ENCOUNTER WITH JUPITER PROJECT GALILEO

STORY BEHIND STEREO AN ELECTRONIC MAGAZINE
CIRCUITS
CASSETTE INTERFACE DOUBLE DICE
LELE SPEEDOMETER
**COLOUR MODULATOR Kit #1 $24.95**

This video modulator has been designed to complement the small home computer. It allows the standard colour television to be used as a high quality colour video monitor. Uses state of the art integrated circuit technology. Direct coupling is employed to provide high level compensation in the vestigial sideband output. The gain device of the LM1889’s croma oscillator is used to buffer, level shift, and invert the incoming composite video input. The signal then passes through the RF modulator where a channel 7 carrier is provided. Requires 12 volt DC for operation.

**VIDEO TO RF MODULATOR**

**Kit #2 $8.95**

Converts a video signal to a RF signal. The RF output terminals connect to the antenna of your TV. Connecting in the video and supplying 5 to 10 volts DC is all that is needed. You turn your channel selector to 4, 5 or 6 (whichever is not used in your area) and tune the adjusting coil for a suitable display.

**POWER SUPPLY**

**Kit #3 $16.95**

This kit has been designed to satisfy the need for an economical power supply. Provides 5 volt DC at lamp for TTL projects plus a separate floating power supply that is variable from 5 to 35 volt DC at 1/2 amp for CMOS and other uses.

**MAD BLASTER**

**Kit #4 $4.95**

The MB-1 produces a load “ear shattering” siren tone. It can supply to 4 watts of obnoxious audio into an 8 ohms speaker. Requires +5-15 volts DC.

**COLOUR ORGAN**

**Kit #5 $14.95**

This kit has been designed to satisfy the need for an economical power supply. Provides 5 volt DC at lamp for TTL projects plus a separate floating power supply that is variable from 5 to 35 volt DC at 1/2 amp for CMOS and other uses.

**SIREN KIT**

**Kit #6 $3.95**

This kit will duplicate the sound of a police siren at a low volume (200 MW) or at a high volume (5 watts) depending upon construction. Closing of the pushbutton will produce the upward wail typical of a police siren, opening will cause the tone to fall downward. Requires 3-12 volts DC.

**LM380 AMP SUPER SNOOP**

**Kit #7 $6.95**

Many applications for this kit, intercom, mini system, telephone amplifier, room bug amplifier and more. Uses ceramic or crystal microphone for input with 10000 volt DC. Requires 9 DC volts for operation.

**CRYSTAL TIME BASE KIT**

**Kit #8 $6.95**

The crystal time base kit provides a highly accurate source of 60 HZ which is useful for operating digital clocks when there is no source of 60 HZ power available.

**ELECTRONIC UNIVERSAL TIMER KIT**

**Kit #9 $5.95**

The universal timer kit provides the basic parts required to provide a source of precision timing and pulse generation. The U.T. makes use of the versatile 555 timer IC which is capable of both astable and monostable operation.

**TONE DECODER KIT**

**Kit #10 $6.95**

Can be used as a tone/touch decoder. Its frequency range is 400Hz to over 5KHz Bandwidth 2% to greater than 15% of center frequency. Output sink current 100mA. Requires +8-15 volts DC. Audio input level should be 50-100mv volts. Useful for touch-tone burst detection, or as a stable tone encoder.

---

**E.T.I. Printed Circuit Boards**

- FM Broadcaster $3.25
- Shortwave Receiver 2.75
- Light Chaser 3.75
- Dual Electronic Dice 4.25
- Audio Compressor 3.25
- Differential Temperature Controller 4.25
- Wheel of Fortune 4.75
- AM Tuner 2.25
- Easy Colour Organ 3.75
- Two Octave Organ 3.25
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- Up/Down Counter 4.25
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- Cable Tester 2.25
- Digital Dial 8.25
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- Eeprom Programmer 12.25
- Tape Notice Eliminator 1.50
- Speaker Protection Unit 5.50

**Everbly available.**

Update with recent projects available soon!
VERSAFLOPPY II DISK CONTROLLER

$498

Controls 4 independent drives; 8" single sided/double density, 9" single sided/double density, and 5½" single sided/single density may be used in combination; control software from available.

SBC200 SINGLE BOARD COMPUTER

$848

280A-CPU runs at 6 MHz. 8K EPROM and 16K RAM, serial and parallel 1/0 ports. 4-channel counters/counter using 280-CTC, programmable baud rate generator. 10 front panel connectors for operation.

EXPANDORAII MEMORY BOARD

$88

Uses 4116 or 4164 1K chips for up to 256K on one S100 board. Bank select option allows 16 boards to be used on one bus. Operates with 280 CPU at 10 MHz. Hidden refresh address selectable.

EXPANDOPROM EPROM BOARD

$63

$348

$100 compatible S100 microprocessor board. 2 of 4 M80 operation. Automatic power-on step to start of any 4K memory block. Socket for 2K EPROM, optional voltages, can be used with many S100 computers.

ROM 100 EPROM PROGRAMMER

$485.00

Complete microcomputer on a board: hex keyboard & display, PROM programmer, Kansas City std. cassette interface; provision for two S100 sockets, wire-wrap area, PROM monitor, DPROM, keyboard support, load & change, CPU Run compiler and advanced 280-CTC.匯出 zero insertion force; socket; software in 780 code.

Z8O STARTER KIT

$78

Complete microcomputer on a board: hex keyboard & display, PROM programmer, Kansas City std. cassette interface; provision for two S100 sockets, wire-wrap area, PROM monitor, DPROM, keyboard support, load & change, CPU Run compiler and advanced 280-CTC.汇出 zero insertion force; socket; software in 780 code.
Features

Project Galileo ............... 35
Project Galileo is an interplanetary probe that will go to Jupiter to make people out there feel like they're being watched. Steve Rimmer investigates the launch at T minus three years (and counting)

Story Behind Stereo ............ 42
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This new chip will do truly astounding things as a voltage controlled attenuator. Stick Pierre Trudeau into it and it'll turn him down to Rene Levesque. Keith Brindley mans the pot.

High Speed Cassette Interface .... 11
Ever listened to computer data at 4800 baud? Ever try writing it down at that speed? Hard, isn't it? This little wonder saves you from blistering your thumb and forefinger.
Double Dice .................................. 19
If you roll regular dice enough times they'll go round, and become useless. ETI has found a solution to this vexing problem...electronic dice. Battery powered, of course.

Bicycle Speedometer ...................... 29
Ride off into the sunset at a speed of your choosing with this project. One thing, though...you've got to do it on a two wheeler. The circuit doesn't seem to work on horses.

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

Binders
Binders made especially for ETI are available for $6.75 including postage and handling. Ontario residents please add sales tax.

Sell ETI and ETI Special Publications
ETI is available for resale by component stores. We can offer a good discount when the minimum order of 15 copies is placed. Readers having trouble in obtaining the magazine could ask their local electronics store to stock the magazine.

Component Notation and Units
We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. ETI has opted for sooner!
Firstly decimal points are dropped and substituted with the multiplier: thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1uF is 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 54, Morriston, Ont. NOB 2CO.
B&R Electronics, P.O. Box 6326F, Hamilton, Ont., L9C 6L9.
Wentworth Electronics, R.R.No.1, Waterdown, Ont., LOR 2HO.
Danocinths Inc., P.O. Box 261, Westland MI 48185, USA.
Exceltronix Inc., 119 College Street, Toronto, Ont., M5T 1S2.
Arkon Electronics Ltd., 409 Queen Street W., Toronto, Ont., M5W 2A5.
Beyer & Markin Electronic Ltd., 2 Jodi Ave., Unit C, Downsview, Ontario M3M 1H1.
Spectrum Electronics, Box 4166, Station D, Hamilton, Ontario L8N 4L5.
RESISTORS
Values from 1 ohm to 10 meg. 1/4 or 1/2 watt. Still only 3¢ each.

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PC BOARD SPECIALS Epoxy Base PC

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| 13"x4" | 35c ea.
| 13"x6" | 50c ea.

ETCHANT

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<td>140 oz</td>
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POWERTONMETERS
A huge selection available. Sliders controls from 99¢ to $2.95; Single pots 49¢ with switch 59¢; Dual pots 69¢ with switch 79¢. See our catalogue for full range and other types.

MINIMUM ORDER $10.00. All merchandise subject to prior sale. Prices subject to change without notice.

SHIPPING.
Add 5% extra to cover shipping, excess refunded. Orders over $75 shipped pre-paid. Ontario residents add 7% P.S.T.

16 CHANNEL LED CHASER KIT. ...$22.95
MODEL EK805P022
A true fast 80 volts capable of delivering 1 amp continuous. Full wave rectification, filtering and a clean dc source for sensitive audio and digital work. An ideal supply for the experimenter.

STEREO AUDIO MIXER KIT. ...$49.95
MODEL EK804AM01
Inputs 2 phono, 1 aux. Master control. Expandable. Frequency response 20Hz to 20KHz; 5¢ output, 0.01% distortion.

STEREO RADIO KIT. ...$8.95
MODEL EK80CR010
A fully assembled AM radio on a circuit board. A very familiar sight seen at discos, department stores, and on neon signs. Suitable for AM radio reception. A full project for the beginners.

1.5 to 24V POWER SUPPLY KIT. ...$24.95
MODEL EK80BP024
A variable Power Supply suitable for many digital and linear applications. Delivers an output current of 100ma from 1.5v to 15v and 500ma from 16v to 24v. 0.28 volt per volt adjustment.

16 CHANNEL MULTI MODE LED CHASER KIT. ...$39.95
MODEL EK800P028
A true fast 80 volts capable of delivering 1 amp continuous. Full wave rectification, filtering and a clean dc source for sensitive audio and digital work. An ideal supply for the experimenter.

LOGIC TRAINER. ...$74.95
MODEL DL701
A new development package for a BASIC DIGITAL LOGIC COURSE. Four gates and a counter. Circuit is included along with an in-depth manual. Protoboard included.

STEREO PHONO PREAMP KIT. ...$11.25
MODEL EK80P001
Anyone with a ceramic input receiver can enjoy the quality of a magnetic cartridge with this simple but very effective Stereo Phono Preamp.

495PA

STROBE LITE KIT. ...$21.95
MODEL EK80L001
Fantastic for special effects. Very fast speed Xenon flash gives you a "STILL MOTION" effect. A real attention getter.

CRYSTAL RADIO KIT. ...$8.95
MODEL EK80CR011
An all tuned circuit radio which uses a resonant circuit and detector for AM radio reception. An ideal project for the beginners.

1.5 to 24V POWER SUPPLY KIT. ...$24.95
MODEL EK80BP024
A variable Power Supply suitable for many digital and linear applications. Delivers an output current of 100ma from 1.5v to 15v and 500ma from 16v to 24v. 0.28 volt per volt adjustment.

5 WATT IC AUDIO AMPLIFIER KIT. ...$19.95
MODEL EK805IC01
A general purpose 5 watt amplifier with Thermal Overload and Short Circuit Protection. Because of its low operating voltage and high

DOMINION RADIO: The Home of Radio and Electronics Supply

Circle No. 12 on Reader Service Card.
**PHILIPS**

**DeForest**

Quality Loudspeakers

---

### TRANSFORMERS

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<th>Transformer</th>
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### CROSS-OVERS

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### SQUAWKERS (MID RANGE) CONE

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### LOW COST MATRIX PRINTER

A new colour matrix printer, which requires no special absorbency paper, has been developed by a British company.

The Integrex CX 80 can print text, graphs, histograms, and colour VDU dumps and so on up to seven different colours. Claimed to be a high cost-effective solution for colour printout, there is no restriction on the mixing of characters, dot addressed areas and colour changes on the same line. Colours are selected by 1 or 7 colour control codes. The printer decides which stripes from the tricolour striped ribbon are selected to produce the required colours, thus greatly simplifying host program requirements. Special paper is not required for this printer, unlike the high absorbency paper required for ink jet types. Normal plain white edge perforated paper is used, width 4" - 10".

The CX 80 is fully dot addressable in all 7 colours; the Character ROM contains 96 ASCII and 64 graphics characters. The 7 wire head produces a character format 5 x 7 plus graphics format 6 x 7. Print width is 80 columns of 0.1" wide characters. Resolution is 60 dots/inch. Print speed is 125 char/sec in a primary colour. There are also 15 user programmable characters. All characters may be printed in double length and/or reverse. Buffer length is two lines. Paper movement is programmable, with form feed and perforation skip up to 42.1" and line feed in 3 modes; 6 lines/line, 8 lines/inch and microstep from 0.007" to 1.77".

The printer is compatible with most processors. The standard interface is Centronics, with RS232/V24 and IEEE488 as options. For information contact Integrex Inc., 233 North Juniper Street, Philadelphia, Pennsylvania, 19107 U.S.A.

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### SATELLITE MAIL

Postmaster General Andre Ouellet announced that Montreal, Ottawa, Halifax, Winnipeg, Calgary and Edmonton have officially joined the Intelpost link operating between Toronto, and cities in England, Europe and the United States. A joint venture between Canada Post, CNCP Telecommunications and Teleglobe Canada, Intelpost is a high-speed facsimile service which allows Canadians to send clear copies of documents across Canada and overseas.

Located at main postal facilities, Intelpost uses CNCP's microwave network and Teleglobe Canada's international satellite facilities to transmit letters, charts, and other documents in seconds. Messages sent by Intelpost cost $4.00 a page in Canada and $5.00 a page internationally and can be picked up in 30 minutes.

Introduced in June 1980, between London, England, and Toronto, Intelpost was the first international electronic mail service of its kind. Washington, New York, Berne, Switzerland, and Amsterdam, the Netherlands, have since joined the system.

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535 Yonge St., Toronto, Ont. M4Y 1Y5

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NEWS

---
Introducing "Jet Stock", a high priority service from ACA Electronic Centres that doesn't cost you anything extra. With "Jet Stock" you get next day shipment of all orders and prepaid delivery across Canada, all at ACA's highly competitive prices.

This exciting new service is yours automatically, when you order products designated as "Jet Stock" inventory, including the following popular equipment:

- Fluke hand-held digital multimeters
- Fluke bench digital multimeters
- Fluke current, HV, RF, and temperature probes
- Fluke multifunction counters
- Anatek laboratory power supplies
- Gould 15 and 25 MHz dual-trace scopes
- Wavetek waveform and function generators
- Shimpo digital tachometers

Accessories and other products are also included. Additional items will be added as market demand and inventory quantities permit.

ON-LINE COMPUTER

This new service has been made possible through an on-line computer system which links all seven ACA offices and which automatically processes all documentation, right down to shipping instructions and inventory replacement orders.

NEXT-DAY SHIPMENT

ACA's extensive inventory program and accelerated shipping procedures ensure that your order is on its way to you not later than the next day after receipt of order.

DOOR-TO-DOOR DELIVERY

Highly efficient door-to-door delivery service now permits overnight delivery to most centres across Canada. Next day shipment followed by overnight door-to-door delivery gets your order to you faster than ever before.

COMPETITIVE PRICES

Automated order processing has permitted us to dramatically improve our service to you while maintaining our highly competitive prices. Now, we even ship prepaid at no extra cost to you.

HOW TO ORDER JET STOCK

Just place "Jet Stock" items on a separate order from other ACA products. That's all. We'll look after the rest.

To find out which products are "Jet Stock" call your local ACA office. And remember, the sooner we receive your order the faster you'll receive delivery.
NEWS

LCD Component Temperature Indicator

Telatemp Corporation, a leading maker of products for surface thermometry, has introduced the industry's first LCD reversible stick-on temperature indicators. The indicators are ideal for monitoring electronic component and PCB board temperatures.

