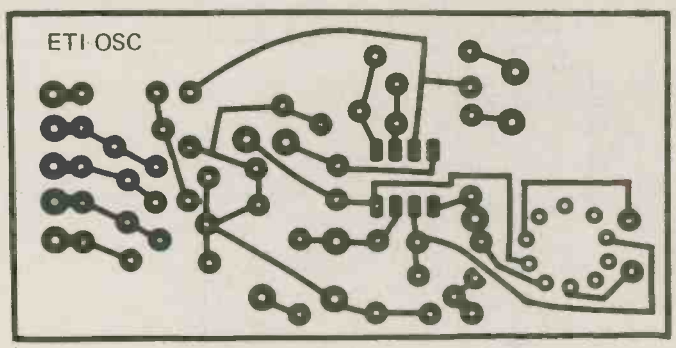
Assembly

Assemble the PC board and mount it in whatever box size you've chosen; the two 9 V batteries can be fitted in proper holders, or you can use battery clips and just tape them in place. The frequency-selecting resistors are mounted on rotary switch S1; you may want to use some spaghetti tubing if it looks like short circuits may happen.

The output jack is a stereo type with the ring contact grounded; this will let you use the unit with balanced inputs. It's particularly useful with balanced patch bays using three-conductor patchcords. You may prefer to fit binding posts.

Calibration

The only calibration necessary is to set gain control VR1 for minimum distortion. Monitor the output of IC1b with a scope and rotate VR1 through its travel; the output should go from no oscillation at full counter-clockwise to a sine wave of about 3.2 V rms with flattened peaks at full clockwise. Rotate counter-clockwise until the oscillation just stops, and then the minimum amount clockwise to get it oscillating again. This will be the point of minimum distortion. If the unit should occasionally fail to start on power-up, you've set the gain a bit too low; slight



The foil side of the printed circuit.

HOW IT WORKS

IC1a is configured as a conventional Wien bridge oscillator, with the value for C1 and C2 chosen to keep the resistance values from loading the output of IC1a at the high frequencies. For operation at much higher frequencies than the ones shown, C1 and C2 may be considerably decreased.

A characteristic of the Wien bridge is that it has zero phase shift at the frequency where R = C's reactance; at this frequency the feedback to IC1a's non-inverting input becomes positive, and the circuit begins to oscillate. As the output rises, it is rectified by IC2 and applied to the zener diode. When the zener diode breaks over, more negative feedback is applied to the inverting input, and the output voltage is held constant.

The amplitude could be stabilised with back-to-back zener diodes, or even regular diodes, but mismatching of the positive and negative cycles causes noticeable distortion. A single zener diode is used with a precision bridge in which the diodes are matched to each other within about one millivolt.

One of the extra diodes included in the 3019 could have been used in place of the zener diode, but breakover voltage is in excess of six volts, and would have resulted in clipping of the output signal. The circuit as shown has a peak output voltage equal to the zener voltage plus the 1.2 V drop across the rectifier.

The signal from the oscillator is applied to the level control, and then amplified to about 4½ volts by IC1b. This is about the maximum available output when using two fresh 9 V batteries; if the unit is used permanently on a test bench, it can be powered by any supply up to ±15 volts.

The output from IC1b is applied to the ladder attenuator. This has steps of 10 dB, or 0.316 times, and is chosen to have constant output resistance of 150 ohms regardless of the switch position. The output is short-circuit proof.

variations in resistance due to temperature may be preventing oscillation. Increase the gain with a very small clockwise rotation of VR1.

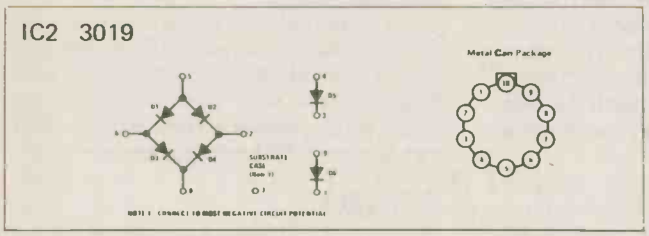
If you have a harmonic distortion analyser, the job is even easier. You should be able to adjust R1 for a distortion reading of less than 0.1%; if it refuses to drop below this, monitor the output of the analyser with a scope to see if hum and noise are obscuring the distortion products. Shielding and filtering out frequencies above 20 KHz may be necessary to get very low distortion readings.

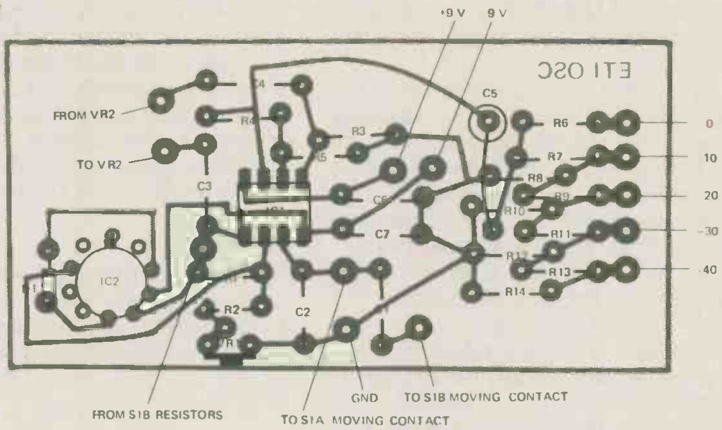
Table 1

Frequencies are approximate due to component tolerances.
For other frequencies, $R = 1/(6.28 \times .01 \times 10^{-6})$

Frequency-selecting Resistors

f	Ra,b
20	820K
30	510K
50	330K
70	220K
100	160K
400	39K
700	22K
1 KHz	16K
4 KHz	3K9
10 KHz	1K6
15 KHz	1K1





(right) The component location drawing.

(below) The circuit schematic. Note that the frequency-selecting resistors Ra, Rb are mounted on S1.

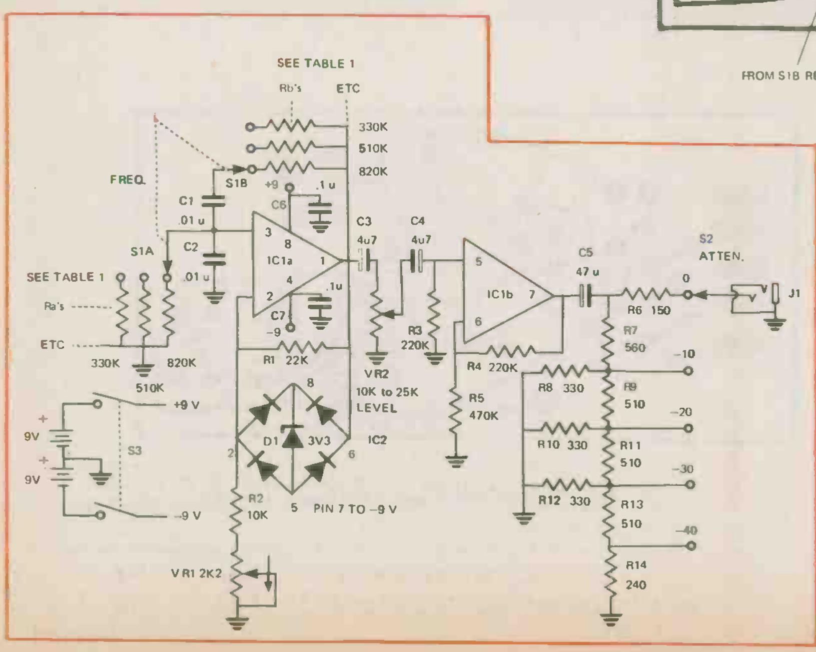


Table 2
Attenuation Setting vs. Output Voltage

Setting, dB	Max. Voltage
0	4.5
−10	1.42
−20	.45
−30	.142
−40	.045

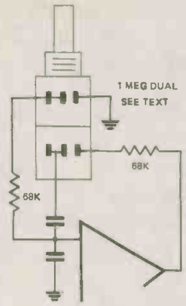


Fig. 1 Substituting a potentiometer for the switch. This is fraught with difficulties — see text.

PARTS LIST

Resistors ¼ W, 5%

Ra,b	see table 1
R1	22K
R2	10K
R3,4	220K
R5	470K
R6	150
R7	560
R8,10,12	330
R8,11,13	510
R14	240
VR1	2K2 miniature vertical mount trim pot, such as Philips 410 series
VR2	10K to 25K linear pot

Capacitors

C1,2	.01 u film type, any voltage rating
C3,4	4u7, 35 V electrolytic or tantalum
C5	47 u, 16 V or larger electrolytic or tantalum
C6,7	.1 u film type, any voltage rating greater than 10

Semiconductors

IC1	TL 072 dual FET op amp
IC2	LM3019 or CA3019 diode array
D1	3V3 400 mW zener diode, 1N746A or equivalent

Switches

SI	2 pole, 11 position shorting rotary switch such as Centralab PA-1004
S2	1 pole, 5 position shorting or non-shorting rotary switch such as Centralab PA-1000
S3	DPST or DPDT subminiature toggle switch

Miscellaneous

3 conductor output jack or binding posts, battery clips or holders, two 9 V regular or alkaline batteries, knobs, PC board, suitable case.

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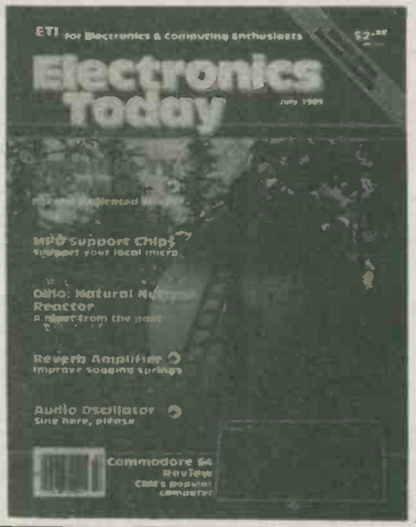

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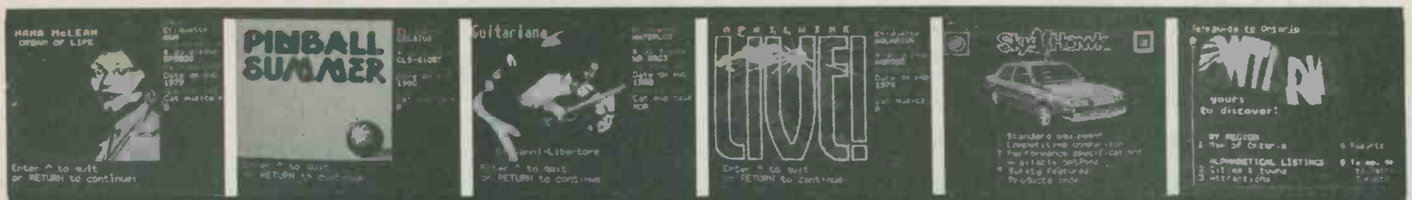


A look at Cantel/Teleguide

They keep promising us that we'll be able to do our shopping via videotex without leaving home, if you like being a computerised hermit. At least you have to go outside to see the Telidon video directories.

by Eric McMillan

MOST VISIONS of the future include some kind of system for shopping, banking, getting news, researching and carrying out a wide range of other activities from our armchairs by way of videotex.

For most of us, that lifestyle is still a little way off, but be can get a foretaste of it with two electronic publishing services available to the public for free. You may already have encountered their video terminals in shopping malls across the country.

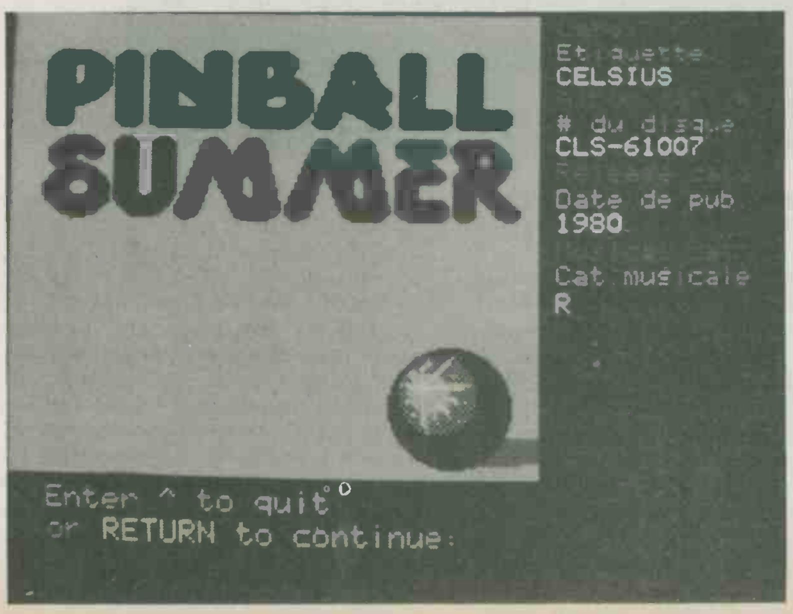
Cantel and Teleguide are based on Telidon, the Canadian videotex technology, and "published" by Infomart, jointly owned by media companies Southam Inc. and Torstar Corp.

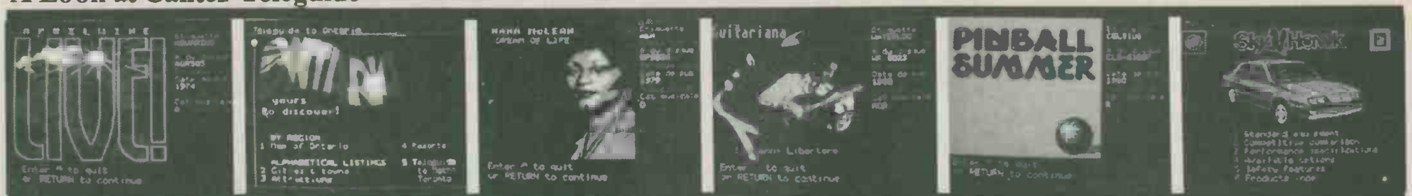
Ideally, we could each have a Telidon terminal in our home through which we could call up information from the central databases as well as input our own messages — something like an elaborate computer-based bulletin board, complete with brilliant graphics and sound effects. At the moment, however, terminal prices are prohibitive (over a thousand dollars), the amount of information stored is too small for more than specialty interest, and the interactive capabilities are still being developed.

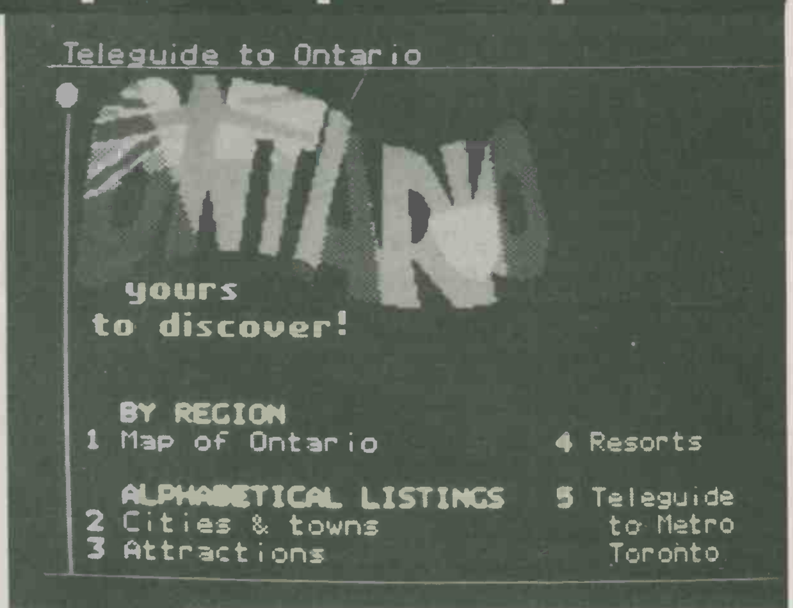
Infomart has found at least four immediate uses for Telidon as it now stands. Two of their operations involve selected audiences: Grassroots provides agricultural services in western Canada, and VISTA is a field test of 500 terminals managed on behalf of Bell Canada, but Cantel and Teleguide can be operated by anyone who can get their hands on a terminal, which isn't difficult.

Cantel's 60 terminals are evenly distributed across Canada. Another 2,000 terminals can run Cantel, although they were set up for other purposes such as Grassroots, B.C. Tel., Sask. Tel., and INet (Intelligent Network). I found one to experiment with at the local Statistics Canada office. They are also found in shopping centres, libraries, and other government service bureaus.

At last count, the Teleguide system, co-sponsored by the Ontario government, has 280 terminals available in malls, hotels and transportation centres in and around Metropolitan Toronto. Both services are free to users, but Teleguide charges a fee to businesses whose wares are listed.