Unlike the industry standard Telatemp Temperature Recorder which permanently records a temperature attained, the new reversible Telatemp LCD Contact Thermometers allow continuous monitoring of changes in surface temperature.

Two models have been designed specifically to monitor component temperatures. Model 660, for 40°C to 60°C, is 5/8" in diameter and is ideal for use with TO-3 and TO-66 metal cans. Model 880, for 45°C to 60°C, can be placed on DIP packages. Other LCD Contact Thermometers include the Model 770-1 (0°C to 30°C and 32°F to 86°F) and Model 770-2 (30°C to 60°C and 86°F to 140°F).

Each LCD Contact Thermometer contains up to seven display windows. Each window has a different rated value in °C increments from 0°C to 60°C. At ±1°C, the windows are green. The windows turn blue when temperatures rise above the rated value or brown when temperatures fall below the rating.

An introductory Component Temperature Indicating/Recording Kit consists of three reversible models and three permanent recorders (value: $15.90) is offered to readers of ETI for just $10.00. Order LCD Kit No. 2. $10.00 U.S. payment must accompany order.

ACA INTRODUCES NEXT DAY SHIPMENT

"Jet Stock", a new concept in order processing, has been introduced by Allan Crawford Associates Ltd. providing next day shipment of orders and prepaid overnight delivery to major centres across Canada, all at no extra charge.

According to Al Martin, National Sales Manager for the Test & Measurement Division of Allan Crawford Associates Ltd., the new service has been made possible by the company's on-line computer system and the high volume of business.

All seven ACA offices across Canada are linked by the on-line computer system. Orders placed through any ACA office for designated "Jet Stock" products will now be shipped not later than the next day. Overnight delivery service is then provided to all major Canadian Centres.

Products presently designated as "Jet Stock" include many models of handheld and bench digital multimeters, multi-function generators, and test meters. Additional products will be added regularly as demand and inventory availability permit.

To obtain this service, however, it is important that non-Jet Stock items must not appear on the same order with designated "Jet Stock" products. Customers can quickly determine which products are designated as "Jet Stock" by contacting the nearest ACA office in Toronto, Halifax, Montreal, Ottawa, Calgary, Edmonton or Vancouver.

Making Telidon Cheaply

Starside Softworks of Toronto has announced a data capture and transfer package for the Apple II computer. This set of programs is for the creation of Telidon pages suitable for use in conjunction with Telidon systems. The package does not provide any high level graphic commands although it is possible to generate PDI commands. An improved version is in the works. Starside Softworks sees this package being used by schools, businesses and individuals who wish to generate pages, but don't have access to costly IP terminals. For more information on Apple/Telidon Ver 1.0 write to Starside Softworks, 177A King Street W., Suite 215, Toronto, Ontario, or telephone (416) 532-0230.

New Zentronics' Zentronics, a division of Westburne Industrial Enterprises Ltd., plans to open a stocking branch in Dartmouth, N.S. The new branch will be opened in mid April & situated at 30 Simmonds Drive, Unit B, Dartmouth, N.S., B3B 1R3, telephone (902) 463-8411. The branch supervisor will be Roy Sutton and inside man is Bob Blackwood.

Multiflex Z80 Review

One point arising from last month's article. The purchaser of the Multiflex Z80A will get an automatic three month subscription to the newsletter. Not one year as stated in the article.

Looking Back

Si Units, December 1980

It has been pointed out to us that the definition of the metre given in the article is quite incorrect. Our reader A.T. Williamson says:

"Not so. They actually decided to use one ten millionth of the quadrant of the earth's circumference represented by the meridian... which passes through Paris. To their credit... (they achieved an error of) less than 0.023%...."

The original article, of course, was completely incorrect on this point. Our apologies to prospective metre stick manufacturers. Ian Sinclair has been sent off to reform school.

Guitar Preamp, May 1981

First off, C4 and C7 on the schematic are incorrectly labelled, their values are 22uF. The Parts List is correct. Also, the track cutting diagram is incorrect. Insert a break at point J8 (this should improve the action of the bass pickup for those who have built the unit).

Ultrasonic Alarm, February 1981

Jan Vincent of Toronto suggests this modification for the unused Schmitt trigger of IC5. Essentially the circuit introduces a time delay to allow you to dash in and shut the unit off before it sounds. The values shown will give a delay of about 20 seconds.

One point worth mentioning. The signal from this gate will be inverted, so you'll have to do some tricks with PNP transistors or the relay contacts.

ETI — JUNE 1981
Use ETI’s supersonic interface to store and retrieve digital data on cassettes at an incredible 4800 bits per second. Design by Hugh Koanantakool.

MODERATE-SPEED cassette systems running at speeds up to 1200 baud have been with us for some time, but unfortunately the standard setters seem to prefer a slower 300-baud Kansas City standard. 300-baud can be too slow if you have a lot of data to manipulate and is suitable only for software distribution. That is, once the original chunk of a software package has been implemented in a system, the user or owner could then make a copy of that piece of software for his (or her) normal use. This working copy should be running at the highest data-transfer rate that the owner can afford. In case of a failure in the fast working copy, the user can always fall back on the original master copy running at the slow rate. This design enables you to store and retrieve digital data using an unmodified cassette recorder at 4800 bits per second. The prototype proved to be as reliable as any 300-1200 baud systems.

Dropout
One reason for cassette load/save failures is tape dropout – momentary loss of playback signal due to the absence of, or damage to, the ferromagnetic coating somewhere on an imperfect tape; or due to bad contact between the tape and the tape head. In audio cassettes, the tape runs at 1.875 inches a second. Thus, for a 300-baud KC (Kansas City) tape, a bit of data occupies approximately 0.00625 inches — how tiny! Any dropouts which are larger than that size will cause one or more bits of errors. The only practical solution is to use high quality cassettes which are certified or known to be originally free from dropouts. This applies to both 300-baud and the fast 4800-baud systems. From experience most tapes which are error-free at 300 baud can cope well at 4800 baud, but in the latter case, cassettes having good high-frequency specifications are preferred.

How Good?
This design aims to surpass all existing cassette interfaces in both speed and reliability, given that it should require no more hardware than other systems to build one. It should run well with an average tape recorder and cassette tapes which can cope with the KC standard or CUTS 1200-baud standard. There will be no timing adjustments. The system can be implemented on any existing serial, asynchronous communication channel and thus can be readily added to most home computers. If it becomes impossible to run the system at 4800 baud due to any reasons including those in my list of observations then you might have to slow down the data rate to, say, 2400 baud.

To do so you only have to slow down your UART (Universal Asynchronous Receiver and Transmitter) clock frequency. There is nothing else to adjust, thanks to the all-digital timing.

Phase Encoding
There is nothing new or magic about the phase encoding format for data storage on magnetic tapes. Figure 1 illustrates how it works. A logic one is represented by the 5 V level and the zero by 0 V (Fig. 1b). Most tape recorders cannot record and playback slowly varying
signals or DC. Therefore, a long series of ones or zeros will just come out the same if we attempt to connect the data signal (also called NRZ or Non-Return to Zero) directly to the recorder. This is because the data signal in NRZ format contains important information which is extended down to the very low frequencies, beyond the frequency range of tape recorders.

Figure 1a shows a carrier wave oscillating at, in this case, 4800 Hz. The carrier is modulated by the data signal of Fig. 1b by the following rules:

(a) The data signal is assumed to be synchronised to the carrier. This means their transitions (edges) are perfectly in alignment.

(b) The carrier wave is inverted if data is a one and normal if non-inverted if data is a zero. The resulting modulated carrier is shown in Fig. 1c.

The phase encoded signal in Fig. 1c is known to contain very little energy at low frequencies and can be recorded and played back with little distortion.

Demodulation

Figure 1d shows the typical replay signal from the tape recording. Notice the rounding of all sharp edges — this is due to the high-frequency cut-off of the tape recorder. Also the high-frequency components of the signal will suffer from more attenuation than the low frequency components. By using some form of equalisation circuit, we can easily improve the signal into that shown in Fig. 1e, which is now good enough for a slicer circuit to decide whether it is high or low. The sliced signal in Fig. 1f is very similar to that of Fig. 1c but it may or may not be inverted by the playback amplifier inside your recorder; pulse transitions may not be so precisely timed as in Fig. 1c due to tape-speed fluctuations and it is more or less independent of the playback volume control setting. We then feed the signal of Fig. 1f to a digital circuit (a demodulator), which recovers the data signal (Fig. 1b) from the sliced signal (Fig. 1f) and presents it to the UART receiver section.

Implementation

You will probably need a "double standard" approach at least in the beginning so that tapes can be converted from the original slow rate to 4800 baud. The interface circuitry can be connected to your computer system using five wires:

- two power lines (common ground and the 5 V supply),
- two serial data lines (one for transmit (load), one for receive (dump), one clock line running at 16x the baud-rate, i.e. 76,800 Hz at 4800 baud.

The only assumption made is that your computer software could handle the UART at 4800 baud. Some systems may not cope with a fast transfer rate. The serial I/O by program control instead of using a dedicated UART could be too slow, or maybe the VDU or TTY is not fast enough to dump some characters, eg file names, in real-time. However, if you are using a memory-mapped VDU (PET, Superboard II, etc) or your system monitor buffers the load time messages in RAM, there is no problem, since no major hardware modifications are to be made and no software or data format to be changed. The fast system has been in use since March 1979, accumulating the bit error rate to better than 1 in 10. The tape conversion process is fairly straightforward; switch your system to the original interface, load the original tape to computer, switch to 4800 baud and record the same software onto a new cassette.

Also, before you erase the old tapes, it may be a good idea to run both systems in tandem until you are sure you can trust the faster system.

Postscript

After experimenting with various kinds of tape recorders it is sad to say that some cassette recorders just cannot cope with the 4800-baud system. These recorders don't work with 300-1200 baud systems anyway, (or work with persistent troubles) and they can't even play back a continuous tone steadily! That is, if you record a tone and play it back, it sounds so wobbly that anyone can detect its poor speed regulation. These properties are usually associated with cheap recorders. Users must avoid recorders with peak speed-fluctuations well over ± 20%, our required tolerance. Poor speed-regulation of a new recorder is associated with the lack of motor-regulator circuit, but it can also happen to a more costly recorder if the pinch-roller circuit has been deformed, eg by leaving the machine off in the play position for a long time.

To sum up, the 4800-baud system may not work with all recorders due to the following reasons, in order of seriousness:

(a) recorder transport mechanics — you need a recorder that can at least reproduce clean steady tone,
(b) tape quality: use tapes which are better than just a "low-noise one, eg "Super Dynamic", "High Frequency", etc,
(c) recorder bandwidth — you tend to get more bandwidth from a radio-cassette than a hand-held recorder.

If your system has an RTS line and you are using it to control the cassette's motor, then you may also use it to control the received data line of this interface as well. When there is no input signal from the recorder, the idling sequence at point L (Fig. 2) is 1010101, which is a series of the valid ASCII "U" characters causing over-run error in the UART. This error is normally reset by the tape loader routine before the data transfer takes place. A normal way
Fig. 1 Timing diagram. The signal output is attenuated to about 100 mV (RMS), suitable for the mic input of most cassette recorders. A high pass filter is included to pre-compensate any loss in high frequency in the cassette. You may not need preemphasis capacitor C2 if you use a hi-fi deck.

Fig. 2 Circuit diagram. You may need a Request to Send (RTS) control. When the RTS output of the UART is active, the computer is ready to accept serial data from cassette interface or modem. When RTS is not used and there is no connection to IC3d pin 8, some series resistance is needed to prevent damage to the IC.

Fig. 3 Adding the fast cassette interface to your system.

NOTE:
IC1 & 4 ARE 4024
IC2 IS 4013
IC3 IS 4030
IC5 IS 4093
IC6 IS 3140
G1 IS 2N3904
G1 IS 1N4148
The upper part of Fig. 2 is the phase encoder. IC1 divides the UART clock signal by 16 to 1x baud-rate. The UART data signal is then brought to synchronisation to our local clock (carrier) by means of a D-type flip-flop (IC2a). This synchronisation circuit makes sure that data transitions at IC2a always take place at the rising edge of the local clock (at A). However, if the computer data and the local clock happen to be in sync already, (a random choice of 1/16), this D-type flip-flop might be in trouble. In reality, this "perfect" chance of trouble never occurs, since the UART's internal +16 clock divider circuit works much faster than IC1, even though both are triggered by the same falling edges of the 16x clock. Thus it is sure to achieve perfect synchronisation.

The lower part of Fig. 2 shows the receiver/demodulator section of the system. First the signal from the recorder's ear-phone plug is fed to IC6 via C3. The values of C3 and R4 are such that any drop in level of the high frequency signal from the average cassette recorder is equalised. IC6 then slices through the average level of the equalised signal (Fig. 1e). IC6 is wired as a Schmitt trigger circuit in order to suppress the background noise during playback. The output of IC6 is further buffered by IC5b. The timing diagram is continued ever there is a level of transition at pin 10 of IC6. IC2c accordingly.

Pulses at H should happen to start IC2b wrongly and get all pulses by using IC2b, connected as a toggle flip-flop. It inverts its state upon receiving a J pulse. All seems to go well but we might still run into trouble if we happen to start IC2b wrongly and get all the datat bits inverted, yet still obeying the data transmission convention is such that on a UART getting ready to transmit, it sends a series of marks (logic one). This means that we always have a steady tone resonated prior to the actual data signal.

From the timing diagrams (Figs. 1 and 4), we may conclude that a "change" of the carrier phase corresponds to a change in the original data stream. This change in turn corresponds to the larger separation between successive H pulses, equal to 1T. Subsequently, long separation of H pulses is detected as a pulse. We can, therefore, recover the original data signal from the J pulses by using IC2b, connected as a toggle flip-flop. It inverts its state upon receiving a J pulse. All seems to go well but we might still run into trouble if we happen to start IC2b wrongly and get all the datat bits inverted, yet still obeying the change conditions discussed. Care must, therefore, be taken to ensure that the logic state of IC2b is always properly defined before data transfer can take place.

Fortunately, the asynchronous serial data transmission convention is such that on a UART getting ready to transmit, it sends a series of marks (logic one). This means that we always have a steady tone resonate prior to the actual data signal. Therefore, we can preset IC2b to logic one before any transfer process commences. This function is carried out by means of IC5c and d. If the carrier is detected continuously for longer than 20 mS, the circuit will assume that this is a series of marks or logic one. It then resets IC2b accordingly. All subsequent data bits will then be demodulated with the correct polarity.

Fig. 4 Timing diagram.

Fig. 5 Component overlay.

**PROBLEMS? NEED PCBs?** Before you write to us, please refer to 'Component Notations' and 'PCB Suppliers' in Table of Contents. If you still have problems, please address your letters to 'ETI Query care of this magazine. A stamped, self addressed envelope will ensure fastest reply. Sorry, we cannot answer queries by telephone.
Solder is solder is solder... or is it? K.T. Wilson takes a closer look.

SIMPLE ENOUGH, isn't it? You just buy a reel of cored solder and that's it. Or is it? In fact there is no single material called solder, and there's a very wide range of behaviour that you can expect from solder, depending on their composition. Add to that dozens of materials that can be used for a flux core, and it doesn't look so simple.

Basically, solder is a mixture of lead and tin. Pure lead melts at about 327°C, tin at 232°C, but mixtures of tin and lead melt at temperatures which depend on the composition. Fig. 1 is a diagram which shows the melting points of various alloys — the important solders are the alloys which contain up to 60% tin. This type of diagram shows an important point — that there are mixtures of tin and lead which have melting points lower than either tin or lead. This lowest melting point is for a 63% tin mixture, called the eutectic — a name given to any mixture of materials whose melting point is the minimum.

The graph of Fig. 1 shows only melting points — but there's more to it than that. Pure materials, such as pure tin or lead, have sharp melting points — meaning that they go from liquid to solid for only a tiny fraction of a degree change in temperature. The eutectic mixture (63% tin) does this also, but all other mixtures of tin and lead which contain more than about 15% tin have a 'pasty' stage (Fig. 2), neither liquid nor solid. This pasty stage is important in soldering, because slight vibration during the setting of solder can cause fractures if there is no pasty range of temperatures. Fig. 2 shows the temperature range of the pasty stages for the various mixtures — not that these are always completely solid at 183°C, so that this is the final setting temperature of any tin/lead solder.

Solder On

The reason for the popularity of the 60/40 alloy (60% tin) is fairly clear. It has a low melting point and a small pasty range; a good combination of qualities for hand-soldering. The low melting point lets us use low-power irons, and also avoids damage caused by the quick burn-off of flux which would occur at higher temperatures. The small pasty range (flux 180°C to 188°C) means that the alloy will set fairly quickly — blow on it once or twice and it's then strong enough to forget about. There are some merits which do not appear in the graph, though. One is that the 60/40 mix is one of the strongest, another is that it is the best electrical conductor of all the tin/lead alloys (about 11.5% of the conductivity of pure copper).

The 60/40 alloy, along with the 50/50, 45/55 and 40/60 alloys are the solders most commonly used for soldering small electrical equipment. Solders with lower tin contents are used for purposes where higher running temperatures are encountered, such as in lamp bases, electric motors, dynamos and fuses.

The lead/tin alloy isn't the only type of solder mixture, though, particularly for the industrial user. A straight lead/tin mixture dissolves copper, and copper is the material that we use for the business end of the soldering iron. The result is that bits of iron wear away very rapidly as the copper of the 'iron' bit dissolves, and the tracks of PCB's can also be dissolved in the same way, causing thinning of the copper layer. This problem is serious for large-scale production soldering work in particular, and can be overcome by making solder which virtually puts an end to the dissolving of copper by the alloy from the bit or the PCB. Copper-alloy solder, invented by Multicore (a British firm), and sold under the...
trade name of SAVBIT is used extensively for large-scale work, and is sufficiently well proven to be approved for soldering work on military equipment.

Gold Solders Never Die
Not all soldering makes use of 60/40 alloys. For high-temperature soldering, alloys with only 5% tin are available (melting at 301°C); at the other end of the composition scale there is non-toxic solder which has 96.3% tin and the remainder silver. Such lead-free solder can be used when soldering has to be in contact with foodstuffs (as in tin-cans for example, or water pipes). Just for a bit of variety, there is also a low melting point solder, melting at 145°C, which contains 50% tin and 18% cadmium. This is of particular use in soldering ceramics to metal alloys. Table 1 shows some alloy compositions.

The metal, of course, is only half of the solder process. When we solder metals together, the temperature that has to be used is high enough to enable the oxygen in the air to attack the metals and the solder as well. In addition, we want the solder to spread over the surface of the metals. Now the spreading of a liquid over a solid is greatly affected by the presence of other materials — for example, water will not spread on glass if there is a trace of silicone grease on the glass. Liquid solder is equally fussy, and traces of dirt on metal surfaces will simply prevent solder from spreading.

A flux is a material which is used to avoid both of these problems. A good flux should help to clean up the metal surfaces (though it can’t be expected to perform miracles) and should form a protective coating around the solder and the metals being joined so as to avoid oxidation.

For non-electrical soldering, acid fluxes can be used. These materials are acid enough to dissolve away impurities; the sort of work that is soldered in this way is usually ‘pickled’ in acid anyway, so that the acidity of the flux is unimportant. For electrical work, however, strongly acid flux of this type has to be avoided like the plague. It’s not very often that we can boil our printed circuit boards in water for several hours to get rid of acid, and if we don’t remove it then the life of the conductors will be pretty short.

Solder Glue
Electrical fluxes are therefore based on resin, the gummy material which is extracted from wood. Molten resin flows evenly over metals, giving protection for the joint for some time. Any resin which remains on a joint is hard and non-corrosive; a useful protective coating in fact.

Unfortunately, resin by itself does not dissolve a film of oxide from a metal surface, so that it doesn’t have the cleaning effect of an acid flux. Fortunately, we can make use here of the fact that soldering is a high temperature operation. Some chemicals, such as the range of salts called halides, will dissociate when heated, meaning that they will release acid vapours which will be neutralised again when the material cools. Chemicals such as tin or lead chlorides can be used for the purpose. The addition of such materials, called activators, to a resin has a very noticeable effect on the fluxing ability of the resin. The release of chlorine from a chloride, for example, cleans metal oxides very effectively, but has less adverse effects than acid on the life of the joint because the chlorine is reabsorbed wherever the material cools. Less strongly active materials can be used when there is any risk of contaminating the area around the joint. In general, fluxes for electronics use have a fairly low halide content. A few types of halide-free fluxes have also been developed, and are used for such applications as circuits which are to be encapsulated. For circuits which must have very long corrosion-free life in hot climates, pure resin-flux is available.

In the early days of soldering, the flux was always applied separately from the solder. Since Multicore pioneered the idea of flux-cored solders, the separate-flux system has died out almost completely. Though several manufacturers now make flux-cored solders, Multicore are still unique in offering five cores (Fig. 3), ensuring quick and even dispersion of the flux. In case you were in any doubt, by the way, resin cored solder is made from a thick rod of solder cast with five holes running through it. These holes are filled with flux, and the whole thing is drawn out into the fine solder which we use.

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**Fig. 2.** The pasty part of the temperature/composition graph.

**Fig. 3.** Cross-section of 5-core solder.
Keep It Clean

And after all that, let's hope we are soldering correctly. Boards such as Veroboard which have copper tracks should be scrubbed clean — don't let the flux have to do all the job of cleaning the board. Similarly, tarnished leadout wires of components should be cleaned by pulling them through loops of emery-paper. For really good joints, it pays to use leads and tracks that are tinned in advance.

Make sure the iron is hot enough. Some irons always seem to run a bit cool and if a very small bit is used, the heat sinking action of a circuit board can be enough to keep the bit too cool to melt the solder properly. A very hot iron, on the other hand, will cause oxidation and burning if it's left on too long. The power output of soldering irons for electronics use is so low that a simple thyristor controller can cope, and excellent heat regulation can be obtained if an auto-transformer is also used (Fig. 4). Incidentally, a lot of awkward problems can be overcome by using ready-formed solder shapes, such as rings and spheres, or by the use of solder and flux mixed in the form of a cream or paint.

May the flux be with you!

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* These alloys are only available as solid wire. For those purposes where solid wire is still used on automatic appliances precision made solid wire can be made in any alloy to special order.
ETI's HELPFUL HINTS PRESENTS...
THE PROF IN HOW NOT TO SOLDER OR THE RETURN OF THE BLOB!

FIRST OF ALL WE'LL DEAL WITH 'TINNING THE BIT', THIS IS OBVIOUSLY A COMPLICATED JOB BUT...

...IT WARMS UP YOUR SOUP WONDERFULLY!

OBVIOUSLY YOU'LL BE WORKING WITH A LOT OF PCB'S...

ALWAYS LEAVE THE COMPONENTS STICKING UP AT ODD ANGLES...

...SO THEY CAN ACCIDENTALLY FLOP TOGETHER...

...WITH THE MOST INTERESTING RESULTS!!

A NICE BIG BLOB OF SOLDER WILL JOIN EVERYTHING!

GETTING A STRONG JOINT IS EASY~

ALWAYS FLICK THE SOLDER OFF THE BIT...

IT GIVES YOU THAT RAKISH DEVIL-MAY-CARE LOOK!

BUT AS A LAST RESORT ~ READ THE ARTICLE ON SOLDERING IN THE NEXT ISSUE...

IT COULD SAVE YOU A LOT OF AGGRAVATION!
DOUBLE DICE

Chance your luck with ETI's latest game of fortune — for those readers who can't find the energy to shake'em — here's a pair you only have to touch.

SUMMER approaches, when more games are played than at any other. A large percentage of these games need some system whereby a random number between 1 and 12 can be quickly and easily generated — the usual way of doing this is with a pair of dice. A good electronic dice project hasn't materialised in any of the electronic magazines recently and so we thought that the time was right for ETI to produce a dice to beat all dice. Although quite ingenious in operation, the ETI Double Dice is simplicity itself to build — apart from the display there are only 18 other components, and all parts mount on a small PCB.

The display is formed from individual LEDs, seven in each die, grouped together into the well-known dice formation. Five ICs perform all logic, control, counting and driving functions of the circuit and both die displays are completely random and non-synchronised.

The device is touch-controlled: simply placing a finger over the two contacts starts operation of the dice. The LEDs light up and are seen to flash at a fast rate (showing that the 1 to 6 sequence is in operation.) Upon removing the finger, the LEDs stop flashing and hold the last number displayed.

After a short time, all the LEDs extinguish, showing that the dice is ready for its next "roll". The display period is defined, mainly, by the value of capacitor C1, and using the value shown a period of about 5 seconds is obtained. Increasing its value lengthens illumination time and vice versa.

LEDs need a fair amount of current to give a reasonable illumination and if they remained on at all times, battery life would be severely limited. The self-cancelling function reduces the average current consumption of the circuit and therefore prolongs battery life.

Construction

Start construction by inserting the six links into the PCB as shown in the overlay diagram. It is helpful to use a pair of long-nosed pliers to bend the link wires before insertion. Resistors, capacitors and IC sockets, if used, should be put in now, but leave the ICs till last.

Next, insert LEDs 1 to 14 into the board in the double dice formation. Mount them about 10 to 15 mm above the PCB so that they stand above the maximum height of the other components. Connect the switch, battery and touch contacts (two wires will do for test purposes), plug in the five ICs, switch on and test the project.

Housing the PCB in a case should not be a problem. Suggestions are: either mount your board on the underside of the case lid, drilling holes for the LEDs to mount into, or make a panel out of coloured transparent plastic (or similar) through which the LEDs will be visible.

You can make your touch contacts out of virtually any small pieces of electrical conductor. We chose to use the heads of metal drawing pins inserted through the case lid. Soldered connections can be made underneath the lid to the board. If you do the same, remember that a metallic lid conducts and the contacts will have to be insulated from it.

PARTS LIST

<table>
<thead>
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<th>RESISTORS (All 1/4W, 5%)</th>
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<tr>
<td>R1 4M7</td>
<td>R2 220k</td>
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<tr>
<td>R3 10M</td>
<td>R4 2k7</td>
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<td>R5 680R</td>
<td>R6 1k</td>
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<td>R7 270k</td>
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<th>CAPACITORS</th>
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<td>C1 1u0 polycarbonate</td>
<td>C2,3 100n polyester</td>
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<th>SEMICONDUCTORS</th>
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<tr>
<td>IC1 4001 quad, 2-input NOR</td>
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<tr>
<td>IC2,4 4025 triple, 3-input NOR</td>
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<tr>
<td>IC3,5 4522 programmable BCD counter</td>
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<tr>
<td>LED1-14 miniature red LEDs</td>
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<td>LED1-14 miniature red LEDs</td>
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Side view of the Double Dice showing the position of the LEDs
The circuit of the Double Dice can be seen in Fig. 1. By cross-referring to it, the operation of the dice may be more easily understood. Most of the circuit is duplicated for each dice (IC2, 3 and common components) – the action of the other dice is identical (using IC4 and 5 instead).

The LEDs are formed on the PCB to a standard dice configuration as in Fig. 3. In this diagram the individual points have been grouped together into three categories A, B and C. By looking at the numbers on a dice in turn, a table can be drawn up, as in Fig. 3, to show that all LEDs in any one category must be either on or off at the same time. Therefore, we can consider the groups as single logical levels in a set code. It just happens that the set code is required is part of the binary code, of which the part of interest is shown in Fig. 4 against the corresponding denary, or ordinary number value.

ICs which count in binary are readily available and the 4522 (IC3) does just that.

Figure 3.

It is a down counter, meaning that it starts its cycle at binary 15 and counts down to 0. On the next count after 0 it would (normally) reset to 15 and start the cycle over again. However, we have taken advantage of the fact that the 4522 is a programmable counter which can, on a command pulse, be programmed or set to a particular number in its cycle. In our circuit this number is 6 (represented by the logic levels at pins 14, 11 and 5, that is 1, 1, 0). The command pulse is obtained from the output of IC2e, which is at logic 1 only when its three inputs are 0. These inputs are in parallel with the LED drive outputs of IC3 so that as the number 0 is displayed by the LEDs the counter automatically jumps to the number 6. The interval between the count to 0 and the display of 6 is so small that to the human eye it appears that the counter progresses naturally from 1 to 6.

IC2a and b form a simple astable multivibrator which produces a square wave of about 100 Hz and which clocks the counter whenever pin 1 of IC2 is at logic 0.

As well as enabling the astable, pin 11 is connected to the input of a monostable multivibrator with an 'on' period of about 5 seconds so that as a finger is put on the touch contacts the monostable enters its 'on' state. The output of the monostable is connected to pin 10 of the counter so that during the 'on' state the LED display is allowed to function. At the end of the 5 second on-period the monostable switches off and the display is disabled (the LEDs are held off) thus saving unnecessary battery drain.

Figure 4.

The PART OF THE BINARY CODE WHICH IS OF INTEREST

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<th>DENARY NUMBER</th>
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<td>7</td>
<td>1 1 1</td>
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PROBLEMS? NEED PCBs? Before you write to us, please refer to 'Component Notations' and 'PCB Suppliers' in the Table of Contents. If you still have problems, please address your letters to 'ETI Query', care of this magazine. A stamped, self addressed envelope will ensure fastest reply. Sorry, we cannot answer queries by telephone.
Engineer's Stethoscope.
How you'll get your car to breath deeply and cough is your hassle. However, if you get it together, here's the box to let you hear what's going on within the works.

Bargraph Car Voltmeter.
Is your battery charged? Over charged? Undercharged? Stolen by Bedouins and spirited off to the Moravian Desert? This project will indicate the state of your electrical system.

IC Master.
$100.00 worth of IC data sheets may sound like what's behind door number four, but this book is probably the best one shot designer's reference going. In thirty days its secrets will be revealed.

Project Fault Finding
Yes, it is a drag to build a 128 megabit computer only to find it can't add. It could be that you've used an incompetent processor, or there could be...a fault. This article will help you locate hassles in your circuits.

Universal Timer.
Just the thing for timing universes that don't last more than a half hour.

AutoSound Survey.
It's hard to understand people who have 125 watt stereos in their MGBs. Possibly pointing the speakers rearward gives them better mileage. Next month, Wally Parsons reviews the E.P.A. rating of the available equipment.

Michael Faraday.
Far from being, as some might suspect, the lead guitarist for the Sesmic Toenail Clipper Band, Michael Faraday was one of the founding fathers of Modern Electronics. Good to know the industry isn't illegitimate. His life and times, next issue.

Current Affairs.
At the moment, the only current affair that comes to mind is between the office gruel bucket carrier and the lady who maintains our dungeon. Therefore, this article will have to deal with electrons and holes and suchlike theory.

How To Solder.
This month we had a look at the magic wire. Next time around, we'll show you how to use it. The month after that we plan to aquire a philosopher's stone and outline how to transmute it into gold. If we figure it out that issue may be in some demand...subscribe now.

LM3914 Circuits.
LM3914 Bar Graph chips are shiny black with silver legs and transistors inside. This will be useful to know if one accosts you in the park. If this does, in fact, transpire, stall it 'till next month when we tell you what to do with it.
This handbook contains entirely new material, written in the style of our first two books "First Book of Transistor Equivalents & Substitutes". The two complement each other and make available some of the most complete and extensive information in this field.