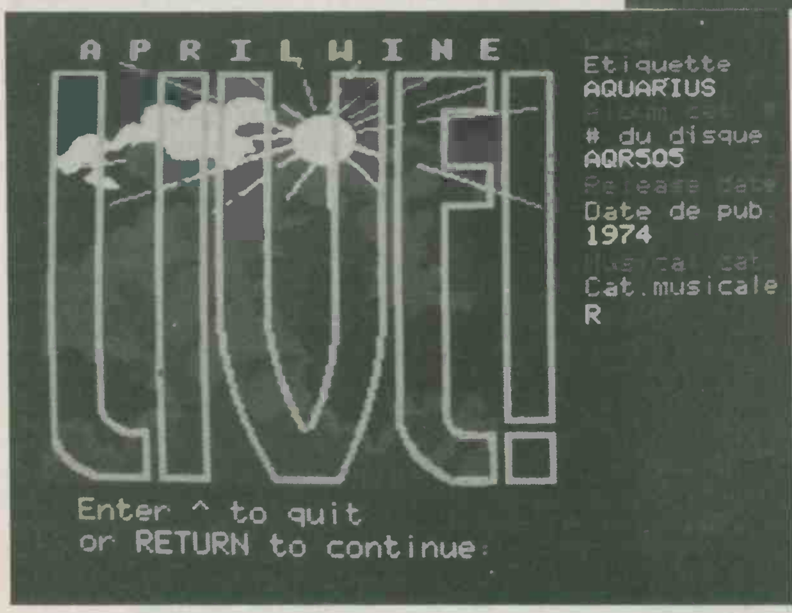






Both systems provide thousands of pages of information, including weather and recreation, with interactivity limited, so far, to the user's power of choosing topics and turning pages by punching in one and two-digit numbers. They are menu-driven, which means you arrive at the item you want by making a choice from a general index, then narrowing down the category through successive indices. Graphics in the two systems are of similar quality and in some instances are apparently identical.

The basic Telidon station consists of a monitor, a decoder, a keyboard, and a telecommunications carrier (cable, telephone, fibre optics, etc.), to connect it with the central computer. The Teleguide terminals I've seen have the Norpak or Microtel decoders and the keyboard built-in with the monitor. The terminal on which I received Cantel employed an Electrohome TV, a Norpak decoder, and a detachable keyboard.



The differences between the two systems are in the content of the services. Cantel was established to give information on federal programs and services and is published through Infomart by the Task Force on Service to the Public (Supply and Services Canada). Although the emphasis is on public terminals, you can subscribe to the service for two dollars an hour if you have the proper equipment at home.

The main menu for Cantel offers you a choice of 22 categories from which to choose, four of which concern using Cantel itself. After playing with it for a while, one begins to realize how the advertised 50,000 pages of Cantel can get used up without exhausting even the skimpy outline of information available.

For one thing, a number of routes can be taken to any one piece of information. Being a writer, by which I mean chronically unemployed, I decided to look for writing or editing jobs via Cantel's National Job Bank. I could move from the main menu to "Highlights" under which some of the most common items are listed and then press the number opposite the job bank. Or I could begin with the "Keywords" index, leading me to alphabetical listings, starting with the first letter, then the first three letters, and further menus until I reach what I'm looking for. Fortunately, "Jobs/Work" has a separate listing on the main menu. Pressing the corresponding number, I reach further lists until the computer knows I am looking for a writing or editing job. I decide between ad copywriter, and journalist, and finally get a listing of two (count 'em, two) journalism jobs in Canada. The Toronto job requires fluency in English, Yiddish and Hungarian, and the other job is in Frobisher Bay. Beggars and writers can't be choosy, so I checked out how to go about applying for the Frobisher Bay position. Another page tells me that, if I see the job I want, I should copy down the number and take it to the local employment office.

It's a little unfair to test the system with journalism jobs because they are generally not advertised through official channels. A search for accounting positions, however, leads to similar results (eight openings in the country).

Perhaps it's unfair to test Cantel on any employment search, given the state of the economy. Starting with "Weather" on the main menu, I could get an overview of forecasts for regions in Canada, but not specific information on cities except those marked with temperatures and symbols on the map. "Grants/Loans" yielded a fairly useful listing of what subsidies are available from Ottawa, any of which could be searched for further details. "Science/Technology" led to a number of categories of which I found the most interesting to be about communications, including a short history of videotex itself.

I'm told that the pages are updated on a daily, weekly, or monthly basis, depending on the kind of information, but I found some of the information was outdated, seemingly stuck in 1980 when it was first entered on the database.

With the large characters for printing and the attractive graphics, most "pages" consisted of single sentences of information, with a couple of options for further searching at the bottom (turning the page, getting back to the sub-menu, finding a related topic). After a choice was made, there was often a two or three-second delay (occasionally as long as six seconds) before the new page was printed, which also took some time when complex graphics were produced. This is maddening when you're trying to get somewhere fast and you've already seen this particular page before, but you can press the button for your next choice before the current picture is completed.

Cantel could be useful for someone with a request for specific information regarding a government service. Currently it is averaging about 2,500 users per day across Canada, adding up to about a million retrievals a month, according to Infomart's Ottawa office.

Obviously the system would be aided enormously by the development of true two-way communication. At present, you can order government publications through Cantel terminals at special locations, and Teli-ordering is expected to be a big part of Cantel's growth through this decade. The Task Force on Service to the Public also anticipates an expansion of Cantel's database to improve its potential for business uses.

Teleguide was devised mainly for residents and tourists to get information on recreation in Ontario. The main menu, when I last tried it, offered 13 choices including entertainment, restaurants, accomodation, sports, weather, time, government information, and "What is Teleguide?"

"Weather" gave a full picture of today's conditions in Toronto, as well as the forecast for tomorrow. "Time" provided the hour and minutes right now in Toronto, in addition to the time in any other part of Canada I desired. "Restaurants" led through a series of menus to determine the kind of food I was seeking before giving examples. "Accomodation" provided not only names and descriptions of places to stay, but also drew maps to show how to get to them. Occasionally, little diversions were suggested. Beneath the weather report, for example, I was told what numbers to press to get the latest USFL scores, which I did.

The time taken to move from one page to the next and to print each page was the same as for Cantel. Teleguide, however, seemed more immediately useful because it was able to provide detailed information that could come in handy right away. I eavesdropped on a group of teenagers who were running through the movie lists to find a show to go to that evening. They had no trouble reaching the information they sought, and apparently made a decision. In fact, most Teleguide terminals I've seen have been in use, although some people I questioned told me they were just curious about the terminals.

When the Teleguide system was announced in 1981, predictions were made of having 2,000 terminals in operation to reach half of all visitors to Toronto, with one million people using them every month. Larry Grossman, Minister of Industry and Tourism, said it could help make Canada the videotex capital of North America and provide 65,000 new jobs in Ontario within a decade.

High hopes are riding on Telidon. Cantel and Teleguide are just two manifestations of videotex which could give you an idea of what the future holds. ETI

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In this book Mr. R. A. Penfold has designed and developed a number of interesting electronic game projects using modern integrated circuits. The text is divided into two sections, the first dealing with simple games and the latter dealing with more complex circuits.

BP95: MODEL RAILWAY PROJECTS **$8.10**

Electronic projects for model railways are fairly recent and have made possible an amazing degree of realism. The projects covered include controllers, signals and sound effects: stripboard layouts are provided for each project.

BP93: ELECTRONIC TIMER PROJECTS **$8.10**
F.G. RAYER

Windscreen wiper delay, darkroom timer and metronome projects are included. Some of the more complex circuits are made up from simpler sub-circuits which are dealt with individually.

110 OP-AMP PROJECTS
MARSTON
HB24 **$13.45**

This handbook outlines the characteristics of the op-amp and present 110 highly useful projects—ranging from simple amplifiers to sophisticated instrumentation circuits.

110 IC TIMER PROJECTS
GILDER
HB25 **$11.45**

This sourcebook maps out applications for the 555 timer IC. It covers the operation of the IC itself to aid you in learning how to design your own circuits with the IC. There are application chapters for timer-based instruments, automotive applications, alarm and control circuits, and power supply and converter applications.

110 THYRISTOR PROJECTS USING SCRs AND TRIACS
MARSTON
HB22 **$13.45**

A grab bag of challenging and useful semiconductor projects for the hobbyist, experimenter, and student. The projects range from simple burglar, fire, and water level alarms to sophisticated power control devices for electric tools and trains. Integrated circuits are incorporated wherever their use reduces project costs.

110 CMOS DIGITAL IC PROJECTS
MARSTON
HB23 **$11.75**

Outlines the operating characteristics of CMOS digital ICs and then presents and discusses 110 CMOS digital IC circuits ranging from inverter gate and logic circuits to electronic alarm circuits. Ideal for amateurs, students and professional engineers.

BP76: POWER SUPPLY PROJECTS **$7.30**
R.A. PENFOLD

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

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

BP84: DIGITAL IC PROJECTS **$8.10**
F.G. RAYER, T.Eng.(CEI),Assoc.IERE

This book contains both simple and more advanced projects and it is hoped that these will be found of help to the reader developing a knowledge of the workings of digital circuits. To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams. Also the more ambitious projects can be built and tested section by section and this should help avoid or correct faults that could otherwise be troublesome. An ideal book for both beginner and more advanced enthusiast alike.

BP67: COUNTER DRIVER AND NUMERAL DISPLAY PROJECTS **$7.55**
F.G. RAYER, T.Eng.(CEI), Assoc. IERE

Numeral indicating devices have come very much to the forefront in recent years and will, undoubtedly, find increasing applications in all sorts of equipment. With present day integrated circuits, it is easy to count, divide and display numerically the electrical pulses obtained from a great range of driver circuits.

In this book many applications and projects using various types of numeral displays, popular counter and driver IC's etc. are considered.

BP73: REMOTE CONTROL PROJECTS **$8.60**
OWEN BISHOP

This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control. Full explanations have been given so that the reader can fully understand how the circuits work and can more easily see how to modify them for other purposes, depending on personal requirements. Not only are radio control systems considered but also infra-red, visible light and ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

BP99: MINI—MATRIX BOARD PROJECTS **$8.10**
R.A. PENFOLD

Twenty useful projects which can all be built on a 24 x 10 hole matrix board with copper strips. Includes Doorbuzzer, Low-voltage Alarm, AM Radio, Signal Generator, Projector Timer, Guitar Headphone Amp, Transistor Checker and more.

BP103: MULTI-CIRCUIT BOARD PROJECTS **$8.10**
R.A. PENFOLD

This book allows the reader to build 21 fairly simple electronic projects, all of which may be constructed on the same printed circuit board. Wherever possible, the same components have been used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects or by re-using the components and P.C.B. all of the projects.

BP107: 30 SOLDERLESS BREADBOARD PROJECTS — BOOK 1 **$9.35**
R.A. PENFOLD

A "Solderless Breadboard" is simply a special board on which electronic circuits can be built and tested. The components used are just plugged in and unplugged as desired. The 30 projects featured in this book have been specially designed to be built on a "Verobloc" breadboard. Wherever possible the components used are common to several projects, hence with only a modest number of reasonably inexpensive components it is possible to build, in turn, every project shown.

BP106: MODERN OP-AMP PROJECTS **$8.10**
R.A. PENFOLD

Features a wide range of constructional projects which make use of op-amps including low-noise, low distortion, ultra-high input impedance, high slew-rate and high output current types.

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING **$8.10**
R.A. PENFOLD

We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

See order form in this issue. All prices include shipping. No sales tax applies.

ETI bookshelf

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING **$8.10**
R.A. PENFOLD
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

CIRCUITS

BP80: POPULAR ELECTRONIC CIRCUITS — BOOK 1 **$8.25**
R.A. PENFOLD
Another book by the very popular author, Mr. R.A. Penfold, who has designed and developed a large number of various circuits. These are grouped under the following general headings; Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Project Circuits and Miscellaneous Circuits.

BP98: POPULAR ELECTRONIC CIRCUITS, BOOK 2 **$9.35**
R.A. PENFOLD
70 plus circuits based on modern components aimed at those with some experience.

The GIANT HANDBOOK OF ELECTRONIC CIRCUITS
TAB No.1300 **$28.45**
About as twice as thick as the Webster's dictionary, and having many more circuit diagrams, this book is ideal for any experimenter who wants to keep amused for several centuries. If there isn't a circuit for it in here, you should have no difficulty convincing yourself you don't really want to build it.

BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS **$5.50**
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
Field effect transistors (FETs), find application in a wide variety of circuits. The projects described here include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various miscellaneous devices which are useful in the home.

This book contains something of particular interest for every class of enthusiast — short wave listener, radio amateur, experimenter or audio devotee.

BP87: SIMPLE L.E.D. CIRCUITS **$5.90**
R.N. SOAR
Since it first appeared in 1977, Mr. R.N. Soar's book has proved very popular. The author has developed a further range of circuits and these are included in Book 2. Projects include a Transistor Tester, Various Voltage Regulators, Testers and so on.

BP42: 50 SIMPLE L.E.D. CIRCUITS **$3.55**
R.N. SOAR
The author of this book, Mr. R.N. Soar, has compiled 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components — the Light Emitting Diode (L.E.D.). A useful book for the library of both beginner and more advanced enthusiast alike.

BP82: ELECTRONIC PROJECTS USING SOLAR CELLS **$8.10**
OWEN BISHOP
The book contains simple circuits, almost all of which operate at low voltage and low currents, making them suitable for being powered by a small array of silicon cells. The projects cover a wide range from a bicyle speedometer to a novelty 'Duck Shoot'; a number of power supply circuits are included.

BP37: 50 PROJECTS USING RELAYS, SCR's & TRIACS **$5.50**
F.G.RAYER, T.Eng.(CEI),Assoc.IERE
Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) have a wide range of applications in electronics today. This book gives tried and practical working circuits which should present the minimum of difficulty for the enthusiast to construct. In most of the circuits there is a wide latitude in component values and types, allowing easy modification of circuits or ready adaptation of them to individual needs.

BP44: IC 555 PROJECTS **$7.55**
E.A. PARR, B.Sc.,C.Eng., M.I.E.E.
Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP24: 50 PROJECTS USING IC741 **$4.25**
RUDI & UWE REDMER
This book, originally published in Germany by TOPP, has achieved phenomenal sales on the Continent and Babani decided, in view of the fact that the integrated circuit used in this book is inexpensive to buy, to make this unique book available to the English speaking reader. Translated from the original German with copious notes, data and circuitry, a "must" for everyone whatever their interest in electronics.

BP83: VMOS PROJECTS **$8.20**
R.A. PENFOLD
Although modern bipolar power transistors give excellent results in a wide range of applications, they are not without their drawbacks or limitations. This book will primarily be concerned with VMOS power FETs although power MOSFETs will be dealt with in the chapter on audio circuits. A number of varied and interesting projects are covered under the main headings of: Audio Circuits, Sound Generator Circuits, DC Control Circuits and Signal Control Circuits.

BP65: SINGLE IC PROJECTS **$6.55**
R.A.PENFOLD
There is now a vast range of ICs available to the amateur market, the majority of which are not necessarily designed for use in a single application and can offer unlimited possibilities. All the projects contained in this book are simple to construct and are based on a single IC. A few projects employ one or two transistors in addition to an IC but in most cases the IC is the only active device used.

BP97: IC PROJECTS FOR BEGINNERS **$8.10**
F.G. RAYER
Covers power supplies, radio, audio, oscillators, timers and switches. Aimed at the less experienced reader, the components used are popular and inexpensive.

BP88: HOW TO USE OP AMPS **$9.35**
E.A. PARR
A designer's guide covering several op amps, serving as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible.

IC ARRAY COOKBOOK
JUNG
HB26 **$14.25**
A practical handbook aimed at solving electronic circuit application problems by using IC arrays. An IC array, unlike specific-purpose ICs, is made up of uncommitted IC active devices, such as transistors, resistors, etc. This book covers the basic types of such ICs and illustrates with examples how to design with them. Circuit examples are included, as well as general design information useful in applying arrays.

BP50: IC LM3900 PROJECTS **$5.90**
H.KYBETT,B.Sc., C.Eng.
The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses, and is more than just a collection of simple circuits or projects.

Simple basic working circuits are used to introduce this IC. The LM3900 can do much more than is shown here, this is just an introduction. Imagination is the only limitation with this useful and versatile device. But first the reader must know the basics and that is what this book is all about.

223: 50 PROJECTS USING IC CA3130 **$5.50**
R.A.PENFOLD
In this book, the author has designed and developed a number of interesting and useful projects which are divided into five general categories: I — Audio Projects II — R.F. Projects III — Test Equipment IV — Household Projects V — Miscellaneous Projects.

224: 50 CMOS IC PROJECTS **$4.25**
R.A. PENFOLD
CMOS IC's are probably the most versatile range of digital devices for use by the amateur enthusiast. They are suitable for an extraordinary wide range of applications and are also some of the most inexpensive and easily available types of IC.

Mr. R.A. Penfold has designed and developed a number of interesting and useful projects which are divided into four general categories: I — Multivibrators II — Amplifiers and Oscillators III — Trigger Devices IV — Special Devices.

THE ACTIVE FILTER HANDBOOK
TAB No.1133 **$14.45**
Whatever your field — computing, communications, audio, electronic music or whatever — you will find this book the ideal reference for active filter design.

The book introduces filters and their uses. The basic math is discussed so that the reader can tell where all design equations come from. The book also presents many practical circuits including a graphic equalizer, computer tape interface and more.

DIGITAL ICS — HOW THEY WORK AND HOW TO USE THEM
AB004 **$11.45**
An excellent primer on the fundamentals of digital electronics. This book discusses the nature of gates and related concepts and also deals with the problems inherent to practical digital circuits.