The popularity of this inexpensive integrated circuit has made this book highly successful. Translated from the original German with copious notes, data and circuitry, a "must" for everyone, whatever their interest in electronics.

The newcomer to electronics will find a wide range of the subjects covered in earlier books. However, later books assume a working knowledge of mathematics. In the projects can be built by the beginner.

Contain a number of simple and more advanced projects, for the home constructor. Included in this book are a number of simple and more advanced projects, for the home constructor.

The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco gear". The approach adopted is to enable him to build up a small studio including a mixer and various sound effects units.

The book is divided into four sections. Each chapter contains a number of design ideas and these can then be used or adapted to individual needs.

A collection of the most popular types of circuits and projects electronic circuitry and is in electronic music and there is a wide range of applications of electronics in electronic music. The purpose of this book is to introduce the LM3900; one of the most versatile, freely obtainable and inexpensive devices available to the amateur. Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses.

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A book which has been designed to be built and tested section by section. Most of the circuits shown in full have been built by the author. Most of the projects can be started by anyone with a basic knowledge of electronics and sufficient patience. The projects are divided into four sections: 1: - Analogue Delay Line 2: - Single Chip Synthesiser; 3: - Programmable Sequencer; 4: - Voltage-controlled Oscillator; 5: - Envelope Shaper with voltage controlled amplifier; 6: - Putting it all together.

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These books are specially imported from England by us. All prices include handling and postage. To order, use the order form in this publication or write to:

ETI Magazine, Unit 6, 25 Overlea Boulevard, Toronto, Ontario, M4H 1B1.

**BP66: Beginners Guide To Microprocessors & Computing** $7.55

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

**BP77: Counter Driver & Numeral Display Projects** $7.55

The author discusses and features many applications and projects utilizing digital devices such as displays, popular counter and driver IC's, etc.

**BP68: Choosing & Using Your Hi-Fi** $7.25

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

**BP69: Electronic Games** $7.55

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

**BP70: Transistor Fault-Finding Chart** $2.40

Author Mr. Chas. Miller has drawn on extensive experience in repairing transistor radios to design this book. The reader will find that this chart will enable him to find the common faults quickly using the concise chart.

**BP71: Electronic Household Projects** $7.70

Some of the most useful and popular electronic construction projects are those that can be used in or around the home. These circuits range from such things as a "Tone Door Bell" and Intricately wired Smoke or Gas Detectors to Baby and Freezer Alarms.

**BP72: A Microprocessor Primer** $7.70

A newcomer tends to be overwhelmed when first confronted with articles or books on microprocessors. In an attempt to give a painless approach to computing, this small book will start by designing a simple computer that is easy to learn and understand. Such ideas as Adding, Addressing, Index Registers, etc. will be developed as to their operation rather than as a logical progression of ideas as they might be in a formal textbook approach.

**BP73: Remote Control Projects** $8.58

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

**BP74: Electronic Music Projects** $7.70

Although one of the more recent branches or amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category, ranging in complexity from a simple guitar effects unit to a sophisticated organ or synthesizer. The purpose of this book is to provide the constructor with a number of practical circuits using the more popular and interesting circuits in this book. Contains new and innovative ideas as well as some which may bear resemblance to familiar designs.

**BP75: Electronic Test Equipment Construction** $7.30

This book covers in detail the construction of a wide range of test equipment for both the hobbyist and radio amateur. Included are projects ranging from a FET Amplified Audio Calibrator, a Frequency Strength Meter and Heterodyne Frequency Meter; to a Field Strength Meter and Heterodyne Frequency Meter.

**BP76: Power Supply Projects** $7.30

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

**BP77: Practical Computer Experiments** $7.30

This book aims to fill the background to microprocessors by describing typical computer circuits. The circuits are grouped under the following headings: Audio Circuits, Radio Circuits, Transistor Circuits, Miscellaneous Circuits.

**BP78: Radio Control For Beginners** $7.30

The aim of this book is to act as an Introduction to Radio Control for beginners to the hobby. The book will commence by dealing with the conditions which 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.

**BP79: Control For Beginners** $7.30

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

**BP80: Popular Electronic Circuits BOOK 1** $8.25

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

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

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

**BP81: VMOS Projects** $8.20

Although modern bipolar power transistors give excellent results in a wide range of applications, they are not without their drawbacks. With the advent of MOSFET devices it seemed that it would only be a matter of time before improved power transistors became available, this has happened and a number of different power MOSFETs are now available to the hobbyist.

This book will primarily be concerned with VMOS power MOSFETs 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: Audio Circuits, Sound Generator Circuits, DC Control Circuits and Signal Control Circuits.

**No.213: Electronic Circuits For Model Railways** $4.50

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

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

Covers constructional details of a number of projects for the shortwave enthusiast and radio "Ham". Included are: an add-in crystal filter, adding an "R" meter in your receiver, crystal locked H.F. Receiver, AM tuner using phase locked loco, converter for 2MHz, 40 to 90MHz RF amplifier, Aerials for the 52, 144MHz bands, Solid State Crystal Frequency Calibrator, etc.

**No.221: Tested Transistor Projects** $5.50

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

**No.224: 50 MOS IC Projects** $4.25

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

Babani Books are now available from Arkon, CESCO, Dominion Radio and General Electronics.
RIGHT NOW, people in Toronto and Montreal are reading the first issues of a very interesting new magazine. Not an ink-and-paper magazine like the one you have in front of you now, but one of Canada's first *Electronic* magazines. It's called *Computerese*, and it represents the beginning of the biggest revolution in the communications industry since the invention of the printing press.

**Videotex, Telidon, and Vista**

These three names represent the driving forces behind this revolution. Videotex is a generic term referring to various digital transmission, storage and retrieval systems that allow users to access large amounts of visual information, typically using television receivers connected to some sort of intelligent terminals. Telidon refers more specifically to a standard for videotex transmission developed by the Canadian Department of Communications (See September, 1980 ETI). Bell Canada has just launched Project Vista, a major field trial of Telidon technology, involving the placement of about 500 receiver terminals in homes, stores and public facilities. These terminals will have access to a central data bank whose content is supplied by various private and commercial operators. The first people to see Computerese will be those who participate in the Vista trial in Toronto and Montreal, but there will be other field trials across Canada and Computerese will be part of them if its founder, Bill Perry, has his way.

The Message is *The Medium*.

Perry intends to make Computerese a progress journal for users of videotex technology, emphasizing the human side of the coming information revolution. "It is our intention", says Perry, "to address the basic issues surrounding videotex and related new technologies (video-disks, fibre-optic transmission, and microprocessors) and discuss their meaning in personal terms."

What are these "basic issues"? Roughly, they fall into three major categories: legal (or political), technical, and sociological. The legal/political issues primarily involve the difficulty of keeping the new "electronic highways" (information networks) free from excessive restriction and out of the hands of commercial monopolies. New developments and the possible merging of personal computing with videotex are examples of the technical issues. The sociological issues are the human factors. How will ordinary people be affected by the information revolution?

**Electronic Publishing**

Computerese is an electronic magazine, quite unlike any other magazine that has ever existed before. Electronic Publishing, the profitable dissemination of information by electronic means, is a new field which may generate revenues in the billions in the next decade. It will also profoundly affect the publishing industry as we know it today, to the extent of forcing small publishers out of business. The "big guys" have already recognized the dangers and have purchased Telidon technology to get a head start in the Electronic Publishing race.

The Electronic Magazine can also be re-edited again and again. Instead of issuing a whole new information package every month, the producer can revise and/or condense what is already in the system and add a little more each month, each week, even each hour. This is where the term "electronic magazine" becomes inadequate, because the Electronic Magazine combines the best features of a book, a magazine, a newspaper, and a cable-TV news channel.

Finally, once videotex technology becomes firmly established, the Electronic
Magazine will have a tremendous economic advantage over its paper counterparts, because many of the steps involved in conventional publishing will be eliminated. For example, this article was written first by hand, then typed into a computer word-processing system, stored on a floppy disk, printed out and delivered to ETI. There it was edited and retyped on a type composer (a sophisticated electronic typewriter capable of producing text in aligned columns, in any of several character styles). The columns of type were then cut up and, together with columns of type were then capable of producing text in steps involved in conventional age over tremendous economic advant-

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broadcast television was only the first phase of a much larger information revolution. In the light of Videotex and related new technologies, scholars are replacing McLuhan's "Global Village" by the concept of many "Electronic Cottages" linked by a world-wide "Electronic Highway".

Broadcast television, the boob tube, the idiot box, whatever you wish to call it, has accomplished the difficult task of placing high-resolution colour video display devices in the majority of North American homes. In Canada the "Electronic Highway" networks are largely in place, thanks to cable TV, a good telephone system, and Anik satellites. And now that we have developed the world's most advanced videotex system, we may well lead the rest of the world into the information age.

If ETI were an Electronic Magazine using a computer data base, things would be a lot quicker. I could have sent in my floppy disk (or transmitted the manuscript over the phone lines in seconds) and within a few hours it could be edited and combined with digitized illustrations, and put on the data base. You could then turn on your TV set and Telidon adapter, punch a few buttons and read the article, all without leaving your favourite chair.

The Electronic Magazine producer can get his final product on the market much faster than the conventional publisher can, without paying for paper, printing, or most photographic processes. Back issues can be stored on magnetic tape or disk and reproduced flawlessly on request.

Home-Grown

These advantages will make electronic publishing a very profitable enterprise, very soon. And it won't be just the "big guys" who will see the profits. The initial investment required to start a magazine will be so low that individual entrepreneurs will have excellent chances of success. There may well be a revival of "cottage industry" in Canada.

Bill Perry has seen this coming for a long time, and intends to devote a large portion of Computerese to discussing the various forms of cottage industries that videotex technology will make possible. These will include artistic endeavours using Telidon's high-resolution colour graphics capabilities, computer software exchanges and other types of clubs, as well as many types of electronic publishing. If it becomes possible to interface home computers to videotex systems in a two-way fashion, as Perry would very much like to see, any microcomputer owner could start his or her own videotex data base and make money providing information to customers who could call up the data base directly.

The Medium Was The Message

This is the promise of the information revolution. Individuals can profit by selling information itself, their own thoughts and ideas, and devise new handicrafts requiring only ideas as raw materials and their own brains as equipment.

When the late Marshall McLuhan studied the mass-communication systems of the sixties and seventies (mostly television), he predicted the evolution of a "Global Village" consisting of millions of eyes glued to millions of TV sets. This has occurred to some extent in North America, which is essentially a "Global Village" whose fads and fashions emanate largely from California, where most major TV shows are produced. But McLuhan had no way of knowing that mass-oriented, broadcast television was only the first phase of a much larger information revolution. In the light of Videotex and related new technologies, scholars are replacing McLuhan's "Global Village" by the concept of many "Electronic Cottages" linked by a world-wide "Electronic Highway".

Two pages from Computerese. Pages such as these can be altered on a monthly, weekly, or even a daily basis. In effect, the user has a magazine that updates itself right in the home.
Tab books from ETI

Master Handbook Of 1001 Practical Circuits
TAB No.800 $18.30
TAB No.804 $18.35

Here are IC and transistor circuits for practically anything and everything — with ALL the data needed to get them to work. The ideal schematic source book for all active technicians, engineers, experimenters, amateurs — for anyone who must occasionally or regularly construct or adapt electronic circuits for any purpose whatsoever. You'll find any circuit you're ever likely to need in the pages of this rich volume. The schematics are classified according to general application and decide Sections themselves appear in alphabetical order.

99 Test Equipment Projects You Can Build
TAB No.805 $11.75

Here's the A to Z guide you need to build all sorts of electronic test equipment — from a simple signal tracer to a sophisticated modularized 50 MHz counter — and virtually everything in between! Here are voltmeters and ammeters, capacitance meters, tracer to a sophisticated modularized 50 MHz counter. TAB No. 805

The schematics are classified according to general application and decide Sections themselves appear in alphabetical order.

The Power Supply Handbook
TAB No. 806 $11.75

A complete one stop reference for the hobbyist and engineer. Contains high and low voltage supplies as well as mobile and fixed units. Everything you need to keep your project perking with the right volts and amps.

Build Your Own Working Robot
TAB No. 841 $8.55

Here are complete instructions — plans, schematics, logic circuits, and wiring diagrams — for building Buster. Not a project for novices. Buster is a sophisticated experiment in cybernetics. You build him in phases, and watch his personality develop as you add progressively more advanced circuitry to his mainframe. The first of this three-phase robot, Buster I, is "leash-led" and dependent on his master for decision-making; you create the "animal" and give him wheels, steering capability, and the capacity to "understand" your basic commands. Phase II makes a robot that can "think" and "learn." The robot incorporates a self-programming computer which can be programmed to deal with any number of problems, from simple speaker-in-a-box setups to complex, multi-driver systems, plus all the information even an expert designer needs to design and build his or her own robot.

A Beginner's Guide To Computers & Microprocessors — With Projects
TAB No.1015 $9.70

Here's a plain-English introduction to the fascinating world of the microcomputer — it's capabilities, parts, functions, and programming ... and how you can have one in your own home. Numerous projects, using actual computer parts, demonstrate the operation of a computer and lead to the assembly of a working microcomputer capable of performing many useful functions around the home and office.

How To Design, Build & Test Complete Speaker Systems
TAB No.1054 $11.85

If you've always wanted to build your own speaker system, here's a book crammed with everything you need to know to do it right...the first time! It contains a variety of ready-to-build speaker system projects, from simple speaker-in-a-box setups to complex, multi-driver systems, plus all the information even a beginner needs to design and build his or her own.

This clear guide shows you exactly how a speaker system works, how its power and resonance are attained, and how speakers may differ from one another. It's as thorough a book as you'll find on the complete subject of speakers, speaker systems, and enclosures.

Digital Interfacing With An Analog World
TAB No. 1070 $12.35

Are you looking for ways to really put your microcomputer to work? This book tells you how to go about it — how to convert energy produce by pressure, force, position temperature, etc. into an electrical voltage or current that your microcomputer can deal with. It's for the user who views the microcomputer as a bit of hardware to be applied, and who views software as either a simple set of instructions to make the machine go or, more importantly, as a valid substitute for hardware. It presents information, in handbook style, for users of microcomputers who want to design a device or system to use a microcomputer at its heart.

Very simply, this book is for the microprocessor/computer user who wants to use the machine to measure certain conditions, or to control external devices.

The Complete Handbook Of Robotics
TAB No.1071 $19.90

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Arr, Billy... Have Ye Ever Been Te Sea?
No, I suppose not... well, better off fer ya, I suppose. Nothin' out there but salt 'n' spray, pirates 'n' ol' Davy Jones's locker. Naw, Ye wouldn't a' liked it one bit. Ye'd get cold, 'n' wet, Ye're not even dressed fer the sea, Billy, me Boy... If'n ye wants to be livin' the life o' a pirate, ye gots to get yerself some cloths, Lad. Like an ETI T-shirt, fer example. Ay, that's what all the swashbucklers 're wearin' these days. Nice sky blue, so's 'is Majesty's Gunners can't sees yer against the sky. Gets yerself a T-shirt if'n ye gets dunked in the icy North Atlantic. Gets Made of fine polyester so's Majesty's Gunners can't sees yer against the sky.

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GUD STUF!
BICYCLE SPEEDOMETER

0 — 99 MPH in sixty minutes — that’s how long it will take you to build this all electronic solid-state speedometer

WITH FUEL getting more expensive, the world’s oil supply running out and gas vanishing in a puff of smoke, it can’t be long now before pedalpower makes a comeback. We can see it now: CB freaks with cycle mounted riggs and six-foot whips on the back. Of course there will be lots of research into optimum wheel size, cruising speed etc. That’s where this dandy little project will come to your aid. Featuring a two-digit readout, bright red LED display with 1 MPH resolution updated every few seconds, it can be built in a trice (ideal if your bike has three wheels) and powered from a single 9 V battery.

Swift And Silent

There have been many bike speedometer designs published over the years but never before has so much been brought to so many with so little. Yes, only Electronics Today can do this for you! No, seriously, before this gets totally over done, we’ll explain. Only three ICs are required plus the two displays and a handful of passive components. The whole thing is very easy to put together so you can assemble it whichever way you like best. The speedometer works by detecting each revolution of the bike’s wheel using magnetically-sensitive reed switches with one or more bar magnets mounted on the wheel. The faster you go, the more pulses are counted and the speed displayed increases. The display blanks out while the counters are advancing to avoid a distracting flicker and the count period is set up by adjustment of a single resistor when the speedometer is mounted on your bike. Okay, so it doesn’t tell your weight, but it won’t burn a hole in your pocket either!

Construction/Setting Up

Nothing to cause any problems here. As usual we’d recommend you use sockets for the ICs. If you use our PCB design you should have success first time though the circuit is simple enough to
BICYCLE SPEEDOMETER

Figure 1. Circuit diagram of the Bicycle Speedometer

be put together on Veroboard or whatever comes to hand . . . except for the original breadboard which went out of fashion when ICs arrived. (You try knocking nails into a piece of wood the size of a postage stamp . . . and anyway, you would look silly with a breadboard between the handlebars!)

Reed switches come with two main switch actions, either single-pole, double-throw or single-pole, double-throw (changeover). You can use two of the former or simply one of the latter (with its centre contact connected to the common point on the circuit board for the two switches (see Fig. 2).

Reed switches are usually supplied as glass tubes with the switch contacts brought out to tags at either end. For better protection against the elements a single pole double throw reed switch is ideal. You can however, do as we did, and get by with two single throw units.

The relationship between wheel diameter, gate period and number of
magnets required is not a simple one. Toy bikes and bikes with 'baby' wheels will get away with one or two magnets. To obtain a reasonable gate period with larger wheels you'll need to use more magnets. In practice, fix between five and 10 small magnets (the type usually supplied with reed switches) around the rim of the wheel (the more the merrier). To stop them falling off it's best to glue them in place or secure them with pads of double-sided tape. Once fixed, a dab of paint or varnish will prevent them from getting rusty.

Connect a 1MΩ potentiometer or preset at the Rx position, get on your bike and adjust the pot until you get the right speed reading. Now, measure its value and make it up from fixed value resistors or just fasten the pot or preset onto the board — there’s plenty of room.

If you use separate reed switches, make sure that both are never on at once or the battery will be short-circuited through them. To safeguard against this you can connect 10k resistors in series with the wires from the battery.

Ideally you’ll need a box with a clear lid so you can see the display without having to cut holes in the box, which would let in water. It's best to mount the box centrally on the bars so that, if the bike takes a tumble no damage will be done. Lacquer the back of the board so that if any condensation appears in the box no shorts will result. The circuit takes about 40 mA of current when running so two batteries in parallel are advisable and there's just enough room under the PCB to put them.

Alternatively, you might like to make a proper facia panel to hold a whole set of instruments (oil pressure, ammeter, etc!?) Watch this space!

**HOW IT WORKS**

A low-frequency astable oscillator provides the master clock for the circuit. IC1a, R2, C1 take care of this. Pulses are then differentiated and squared up by IC1b and IC1c to provide clock enable and reset signals. Figure 3 shows this in detail.

Integrated circuits IC2 and IC3 form a two-digit counter and display driver, which needs only correct timing and clock pulses to operate both 7-segment displays. While IC1b's output is low the counters are enabled and clock pulses from IC1d cause the counters to advance. When IC1b goes high the counters are disabled and the count is displayed on the 7-segment displays. The combination of IC1d and IC1e forms a simple but effective de-bouncing circuit. Some form of signal conditioning circuit like this is nearly always required when mechanical switches are interfaced to digital counters. Resistors R4 through R17 limit the current in the displays and C4 provides overall decoupling.

---

**PARTS LIST**

**RESISTORS**
- R1 100k
- R2 10M
- R3 10k
- R4-R17 680R

**POTENTIOMETER**
- Rx 1MΩ linear potentiometer

**CAPACITORS**
- C1 1uF, 16 V tantalum
- C2 2uF, 16 V tantalum
- C3 10n ceramic
- C4 47uF, 16 V tantalum

**SEMICONDUCTORS**
- IC1 4584 or 40106 hex inverting, Schmitt trigger
- IC2,3 4026
- D1,2 1N4148 diode
- DS1,2 FND357, common cathode, 7-segment displays

**MISCELLANEOUS**
- SW1,2 reed switch inserts
- SW3 single-pole, double-throw toggle switch
- Magnets
- Battery and clip
- Case to suit

**How it works**

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DB STEPPED
GAIN CONTROL

A handy little piece of test equipment is a preamplifier with stepped gain control selected by a rotary switch. The circuit here uses a single IC, a 741, 14 resistors and a single-pole, 12-way rotary switch. The voltage gain of an op-amp (and that is what the 741 is) is determined by the ratio of \( R_{f} / R_{in} \); thus by having \( R_{f} \) switched, the voltage gain can be varied.

The input impedance of the preamplifier is set by \( R_{i} \) to 10k. Having the gain set in decibel (db) intervals is most useful in audio applications because our hearing, like dBs, is logarithmic. The gain in db is defined as being equal to \( 20 \times \log_{10} (V_{out}/V_{in}) \) (Voltage Gain) which equals \( 20 \times \log_{10} (R_{f}/R_{i}) \). Therefore a voltage gain of 1 is \( 20 \times \log_{10} 1 = 0 \text{db} \) but a voltage gain of 2 is \( 20 \times \log_{10} 2 = 6 \text{db} \).

Although this may at first seem like a complex approach, the decibel is an easy to use method for describing gain and attenuation since all you have to do is add and subtract them. For instance, say a +/- 10 dB is a voltage gain of 9+15-3-3 which is 18 dB (this is a voltage gain of times 8). Note that negative dB means attenuation (reduction in strength). Now consider the same situation without using dB; a signal passes through four devices with gains of 9 dB, 15 dB, -3 dB and -3 dB, the overall signal gain is 9+15-3-3 which is 18 dB.

REMOTE AND TOUCH VOLUME CONTROLS

An electronic attenuator such as the MC3340P IC can be used as the basis of a remote volume control, as shown in the first circuit. RV1 controls the voltage gain of the MC3340P, which varies from typically 13 dB at minimum resistance to about -80 dB at maximum resistance. Since only a DC level is controlled by RV1, any AC pick-up in the connecting cable can be filtered out, which is the purpose of C2. The cable only needs to have two conductors, it can be many metres long, and does not have to be a screened type. C1 and C4 are merely input and output DC blocking capacitors respectively. C3 rolls off the RF response of the circuit so as to aid stability and prevent RF breakthrough.

The MC3340P can be used as the basis of a novel touch operated volume control, as shown in the second circuit. This has the advantage over a conventional volume control of having no moving parts to wear out. The device is controlled by a voltage rather than a resistance and gives the same attenuation range as the previous circuit.

The control voltage is obtained from a charged capacitor (C1) via an op amp unity gain buffer stage utilizing IC1. IC1 has a PMOS input stage which produces a typical input resistance of 1.5 million Meg ohms. This ensures the charge on C1 is not significantly affected by the amplifier of attenuator circuit, so that once set it remains virtually unaltered for a long period of time.

The charge voltage on C1 is set by the operator who, by touching the lower two contacts, can charge C1 via R1 and his or her skin resistance. This decreases the control voltage fed to IC2, and increases the volume. Touching the upper two contacts causes C1 to gradually discharge, increasing the control voltage and decreasing the volume. When the unit is switched off, C1 gradually discharges. At switch on it is necessary to bring the volume up to the required level, rather like using an ordinary combined on/off switch and volume control. Both circuits will handle input levels of up to 500 mV RMS, with a THD figure of only about 0.6% at high volume settings, rising to about 2% or so at low settings.

**Figure 3. Waveforms within the circuit, not to scale**
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PROJECT

GALILEO

Sailing, sailing, over the bounding vacuum,
Reef the mains'! lads. Avast ye swabs, we's bound for Jupiter. Cap'n Steve Rimmer shivers the the interplanetary timbers.

What Goes Up...

GALILEI GALILEO was a fairly together head. For example, he is credited with inventing the telescope, by which all astronomy and peeping Tom-ing is made possible. This, in fact, is not altogether accurate. Actually, he had the good sense to realize that inventions are much easier to invent when somebody else does all the hard work. Clever man, he borrowed the design from somebody else.

Galileo was not thought too kindly of in his day... he had the poor foresight to come up against the major nasties of the period; de church. For one thing, he maintained that the sun, not the Earth, was the center of the solar system, and that most of the ideas held in this area at the time were dead wrong. The church had a point; there's nothing like getting a whole truckload of textbooks printed up just to have someone come along and try to get you to trash them. Eventually they made a deal with him. For his part, he'd change his views and for their part they wouldn't lay a heavy medieval torture chamber trip on him. Being a reasonable man, and not terribly into pain, he acquiesced. Of late, the church has come 'round to Galileo's way of thinking... the moral majority will soon see to changing that.

A while ago, NASA came up with a really freaky idea, this being to send a little whizzbang out to check out what was going on under the cloud cover of Jupiter. They decided to name it after old Galilei, essentially for two reasons. First of all, he discovered four moons of that planet, giving him some stake in the affair. Secondly, and perhaps, most important, the thing was not destined to come off quite as planned. Of course, NASA didn't know that at first, but, then, neither did Galileo. He lived a long time before Murphy.

The Craft

The initial concept for Project Galileo was to have this rather odd looking space craft which would go sailing out into space early last year, and hit the suburbs of Jupiter in 1985. The timing of all this was to be fairly acute, because right around now, as it happens, all the planets are rather nicely lined up, meaning that an outward bound probe can use the gravitational fields of the innermost ones to sling it along. This means that the little fellow would get where it's going a whole lot faster, and with the expending of much less fuel. Things won't be so propitious for quite a number of years to come, so there has been quite the push on to get some hardware out there while things are still cool. The two Voyagers were a part of this effort, each producing some fairly mind bending stuff from the outer solar system. Galileo was due to leave for Jupiter and all points East just before the window began to close.

Initially, the probe was to be a single unit, which would separate into two sections upon reaching its destination. The larger of the two was to be the Orbiter, which would hang around above the planet to gather and relay data. The smaller was the probe proper, which was to go sailing into the atmosphere bristling with instruments, in order to send back data and give anyone living down there an acute sense of paranoia.

To put it simply, though, things have not gone off quite as planned. The initial concept was for the whole works to be put into Earth orbit by one of the early space shuttle missions, from whence it would go dancing lightly off toward the stars. Well, as you may have noticed, there haven't been many shuttles going up of late, which could very well have put a damper on things. This, however, isn't a wholly relevant problem, as the probe wouldn't have been ready to go on schedule, even if the launch vehicle had.

There have been quite a number of hardware hassles with the actual probe, many stemming from disagreements over what exactly the thing should be designed to do and withstand when it hits Jupiter. No small problem, this, as nobody really has any clear idea of what the neighbourhood's really like... except that I certainly wouldn't want to live there. In order to have a better chance at getting good data out of the shot, the system has been becoming increasingly complex. This, in turn, has made it heavier.

At the same time as the probe has been developing obesity problems, the lads working on the drive mechanism to kick it out to the far fringes haven't been asleep at the switch. In fact, their end of things has been gaining a bit on the initial specs too. By the time everything was considered relatively space worthy, the whole works was just too huge to be managed by the shuttle. Even after some trimming getting the thing into space would have meant modifying the lifters considerably, stripping the beast to the bones, and burning everything at somewhat more than one hundred percent capacity... not too well received, considering that, by the time the Galileo mission rolled around, the shuttle was set to have had but two previous flights on its log.

The ideal window for the mission, sometime in 1982, is now considered to be pretty well un-attainable, and things have been largely retrenched to shoot for early 1984. This is still not a bad bit of timing. Mars will still be in position to assist with the trajectory of the orbiter to a large degree, though, of course not so much as it would have been were the whole works to have sailed as originally planned. However,
because of this weakened assist, it has been decided to be good and proper that the probe be fitted with an extra booster to be jetisoned after leaving the Martian influence.

Junk men are going to really have wonderful things to say about NASA, in a hundred years.

The new plan also calls for a split mission, in which the probe and the orbiter travel in separate accommodations. In fact, they take wholly different routes. The probe won't be swinging by Mars at all, but will go more or less directly to Jupiter under its own steam. This will result in its taking considerably longer to arrive; three and a half years, as opposed to two and a half for the orbiter.

Here in we get into another of these cause and effect hassles. If the probe is to go solo, it will be wanting a space craft of its own for the trip, so as not to upset the Union of Interplanetary Probes, Satelites and Infernal Galactic Whizzbangs. At the moment, this is being designed and built by Hughes Aircraft Company for forty million dollars. If that doesn't keep the nasty union happy, it deserves to sulk.

Now then, we also come up with another problem, namely, that the orbiter, which was originally supposed to relay the data from the probe to Earth (that's us, the good guys) won't be in the right location to do so, given this new trajectory. Therefore, it has been relieved of this function, along with the necessary transponders, dishes and other spindles that went with the job, in favour of the hardware that will carry the probe. This is possible because the actual descent time of the probe will be quite short. Even though the carrier will not enter Jovian orbit, it will still be around long enough to pass on the data from the probe. After that, well, it's pink slip time, boys. Little fellow's off to the far flung reaches of space.

(Somewhere, out in space, there are some little green men watching all this. The first thing they'll get from us will be a TV transmission of Felix the cat, followed shortly there after by a novel variety of what could very easily be abandoned Volkswagons. Beam me up, Scotty. There's no intelligent life on the planet.)

The metamorphosis of the Galileo project has changed it considerably. It was, at one time, to be essentially an orbiting observation platform which would, somewhere along the line, heave a probe into the planet's atmosphere to check things out first hand. Now, though, it has become two wholly unique missions, pretty well
independent of each other. It may very
well crawl back into the cocoon for a
third time before launch day . . . er,
days.

**The Works**
The hardware of the mission will,
naturally, be of a slightly changed con-
figuration. It was originally to be a one
piece affair that gradually came undone
as things progressed, splitting into the
orbiter and the probe. Now, however, it
will consist of no less than three
separate bits, these being the orbiter,
the probe, and the newly developed
probe carrier. This last is still partially
a figment of someone’s imagination at
Hughes, so very little is to be said of it.

The probe itself will remain largely
unchanged from its initial design con-
cept, at least in its major details. It
is comprised of two concentric pieces,
the deceleration module and the descent
module. The deceleration module is
basically the heat shield and its associated
workings, which is to keep the innards
from getting crisped as the probe hits
the Jovian atmosphere. Once there
is sufficient atmosphere around the probe,
the deceleration module will deploy a
parachute, which will slow down the fall
considerably. Even with this, though,
the heat shield wants to be fairly beefy . . .
in fact, nearly half the weight of the
probe is tied up in this one component.
It is, naturally, fairly conservatively
designed, as the Universal Interplanetary
Probe Designer’s Cookbook doesn’t list
very much data about what’s going on
beneath the Jovian smog.

By the time the probe gets down into
the atmosphere, and wants to start
doing its thing, it will no longer be
travelling fast enough to have to be con-
cerned about getting fried, so the heat
shield will be jettisoned, and mankind
will have boldly littered where no man
has littered before.