MASTER HANDBOOK OF 1001 PRACTICAL CIRCUITS
TAB No.800 **$20.45**
MASTER HANDBOOK OF 1001 MORE PRACTICAL CIRCUITS
TAB No.804 **$24.45**
Here are transistor and IC circuits for just about any application you might have. An ideal source book for the engineer, technician or hobbyist. Circuits are classified according to function, and all sections appear in alphabetical order.

THE MASTER IC COOKBOOK
TAB No.1199 **$18.45**
If you've ever tried to find specs for a so called 'standard' chip, then you'll appreciate this book. C.L. Hallmark has compiled specs and pinout for most types of ICs that you'd ever want to use.

ELECTRONIC DESIGN WITH OFF THE SHELF INTEGRATED CIRCUITS
AB016 **$13.45**
This practical handbook enables you to take advantage of the vast range of applications made possible by integrated circuits. The book tells how, in step by step fashion, to select components and how to combine them into functional electronic systems. If you want to stop being a "cookbook hobbyist", then this is the book for you.

AUDIO

BP90: AUDIO PROJECTS **$8.10**
F.G. RAYER
Covers in detail the construction of a wide range of audio projects. The text has been divided into preamplifiers and mixers, power amplifiers, tone controls and matching and miscellaneous projects.

205: FIRST BOOK OF HI-FI LOUDSPEAKER ENCLOSURES **$3.55**
B.B. BABANI
This book gives data for building most types of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential horn, folded horn, tuned port, klipschorn labyrinth, tuned column, loaded port and multi speaker panoramic. Many clear diagrams for every construction showing the dimensions necessary.

BP47: MOBILE DISCOTHEQUE HANDBOOK **$5.90**
COLIN CARSON
The vast majority of people who start up "Mobile Discos" know very little about their equipment or even what to buy. Many people have wasted a "small fortune" on poor, unnecessary or badly matched apparatus.

The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco" gear.

HOW TO BUILD A SMALL BUDGET RECORDING STUDIO FROM SCRATCH. . .
TAB No.1166 **$16.45**
The author, F. Alton Everest, has gotten studios together several times, and presents twelve complete, tested designs for a wide variety of applications. If all you own is a mono cassette recorder, you don't need this book. If you don't want your new four track to wind up sounding like one, though, you shouldn't be without it.

BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING **$5.50**
M.K. BERRY
Electronic music is the new music of the Twentieth Century. It plays a large part in "pop" and "rock" music and, in fact, there is scarcely a group without some sort of synthesiser or other effects generator.

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

BP74: ELECTRONIC MUSIC PROJECTS **$7.70**
R.A. PENFOLD
Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category. The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as a Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser-Units, Tremelo Generator etc.

BP81: ELECTRONIC SYNTHESISER PROJECTS **$7.30**
M.K. BERRY
One of the most fascinating and rewarding applications of electronics is in electronic music and there is hardly a group today without some sort of synthesiser or effects generator. Although an electronic synthesiser is quite a complex piece of electronic equipment, it can be broken down into much simpler units which may be built individually and these can then be used or assembled together to make a complete instrument.

ELECTRONIC MUSIC SYNTHESIZERS
TAB No.1167 **$11.45**
If you're fascinated by the potential of electronics in the field of music, then this is the book for you. Included is data on synthesizers in general as well as particular models. There is also a chapter on the various accessories that are available.

TEST EQUIPMENT

BP75: ELECTRONIC TEST EQUIPMENT CONSTRUCTION **$7.30**
F.G. RAYER, T.Eng. (CEI), Assoc. IERE
This book covers in detail the construction of a wide range of test equipment for both the Electronics Hobbyists and Radio Amateur. Included are projects ranging from an FET Amplified Voltmeter and Resistance Bridge to a Field Strength Indicator and Heterodyne Frequency Meter. Not only can the home constructor enjoy building the equipment but the finished projects can also be usefully utilised in the furtherance of his hobby.

See order form in this issue. All prices include shipping. No sales tax applies.

99 TEST EQUIPMENT PROJECTS YOU CAN BUILD
TAB No.805 **$16.45**
An excellent source book for the hobbyist who wants to build up his work bench inexpensively. Projects range from a simple signal tracer to a 50MHz frequency counter. There are circuits to measure just about any electrical quantity: voltage, current, capacitance, impedance and more. The variety is endless and includes just about anything you could wish for!

HOW TO GET THE MOST OUT OF LOW COST TEST EQUIPMENT
AB017 **$10.45**
Whether you want to get your vintage 1960 'TestRite'signal generator working, or you've got something to measure with nothing to measure it with, this is the book for you. The author discusses how to maximize the usefulness of cheap test gear, how to upgrade old equipment, and effective test set ups.

THE POWER SUPPLY HANDBOOK
TAB No.806 **$16.45**
A complete one stop reference for hobbyists and engineers. Contains high and low voltage power supplies of every conceivable type as well mobile and portable units.

BP70: TRANSISTOR RADIO FAULT-FINDING CHART **$2.40**
CHAS. E. MILLER
Across the top of the chart will be found four rectangles containing brief descriptions of various faults; vis: — sound weak but undistorted; set dead; sound low or distorted and background noises. One then selects the most appropriate of these and following the arrows, carries out the suggested checks in sequence until the fault is cleared.

ELECTRONIC TROUBLESHOOTING HANDBOOK
AB019 **$12.45**
This workbench guide can show you how to pinpoint circuit troubles in minutes, how to test anything electronic, and how to get the most out of low cost test equipment. You can use any and all of the time-saving shortcuts to rapidly locate and repair all types of electronic equipment malfunctions.

COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS
AB018 **$10.45**
A complete guide on how to read and understand schematic diagrams. The book teaches how to recognize basic circuits and identify component functions. Useful for technicians and hobbyists who want to avoid a lot of headscratching.

RADIO AND COMMUNICATIONS

BP79: RADIO CONTROL FOR BEGINNERS **$7.30**
F.G. RAYER, T.Eng.(CEI),Assoc.IERE.
The aim of this book is to act as an introduction to Radio Control for beginners to the hobby. The book will commence by dealing with the conditions that are allowable for such things as frequency and power of transmission. This is followed by a "block" explanation of how control-device and transmitter operate and receiver and actuator(s) produce motion in a model.

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

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

BP96: CB PROJECTS **$8.10**
R.A. PENFOLD
Projects include speech processor, aerial booster, cordless mike, aerial and harmonic filters, field strength meter, power supply, CB receiver and more.

222: SOLID STATE SHORT WAVE RECEIVERS FOR BEGINNERS **$5.20**
R.A. PENFOLD
In this book, R.A. Penfold has designed and developed several modern solid state short wave receiver circuits that will give a fairly high level of performance, despite the fact that they use only relatively few and inexpensive components.

BP91: AN INTRODUCTION TO RADIO DXing **$8.10**
This book is divided into two main sections one to amateur band reception, the other to broadcast bands. Advice is given to suitable equipment and techniques. A number of related constructional projects are described.

BP105: AERIAL PROJECTS **$8.10**
R.A. PENFOLD
The subject of aerials is vast but in this book the author has considered practical designs including active, loop and ferrite aerials, which give good performances and are reasonably simple and inexpensive to build. The complex theory and math of aerial design are avoided.

BP46: RADIO CIRCUITS USING IC's **$5.90**
J.B. DANCE, M.Sc.
This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. The chapter on amplitude modulated (a.m.) receivers will be of most interest to those who wish to receive distant stations at only moderate audio quality, while the chapter on frequency modulation (f.m.) receivers will appeal to those who desire high fidelity reception.

BP92: ELECTRONICS SIMPLIFIED — CRYSTAL SET CONSTRUCTION **$7.30**
F.A. WILSON
Aimed at those who want to get into construction without much theoretical study. Homewound coils are used and all projects are very inexpensive to build.

REFERENCE

THE BEGINNER'S HANDBOOK OF ELECTRONICS
AB003 **$11.45**
An excellent textbook for those interested in the fundamentals of Electronics. This book covers all major aspects of power supplies, amplifiers, oscillators, radio, television and more.

ELEMENTS OF ELECTRONICS — AN ON-GOING SERIES
F.A. WILSON, C.G.I.A., C.Eng.,
BP62: BOOK 1. The Simple Electronic Circuit and Components **$8.95**
BP63: BOOK 2. Alternating Current Theory **$8.95**
BP64: BOOK 3. Semiconductor Technology **$8.95**
BP77: BOOK 4. Microprocessing Systems And Circuits **$12.30**
BP89: BOOK 5. Communication **$12.30**
The aim of this series of books can be stated quite simply — it is to provide an inexpensive introduction to modern electronics so that the reader will start on the right road by thoroughly understanding the fundamental principles involved.

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

Each book is a complete treatise of a particular branch of the subject and, therefore, can be used on its own with one proviso, that the later books do not duplicate material from their predecessors, thus a working knowledge of the subjects covered by the earlier books is assumed.

BOOK 1: This book contains all the fundamental theory necessary to lead to a full understanding of the simple electronic circuit and its main components.

BOOK 2: This book continues with alternating current theory without which there can be no comprehension of speech, music, radio, television or even the electricity utilities.

BOOK 3: Follows on semiconductor technology, leading up to transistors and integrated circuits.

BOOK 4: A complete description of the internal workings of microprocessor.

BOOK 5: A book covering the whole communication scene.

BP85: INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE **$12.25**
ADRIAN MICHAELS
This book will help the reader to find possible substitutes for a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer selection of modern transistors. Also shown are the material type, polarity, manufacturer and use. The Equivalents are sub-divided into European, American and Japanese. The products of over 100 manufacturers are included. An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists. Fantastic value for the amount of information it contains.

BP108: INTERNATIONAL DIODE EQUIVALENTS GUIDE **$8.35**
ADRIAN MICHAELS
This book is designed to help the user in finding possible substitutes for a large user orientated selection of the many different types of semiconductor diodes that are available today. Besides simple rectifier diodes also included are Zener diodes, LEDs, Diacs Triacs, Thyristors, Photo diodes and Display diodes.

BP1: FIRST BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES **$2.80**
B.B. BABANI
This guide covers many thousands of transistors showing possible alternatives and equivalents. Covers transistors made in Great Britain, USA, Japan, Germany, France, Europe, Hong Kong, and includes types produced by more than 120 different manufacturers.

BP14: SECOND BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES **$4.80**
B.B. BABANI
The "First Book of Transistor Equivalents" has had to be reprinted 15 times. The "Second Book" produced in the same style as the first book, in no way duplicates any of the data presented in it. The "Second Book" contains only additional material and the two books complement each other and make available some of the most complete and extensive information in this field. The interchangeability data covers semiconductors manufactured in Great Britain, USA, Germany, France, Poland, Italy, East Germany, Belgium, Austria, Netherlands and many other countries.

TOWER'S INTERNATIONAL OP-AMP LINEAR IC SELECTOR
TAB No.1216 **$13.45**
This book contains a wealth of useful data on over 5,000 Op-amps and linear ICs — both pinouts and essential characteristics. A comprehensive series of appendices contain information on specs, manufacturers, case outlines and so on.

CMOS DATABOOK
TAB No.984 **$9.95**
There are several books around with this title, but most are just collections of manufacturers' data sheets. This one, by Bill Hunter, explains all the intricacies of this useful family of logic devices . . . the missing link in getting your own designs working properly. Highly recommended to anyone working with digital circuits.

MISCELLANEOUS

BP68: CHOOSING AND USING YOUR HI-FI **$7.25**
MAURICE L. JAY
The main aim of this book is to provide the reader with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of hi-fi equipment now on the market.

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

BP101: HOW TO IDENTIFY UNMARKED IC'S **$2.70**
K.H. RECORR
Originally published as a feature in 'Radio Electronics', this chart shows how to record the particular signature of an unmarked IC using a test meter, this information can then be used with manufacturer's data to establish the application.

BP100: AN INTRODUCTION TO VIDEO **$8.10**
D.K. MATHEWSON
Presents in as non-technical a way as possible how a video recorder works and how to get the best out of it and its accessories. Among the items discussed are the pros and cons of the various systems, copying and editing, international tape exchange and understanding specifications.

AUDIO AND VIDEO INTERFERENCE CURES
KAHANER
HB21 **$9.45**
A practical work about interference causes and cures that affect TV, radio, hi-fi, CB, and other devices. Provides all the information needed to stop interference. Schematic wiring diagrams of filters for all types of receivers and transmitters are included. Also, it supplies simple filter diagrams to eliminate radio and TV interference caused by noisy home appliances, neon lights, motors, etc.

BASIC TELEPHONE SWITCHING SYSTEMS
TALLEY
HB27 **$16.00**
The Revised Second Edition of this book, for trainee and engineer alike, includes updated statistical data on telephone stations, and new and improved signaling methods and switching techniques. It also includes E & M signaling interface for electronic central offices and automatic number identification methods used in step-by-step, panel and crossbar central offices.

INTERRELATED INTEGRATED ELECTRONICS CIRCUITS FOR THE RADIO AMATEUR, TECHNICIAN, HOBBYIST AND CB'ER
MENDELSON
HB29 **$11.45**
This book provides a variety of appealing projects that can be constructed by anyone from the hobbyist to the engineer. Construction details, layouts, and photographs are provided to simplify duplication. While most of the circuits are shown on printed circuit boards, every one can be duplicated on hand-wired, perforated boards. Each project is related to another projects so that several may be combined into a single package. The projects, divided into five major groups, include CMOS audio modules, passive devices tohelp in benchwork, test instruments, and games.

BASIC CARRIER TELEPHONY, THIRD EDITION
TALLEY
HB28 **$16.45**
A basic course in the principles and applications of carrier telephony and its place in the overall communications picture. It is abundantly illustrated, with questions and problems throughout, and requires a minimum of mathematics.

ROBOTICS

THE COMPLETE HANDBOOK OF ROBOTICS
TAB No.1071 **$16.45**
All the information you need to build a walking, talking mechanical friend appears in this book. Your robot can take many forms and various options — light, sound, and proximity sensors — are covered in depth.

HOW TO BUILD YOUR OWN SELF PROGRAMMING ROBOT
TAB No.1241 **$14.45**
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COMPUTERS
(HARDWARE)

THE ESSENTIAL COMPUTER DICTIONARY AND SPELLER
AB011 **10.45**
A must for anyone just starting out in the field of computing, be they a businessman, hobbyist or budding computerist. The book presents and defines over 15,000 computer terms and acronyms and makes for great browsing.

A BEGINNER'S GUIDE TO COMPUTERS AND MICROPROCESSORS — WITH PROJECTS.
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Here's a plain English introduction to the world of microcomputers — it's capabilities, parts and functions . . . and how you can use one. Numerous projects demonstrate operating principles and lead to the construction of an actual working computer capable of performing many useful functions.

BP66: BEGINNERS GUIDE TO MICROPROCESSORS AND COMPUTING **$7.55**
E.F. SCOTT, M.Sc., C.Eng.
As indicated by the title, this book is intended as an introduction to the basic theory and concepts of binary arithmetic, microprocessor operation and machine language programming.
There are occasions in the text where some background information might be helpful and a Glossary is included at the end of the book.

BP72: A MICROPROCESSOR PRIMER **$7.70**
E.A. PARR, B.Sc., C.Eng., M.I.E.E.
A newcomer to electronics tends to be overwhelmed when first confronted with articles or books on microprocessors. In an attempt to give a painless approach to computing, this small book will start by designing a simple computer and because of its simplicity and logical structure, the language is hopefully easy to learn and understand. In this way, such ideas as Relative Addressing, Index Registers etc. will be developed and it is hoped that these will be seen as logical progressions rather than arbitrary things to be accepted but not understood.

BEGINNERS GUIDE TO MICROPROCESSORS
TAB No.995 **$11.45**
If you aren't sure exactly what a microprocessor is, then this is the book for you. The book takes the beginner from the basic theories and history of these essential devices, right up to some real world hardware applications.

HOW TO BUILD YOUR OWN WORKING MICROCOMPUTER
TAB No.1200 **$16.45**
An excellent reference or how-to manual on building your own microcomputer. All aspects of hardware and software are developed as well as many practical circuits.

BP78: PRACTICAL COMPUTER EXPERIMENTS **$7.30**
E.A. PARR, B.Sc., C.Eng., M.I.E.E.
Curiously most published material on the microprocessor tends to be of two sorts, the first treats the microprocessor as a black box and deals at length with programming and using the "beast". The second type of book deals with the social impact. None of these books deal with the background to the chip, and this is a shame as the basic ideas are both interesting and simple.
This book aims to fill in the background to the microprocessor by constructing typical computer circuits in discrete logic and it is hoped that this will form a useful introduction to devices such as adders, memories, etc. as well as a general source book of logic circuits.

HANDBOOK OF MICROPROCESSOR APPLICATIONS
TAB No.1203 **$16.45**
Highly recommended reading for those who are interested in microprocessors as a means of a accomplishing a specific task. The author discusses two individual microprocessors, the 1802 and the 6800, and how they can be put to use in real world applications.

MICROPROCESSOR/MICROPROGRAMMING HANDBOOK
TAB No.785 **$16.45**
A comprehensive guide to microprocessor hardware and programming. Techniques discussed include subroutines, handling interrupts and program loops

BP102: THE 6809 COMPANION **$8.10**
M. JAMES
The 6809 microprocessor's history, architecture, addressing modes and the instruction set (fully commented) are covered. In addition there are chapters on converting programs from the 6800, programming style, interrupt handling and about the 6809 hardware and software available.