The descent module looks like half a
grapefruit that has begun to sprout. It
carries all the instrumentation to make
the most of the rather short time it
will have in the cloud cover before getting
squashed. Unlike the orbiter, which is
nuclear powered, the probe will get
juiced by a lithium battery pack. Not
exactly your typical D cells, these. It
will switch itself on about five hours
prior to the big leap, checking out
lightning and radio emissions from
Jupiter. The transmitter will be
activated when the heat shield is
shrugged off, at which point any data
stored in the probe’s memory will be
fired along. After this, the descent
module will just transmit like mad until
the warranty runs out.

This happens concurrently with
system failure.

What will eventually snuff the probe,
 somewhere along its descent, is the com-
 bined heat and pressure down there. A
 lot of thought has been given to keeping
 things happening for as long as possible
 under these most unpleasant of
 conditions. The pressure is the worst
 problem. If the case of the probe were
 to be built to withstand it, it would be
 the heaviest part of the whole venture
 several times over. What’s to happen
 instead is to build the thing to
 purposefully leak, and equalize itself.
 This, in turn, raises the problem of what
 the atmospheric gases are going to do
 once they get inside the probe, and start
 wandering the circuits. This, however,
is considered to be a much more
manageable hassle than the prospect of
having the little beasty turn into a pan-
cake.

**Orbiter**
Meanwhile, up in space, there flies
Orbiter. No longer having anything
to do with the probe’s descent, it will
shoot itself into an elliptical orbit
around the planet, partially assisted by
the gravity of Io, one of the moons.
By the time all the manoeuvring has
been completed, the craft will be in a
position to pass as close as 900,000 kilo-
metres from the Jovian atmosphere.
From this point on, the orbit will
modify itself periodically each time the
Orbiter hits the gravitational field of
Ganymede, providing at least eleven
close passes to the planet, and at least as
many to the outer Galilean satellites.
It will be possible, during the closest
passes, to resolve details less than half
the length of a football field across.

The design life of the orbiter is to be
about twenty months . . . it may very
well exceed this by a considerable
margin. Because the sunlight out
around Jupiter isn’t terribly intense
(definitely not the ideal vacation spot
if you’re after a tan), solar powered
energy sources wouldn’t be all that cool.
Thus, the juice will be provided by
other, more atomic means. Two power
cells will sit just behind the main dish.

Now, as to what gets powered . . .
there are more high technology electric
nit-pickers bristling off this thing than a
Lincoln from Texas. First off, we find
a TV camera, to shoot back some more
of those trendy images we’ve all gotten
used to seeing in Time Magazine.
Unlike the previous planetary probes,
which used vidicon tubes, the Galileo
camera will be all solid state . . . CCD
image sensor, you know, which is said
to actually exceed the resolution of a
tube, as well as having a broader spectral
response.

Next to the camera there sits an
infra-red mapping spectrometer . . . you
can’t get one of these on a Lincoln, even
as an option. This is actually a camera,
of sorts, too, but it churns out plots of
the infra-red scene down below. Because
infra-red radiation can pass through dense cloud cover without
being diffused or diffracted, this little
box will permit scientists to check out
the lower reaches of the planet. An
ultra-violet spectrometer will cover the
upper cloud masses, as well as providing
for the surfaces of the Jovian satellites,
which don’t have atmospheres . . . or
much happening in the infra-red
spectrum, for that matter.

The last instrument in this particular
package is the photopolarimeter/radio-
meter. The big brown book of Fun
with Science out in the front office
doesn’t list what this is, so I’ll just have
to give you what NASA gave us. By
some devious means it detects the
temperature of things very remote to
itself, such as the planet’s atmosphere
and the surfaces of the moons. By
doing this, it can, among other things,
check out a lot of data about the
planet’s cloud cover, by correlating this
information with the results of other
experiments.

The back end of the orbiter will be
permitted to spin. It will carry a
number of instruments, including any or
all, probably all, of the following.
There’s the ever popular magnetometer,
which will hang out on a long boom so

---

**Galileo in its present location: on the drawing board.**
that the electrical currents and magnetic fields kicking around the craft won’t upset its delicate temperament. It will check out variations in the magnetic fields of the various heavenly bodies in question. No, taking one down to the bar next Friday won’t help you in the least.

Plasma collectors will pick up data on low energy particles and ionized gasses out in the fringes. There’s a particle detector for high energy ones. Jupiter has a series of radiation belts, particles trapped in its magnetic fields, just like the Van Allen belts of Earth. They probably also have Northern lights out there, although I don’t know of anyone who’s come back talking about them.

Stuck out with these instruments will also be some apparatus for radio propagation experiments, and celestial mechanics plotters to map anomalies in the gravitational field of the planet and its moons. This would, in turn detect either large concentrations of mass or buried Martian space craft. We don’t actually hold out much hope for the Martian space craft.

The Future
Pretty wild right? I’ll bet you’re all fired up, right about now, to trek right out, build yourself a space ship, and go explore the outer worlds. Hey, no sweat. Next Month in ETI we’ll be beginning a new series on the construction of interplanetary probes and shuttles for the novice builder. Included will be such topics as fashionable Gloria Van der Pickup designer space suits, how to home brew a nuclear power cell, 64 LM741 circuits for use in deep space, and a furlable parabolic dish antenna you can build out of metallized mosquito netting and an umbrella. We’ll also have a special bit on how to survive on the Jovian satellites by farming the ammonia fields. Hopefully, there’ll be a great new mail order offer, too, for a rub down transfer of a man and a woman without any cloths on, and a bunch of scientific looking diagrams to put on the outside of your craft, in case you miscalculate and it takes off for Alpha Centauri.

Maybe we can even get an interview with old Galilei himself. He’s probably hanging out around Jupiter these days, watching the fun . . . and thinking about taking up skeet shooting.
### SPEAKER KIT SALE

**Two 15" — 200 Watts ea System**
- 19" W, 48½" H, 16" D
- $199.95 ea.
- Kit — K201
  - Two 15" Woofer
  - Two 5" Midrange
  - Two 3½" Horn Tweeter
  - One 2 x 6 Horn Tweeter
  - Crossover Network
  - Terminal, Plan, Wire

**Two 12" — 150 Watts ea. system**
- 18" W, 43" H, 14" D
- $179.95 ea.
- Kit — K1206
  - Two 12" Woofer
  - Two 5" Midrange
  - Two 2 x 5" Horn Tweeter
  - Two Controls
  - Crossover Network
  - Terminal, Plan, Wire

**Two 12" — 150 Watts ea. system**
- 14" W, 38" H, 14" D
- $149.95 ea.
- Kit — K1204
  - Two 12" Woofer
  - One 5" Midrange
  - One 2 x 5 Horn Tweeter
  - Two Controls
  - Crossover Network
  - Terminal, Plan, Wire

**Two 12" — 100 Watts ea. system**
- 15" W, 25" H, 12½" D
- $89.95 ea.
- Kit — K1203
  - One 12" Woofer
  - One 5" Midrange
  - One 3" Tweeter
  - One Control
  - Crossover Network
  - Terminal, Plan, Wire

**15" — 150 Watts ea. system**
- 18½" W, 28½" H, 14½" D
- $139.95 ea.
- Kit — K1505
  - One 15" Woofer
  - Two 5" Midrange
  - One 3" Tweeter
  - One 2 x 5" Horn Tweeter
  - Crossover Network
  - Terminal, Plan, Wire

**15" — 150 Watts ea. system**
- 18½" W, 48½" H, 16" D
- $199.95 ea.
- Kit — K201
  - Two 15" Woofer
  - Two 5" Midrange
  - Two 3½" Horn Tweeter
  - One 2 x 6 Horn Tweeter
  - Crossover Network
  - Terminal, Plan, Wire

**15" — 150 Watts ea. system**
- 18" W, 32" H, 14" D
- $149.95 ea.
- Kit — K1503
  - One 15" Woofer
  - One 5" Midrange
  - One 3½" Horn Tweeter
  - Crossover Network
  - Terminal, Plan, Wire

**15" — 150 Watts ea. system**
- 18½" W, 28½" H, 14½" D
- $89.95 ea.
- Kit — K1503
  - One 15" Woofer
  - One 5" Midrange
  - One 3½" Horn Tweeter
  - Crossover Network
  - Terminal, Plan, Wire

Enclosure (Box) not included. Rings are optional.

**Woofer**
- 16" 78 oz, 300 Watts
- 15" 54 oz, 200 Watts
- 15" 40 oz, 150 Watts
- 15" 30 oz, 100 Watts
- 15" 20 oz, 80 Watts
- 12" 38 oz, 150 Watts
- 12" 30 oz, 150 Watts
- 12" 20 oz, 80 Watts
- 12" 20 oz, 60 Watts
- 10" 20 oz, 60 Watts
- 10" 16 oz, 60 Watts
- 8" 18 oz, 60 Watts

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</tr>
<tr>
<td>8&quot;</td>
<td>18 oz</td>
<td>60</td>
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</tbody>
</table>

**Midrange**
- 5" 10 oz, 150 Watts
- 5" 7 oz, 100 Watts
- 5" 5.3 oz, 80 Watts
- 3" 6 oz, 40 Watts
- 3" 4 oz, 30 Watts
- 2 x 6" Piezo Horn
- 2 x 5" Piezo Horn

**Tweeter**
- 5" Piezo Horn
- 3½" Ribbon
- 3" JVC
- 3" Phenolic
- 3" Dome
- 3 way crossover network

**Crossover Network**
- 150 Watt

Add 5% for postage and handling. Add 7% sales tax (Ontario residents). Prices are subject to change without notice.

---

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Postal Code: __________

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Circle No. 8 on Reader Service Card.
### Sabtronics

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<thead>
<tr>
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<th>Model</th>
<th>Description</th>
<th>Kit</th>
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<td>A</td>
<td>2010A</td>
<td>LED Bench DMM</td>
<td>$134.00</td>
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<tr>
<td>B</td>
<td>2015A</td>
<td>LCD Bench DMM</td>
<td>$159.00</td>
<td>$238.00</td>
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<tr>
<td>C</td>
<td>8610A</td>
<td>600 MHz 8 Digit Frequency Counter</td>
<td>$59.00</td>
<td>$209.00</td>
</tr>
<tr>
<td>D</td>
<td>5020A</td>
<td>Function Generator 2 to 200 KHz</td>
<td>N/A</td>
<td>$184.00</td>
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<td>E</td>
<td>8000B</td>
<td>1 GHz Frequency Counter</td>
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<td>F</td>
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<td>LCD Hand Held DMM</td>
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<td>LCD Hand Held DMM Thermometer with Probe</td>
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<tr>
<td>H</td>
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<td>600 MHz 9 Digit Frequency Counter</td>
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<td>I</td>
<td>8110A</td>
<td>100 MHz Frequency Counter</td>
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### Accessories

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<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>THP-20</td>
<td>Touch &amp; Hold Probe, for use with Models 2010A, 2015A, 2035A and 2037A DMMs. Permits a reading to be held in the display.</td>
<td>$34.00</td>
</tr>
<tr>
<td>HVP-30</td>
<td>High Voltage Probe, extends the DC voltage range of any 10 MOHM input impedance DVM to 30,000V. Accuracy 2%.</td>
<td>$59.75</td>
</tr>
<tr>
<td>AC-110</td>
<td>Battery Eliminator, permits AC line operation for Models 2035A and 2037A DMMs.</td>
<td>$11.95</td>
</tr>
<tr>
<td>AC-120</td>
<td>AC Adapter/Charger for All Bench Portable Models.</td>
<td>$14.75</td>
</tr>
<tr>
<td>N-120</td>
<td>NiCd Batteries, provides 8-12 hours continuous use.</td>
<td>$16.75</td>
</tr>
<tr>
<td>FP-10</td>
<td>Audio Frequency Probe, for Audio or RF measurements (switch selectable).</td>
<td>N/A at time of printing</td>
</tr>
<tr>
<td>RFA-10</td>
<td>Telescopic RF-pick up Antenna, for use with all BNC input connector type Frequency Counters.</td>
<td>$16.95</td>
</tr>
</tbody>
</table>

Dealers Welcome. Please call for further information and quantity pricing. Include $6.75 for shipping and handling charges per instrument and/or accessories. All above merchandise has Federal Sales Tax in price, just add Provincial Sales Tax (Ontario Residents Only) @ 7% and $5.75 Instrument. Prices Subject To Change Without Notice.

FREE GIFT pack ($5.00 Value) of assorted prime components and/or controls, switches etc. will be mailed to you with your order if it is one of the first ten mail orders received. Minimum order is $10.00.

To speed delivery enter Charge or Master Charge numbers when issuing personal cheques. This will enable us to process your order in the least amount of time.

Unless otherwise indicated all items T.N.I.P. (taxes not in price). Please add 5% for postage and handling minimum $2.00. Excess will be refunded. Federal Tax @ 9%. Provincial Tax @ 7%, Ontario Residents only.

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Portable Alarm Clock

Unique, compact portable clock, multi-function LCD digital module, with highly accurate quartz crystal oscillator.

This Portable Alarm Clock comes complete with a standard Eveready 386 battery installed with a one year guarantee against defects. This guarantee does not cover abuse and or any tampering, nor does this guarantee imply or cover the life expectancy of the battery.

- 3 ½ digit with alarm on indicator
- Large clear 10mm high LCD
- 7 functions Hours/minutes/seconds/month/day/alarm/noozle
- Built in easel stand
- Illumination device to facilitate reading in darkness.

Price $25.95 (F.S.T. Inclusive) Plus 7% P.S.T. (Ontario Residents Only) and $1.75 for Postage and Handling.

Pen Watch

Highly accurate, easy to read time piece, combined with 100% stainless steel construction, a quality writing instrument, powered by a standard Eveready 392 silver oxide battery.

Your Pen Watch comes complete with battery and a one year guarantee against defects, battery excluded.

Price $29.95 (F.S.T. Inclusive) Plus 7% P.S.T. (Ontario Residents Only) and $1.75 for Postage and Handling.

- 3 ½ digits 5 functions (Hour, Minute, Second, Month, Date)
- Highly accurate quartz crystal
- 4 year permanent calendar
- International standard "Parker" size refill
- 2 section slim stainless steel barrel

Capacitors

Polyurethane Capacitors:

<table>
<thead>
<tr>
<th>Value (µF)</th>
<th>Tolerance</th>
<th>Price (each)</th>
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<tbody>
<tr>
<td>100µF @ 25V</td>
<td>±10%</td>
<td>$0.18</td>
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<td>10µF @ 25V</td>
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<td>$0.02</td>
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<tr>
<td>0.01µF @ 25V</td>
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Polystyrene Capacitors:

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<td>$0.01</td>
</tr>
<tr>
<td>0.01µF @ 25V</td>
<td>±10%</td>
<td>$0.01</td>
</tr>
</tbody>
</table>

Resistors

1% Precision Metal Film ¼ Watt Resistors: Low thermal noise, excellent stability. All industry standard values available, over 600 different values to choose from.

Special order item only, allow 2 - 3 weeks delivery. Minimum order of 100 of the same value for $19.80. 1000 of the same value for $76.00.

5% Carbon Film ¼ Watt Resistors:

- 10, 2.2, 2.7, 3.3, 7.5, 10, 15, 16, 22, 27, 33, 47, 56, 68, 75, 100, 120, 150, 160, 220, 270, 330, 470, 510, 680, 750, 820, 1k, 1.8k, 2k, 2.2k, 2.7k, 3k, 3.3k, 3.6k, 3.9k, 4.7k, 5.1k, 5.6k, 6.2k, 6.8k, 7.5k, 8.2k, 10k, 11k, 12k, 13k, 15k, 18k, 22k, 24k, 27k, 33k, 39k, 47k, 51k, 56k, 62k, 68k, 75k, 100k, 120k, 130k, 150k, 180k, 220k, 270k, 330k, 390k, 470k, 510k, 560k, 620k, 680k, 750k, 820k, 910k, 1M, $2.78 -ea.

10% Carbon Film ¼ Watt Resistors:

- 10, 2.2, 2.7, 3.3, 7.5, 10, 15, 16, 22, 27, 33, 47, 56, 68, 75, 100, 120, 150, 160, 220, 270, 330, 470, 510, 680, 750, 820, 1k, 1.8k, 2k, 2.2k, 2.7k, 3k, 3.3k, 3.6k, 3.9k, 4.7k, 5.1k, 5.6k, 6.2k, 6.8k, 7.5k, 8.2k, 10k, 11k, 12k, 13k, 15k, 18k, 22k, 24k, 27k, 33k, 39k, 47k, 51k, 56k, 62k, 68k, 75k, 100k, 120k, 130k, 150k, 180k, 220k, 270k, 330k, 390k, 470k, 510k, 560k, 620k, 680k, 750k, 820k, 910k, 1M, $2.78 -ea.

Potentiometers

Smooth quiet rotary pots, pc terminals with 3/8 inch standard threaded bushing. (Audio)

Log Taper:

- 25K, 50K, 100K single $2.25 ea.
- 25K, 50K, 100K dual $4.35 ea.

Linear Taper:

- 10K, 25K, 50K, 100K, 250K.
- 10K, 50K, 100K, 500K.
- 1M, $2.78 ea.

- 1M, $4.35 ea.

60mm Slide Potentiometers, approx 3/8 inch inches long. Smooth gliding and quiet slide pots. (Audio)

Log Taper:

- 10K, 25K, 50K, 100K, 250K.
- 10K, 50K, 100K, 500K.
- 1M, $2.78 ea.

- 50K, 1M, $2.78 ea.
We have become complacent over the past few years. Technological developments come so quickly that we rarely pause to consider how they were developed. Ian Sinclair looks into the (surprisingly) long history of stereo and where future research may lead.

Now that we have the technical ability to process almost anything with electronics, it's interesting to note how many ideas which have been around for a long time are now being used at last. Stereo sound was one of the first of these ideas to be picked up, particularly when transistors became cheap enough to allow two amplifiers to be built for a price which previously bought only one. In this article, we'll try to trace the shaky beginnings of today's stereo.

Musicians have, of course, played with different arrangements of choirs and orchestras for centuries, and in many cathedrals, carefully chosen seating arrangements for the choristers were found by trial and error to give much clearer sound over a large space. By contrast, many composers preferred to write for small groups of players, deliberately avoiding the large spread of sound of the full orchestra.

The effect of the arrangement and spacing of sound sources which was well known to musicians was not lost on the physicists either, though it took some time before their knowledge of sound waves was sufficient to match up to the needs of analysing something so complex. Much of our knowledge of sound waves was laid down by the great physicist Helmholtz, and carried on by Lord Rayleigh of Terling, Essex. Rayleigh's Theory of Sound, published in 1896, is still the sourcebook for anyone investigating sound waves, and his work is the real starting point of the stereo systems which were developed after that time.

Rayleigh conducted a large number of experiments to find what factors determined how the human hearing system could 'localise' sound; that is, discover where the source of a sound appeared to be. One of his classic experiments involved fitting a listener with a pair of tubes, one to each ear, and sounding identical tuning forks at the end of each tube. He used this scheme for tuning forks with a wide variety of pitches, and found that the listener, who was blindfolded, imagined that the sound was directly in front of him, when the higher-frequency tuning forks were used. This illusion did not persist when low frequencies were used, and could be restored only when a single fork was used and its sound taken through tubes of equal lengths to both ears.

Rayleigh's experiments and theory weren't at all ahead of technology. Some fourteen years earlier, a telephone engineer in Paris had patented a system for enabling latecomers to a theatre to hear a realistic performance. His idea was to use two microphones, one on each side of the stage. Each listener had also two earphones, left and right, so that the effect was that of headphone stereo. Since no amplification was needed, the system was quite practicable, and was, in fact, exhibited in action in 1881.

The lack of amplification in all early sound systems forced inventors to concentrate on headphone systems. Now, though headphones produce interesting effects, there is a vast difference between the sound heard on headphones, with its artificial separation, and the sound you hear live, or through loudspeakers. A good description of the difference is that headphone sound always makes your ears feel fifty feet apart, and this must be caused by the complete separation of signals which doesn't happen under normal listening conditions.

Early attempts at providing some form of loudspeaker stereo had to use the horn gramophone, and some of these were actually made.
Two Channel Radio

World War I turned inventor's minds to less harmless pastimes, and at the end of the conflict, the new possibilities which were opened up by radio broadcasting began to excite considerable interest. One scheme which was tried in 1925 was the separate broadcasting of two channels on different wavelengths. The medium-wave bands were not so crowded then as they are now -- you didn't get the call-sign of Radio Bohemia continually coming over the station you wanted in those days!

In Berlin, stereo experiments were carried out using 430 and 505 metre transmitters, and at New Haven, Connecticut, station WPAJ won a place in history as a stereo transmitter using 270 metres and 227 metres. Details of the Haven system is quite well documented.

By 1932, Blumlein had turned his attention to the problem of coding two separate signals onto discs. The obvious method, stemming from gramophone history was to use both lateral and hill and dale recording on the same groove. This isn't entirely satisfactory, because one of the reasons for abandoning hill and dale recording was that the pickup could not follow the dales at high frequencies; it simply slipped from one hill to the next. Blumlein suggested that the two walls of the disc, set at 90° to each other (and at 45° to the vertical) could be separately modulated, and this is the scheme which was eventually used.

Degrees Of Stereo

Now, earnest students of physics will have realised what the significance of 90° is in all this, but everyone else deserves some sort of explanation. Without going into a lot of detail, any motion in a straight line can be imagined as being caused by two movements at right angles to each other.

For example, if you pull on the two strings illustrated in Fig. 4, then the block moves in the straight line which is shown. These two motions at right angles to each other are quite independent -- changing one does not affect the other. Translating this into something closer to our applications now, imagine a device which consists of a miniature railway track with a plunger touching channels. The important point about a sum-and-difference system (Fig. 2) is that the sum signal is a normal mono signal, which can be used by mono equipment, and the difference signal is of comparatively small amplitude, easier to transmit. The sum-and-difference system has survived in FM stereo, though it was not used for either tape or disc stereo systems after World War II. The principles were revived, however, for most of the so-called 'quad' systems.

For The Record

Curiously enough, disc stereo was not in such an advanced state. It's curious because all the information that was needed was already present. The early cylinder recordings had used what was known as 'hill and dale' recording (Fig. 1) -- the sound waves were recorded as a pattern of vertical bumps on the cylinder. Emil Berliner's flat discs of 1888 used lateral recording, the familiar groove which waves from side to side. It must surely have occurred to many inventors that it should be possible to record one programme on a vertical recording and another on a lateral recording in the same groove -- and yet there's no trace of it.

Stereo as we know it has its roots in the work of one man -- Alan Blumlein of EMI. Blumlein was probably the ultimate virtuoso of electronics; his patents cover all aspects ranging from stereo sound through most of television to radar. What he might have eventually accomplished is something we can only guess at, because he was killed in an air crash, during radar tests, in the early days of World War II.

His work at EMI started in 1929, and by 1931 he had taken out the patent which forms the foundations for most of today's stereo systems. This patent outlines all the requirements that we use today, and suggests in particular, the use of sum and difference rather than straightforward L and R sound.
the surface of a plate between the rails (Fig. 5). If the plate is shaped like a wave, the plunger will be forced to move up and down as the 'truck' is moved along. The up-and-down movement, wave, the plunger will be forced to take place at 90° to each other, provided that their directions simultaneously – this is as close as we can come to showing what takes place on a stereo recording. Imagine now that the whole caboodle is tilted through 45° – and you're there!

**Fantasy Sounds**

By the early thirties, all of the methods for obtaining and transmitting stereo had been worked out. The sum-and-difference coding for radio had been contributed by Blumlein, the 45°/45° disc was his work as well, and the third system, separate channels on tape was still waiting for further development of tape recorders.

There, for some reason, it rested. It was as if people couldn’t take any more novelties, or perhaps that everyone sensed a coming war. Whatever happened, stereo sound didn’t change, at least as far as the home user was concerned. Where it all started to happen was where there was money to play with, in the film world. The historic date was 1935, when the Bell Telephone Laboratories demonstrated before the Society of Motion Picture Engineers (SMPTE now, the T standing for Television) a stereo sound system for films, using twin tracks of the conventional type. It made some impression, but only on a few dedicated engineers. The big break-through came only in 1941 when Walt Disney Studios made Fantasia, a film of such remarkable originality that it still goes the rounds today. The theme of Fantasia is the fitting of cartoons to music, and Disney’s engineers, who had heard the demonstrations in 1935, were convinced that a very large step forward in cinema sound was desirable. They certainly achieved it, after umpteen experiments and as many as ten full scale attempts, they ended up with an eight channel recording system. Their idea, later expressed in an article, was that if this improvement in sound was to catch the attention of the public it must be a dramatic improve-

**Coils And Cutters**

By the mid ‘50s everyone was waiting for stereo to happen, and there were countless proposals, ranging from the well-researched to the simply silly, lined up. As usual someone had to break the ice and take the first step into the water. The someone in this case was that champion of all the innovating companies in electronics, RCA. At that time, virtually all the disc cutting heads were made by one company, Westrex, a branch of Westinghouse. In 1957 RCA instructed Westrex to make them a 45°/45° stereo cutting head – with the option that if they didn’t, RCA would start manufacturing the heads themselves. It was an offer Westrex couldn’t refuse, because several other companies were already in the business of developing such cutters, notably Telefunken in Germany, Decca in Britain and Orototfon in Denmark. Westrex went ahead to develop a type of cutting head which, with later refinements, is still in use today.

The Westrex head uses two separate moving coil assemblies. The moving coil principle is an old and well known one in the history of disc cutting and reproduction, and is illustrated in Fig. 6. A coil is driven with signals, and its magnetic field, which increases and decreases in step with the signal current, causes variable forces on an iron core. If the coil is suspended on springs, it will move in sympathy with the variations in magnetism, so producing a mechanical movement which keeps in step with the waveform of the signal. This is the motion which is used to operate the cutting stylus, and the Westrex arrangement consisted of two moving coil drives (or motors, as they are called) set at 90° (Fig. 6).

Once the Westrex stereo cutter went into production, the manufacturing of stereo discs became possible. By that time, the microgroove long-play disc had been developed also, and the modern stereo disc became a reality.

The Walt Disney film, Fantasia, heralded the first commercial use of multitrack recording techniques. The soundtrack has since been remixed for stereo. Copyright Walt Disney Productions.
Through The Air
Stereo radio, as we've seen earlier, actually started much earlier than stereo discs, though the systems which used separate channels broadcast on separate wavelengths were not compatible. Compatibility is always a problem which tends to prevent new systems from being developed for any established process. The argument is that the customer already has equipment which mustn't be made out of date. The fact that advertising is continually trying to tell the same customer that his equipment is out of date is conveniently ignored. The compatibility problem has affected two systems in particular - stereo radio and colour TV. The argument in each case was that the existing owner of radio or TV should continue to be able to receive the same transmissions.

As it happened, the first FM transmitter had been built by the beginning of World War II, by Edwin Armstrong, inventor of frequency modulation, and in the post-war years, FM transmitters multiplied rapidly in the USA. The users of FM tended to be listeners who were interested in higher quality reproduction of music, so the FM transmitters were seen as the natural medium for stereo transmissions. The bandwidth of an FM broadcast is much greater than that of medium wave, however, and this, along with the compatibility problem, ruled out the use of transmitting each channel on a separate frequency.

Transmission Systems
Once again, the field was open to inventors to devise methods of modulating the two channels onto one single carrier in such a way that an existing one million radios would continue to receive an acceptable signal, but a specially adapted stereo radio would be able to separate the two channels. A large number of proposals were put forward mostly hinging on the use of a subcarrier. A subcarrier is a sinewave which can be modulated by a signal, and which is then, in turn, modulated on to a main carrier along with other signals. This time, the systems had to pass the scrutiny of the Federal Communications Commission, the body which controls broadcasting technical standards, and it showed! The FCC had previously insisted (1953) that any colour system should be compatible, and it certainly wasn't going to make its rules any easier for half-baked schemes to provide FM stereo.

The system which was eventually chosen was the Zenith Radio-General Electric joint submission. This is the stereo system which, unlike the NTSC colour system, is used world-wide with only minor modifications, and a brief reminder of its principles might be useful.

The Zenith GE system (Fig.7) relies on Blumlein's principle of sum and difference signals, L + R and L - R. The sum signal, L + R, is frequency modulated onto the main carrier in the usual way, so that the user of mono equipment has the same signal input to his receiver as he had before. The carrier is also modulated with two other signals. One of them starts as a subcarrier at 38 kHz, which is amplitude modulated by the difference signal, L - R. The subcarrier is then removed, leaving only the modulated sidebands, mainly low amplitude, to be modulated onto the main carrier. The third signal which is modulated onto the main carrier is a low amplitude sinewave at 19 kHz, which is obtained to the transmitter by dividing down the 38 kHz subcarrier frequency.

Modern tape decks for home use boast features undreamed of 20 years ago. The compact cassette took stereo to the streets.
STORY BEHIND THE STERE

At the receiver, these signals can be separated without much difficulty (Fig. 8). A mono receiver detects only the sum signal, with its normal de-emphasis circuits (low pass filter) removing the 19 kHz sinewave (the 'pilot tone') and the sidebands of the sub-carrier. A stereo receiver uses no filtering immediately after the demodulator, so that the pilot tone can be detected, amplified and frequency doubled to 38 kHz again. This newly regenerated carrier frequency can now be used to demodulate the subcarrier sidebands (a method called synchronous demodulation is used) to recover the L - R signals. The L + R and L - R signals can be combined to provide the L and R signals which are the stereo channel signals.

On Tape
Tape recorders? Oddly enough, though stereo on tape was used comparatively early by the manufacturers of discs, stereo tape for the home user came a lot later. The use of tape was only ever a minority interest in any case, apart from the brief craze for tape-recording in the early sixties, until tape became capable of providing better quality sound at reasonable prices. Though stereo tape recorders eventually became available, with such excellent machines as the Revox providing considerable competition to the best of discs, tape stereo still remained a minority pursuit. Things stayed this way until the cassette developed four channels and efforts were made to sort out the miserably poor signal-to-noise ratio.

Because commercially-made stereo cassettes could be bought, unlike stereo tapes, stereo on cassette flourished despite its technical shortcomings. Rapid development ensured that whatever stereo equipment you bought one year would be out of date by the next year, so keeping manufacturers keenly interested in research. In some cases, the research simply resulted in more shiny cases with less inside them, but some very important advances were made in tape material, in circuit techniques (such as Dolby and dbx), and in convenience (such as being able to set up the recorder easily for different types of tape). Because cassette stereo was the most recently developed stereo system, it's still developing, trying to reach nearer perfection before the next big breakthrough.

The next one? There are digital tapes, laser-read discs, and presumably, laser-read tapes all being developed, all with the promise of high packing density (lots of music in a small space) and very low noise levels. That doesn't mean that manufacturers have learned from early mistakes — there are as many systems competing now as ever were, some with such obvious flaws that it's difficult to imagine they were being seriously put forward except as a way of keeping a place in line. All we can do is wait and hear!