AN INTRODUCTION TO MICROPROCESSORS EXPERIMENTS IN DIGITAL TECHNOLOGY
HB07: **$16.45**
SMITH
A "learn by doing" guide to the use of integrated circuits provides a foundation for the underlying hardware actions of programming statements. Emphasis is placed on how digital circuitry compares with analog circuitry. Begins with the simplest gates and timers, then introduces the fundamental parts of ICs, detailing the benefits and pitfalls of major IC families, and continues with coverage of the ultimate in integrated complexity — the microprocessor.

DESIGNING MICROCOMPUTER SYSTEMS
HB18: **$18.00**
POOCH AND CHATTERGY
This book provides both hobbyists and electronic engineers with the background information necessary to build microcomputer systems. It discusses the hardware aspects of microcomputer systems. Timing devices are provided to explain sequences of operations in detail. Then, the book goes on to describe three of the most popular microcomputer families: the Intel 8080, Zilog Z-80, and Motorola 6800. Also covered are designs of interfaces for peripheral devices, and information on building microcomputer systems from kits.

S-100 BUS HANDBOOK
HB19: **$26.00**
BURSKY
Here is a comprehensive book that exclusively discusses S-100 bus computer systems and how they are organized. The book covers computer fundamentals, basic electronics, and the parts of the computer. Individual chapters discuss the CPU, memory, input/output, bulk-memory devices, and specialized peripheral controllers. It explains all the operating details of commonly available S-100 systems. Schematic drawings.

BASIC MICROPROCESSORS AND THE 6800
HB06: **$24.45**
Provides two books in one: a basic guide to microprocessors for the beginner, and a complete description of the M6800 system for the engineer.
Each chapter is followed by a problem section.

DIGITAL INTERFACING WITH AN ANALOG WORLD
TAB No.1070 **$16.45**
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HOW TO TROUBLESHOOT AND REPAIR MICROCOMPUTERS
AB013 **$13.45**
Learn how to find the cause of a problem or malfunction in the central or peripheral unit of any microcomputer and then repair it. The tips and techniques in this guide can be applied to any equipment that uses the microprocessor as the primary control element.

TROUBLESHOOTING MICROPROCESSORS AND DIGITAL LOGIC
TAB No.1183 **$16.45**
The influence of digital techniques on commercial and home equipment is enormous and increasing yearly. This book discusses digital theory and looks at how to service Video Cassette Recorders, microprocessors and more.

HOW TO DEBUG YOUR PERSONAL COMPUTER
AB012 **$13.45**
When you feel like reaching for a sledge hammer to reduce your computer to fiberglass and epoxy dust, don't. Reach for this book instead and learn all about program bug tracking, recognition and elimination techniques.

COMPUTERS
(SOFTWARE)

BP109: THE ART OF PROGRAMMING THE 1K ZX81 **$8.10**
M. JAMES and S.M. GEE
This book shows you how to use the features of the ZX81 in programs that fit into the 1K machine and are still fun to use. Chapter Two explains the random number generator and uses it to simulate coin tossing and dice throwing and to play pontoon,. Chapter Three shows the patterns you can display using the ZX81's graphics. Its animated graphics capabilities, explored in Chapter Four, have lots of potential for use in games of skill, such as Lunar Lander and Cannon-ball which are given as complete programs. Chapter Five explains PEEK and POKE and uses them to display large characters. The ZX81's timer is explained in Chapter Six and used for a digital clock, a chess clock and a reaction time game. Chapter Seven is about handling character strings and includes three more ready-to-run programs—Hangman, Coded Messages and a number guessing game. In Chapter Eight there are extra programming hints to help you get even more out of your 1K ZX81.

BP114: THE ART OF PROGRAMMING THE 16K ZX81 **$10.40**
M. JAMES & S.M. GEE
The book starts by introducing the 16K RAM pack and the printer. It continues by explaining how the extra storage is used and presents a memory test program to check that the 16K RAM pack is operational. Chapter Three covers some utilities that you will find useful in writing longer programs. Chapter Four is an interlude from serious applications, presenting four games programs that make the most of the extended graphics capabilities now available to you. Chapters Five to Eight deal with writing and debugging large programs, storing them on cassettes and printing out both programs themselves and their results. These chapters also introduce programs for editing data bases and statistical analysis for financial management and covers text and graphics printing. Chapter Nine takes a look at randomness. Chapter Ten introduces machine code and explains why you might like to use it.

BEGINNER'S GUIDE TO COMPUTER PROGRAMMING
TAB No.574 [redacted]45
Co[redacted] to
the [redacted] a
car [redacted] a
log [redacted] basic steps to machine language.

OUT OF PRINT

HOW TO PROFIT FROM YOUR PERSONAL COMPUTER: PROFESSIONAL, BUSINESS, AND HOME APPLICATIONS
LEWIS
HB01 **$19.45**
Describes the uses of personal computers in common business applications, such as accounting, managing, inventory, sorting mailing lists, and many others. The discussion includes terms, notations, and techniques commonly used by programmers. A full glossary of terms.

THE JOY OF MINIS AND MICROS: DATA PROCESSING WITH SMALL COMPUTERS
STEIN AND SHAPIRO
HB03 **$18.00**
A collection of pieces covering technical and management aspects of the use of small computers for business or science. It emphasizes the use of common sense and good systems design for every computer project. Because a strong technical background is not necessary, the book is easy to read and understand. Considerable material is devoted to the question of what size computer should be used for a particular job, and how to choose the right machine for you.

BASIC FROM THE GROUND UP
SIMON
HB15 **$19.45**
Here's a BASIC text for high school students and hobbyists that explores computers and the BASIC language in a simple direct way, without relying on a heavy mathematical backbround on the reader's part. All the features of BASIC are included as well as some of the inside workings of a computer. The book covers one version of each of the BASIC statements and points out some of the variations, leaving readers well prepared to write programs in any version they encounter. A selection of exercises and six worked out problems round out the reader's experience. A glossary and a summary of BASIC statements are included at the end of the book for quick reference.

BASIC COMPUTER PROGRAMS FOR BUSINESS: STERNBERG (Vol. 1)
HB13 **$18.45**
A must for small businesses utilizing micros as well as for entrepreneurs, volume provides a wealth of practical business applications. Each program is documented with a description of its functions and operation, a listing in BASIC, a symbol table, sample data, and one or more samples.

BP86: AN INTRODUCTION TO BASIC PROGRAMMING TECHNIQUES **$8.25**
S. DALY
This book is based on the author's own experience in learning BASIC and in helping others, mostly beginners, to program and understand the language. Also included are a program library containing various programs, that the author has actually written and run. These are for biorhythms, plotting a graph of Y against X, standard deviation, regression, generating a musical note sequence and a card game. The book is complemented by a number of appendices which include test questions and answers on each chapter and a glossary.

THE BASIC COOKBOOK.
TAB No.1055 **$10.45**
BASIC is a surprisingly powerful language . . . if you understand it completely. This book, picks up where most manufacturers' documentation gives up. With it, any computer owner can develop programs to make the most out of his or her machine.

PET BASIC — TRAINING YOUR PET COMPUTER
AB014 **$20.45**
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—ROGRAMMING IN BASIC FOR PERSONAL COMPUTERS
AB015 **$13.45**
This book emphasizes the sort of analytical thinking that lets you use a specific tool — the BASIC language — to transform your own ideas into workable programs. The text is designed to help you to intelligently analyse and design a wide diversity of useful and interesting programs.

COMPUTER PROGRAMS IN BASIC
AB001 **$15.45**
A catalogue of over 1,600 fully indexed BASIC computer programs with applications in Business, Math, Games and more. This book lists available software, what it does, where to get it, and how to adapt it to your machine.

PET GAMES AND RECREATION
AB002 **$17.45**
A variety of interesting games designed to amuse and educate. Games include such names as Capture, Tic Tac Toe, Watchperson, Motie, Sinners, Martian Hunt and more.

BRAIN TICKLERS
AB005 **$9.00**
If the usual games such as Bug Stomp and Invaders From the Time Warp are starting to pale, then this is the book for you. The authors have put together dozens of stimulating puzzles to show you just how challenging computing can be.

PASCAL
TAB No.1205 **$16.45**
Aimed specifically at TRS-80 users, this book discusses how to load, use and write PASCAL programs. Graphic techniques are discussed and numerous programs are presented.

See order form in this issue. All prices include shipping. No sales tax applies.

Bomb Drop Sound Effects

One of the attractions of the more sophisticated video games seen in arcades these days is the realistic array of sound effects that go with the action, gunshots, bomb whistles and explosions, etc. Make some yourself with just one IC. Design by Phil Wait.

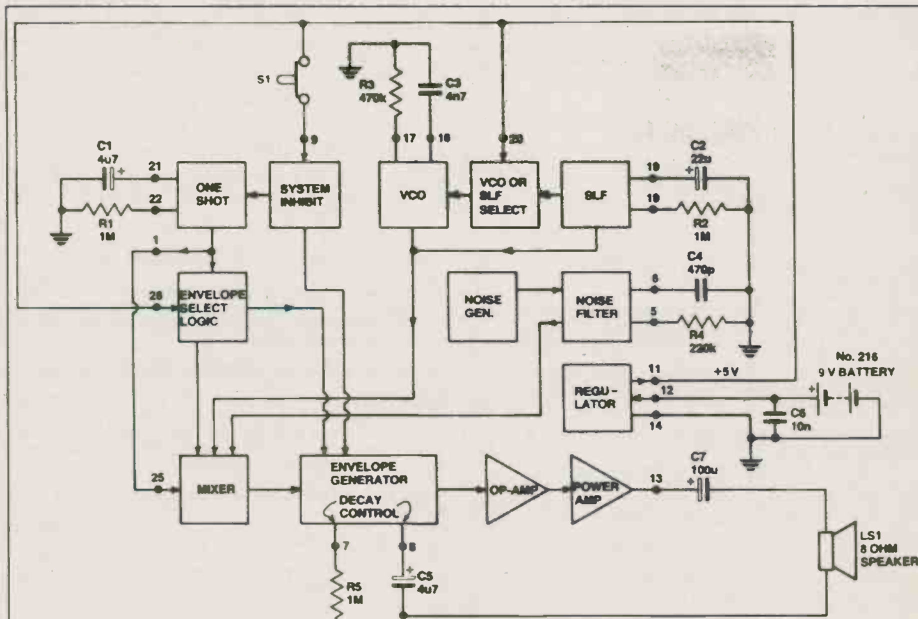


Fig. 1 Circuit diagram of the Bomb Drop and Explosion sound effects board.

THOSE 'CANNON SHOTS' and explosions that go with the popular 'Space Invaders' video games and its variants add a measure of interest, feedback and stimulation to the action in which you participate on screen. Those sounds are electronically synthesised, they consist of a complex mixture of waveforms that make up the required sound.

A 'bomb drop and explosion' is a remarkably complex sound when analysed carefully. Looking at it simply, there is a descending tone followed by a burst of noise that dies away in intensity. The descending tone starts at quite a high pitch and is not a 'pure' tone (i.e. a sine wave). The explosion is a burst of noise that commences suddenly and dies away slowly in a recognisable way (usually exponentially). While it is possible to electronically produce very nearly an exact replica of a bomb drop and explosion, some compromises are acceptable to reduce the complexity and cost of the task and yet produce a recognisable replica of the sound.

To produce such sound using conventional components, transistors, diodes, op-amps, resistors and capacitors, would require a whole legion of components. Fortunately, the IC manufacturers can come to our rescue here and much of the circuitry can be incorporated into a complex integrated circuit requiring the addition of a minimum of external components and the appropriate interconnections to synthesise the required sound. Generating a wide variety of sounds fortunately requires only a limited number of functional blocks, such as: a noise generator, voltage controlled oscillators, multivibrators, envelope generators (a sort of modulator), mixers and amplifiers.

Texas Instruments have designed a series of complex function ICs for various applications and among them is the SN76488 Complex Sound Generator. This chip contains both linear and digital circuitry and is intended for use in applications requiring audio feedback to the user — video games, pinball, alarms, toys, etc, or industrial indicators, feedback controls and the like. Power consumption is quite low, allowing battery operation, and only a single supply rail is required.

The SN76488 is contained in a 28-pin package and can be purchased for less than $10. It is quite a versatile chip, but we have chosen to describe how to obtain only one sound effect, this being a bomb drop.

Construction

Commence construction by assembling the passive components, followed by the IC. This is not a CMOS device and no special care is required, apart from being careful not to bend any pins under the device when inserting it. If you wish, a socket may be used for the IC.

Wiring to the switches, the speaker and the supply should be attached last.

The unit may be mounted in any convenient-sized box and the speaker mounted on the front. Alternatively, it may be wired into an existing piece of equipment. We'll have to leave these arrangements up to you.

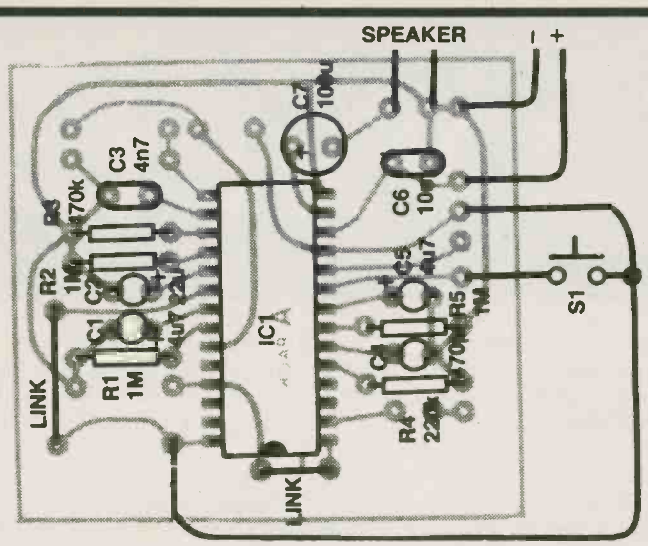
HOW IT WORKS

This unit employs most of the function blocks in the SN76488. The SLF provides a linearly increasing voltage waveform, or ramp, to the VCO, taking several seconds for the ramp voltage to rise from zero to maximum value. The causes the VCO to produce a tone which 'glides' down in pitch, making the 'bomb drop' effect. The explosion is generated by the Noise Generator/Filter and the Envelope Generator. It starts with a burst of noise, which dies away in intensity exponentially in a few seconds.

The whole sequence is triggered by operating the pushbutton, PB1. This applies a high (+5 V) to the input of the System Inhibit block, pin 9. This in turn triggers the One Shot and the Envelope Generator. At the commencement of the One Shot timing period, the One Shot triggers the SLF HI/LO Sync, starting the SLF, and the VCO does its things. At the end of the One Shot timing period the Envelope Select Logic becomes operative, the SLF is disabled and the Envelope Generator commences to do its thing. The Mixer selects the VCO output at the start of the One Shot timing period and the Noise Generator/Filter output at the end of the One Shot timing period. Thus the two sounds are switched through to the audio output stage in sequence, the Envelope Generator modifying the noise so that it dies away, the time it takes to do so being controlled by the time constant of R5, C5.

The starting pitch of the VCO is determined by R3 and C3, the rate of rise of the voltage ramp produced by the SLF is determined by C2 and R2, while the One Shot timing period is determined by the time constant of C1 and R1. The frequency characteristics of the broad-band noise produced by the Noise Generator are modified by R4 and C4 connected to the noise filter control pins (5 and 6).

Audio output is coupled to the loudspeaker via C7, a 100uF electrolytic capacitor.



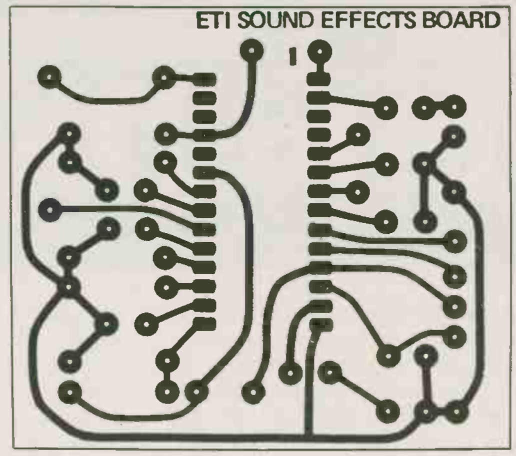


Fig. 2 Component overlay for the Bomb Drop board.

Projectile Project

This produces a 'bomb drop and explosion' sound at the press of a button. Alternatively, the push-button PB1 could be replaced by a pair of relay contacts operated by a piece of equipment or a transistor (emitter to pin 9, collector to other side of PB1) that is turned on by a logic high applied to its base via a resistor.

This project is one of the most complex, using almost every functional block within the SN76488. Varying R3 and C3 a little will vary the pitch range of the 'bomb drop' (descending whistle), while varying R4 or C4 a little will alter the characteristics of the explosion. Note that it is generally easier to 'fine tune' things by varying the resistor values. The duration of the event can be varied by changing the value of either C1 or R1 and the decay of the explosion can be changed by varying R5 (varying C5 produces quite gross changes in the decay period).

Watch that you insert the link on the PCB located at the 'notch' end of the IC.

PARTS LIST

Resistors (all ¼W, 5%)	
R1,2,5	1M0
R3	170k
R4	20k
Capacitors	
C1,5	4u7 16 V PCB electrolytic
C2	22u 16 V tantalum
C3	4n7 ceramic
C4	470p ceramic
C6	10n ceramic
C7	100u 16 V PCB electrolytic
Semiconductors	
IC1	SN76488 (see Buylines)
Miscellaneous	
PB1	SPST push-button switch
PCB; 50 mm diameter 8 ohm speaker; 9 V battery and clip.	

ETI

Into Digital Part 11

THIS MONTH we're going to have a look at binary arithmetic, and give you a short introduction to microprocessors.

So far, arithmetic has consisted of addition, using the full adder circuits. In fact, binary arithmetic starts and finishes with addition — there's nothing else! Now, before you write in saying that your calculators can add, subtract, multiply, divide, find square roots and the number you first thought of, hold everything! I didn't say those actions weren't done, what I said was that addition is done in binary and no other action is. The reason is that all arithmetic can be fiddled so that only addition needs to be done, and the only other processes which are needed are the use of shift registers.

I know what the next question is. If you can multiply and divide, take square roots and find sines of angles all by simple addition, why don't we do this in everyday life? The answer is speed. Doing a multiplication or a square root by addition might involve several hundred additions, and it's too tedious for a human. For a brainless machine operating as fast as its clock pulse rate will let it, though, there's nothing to it.

Algorithms And Two's Complement

There's nothing to it — at least for the machine. For the guy who designs the machine, though, there's a lot to it. The routines which are used to break down comparatively complicated processes like finding sines of angles into simple additions are called algorithms, and there's nothing simple about most algorithms. They're not new; many of them have been known for centuries and were used long before multiplication tables or other aids to mental calculations existed. We'll look at just two simple algorithms here.

```
  1 1 0 0 1 0 1 0          0-1=1 BORROW 1
 -0 0 1 1 0 1 0 1
 ----------------
  1 0 0 1 0 1 0 1
 ----------------
```

Figure 1 Binary subtraction: 1 from 1 gives 0, 0 from 1 gives 1, and 1 from 0 gives 1 borrow 1. The technique is the same as in scale-of-ten subtraction.

Two's complement goes something like this. To start with, you must have an agreed size of binary number — four digits, eight, sixteen or whatever. Suppose we settle on eight, which is the number of digits that a microprocessor handles (pocket calculators usually use four). That means we'll always write eight digits even if most of them are zeros. For example, binary 1 will be 00000001 and 2 (binary 10) will be 00000010. Both numbers are written in this form. The number which is to be subtracted or taken away from the other one is now complemented. That means writing 0 for each 1, and 1 for each zero: it's the action which an inverter carries out. The complement of 00000101 is 11111010 for example. Then 1 is added to the lowest bit of the complement. For example, the complement 11111010 becomes 11111011 when the extra 1 is added, and a complement which was 11111011 would become 11111100 (remember your addition 1 + 1 = 0 and carry 1).

Simple isn't it? But what if the number you are using happens to be positive and yet big enough to have a 1 on the left-hand side (any number between 127 and 255, for example)? Incredibly enough, it doesn't matter! The arithmetic works out correctly no matter how the numbers are arranged, and it's possible to use a few additional gates to signal to you if there's a booboo going on somewhere, like a number which is positive but has a 1 on the left-hand side or a number which should be negative but has a 0 on the left-hand side. For the moment, we'll leave that one.

A number which uses the highest order digit to indicate the sign (+ or —) is called a *signed* binary number, and it's the assistance of such numbers which makes binary subtractions possible with only adder circuits. If, by the way, you need to use larger numbers than eight bits can cope with (+122 to —128 for signed numbers, 0 to 255 for unsigned), then another eight bits can be used, so that signed numbers up to 32,768 or unsigned numbers up to 65,536 can be used. If that's not enough, a third group of eight can be used, and so on. For very large numbers, scientific notation is used, with each number represented as a binary fraction and a power of two so that it isn't necessary to use a large number of digits to represent very large numbers. Scientific notation in decimal numbers is illustrated in **Fig. 3**: binary representation follows the same scheme.

```
a                      1 1 0 0 1 0 1 0 ─┐
      SUBTRACT         0 0 1 1 0 1 0 1  │
          COMP         1 1 0 0 1 0 1 0  │
            +1                       1  │
                     ----------------   │
                       1 1 0 0 1 0 1 1  │
ADDORIGINAL            1 1 0 0 1 0 1 0 ◄┘
                     ----------------
DISCARD CARRY (1)      1 0 0 1 0 1 0 1

b                 1 1 0 1 0 1 ─┐
     SUB              1 1 1 0  │
     PAD          0 0 1 1 1 0  │
    COMP          1 1 0 0 0 1  │
      +1                    1  │
                 ------------  │
                  1 1 0 0 1 0  │
     ADD          1 1 0 1 0 1 ◄┘
                 ------------
DISCARD CARRY (1) 1 0 0 1 1 1

c                   1 0 1 1 0
     SUB        1 0 1 0 1 1
    COMP        0 1 0 1 0 0
                          1
      +1       ------------
                0 1 0 1 0 1
     ADD        0 1 0 1 1 0
               ------------
                1 0 1 0 1 1
                NEGATIVE NUMBER
```

Figure 2 Two's complement subtraction. The number to be subtracted is put into two's complement form, equivalent to placing a negative sign in front. The numbers are then added, and the carry is discarded.

This last figure is called the 2's complement, and is *added* to the other number. The result is the number we should expect if a subtraction were carried out. Notice that we deal with 8-digit numbers only. If there is a carry-out from the eighth place, we ignore it, we don't make the carry into a ninth digit. **Fig. 2** shows some examples of subtractions done using the two's complement algorithm.

Now there's one point you'll notice from all these examples. When you take a large number away from a small one, the result is negative in ordinary decimal numbers, but there's no sign visible in the binary numbers. That's because binary doesn't have signs, only 0 and 1. Looking a bit more closely, though, you'll see that when a subtraction of this sort has been carried out, the highest order digit (the one on the left, lad, on the left) is always a 1. This is, in fact, how we indicate sign. A zero in the left indicates positive sign, a 1 indicates negative sign.

1300 IN SCIENTIFIC NOTATION IS 1.3×10^3
(BECAUSE 1300 IS 1.3×1000 AND $1000 = 10^3$)
SIMILARLY 101101 CAN BE WRITTEN AS 1.01101×2^5
OR $.101101 \times 2^6$

Figure 3 Scientific notation. Any number can be expressed as a small number (or fraction) multiplied by some power of the base. In denary (ten) scale, the base is ten, in binary it is 2. Scientific notation enables us to work easily with the very large or very small numbers.

Multiplying The Species

Binary multiplication can also be carried out using adding circuits, but with the addition of shift registers. All multiplication is addition anyhow; when we say 5 by 7 (or 5 sevens), we mean the number we get by adding five sevens together. Even for a machine, this is a bit tedious, and binary multiplication is carried out very simply by adding a shift. The number of adds and shifts is equal to the number of digits in one of the two numbers being multiplied.

Take, for example, the multiplication of 1101 by 101 (13 by 5 = 65) which is shown in conventional form in **Fig. 4**. The numbers are multiplied on paper by using

```
        1 1 0 1
          1 0 1
    -----------
        1 1 0 1
      0 0 0 0
    1 1 0 1
    -----------
  1 0 0 0 0 0 1
```

Figure 4 Multiplying two binary numbers. When a 1 is used as a multiplier, the number being multiplied is written down, when a 0 is used the result is 0. These lines are shifted left for each new digit of the multiplier, and then added.

exactly the same scheme as we use when we're multiplying two large scale-of-ten numbers, multiplying by the units digit, shifting one place and multiplying by the next digit and so on.

What makes this so much easier in binary scale is that the digits must be 0 or 1. If the multiplication is by 0, then the result is 0, if the the multiplication is by 1, then the result is a copy of the number which is being multiplied.

For the next digit along, the procedure is the same, except that each digit is shifted one place to the left. The result is added to the first result. This is repeated for each digit of the number which is the multiplier, and the sum of all these steps is the final answer.

Practical Multiplication

It's easy enough on paper, less easy to do in practical terms. **Figure 5** gives an example of the sort of hardware that is needed — the registers must be large enough to cope with all the figures in the answer. For our example, we've used 8-bit registers, since this is a very common register size

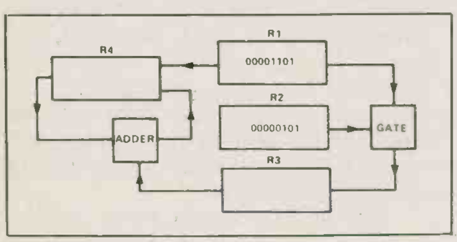


Figure 5 An arrangement of registers which could be used to multiply two numbers, provided that the correct sequence of control pulses could be obtained.

these days. The procedure goes something like this. The number to be multiplied is contained in one register, labelled R1 and the number we shall multiply by in another register R2.

Register R2 is now shifted right by a clock pulse and the digit which comes out is used to control a gate. If this digit is 1 (and in this example it is), then the number in R1 is gated into another register, R3. If the digit from R2 is 0, then register R3 is cleared, so that it contains 00000000.

The next clock pulse shifts R1 one place left and latches the contents of R4, one empty register into an adder. At the same time, the number in R3 also latches to the adder. At the next clock pulse the sum (still 1101) is fed back into R4.

Now that R4 contains 00001101, the process starts again. The digit which comes from R2 on the next clock pulse is zero, so that R3 is cleared, and R1 is then left-shifted again. With R3 cleared, the adder adds 00000000 from R1 and 00001101 from R4, and places the result, still 00001101 back into R4.

The next clock pulse feeds out another 1 from R2 so that R1 delivers 00110100 (remember it has been shifted twice) into R3 and the adder. This is added to the sum so far, giving 01000001. When R2 is an 8-bit register, the shifting will continue until eight bits have been shifted out of R2, but since the next five bits are 0 in our example, there will be no change in the final answer which is stored in R4.

This, of course, is just one possible way of arranging a multiplication, and there are many others. In particular, one way shifting is more desirable on each register so that a rotation of seven places may have to be used in place of a left shift if only right shift and rotation are possible. The principles are the important things here, though, namely that multiplication can be carried out using only addition and shifting, and that the same is true of division, though the process is a little more complicated.

Other Tricks

Once you can carry out division and multiplication, all other processes can be done using repeated steps. Just to give an example, **Fig. 6** shows how a square root can be found using division and addition. You make a guess at the root — quarter or one-third of the number is as good as any — and then add the guess number to the result of dividing the original number by the guess. Take half of the sum, and use this as a guess again, going through the same procedure. After a few repetitions, you find that the 'guess' is almost unchanged from one attempt to the next, and so the 'guess' is now a very close approximation to the square root.

FORMULA: $R1 = \frac{1}{2}(\frac{N}{R} + R)$

$R2 = \frac{1}{2}(\frac{N}{R1} + R1)$

$R3 = \frac{1}{2}(\frac{N}{R2} + R2)$

etc.

N = NUMBER WHOSE ROOT IS NEEDED
R = 1st GUESS AT ROOT
R1 = BETTER APPROXIMATION
R2 = CLOSER APPROXIMATION
etc.

EXAMPLE: FIND $\sqrt{30}$ GUESS 7

$R1 = \frac{1}{2}(\frac{30}{7} + 7) = 5.6428$

$R2 = \frac{1}{2}(\frac{30}{5.6428} + 5.6428) = 5.4796$

$R3 = \frac{1}{2}(\frac{30}{5.4796} + 5.4796) = 5.4772$

$(\sqrt{30} = 5.4772255)$

Figure 6 An algorithm for the square root. Unlike some series of this kind, this one converges rapidly, which means that only a few repetitions are needed to obtain a quite accurate result.

This is a good example of an algorithm in action — this example is a good algorithm which ends up with a correct value after only a few repetitions. Similar methods, called iterative (meaning repeating) methods are used for all the other functions which as calculator uses, from squares through sine, cosine, tangent and their inverses, to logarithms and powers of numbers.

Another Process?

Looking back, we've now used or mentioned quite a large number of digital ICs — enough to construct most of the digital circuits you're likely to come across. Wouldn't it be useful if someone could just make all these chips into one large device which you could connect in any way for any sort of digital circuit?

That's not an original thought, and the answer is that such a chip would have so many pins and need so many interconnections that the job would be impossible. The idea of a 'universal' digit chip is not such an impossible dream, though. It's been done, and the device is called the *microprocessor*.

How can a chip with only forty pins carry out the job of any number of digital ICs? The answer is one at a time! If you're only carrying out one action at a time, you only have to feed in one group of digits at a time, and all the connections inside the unit can be made or broken by gates. The way we decide what is done is by a program, a set of instructions which cause gates to be opened or closed inside the microprocessor. At each step in a program, bits will be transferred into or out of the microprocessor, or from one shift register to another. These bits can pass through adders, be complemented, gated by AND, OR or XOR gates, shifted or rotated in registers and undergo all the various actions which should now be familiar. The important difference which makes it all possible is that the action is always sequential. For example, a microprocessor which is programmed to AND three bits will not carry out the operation in one step the way a three-input AND gate would. Instead, one bit is put into a register and stored. The next bit is then taken in and AND-ed with the first, with the result stored in the same register. Finally, the third bit is taken in (or *read*) and ANDed with the bit in the register. If this is done fast enough, the results are as useful as those produced by a three-input gate, with the added advantage that most microprocessors can handle eight bits at a time, so that eight lots of AND-ing can be 'ANDled!

The microprocessor is the big chip of all digital chips, and although it's way and above all others in its complication, we've reached the stage where we can understand what it does. This final part, then, is devoted to the microprocessor. There's no practical work this month, because we would need a lot more space to describe a practical layout.

What is a microprocessor then? It's a chip which is filled with gates and registers arranged in groups of eight (usually), and with lots of internal connections. What makes it so useful is that the gates can be controlled by signals fed into the microprocessor and can then in turn decide what happens to the next signal or signals along. Everything about a microprocessor is arranged to fit a time sequence, controlled by clock pulses. The sequence never changes — it consists of a set of eight signals which open some gates and close others, followed by more signals which then pass through the open gates.

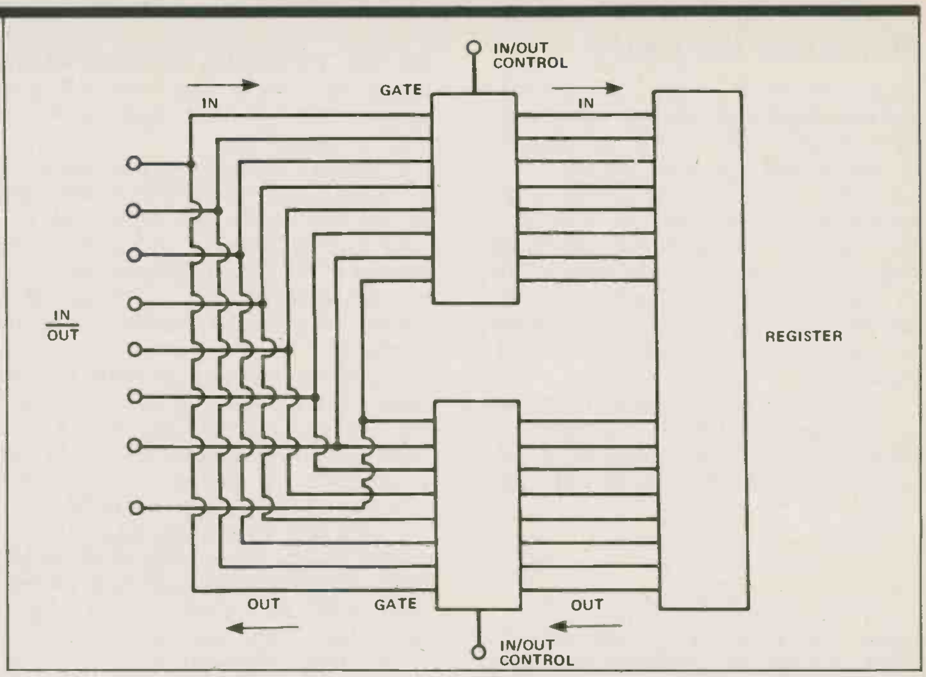


Figure 8 How the microprocessor ANDs bits. One bit is fed in to a register through a gate and is stored in the register. The second bit is then fed in, ANDed, and then the result is fed out. The operation can just as easily be performed with eight bits as with one, and only the eight input pins are needed for the inputs and output, because the inputs are fed in at different times.

The first set of eight signals is a program instruction, the next lot is data. What's the difference? Only the sequence!

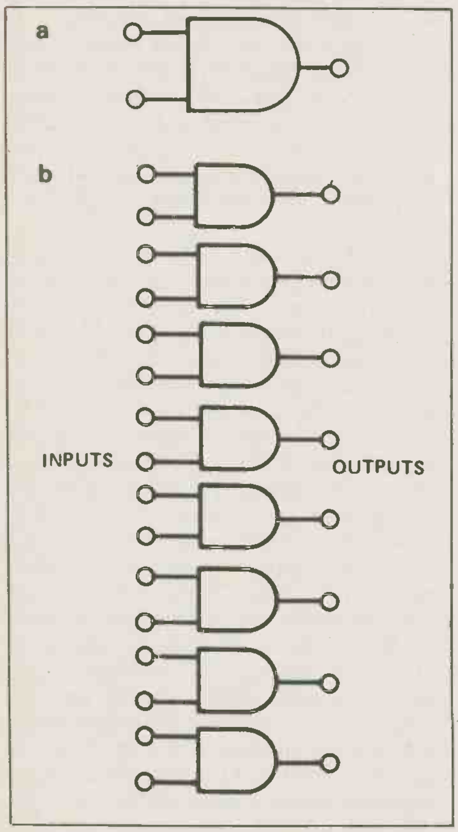


Figure 7 One operation — ANDing. A single AND gate (a) can AND two bits. To AND a set of eight bits (b) would need eight AND gates, with sixteen inputs and eight outputs.

First Mouthful

A group of eight digital signals is called a byte. There's no special reason for having eight. Pocket calculators operate quite happily with four bits at a time, but things can operate faster when we deal with 8 at a time. Large computers deal with 16, 32 or even 64 bits at a time, which speeds some operations up a lot more. Eight just happened to be a useful increase from four without needing a lot more pins on the package.

What can you do with eight bits, then? The answer is eight times as much as you can do with one. You can carry out eight ANDs, eight ORs, add eight-bit numbers, shift left or right — just the sort of digital operations we should be accustomed to by now. Everything the microprocessor does is based on these straightforward digital operations plus one more — the ability to copy a set of eight bits from one register to another. There's nothing novel about the copying (or transfer) action either, it's just an example of using the output of one register as the input of another.

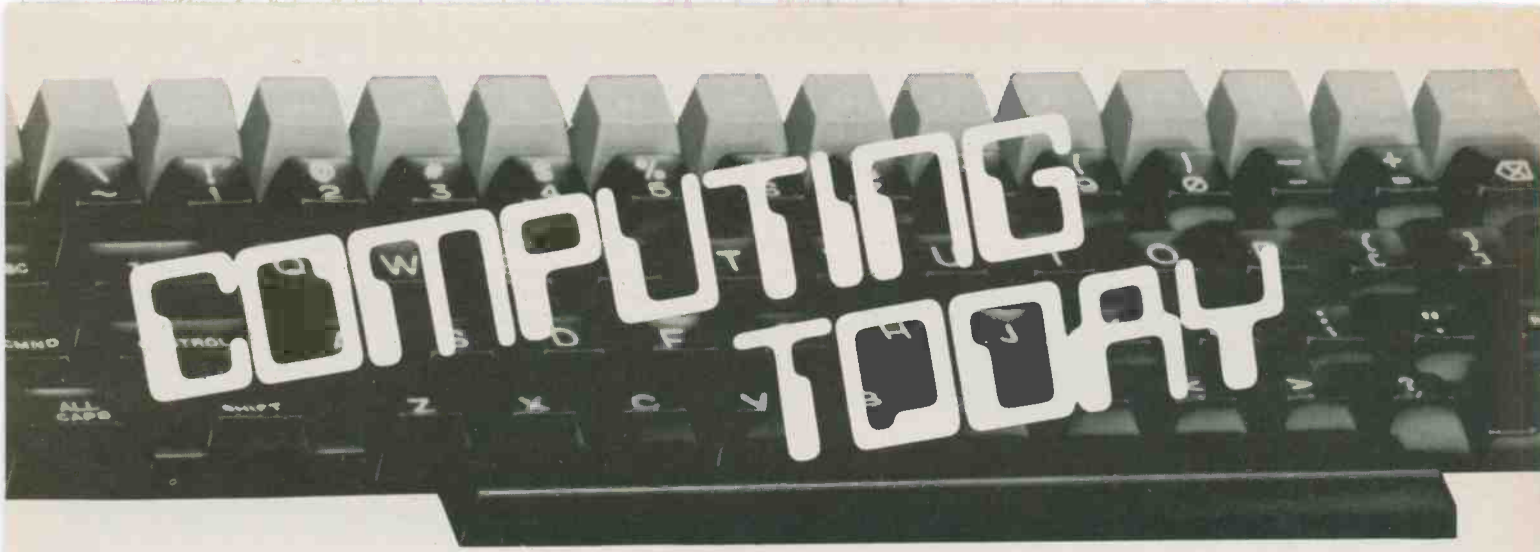
Force-feeding

The microprocessor, then, doesn't do anything which wasn't done by separate chips previously but it takes up a lot less space and costs a lot less as well. For the guy who was familiar with the way computers were designed long before ICs came along, the microprocessor is a simple way of doing what needed a whole lot of circuitry before. When you've come along a different path, however, from linear ICs into digital ICs, it all looks a bit (sorry!) bewildering, with a language of its own which was borrowed from computing. Let's explain, simplify, and cast a little light.

Suppose you want to AND two bits. Simple, use a two-input AND gate (**Fig. 7a**) and the job is done. If you want to AND eight lots of two bits, it just means that you use eight lots of AND gates which will have a total of sixteen inputs and eight outputs, as shown in **Fig. 7b.** That's 24 pins to be connected to a PCB, 24 joints to go wrong and probably two chips on the board. Now the key to the difference between this conventional digital method of gating and the use of a microprocessor is the timing. With eight 2-input AND gates, you can put in all of your sixteen signals together — you'll have to, otherwise the gates won't operate correctly. The microprocessor will accept only eight signals at a time, so the only way we can AND two lots of eight is to feed in one lot, store it in a register, feed in the next lot of eight, store that, and then AND the two lots, and feed the results out. It sounds complicated but in a lot of ways it's simpler. For one thing, we need only eight pins for our eight bits, and we can feed in or out of the same set of eight pins (see **Fig. 8**).

Next month, we'll examine the fundamentals of how microprocessors use the various circuits we've been dealing with in this series. It will also be the last instalment in Into Digital Electronics.

ETI



THIS MONTH being warm and hazy and not much good for serious stuff, let us consider the mysteries of computer games. This one is for the TRS-80 model III and IV, although it will be adaptable to most any system with a bit of fighting. It is called "finger the politician".

You are the glove of truth. "The what?", you may well ask. Well, the Model III has a weird graphics character set, and, if you string 244, 245 and 246 together you get a flying finger. I've wanted to make this into a video game since the first moment I saw it, but most of the initial attempts were too rude. The glove flies around the screen as controlled by the key pad.

The finger moving routine in this program will actually prove fairly handy for a number of other game applications. Unlike most games it doesn't require that you keep hitting a key to make the action continue. Once the glove is started off in one direction it will keep moving until it hits the edge of the screen or 'til another key is hit to change its vectors.

The screen of the computer is dotted with . . . well, again, the TRS-80 III has some good characters for this sort of foolishness. 196 is a smiling face, while 197 depicts a frown. The smiles are citizens and the frown is a bald politician with a big nose . . . you pick which one. The co-ordinates of these are stored in two arrays, which are scanned and re-randomized every five times the position of the glove is updated. This causes the faces to be constantly disappearing and re-appearing elsewhere on the screen.

The idea is to fly the glove around with the numeric keypad and prod the frowning politician without prodding the smiling citizens. (I know, it's a silly plot.) After fifty five seconds a score is figured on the basis of your success.

The co-incidence detector in this game will be useful if you decide you want to do up similar things with better plots. If you try to compare both the X and Y co-ordinates for all of the array entries you will find, for most BASICs, that things slow down to a drunken crawl. You can cheat on this, though, in the way shown here. First off, you'd begin by comparing the Y co-ordinates. The Y's are a better choice than the X's because there are fewer of them. If you don't get a match on the Y's you can give up and go home.

In this program, we further cheat by only looking to see if the X value specified for the co-incident Y is a match with the position of the cursor. This takes advantage of the nature of the random numbers in the Model III, and is only wrong about two percent of the time . . . i.e., you can get two faces on the same line with the glove on top of the second one and have the co-incidence go unnoticed. However, this is quite rare.

Sometimes one must hack in the interest of speed.

Another kind of neat thing about this game is that it has memory. The disk file stuff at the end will store the highest score to intimidate lesser players with.

BASIC speaking louder than words, I shall cease writing and simply present . . ze code! Fly your fingers well. **ETI**

```
110 REM ''''''''''''''''''''''''''''''''''''''''''
20 REM '    Finger the politician hiding         '
30 REM '    in a croud..................         '
40 REM '                                         '
50 REM '    For the TRS-80 III and IV            '
60 REM '    Copyright (c) 1983                   '
70 REM '    Steve Rimmer                         '
80 REM ''''''''''''''''''''''''''''''''''''''''''
90 PRINT CHR$(21)
100 SYSTEM "time 00:00:59"
110 DEFINT A,B,C,S,X,S,N,M,R,P,Q,L
120 DIM A(20),B(20),C(20)
130 F$=CHR$(244)+CHR$(245)+CHR$(246)
140 E$="   "
150 CLS
160 PRINT CHR$(15);
170 X=10 : Y=10
180 GOSUB 470
190 GOTO 390
200 REM move the finger
210 A$=INKEY$
220 IF VAL(RIGHT$(TIME$,2))>55 THEN 800
230 S=S+1 : IF S=4 THEN S=0 : GOSUB 580
240 IF A$="1" THEN J=1:K=-1
250 IF A$="2" THEN J=1 : K=0
260 IF A$="3" THEN J=1:K=1
270 IF A$="4" THEN K=-1:J=0
280 IF A$="6" THEN K=1 : J=0
290 IF A$="7" THEN J=-1:K=-1
300 IF A$="8" THEN J=-1 : K=0
310 IF A$="9" THEN J=-1:K=1
320 IF A$="0" THEN PRINT CHR$(14);:END
330 IF X>75 AND K=1 THEN K=0
340 IF X<2 AND K=-1 THEN K=0
350 IF Y>20 AND J=1 THEN J=0
360 IF Y<2 AND J=-1 THEN J=0
370 PRINT@(B,A),E$
380 X=X+K:Y=Y+J
390 PRINT@(Y,X),F$;
400 A=X:B=Y
410 GOSUB 660
420 GOTO 210
430 REM get location of cursor
440 X=POS(0)
450 Y=ROW(0)
460 RETURN
470 REM scatter faces
480 R=RND(12)+6
490 P=INT(RND(R))
500 FOR X=1 TO R
510 M=RND(60)+10
520 N=RND(20)+2
530 A(X)=M : B(X)=N
540 IF X=P THEN C(X)=197 ELSE C(X)=196
550 PRINT@(N,M),CHR$(C(X))
560 NEXT X
570 RETURN
580 REM move the people around the screen
590 PRINT@(B(Q),A(Q))," ";
600 M=RND(60)+10
610 N=RND(20)+2
620 A(Q)=M:B(Q)=N
630 PRINT@(B(Q),A(Q)),CHR$(C(Q))
640 Q=Q+1 : IF Q > R THEN Q=1
650 RETURN
660 REM coincidence detector
670 F=1
680 FOR L=1 TO R
690 IF Y=B(L) THEN F=I : D=L
700 NEXT L
710 IF F=1 AND X=A(D) OR X+1=A(D) OR X+2=A(D) THEN GOSUB 730
720 RETURN
730 REM handle coincidence
740 IF C(D)<> 197 THEN 770
750 PC=PC+1 : PRINT@(0,45);PC" Politicians fingered!!!"
760 GOTO 790
770 CC=CC+1 : PRINT@(0,5),CC" Innocent citizens bothered..."
780 A(D)=RND(60)+10 : B(D)=RND(20)+2
790 RETURN
800 REM dun
810 CLS
820 PRINT:PRINT:PRINT:PRINT:PRINT
830 PRINT"     You fingered "PC" politicians while making life"
840 PRINT "      miserable for a mere "CC" citizens."
850 TS=PC*20-CC :GOSUB 900
860 PRINT : PRINT : PRINT
870 PRINT"    Hit any key to end, R to replay."
880 A$=INKEY$:IF A$="" THEN 880 ELSE IF A$="r" OR A$="R" THEN RUN 100
890 PRINT CHR$(14):CLS:END
900 REM disk drive routine
910 ON ERROR GOTO 1010
920 OPEN "I",1,"SCORES"
930 INPUT #1,DS
940 CLOSE #1
950 PRINT"     THE HIGHEST SCORE SO FAR IS "DS"!!!"
960 IF TS>DS THEN PRINT"     You have fingered it!!!!" ELSE 1000
970 OPEN "O",1,"SCORES"
980 WRITE #1,TS
990 CLOSE #1
1000 RETURN
1010 REM trap disk errors
1020 OPEN "O",1,"SCORES"
1030 WRITE #1,0
1040 CLOSE #1
1050 RESUME
```

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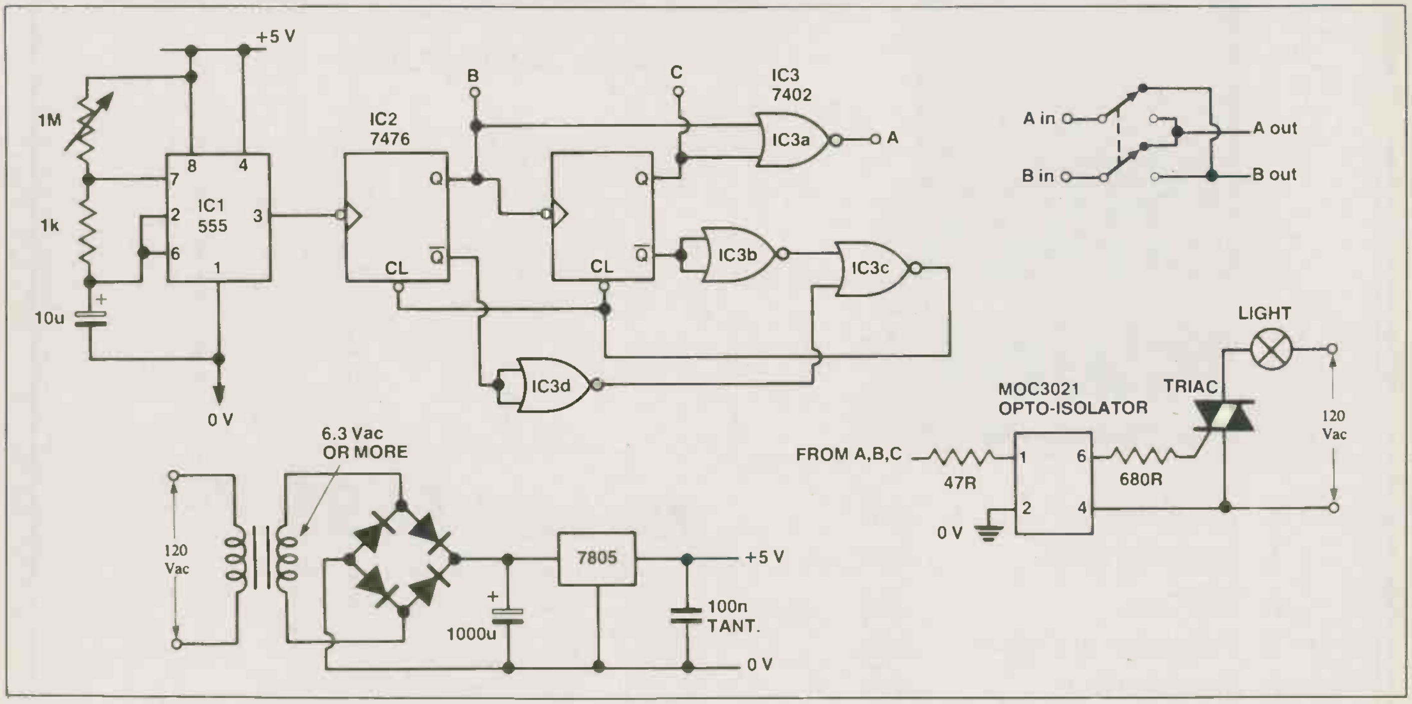

Three-channel light chaser
Stephen Pierrehumbert

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Continued on page 74

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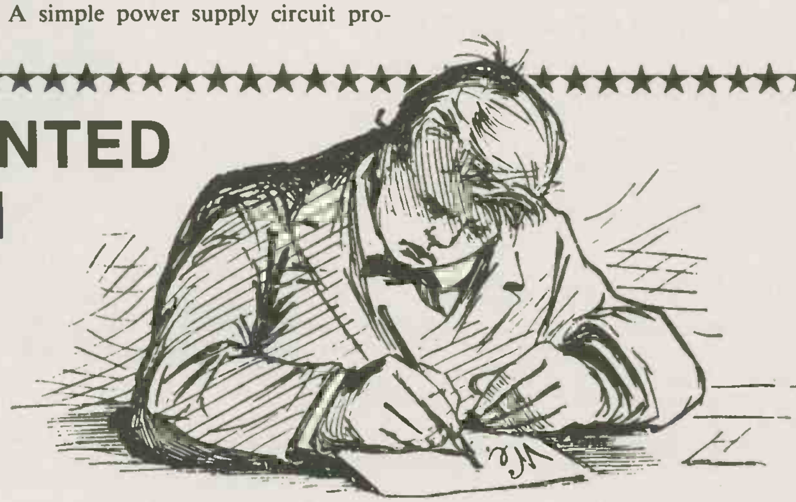

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ZX81 interface board featured in April ETI complete kit $34.95, circuit brd only $12.00. ZX81 motherboard accepts two vector or Radio Shack type multi-purpose plug boards, plus all Sinclair accessories assembled $29.95. Also ZX81 video amp, drives composite type monitors $9.95. Include $2.00 each order P & H. **JDC** 5-14 Sentinel Rd., Downsview, Ont. M3M 2Y5.

APPLE™-builders need "APPLE-SEED"! Comprehensive step-by-step instruction manual for assembling your microcomputer kit. 60 pages, 70 illustrations. Send $9.95 (includes postage) to: **NUSCOPE ASSOCIATES,** P.O. Box 742, Stn. B, Willowdale, Ont. M2K 2R1. Quantity discounts.

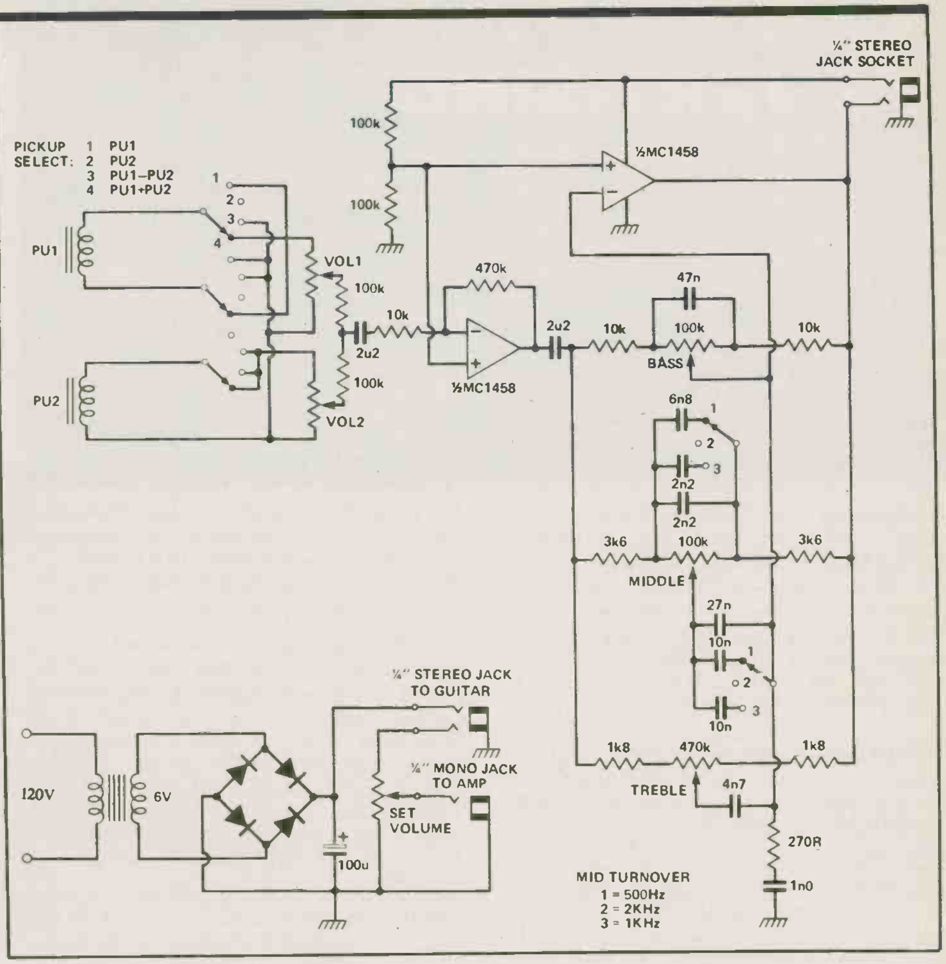
SINCLAIR-TIMEX hardware — floppy disc drive — 5.25" — 35 track — double sided — double disc — 437K. Interface, etc. available. Friendly, mass storage device — (tapes) load 27K in 23 seconds — V.S. — 7 minutes — 11 KB rate - access at speed, accuracy of a mainframe. Software — (600 programs, listings available) write needs, K capacity, business — finance*, education*, games-graphics*, home-personal*, math-engineering*, program aids*. *Send $2.00 for each star (order refundable) Word processor pack. Includes, processor, listing generator, hex monitor, ASCII conversion one cassette $29.95. P.P. add tax. Write ZX81 machine code in hex. One cassette and listing $19.95. P. P. add tax. **CDN. COMPUTER SOURCE CENTER.** P.O. Box 3637, Stn. "C", Ottawa, Ont. K1Y 4J7.

Continued from page 73

Electronic Guitar

Quentin Rice

The circuit shown here has fitted inside a friend's Rickenbacker bass to increase the versatility of the guitar. Its controls are as follows: pickup/phase select, volume 1 and 2, bass, middle and treble tone controls and middle turnover frequency. It has low current consumption and can be used either with a battery, or with the 'phantom' power supply connected to the jack socket. It seems likely that most guitars will feature active circuitry in the future, giving musicians greater flexibility during a live performance.



Smith-Corona introduces the first printer with real character at the unreal price of $1095.*

The Smith-Corona Daisy Wheel Printer

Until now, if you wanted to include a reasonably-priced printer as part of your computer or word processing system, you had to use a dot matrix printer. Daisy wheel printers were just too expensive.

Not anymore. Now Smith-Corona* offers a daisy wheel printer at such an incredibly low price, you can't afford *not* to include it. That means that even the smallest installation or business can now have letter quality printing capabilities at every work station.

The Smith-Corona printer operates with micro-processor-controlled daisy wheel technology, and is available with industry standard serial or parallel data interfaces.

Best of all, it produces results identical to those of our very finest office typewriters – printing with real character. So it can be used to create letters or documents that have to look perfect. As well as financial statements, inventory reports, direct mail campaigns – anything that requires quality printing.

And it's easy to use – just turn on the power, load the paper and away it goes. (It works equally beautifully with letterhead bond or fanfold paper.) There are drop-in ribbon cassettes and a choice of easy-to-change, snap-on daisy print wheels for a variety of fonts.

So why not get your hands on a real bargain: letter-perfect printing at an amazingly low price. Because, thanks to Smith-Corona, a printer with real character is no longer expensive.

Ask for it by name. **Smith-Corona**

DIVISION OF SCM® (CANADA) LIMITED

suggested retail price

Please send me more information on the Smith-Corona daisy wheel printer.

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Title________________

Company Name________________

Business Address________________

City________ Prov.________ Postal Code________

Type of Business________________

Mail coupon or call:
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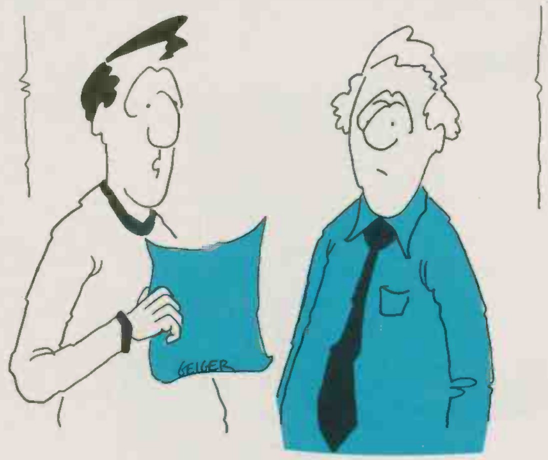
Smith-Corona
29 Gervais Drive, Don Mills, Ontario M3C 1Z1
(416) 449-0164

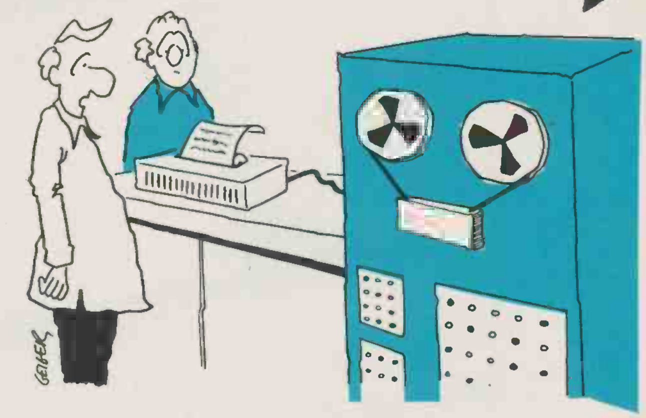
ETI

Circle No. 27 on Reader Service Card.

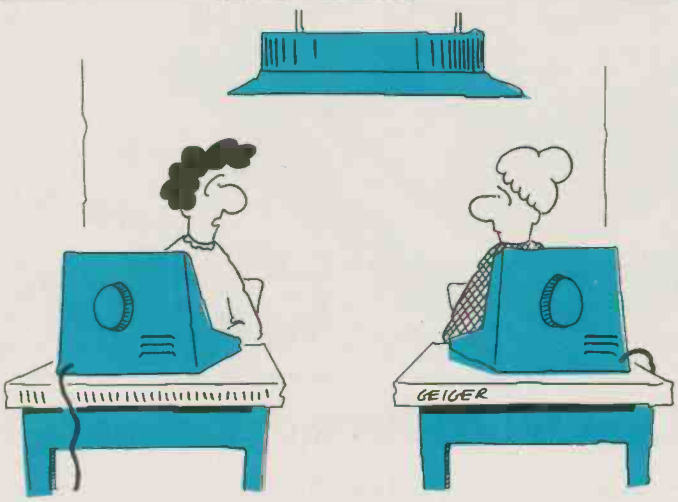
The Fun of Electronics



"I had trouble understanding this schematic until I realized that Q3 is actually a bug that got squashed on the paper."

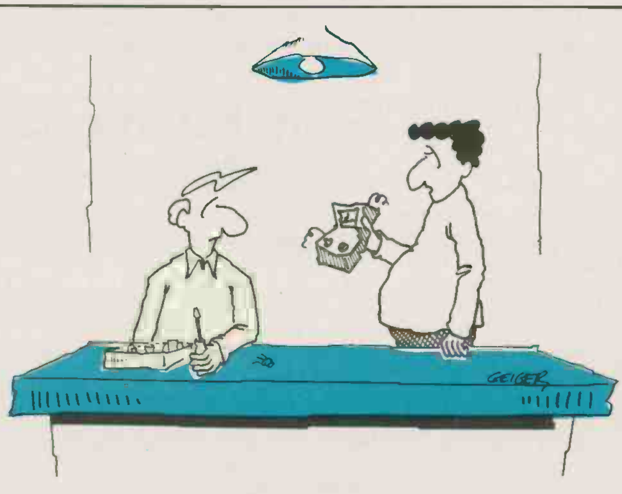


"Remarkable! Just before the system crashed, it managed to print out a last will and testament."



"You know, sitting at these VDT's all day is exhausting — I can't wait to get home and relax in front of the television set."

"I want to exchange this chess game for one that doesn't giggle."



"I accidentally stepped on your meter — you may have to recalibrate it or something."

"The video disks didn't go over as well as we'd hoped."

Parts ELECTRONIC COMPUTER Galore

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MODULATORS

We have a number of modulators and cables/adaptors for home computers and video uses.

(1) A low cost video only modulator for the simples uses. Runs on 12 v. Channel 3-4 . . . . $4.95

(2) A higher quality video only unit, fits right inside a 6502 machine and connects to its internal connector. Comes complete with a Computer/TV switch and 6' RCA cable $15.00

(3) Still better, same as above but with audio capability. Fits inside a 6502 machine and connects to internal connector, with a TV/computer switch and 6' RCA cable $18.00

(4) The best, a high quality crystal controlled unit for VTR or high res graphics use. Does not fit inside for best RFI rejection. Runs on 12 volts and has full video and audio capabilities. Comes with a TV/Computer Switch $39.95

(5) RCA/RCA cables for video use
- 6' cable, good for most uses $1.95
- 12' cable, for extra length $3.95
- 25' cable, for extra length $5.95

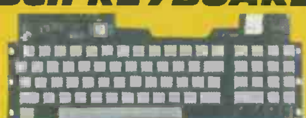
(6) ADAPTORS to allow interconnection amongst various systems
- (a) RCA/BNC Connects an RCA cable to a BNC monitor (Electrohome) $1.95
- (b) RCA/PL259 Connects an RCA cable to a PL259 monitor (Ham, Professional) $1.95
- (c) F59 Push on connector, takes a F59 male screw-on and converts it to a quick connect push-on-off $0.99

MODEM

The attractive EMP modem, a 300 baud direct connect modem that is Bell 103 compatible. Full CSA approved complete with manual and modular phone plug for quick connection. Just the thing for our new dial-in catalog. Operates as either answer or originate end and full duplex data flow. Has carrier detect light for easy monitoring. Many of these have been sold at $199.00

Parts Galore Special Price $119.00

ASCII KEYBOARDS



Our ASCII keyboards are by ALPS, a famous Japanese switchmaker and feature high quality debounced switches. Full upper and lower case capability. Direct plug in compatible with all 6502 boards and 'SURF' board. Available in numeric and std style.

(a) Standard KB $89.00

(b) Numeric KB $99.00

VIC 20 EXPANSION CARD

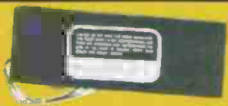
Our newest product, available in two sizes to add edge connectors to your VIC-20 home computer.

Smaller size, 6 slots added $15.95

Larger size, 10 slots added $19.95

44 pin (22 x 2) edge connectors for the above expansion PCB . . . . $2.95 ea.

POWER SUPPLY



Our famous "BLACK BEAUTY" power supply, now reduced in price but not in quality. This power supply is the most powerful one we have, rated at 5V-5A, 12V-2.5A (3A surge) -5V-½A, -12V-½A it easily beats all the rest $99.00

OUR 6502 BOARD VERSUS THE SURPLUSTRONICS' 6502 BOARD

ALSO CALLED THE "SURF" BOARD.

We have been watching the "SURF" board for some time now and have come to the conclusion that we should do something to counter the somewhat grandiose claims that we have read about. We decided to analyze under 4 areas, namely

1. Cost 2. Quality 3. Compatibility 4. Versatility

We invite you to check out our observations in these 4 categories with any independent source, friend, or your own common sense and to agree or disagree, as you choose.

1. COST. The cost of the "SURF" and 1 Z-80 PCB is $57.00
   We charge the same for our 6502 board and any 4 of our many peripheral cards. The cost to stuff the boards is the same as the same parts are there whether or not they are on the mother board or on a peripheral board. To be sure we need 3 more edge connectors as we have 8 slots, but then we do not use 4164's (cost more than 4 times a 4116), or 350ns 2716's (cost more than the schottky proms for Disc pcb) or that huge number of 0.1 uf capacitors. On balance the cost difference is less than $10.00 if all parts bought from the same source. If you buy all parts from us versus them, you will save about $75.00 on the system with us.
2. QUALITY. The quality of the boards is not the same, our PCB has a harder epoxy mask that makes solder bridging less likely. The high density of the surf board makes solder bridges and shorts harder to detect at the time of manufacturing, stuffing and debugging. By high density we mean a lot of parts very close together, a result of putting a lot of functions on the same board. In addition we have a higher quality keyboard, a better power supply and a solid ABS case instead of an easily scratchable painted plastic case.
3. COMPATIBILITY. By compatibility we mean the ability to run all kinds of software, especially that using CP/M and 80 column abilities. We feel superior in this area as we are directly compatible with no changes to software or hardware to interfere with compatibility.
4. VERSATILITY. Versatility means the ability to use any new peripheral card that comes along. The design of the "SURF" uses up 3 slots and if you buy a Disc Card, 80 Column card, or 64K RAM card, or RAM DISC card that can only be implemented in one of those 3 slots then you cannot use it without some changes to the PCB with jumpers. We keep all the versatility of the original.

We invite challenge, please tell us of your opinions whether or not you agree with us. We like to tell it like it is without trying to say we have the worlds' best buy etc via advertising hype. We think that the facts speak for themselves if they are perceived.

FREE EPROM LABELS

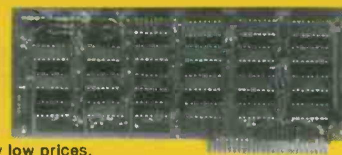
Have you ever tried to get those little labels made of matte aluminum foil that you put over the little window of an EPROM? Hard to find aren't they? Well we went and had 50,000 printed and we are giving 48 of them away free of charge to every one who sends us a self addressed stamped envelope. If you want to buy some they are 96/$1.00 and you can add $1.00 worth to any order or get 48 freebies with any order with a self addressed stamped evelope.

EPROM LABELS . . . . 96/$1.00

NEW LOCATION

At 331 Queen St., West (at Beverley). Come on down and look us over.

PERIPHERAL CARDS

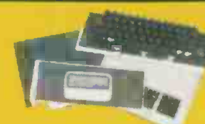


New low prices.

- a) Z-80, A versatile card that uses an onboard Z-80 allowing access to all the 8080 and Z-80 programs written in CP/M tm. Allows use of CP/M 56 on your Apple tm or 6502 system. $69.95
- b) 80 Character, another good card that expands your video screen to 80 columns from 40 to get lots of fine print in there. Very useful with several word processors. $79.95
- c) 16K, Allows you to expand your system to 64K to get a bit more in, such as CP/M 56, or another language $59.95
- d) Floppy Disc, A card that allows you to connect up to 2 floppy disc drives to your system, a real must have board $59.95
- e) ROM, a board that allows you to add another purchaseable language to your system and have it always there when you turn on $49.95
- f) Prototype card, everywhere there are holes on 0.1" centres $10.00
- g) TAMECARD, Our version of the wildcard that allows you to take a snapshot of RAM at any location and save it to another location to allow an end run around protection methods. A very useful card $79.95
- h) MEGABIT RAM, a 128K RAM card using 4164's for max density storage, very useful to expand your system storage capacity 64K $149.95
  128K $239.95

Remember, any bare PCB is $15.00 and the following wholesale discount applies, so get together in a group. 10 PCB @ $10.00 ea., 25 PCB @ $9.00 ea., 50 PCB @ $8.50 ea., 100 PCB @ $8.00 ea., and 500 PCB at $7.50 ea. You can order any combination of PCB that reaches the discount number but they must all go to the same address.

GREAT DEAL



THE GREAT DEAL
CARRIES ON FOREVER AND GETS BETTER

We made an even better buy on over 1000 sets of power supply, 6502 board, numeric keyboard and numeric ABS case (solid coloured ABS All the way through, not just painted plastic) and can now offer the great deal with numeric case and keyboard for the amazing price of . . . . **$275.00** along with any 4 of the peripherals listed above as a bare pcb with parts layout. The price is the same for numeric or non-numeric styles of KB and case for this great deal. Please specify numeric or non-numeric when you order.

AN EVEN GREATER DEAL $800.00

WHAT ABOUT THOSE OF YOU WHO WANT AN EVEN GREATER DEAL? WHERE DO WE GO FROM THE GREAT DEAL? HERE'S WHERE. WE OFFER THE FOLLOWING:

1. A wired and tested 6502 board.
2. Numeric case.
3. Numeric keyboard.
4. Heavy duty (BLACK BEAUTY) power supply.
5. Any 3 wired and tested peripheral boards from the ones listed in this ad, less cable, except megabit RAM.
6. All the other bare peripheral boards that you don't have in the above 3 wired and tsted.

ALL FOR THE AMAZING PRICE OF $800.00

SYSTEM SAVIOUR

Hot and getting hotter??? Got an older power supply??? Then you need a SYSTEM SAVIOUR. This is not a religious object, it is a nicely packaged 3½" muffin fan in a molded plastic housing that fits against the slots on the side of our 6502 computer case and draws out the hot air. Widely used by all major political parties, especially the NDP, now at a new low-low price. Complete with 2 grounded 3 wire switched sockets, pilot light, surge protector and on-off switch to turn off your system and two plugged in items. Fully fused **$59.95**

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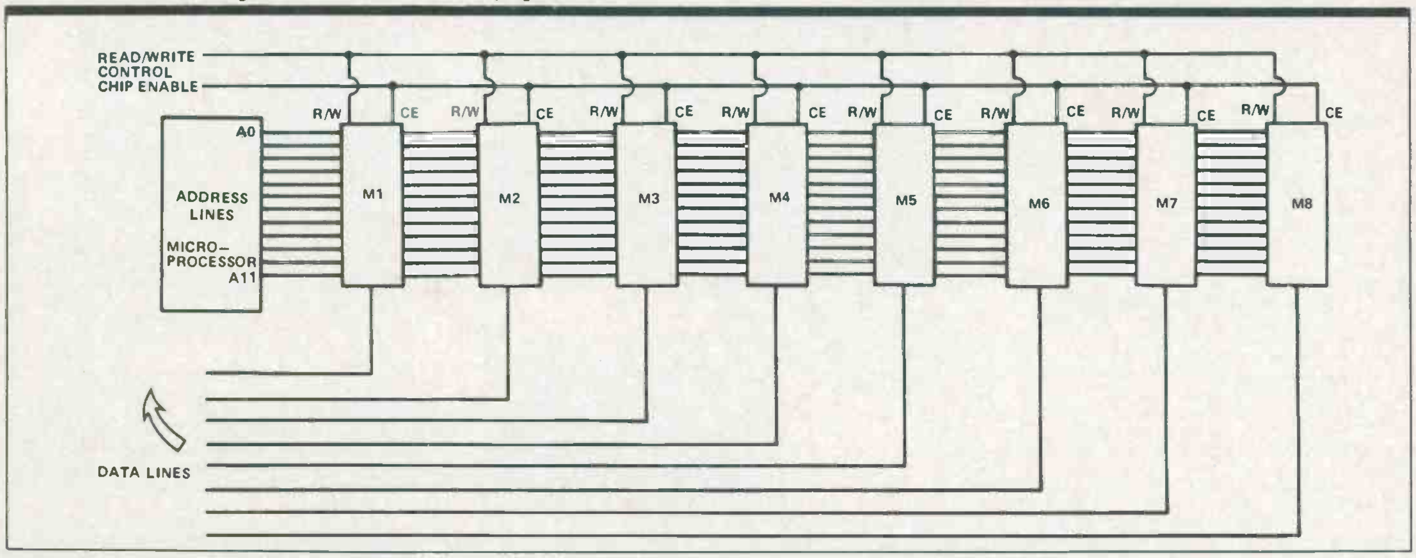


Fig. 9 Using single-bit memory chips. Eight chips are needed to form a memory bank and the read/write and chip-enable signals for each chip must be taken from the microprocessor — they will probably need to be buffered.

which is connected to the data lines and also to the control lines. A typical port or PIO (Peripheral Input/Output) will have one or two sets of input or output pins — the usual eight connections to the data bus, and several (typically six) pins for control signals. It's a one-chip method of obtaining input or output at a time when the memory chips are not being used and because it's a single IC, manufacturers usually load on a lot of extra functions, such as being able to use some bits for inputs and others for outputs simultaneously.

Port ICs are generally designed specifically for one particular CPU, though they are capable of a remarkable number of actions. No two are completely alike and there are always some restrictions on their use as compared to memory mapping. For this reason, memory mapping is used much more.

There's no end to the number of specialised chips which are produced for use with CPUs like the Z80. Even the humble SC/MP has a combined port/memory chip, the INS8154, which almost needs an instruction manual of its own. The units dealt with here are, however, the ones you're most likely to find in smaller systems and, more important, the chips you will use if you start designing your own microprocessor systems. Good Luck!

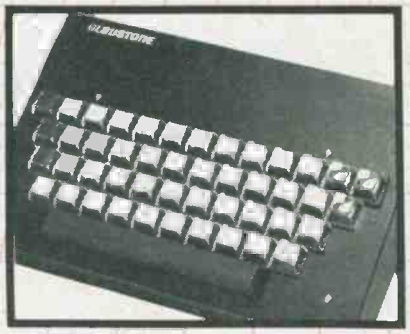
ETI

Top Selling Hardware for TS1000 and ZX81

Best Selling Software

Gladstone Professional KEYBOARD & CASE

$129.95



A full sized professional keyboard for TS1000/ZX81. Features 47 keys and a full-sized space bar. Connects to the **TS1000/ ZX81** with no soldering required, via a plug-in flexible connector. Expansion devices (i.e: RAM packs etc.) connect to the **TS1000/ ZX81** edge-connector which extends from the rear of the cabinet.

- American made • keycap legends will NOT wear out
- Keys with life rated at 20 MILLION cycles

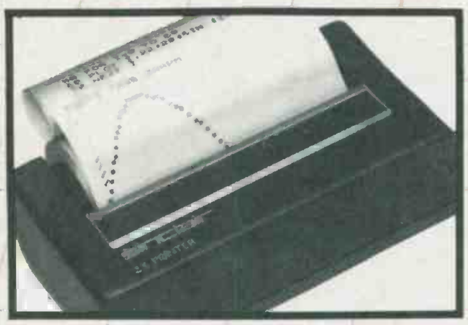
Keyboard and metal case both for **$129.95** (K71)

Gladstone 64K RAM

$159.95

That's right, **64K RAM** for your **Timex Sinclair**, for **$159.95!** Increased production allows lower price on this American made quality RAM pack. 64K expands the capacity of the **TS1000** to its maximum, enabling longer programs and greater databases. Completely reliable, and warranted for 6 months.

Precision tooling of the case with a close cosmetic match to the finish of the **Timex Sinclair** computer. **Gladstone's 64K RAM** adds programming power to the already powerful **Timex Sinclair TS1000.**
G64 **$159.95**



$119.95

ZX PRINTER

The finishing touch to a Timex Sinclair computer system. The **ZX Printer** offers full alphanumerics and highly sophisticated graphics.

A special feature is **COPY**, which prints out exactly what is on the whole TV screen without the need for further instructions.

At last you can have a hard copy of your program listings — particularly useful when writing or editing programs.

And of course you can print out your results for permanent records or sending to a friend.

Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The **ZX Printer** connects to the rear of your computer — using a stackable connector so you can plus in a RAM pack as well. A roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions. S70 **$119.95**

ZX FORTH

FORTH is an interactive, compiled language that expands the capabilities of the **TS1000** and **ZX81**. It has the simplicity of BASIC but runs up to ten times faster! **FORTH'S** most distinctive feature is its flexibility. Its unit is the WORD. The programmer can use existing **WORDS** to define new ones. ZX FORTH has over 250 commands and occupies only 6K of memory. Z43 **$39.95**

FASTLOAD

An incredible breakthrough in **TS1000** and **ZX81** software development. Enables you to load and save programs up to 6 times faster than normal. You can easily convert your existing programs into new I.P.S. **FASTLOAD** programs. And unlike other systems, **NO ADDITIONAL HARDWARE** is required! **FASTLOAD** has won rave reviews from users, and has proven to be exceptionally reliable in test after test. Occupies only 1/2K of memory. Z61 **$24.95**

ZX Assembler

This Machine Code program occupies 7K of memory and locates itself at the top of memory. The program is a full Editor/Assembler and Monitor. Labels may be used instead of any string. The features include Line Insertion/Delete, Insert Characters, Auto Repeat on all keys. The monitor has facilities to inspect memory, registers and run machine code programs. Z40 **$19.95**

Machine Code Monitor and Disassembler

ZXBUG is a powerful tool for machine language programming. It is 4K long and uses memory from 71EO to top memory. **ZX BUG** works in hexadecimal (base 16), not decimal, so all addresses are a maximum of 4 Hex bits long. Provides a total of 28 commands. Z41 **$19.95**

Top Selling Games

ZX Scramble You are flying into the heart of alien territory. They repond with missiles and flying bombs. Destroy them before they destroy you!
Z90 **$19.95**

Trader A trilogy of 16K programmes that combine to give an epic 48K graphic adventure. As a galactic trader, you deal with some very bizarre customers indeed. Will you live to tell the tale?
P10 **$24.95**

Galaxy Invaders Another arcade classic, masterfully translated to the **TS1000** and **ZX81**. Protect your seven lives against fleets of hostile invaders. Fast, exciting and unpredictable. Z91 **$19.95**

$40.00* FREE Software

with purchase of Sinclair ZX81 Personal Computer!

With your purchase you will receive FREE
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includes TWO Software cassettes!
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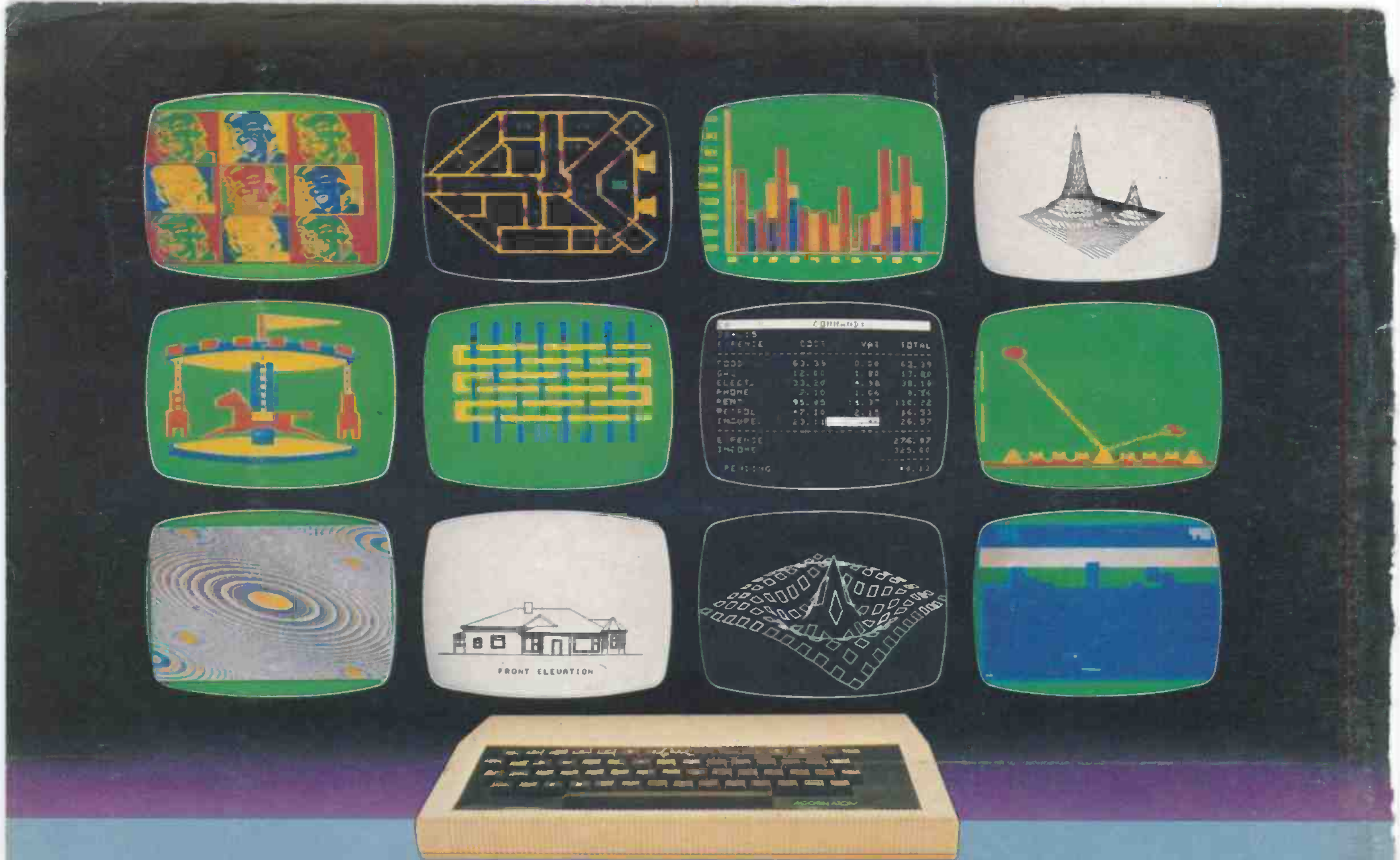


Unleash the power of the ATOM for as low as $199.95

The Acorn ATOM is everything you need in a personal computer. A powerful, full facility computer at an extraordinary low price. It's full sized professional keyboard is easy to use and has a hardware/software combination of incredible power and versatility. Just connect directly to any domestic TV and you're ready to begin. The next stage is to increase the ROM and RAM on your basic ATOM, from 8K + 2K to 12K + 12K. This will give you direct printer output, floating point mathematics, scientific and trigonometic functions, and high resolution graphics. From there you can expand indefinitely!

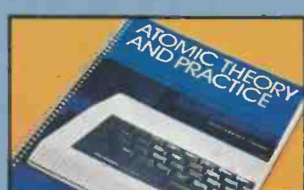
Just look at these features!

• *Colour • Sound • *High resolution graphics • *9 different graphics modes • RF modulated and composite video output • Built-in cassette interface • Expandable to 64K RAM plus 6K of fast graphics RAM • Excellent low-cost software • Mneumonic 6502 Assembler including Macros and conditional assembly • Printer interface available.

* 12 + 12 models only

FREE Manual

Free with every ATOM is a complete, easy to learn computer manual. The first section explains and teaches you BASIC, the language most personal computers and the ATOM operate in. Within no time you'll be writing your own programs. The second section is a reference for you giving a full description of your ATOM's facilities and how to use them. Both sections are fully illustrated with sample programs which makes learning fun!



The Acorn ATOM features:

Software: Pre-recorded selection of cassette-based and ROM based software • Languages built in are BASIC and ASSEMBLER, and can be adapted to LISP and FORTH • fascinating games, household and business applications and educational programs • Allows high speed execution • Links to machine code programs.

Circle No. 32 on Reader Service Card.

Hardware. Full-sized QWERTY keyboard • 6502 microprocessor • rugged injection molded case • 12K ROM • 12K RAM • Audio cassette interface • TV output with high resolution colour graphics/sound • 6847 video display generates video signals for 9 different modes • Wide range of serial I/O functions and dual timers.

Acorn ATOM Computer

2K RAM/8K ROM (B &W)	**$199.95**
12K RAM/12K ROM (B &W)	**$349.95**
12K RAM/12K ROM (Colour)	**$439.95**

Many additional RAM add-ons and plug-in ROM's available. AC adaptor also available.

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