---

**Fig. 8.** At the receiver, the 19kHz sinewave is selected by filtering, and then frequency-doubled to 38kHz so that it can be used to demodulate the sidebands of the subcarrier signal. Once the L-R signal has been recovered in this way, it can be combined with the L + R signal to form separate L and R signals.

**Fig. 7.** Stereo transmission, three signals are modulated on the main VHF carrier. One is the usual (mono) L + R audio signal, one is the sidebands of the subcarrier (carrying L-R), and the third is a low-amplitude 19kHz sinewave which is used for decoding at the receiver.
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When the announcement of this discovery was made, John got real excited, jumped up and down and accidentally fell into the magazine storage pit. Bit of a drag, but you can understand how he felt. ETI's Hobby Project Book has 25 first rate projects, including an LED Tachometer, A Graphic Equalizer and a Linear Scale Ohm-Meter. If you send us $3.95, we'll send you one... better hurry, though. Our chaps been down there a while, and he must be getting hungry by now.

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Ever wondered how those self focusing cameras work? Well you're going to find out anyway. Steve Rimmer plumbs the depths.

There's nothing more frightening than coming home from a long day, hard at work doing nothing, yes, slaving over a hot electric guitar. Well, I didn't know it was hot when I bought it... only to find an addition to one's décor. I mean, like, I was very thoughtful in laying out the place, you know. I have four old style plastic milk crates holding up the TV, and two more, matched ugly green ones, dig it, for the stereo. The couch is truly priceless...I came upon it in a quaint little out of the way little boutique called Harry's Emporium of Swill and Viliness, where the owner personally offered me the piece right then and there if I could have it off the premises by noon. The lighting is diffused into a gentle, incandescent glow by an Allen's Apple Juice can with welding torch holes in it. The walls are accented by several original works of art, absolutely none of which are on black velvet, plus two excellent reproductions, one of which illustrates the Grateful Dead in concert, and the other being a blow up of a Springsteen cover. There are also several custom made ragged holes where assorted glass vessels once intended for the containment of fermented drink have impacted with the gyprock? It's the sort of dwelling one could expect to find in Dive Beautiful or Better Hovels and Gutters... at least it was. However, just the other day I repaired to my lushly appointed retreat only to find...

Max was there, sitting in front of my tube watching a videotape of the All Night Show munching raw hamburger and salt. 'Air conditioner's busted over at m' flop, man. Stickier'n candy bar in yer jeans.'

'Is that the one you tried to make into an energy efficient still?' I ask, naive.

'Hello, ya... was doin' just marvy, man. Just tight, right, an' then... boom.' He gestures to simulate a mushroom cloud. I think he's on a mushroom cloud. 'Service man said he doesn't work on slag.'

'That's 'cause you had a penny in the fuse box, man...'

'Wha...oh, no, man, that melted ages back. I eventually just said ace it, like, an' I stuck a big hunk o' wire 'cross the thing. Fixed it good.'

'You lookin' at a prolonged occupancy here, Maxwell, old thing?'

Well, y'know, gotta have a conditioner, man. That solar heating thing I put in is nice, but you can't shut those suckers off. I eventually laid on him a rather neat little troll I had been given to review. He kind of got off on it...he kind of got off on it so much that he didn't really want to give it back. I eventually had to get Josie to threaten to hit him with the dreaded Curse of Sobriety if he didn't cough it up. This, of course, was to no good end. He's back living in front of my set, rolling ginseng joints. This month we're going to get into the Polaroid Ultrasonic Ranging System.
This is, in spread out form, Polaroid's fiendishly sophisticated Ultrasonic Ranging System, initially developed for use on their automatic focussing instant cameras. It is, in operation, deceptively simple. To range an object, one simply switches on the power and aims the box at the rangee, reading the distance off the LED display in feet and tenths of feet. If the interval can be kept between 0.9 and 35 feet, the system expresses itself to be getting on rather well.

The purpose of the kit is to serve as a demonstration of the performance of the system, and to give the great itching hoards of the orb a chance to fiddle with the actual transducer. It is, in fact, the transducer that Polaroid's trying to get everyone shook up about. methinks the R&D budget for this one was a bit steep, and they want some of it back. The idea seems to be to get some designs happening around this device.

In any case, let the inspired take note that the hairy minions of Dr. Land are only offering the transducer for sale, outside the confines of the designer's kit. the circuit boards aren't available in mass quantities.

My Foot In The Works.

Lookit me, ma, I'm a transducer. Check out what I'm up to now.

The operation of the transducer in the Polaroid system is quite interesting. The principal of sonar ranging is, of course, quite simple. There is a transducer of some sort, essentially a speaker at first, which emits a pulse of sound, or, rather, ultra-sound, I guess... energy at some frequency slightly above the range of human hearing. Now, as we all know, or, at least, should, sound takes a finite time to travel from point A to point B, and, in fact, it's pretty slack about it. Sound, furthermore, has the useful property of being easily reflected, to some degree, from most surfaces. Thus it is that our burst of ultrasonic energy shot out from the aforementioned hypothetical transducer will go screaming out. Until it intercepts some solid object, at which point it will rebound away, and some portion of it will motor its way back toward the original source. Having done so, what we need is a second transducer, or, alternately, to have our original transducer serve a dual function. For if there was a microphone at the point from which the sound was initially radiated, it could pick up the returning pulse. If this pulse were to be stuck up alongside the original, outward bound pulse, there would be a period of time between the two corresponding to twice the distance between the transducer and the object, at the speed of sound. Blows the consciousness into the fourth dimension, I know.

Now, there are lots of things one can do with these pulses, but most of them get into some sort of gating arrangement. What goes down in the Polaroid kit is probably the simplest to understand. What we're into here is a clock, which is running at a fixed speed, such that one pulse will give a reading of one tenth of a foot when it hits a counter. Thus, when the first pulse, the driving tone, comes through, this clock is gated on, and the counter starts wildly racking up the digits. When the return pulse hits land, it switches off the counter, and the resulting three digits are dumped to the LEDs. If the clock period was accurate, we would now have a digital readout of the distance between the transducer and the object. In the time it took you to read this, the reading would have been updated about fifty times. Yes, Max, this is one of those things that's a lot easier to do than to explain.

What limits the effectiveness of sonar ranging is very much what does in human hearing, roughly the same sort of mechanism. Ambient noise will bother the system, as the transducer, when acting as a receiver, may not be able to differentiate between a lot of white noise, a portion of which will have its distribution at the same frequency as the sonar pulse, and the returning pulse itself. As the distance gets greater, naturally, the pulse gets weaker, so this problem is aggravated the further off the subject is. Obviously, for any given ambient noise scene, there will be a distance beyond which things get universally uncool. However, even before this point is reached, the system may get quite erratic.

The second hassle involves standing waves, and other oddities of pitch versus space. Without getting into all the math involved, which I flunked miserably anyway, if one has any internal space, such as the distance between the ranger and the rangee (no remarks about Silver and Tonto, s.v.p.), one has a tuned cavity of some sort. If one places a point source of sound in this thing, given the right pitch, there will come a point where in any given area in the cavity is in a node, a region of high intensity sonic energy, or an anti-node, a region where all the phase thingys conspire to cancel out. Tough luck if your transducer happens to be scrunched in an anti-node with respect to the object to be ranged.

Lastly, and, admittedly, not too important, is the hassle of having multiple return echoes. Naturally, the sonar pulse will not lance out of the transducer like Jim Kirk's phaser beam, but will emerge in a roughly conical sort of pattern. Part will be reflected by the object of the ranging, and part by the rusted 1958 Edsel coupe sitting upside down on top of a Volkswagen somewhat behind and to the right. There is also a herd of crazed Albanian killer llamas thundering across the tundra, which will no doubt cause reflections of their own. It is therefore necessary to distinguish the first, and meaningful echo from all the rest of the grass, and deal with it alone. After that, the system should illuminate a LED to tell you the system may have an electronic malfunction.

Now, as far as the demo kit is concerned, most of these little inconveniences aren't too planet shaking, but, as you may recall, digging deep into your phyche, we
noted that the system is, in fact, lifted lifted from those little Polaroid cameras, and great woe would be betided if the ranging thing started going squirrely with ten dollar film packs. Thus, quite a lot of really genuine cleverness has gone into the engineering of the system, which we'll now have a peer at, for those bent on devising applications for the transducer. It should be kept in mind that no matter how slimy one may feel about lifting circuit designs, these ones do work.

**Working With My Foot.**

The transmitted pulse is actually not a single burst of ultrasonic tone, but rather, a careful blending of four carefully aged and mellowed frequencies; eight cycles at 60 kHz, eight at 57 kHz, sixteen cycles at 53 kHz and twenty four cycles at 50 kHz. The whole works plays for one millisecond. This gets around the phase cancellation hassles at any specific frequency.

The receiver also has a neat trick. Its bandwidth is self adjusting. After the outgoing pulse lets loose, a counter starts to increment, generating a sixteen level stair step waveform, which controls the Q of the receiver's bandpass filter. The longer it takes for the pulse to come back, the narrower the filter becomes. Its centre frequency is at 50 kHz when its at its sharpest. Now, what this means is that it is better able to pull a weakened returning signal out of the grass, essentially by cutting out increasingly more of the grass. It also reduces the effectiveness of the multiple frequency phase cancellation fixer at greater distances, but one would suppose that this becomes less of a problem as the light years increase.

There are two grades of transducers available, which are, in probability, two sorts through the output of the assembly line. The better of the two is Instrument grade. There's also Commercial grade beastiles available, which are somewhat cheaper, but with looser specs. Concerning playing with them, the good stuff only costs about seven bucks each, which isn't too heavy. As far as what their capabilities are, the Instrument grade transducers are used in the design kit, so one can be sure they're good for a range of at least .9 to 35 feet.

Your average transducer is .328 inches thick, and 1.690 inches in diameter, or about the size of the lid of a baby food jar. The housing is all natural plastic, guaranteed not to rust, dissolve or reform into a Barbie doll. Its weight is not given in the back of the manual, so I won't include it here. I suppose it's fairly irrelevant anyway.

The transducer is a bit demanding in terms of its desires for voltages of one sort or another. First off, it likes a 150 volt DC bias across its terminals, and a drive signal of at least 150 volts AC. Neither of these involve any real amount of current, though, so little ginchy power inverters and backwards matching transformers are perfectly suitable for juicing it. It exhibits a 400 to 500 picofarad capacitance across its terminals when biased to 150 volts. Under these circumstances, it exhibits a transmitting sensitivity of at least 110 db, and a receiving sensitivity of at least -42 db. It will operate over a range of 32 to 140 degrees, and 5 to 95 percent humidity. Its typical dispersal pattern gives it a pattern that is about 50 db down 30 degrees off axis.

Groovy numbers, man. (Can you smoke it?)

**Footing The Bill.**

The applications for the transducer are limited only by your imagination and the bounds of reasonable intelligence. Yes, I suppose it would make a nice ultra-tweeter, but do you really need one? However, there are all sorts of fairly practical uses for it that come to mind, such as an ultrasonic measuring tape, a parking aid, automatic garage door opener, ultrasonic remote control system...I don't see why it couldn't be used as a doppler intruder alarm thing, too.

And that, yes, that would be a very practical application. Because it could drive a relay. And the relay could drive a solenoid. And the solenoid could be inside me fridge. Yes, lads, and whenever Max came in to satiate an attack of the raving munchies, the solenoid would lock the fridge, and he wouldn't get in. My food would be... no no no, never mind.

Forget it. He'd eat the cat. Stay tuned.
SINCLAIR'S LATEST

Having broken cost barriers with his ZX80 computer, Clive Sinclair now refines and expands his system. John Van Lierde reports.

SOME MONTHS ago (February, 1981 to be precise) I looked at the Sinclair ZX80. The ZX80, I felt, represented a significant step in low cost ready-to-run computers.

The machine I reviewed at the time suffered from some limitations. The major one, its integer only BASIC, severely restricted the number of interested users. Its inability to communicate in ASCII prevented users from adding such desirable peripherals as printers and real keyboards. Lastly, its 1K memory, while suitable for general work, did not allow the programmer to utilize any number of dimensioned or string variables.

Since then, Sinclair has introduced a number of products that make his computers more attractive to potential computer buyers.

New! Improved!

First off is a new version of the miniscule machine dubbed, appropriately, the ZX81. Like its predecessor, the ZX81 embodies many unique features, both hardware and software. The first surprise is the price, almost 40 percent off the unit of the ZX80! How is this done? Is it slave labour? Stolen chips? Hamsters on treadmills? No, it's high tech. Essentially, the secret lies in the replacement of some 18 ICs with a single uncommitted logic array. This done, the entire machine has been reduced to keyboard, RF modulator, and four (count 'em) ICs. These are: the CPU, ROM and RAM and the logic array. Not bad!

The ZX81 board (left) and the ZX80 board (right), notice the difference in parts count.

The Sinclair ZX81 computer. Note that some keys have three or four functions. Additionally, integral functions such as PEEK and POKE have been brought down to the keyboard.

The ZX81 embodies all the standard ZX80 features and then some. Aside from 'one touch' command entry, Sinclair's unique error checking facility and others, the machine now boasts such capabilities as: floating point arithmetic; a full complement of mathematical and scientific functions accurate to eight decimal places; multidimensional strings and arrays; graph drawing and animated display capability. In operation it is similar to the ZX80. Four sockets make the necessary connections to power, cassette input and output, and television. Power it up and it's ready.

The machine comes with the standard 1K of RAM. Needless to say, this is unsuitable for any heavy duty work, and so Sinclair offers a 16K RAM pack to alleviate this heretofore painful space restriction. There are even hints of a disk system somewhere in the future.

Sinclair has also come to terms with the need for hard copy and will be introducing a printer soon. Details are sketchy, but it seems that can duplicate the contents of the video display, characters and graphics. This would mean a 32 character line. Judging from the picture and the description, the proposed printer is of the thermal or static discharge type.

Old Machines Don't Die

But what about ZX80 owners? Sinclair hasn't forgotten them. An 8K ROM is available as a replacement for the original 4K part. Just plug it in. All the ZX81 features are now enabled with the exception of animated graphics. Additionally the aforementioned 16K RAM will also work in the ZX80.

Already the ZX80 has generated considerable interest and there is a growing add-on peripheral market. We have been told that there are such extras available as a keyboard beeper (which is probably quite useful), a $99 (US) printer, and an add-on real keyboard for about $100 (US).
Clive Sinclair with his pocket TV. Ultimately it may lead to 'pocket' computers with graphic capabilities.

A 16K RAM module is available. This is compatible with both the ZX80 and the ZX81.

A preview of the ZX printer. Designed exclusively for use with the ZX81, it will also work on ZX80s equipped with the 8K ROM.

Flat, The Shape Of the Future?
Finally, Clive Sinclair recently announced the development of a flat video picture tube. Initially, it will be produced as a pocket television, but word has it that the flat screen TV will be worked into the ZX computer system. This would result in a small, portable and very powerful system.

Having seen what has been promised, it would appear that ZX computer system is maturing to a level of power and capability at a price that should make it attractive to a large number of people. It’s certainly worth a second look.

**Designer Circuits**

**SIMPLE PHOTOGRAPHIC TIMER**

Although this timing device may seem to be rather unsophisticated, it is a handy little gadget for timing darkroom exposures, or time exposures, or time exposures made on a camera with the shutter set to the "B" position. The unit simply flashes a LED indicator briefly at 1 second intervals. If, for example, one wishes to make a ten second time exposure, then the shutter is opened during any convenient flash produced by the unit, and then closed a further ten flashes have been produced. Adequate accuracy for normal requirements can be obtained in this way.

The circuit is based on the CMOS version of the well known 555 timer device. The CMOS version has the advantage of having a current consumption which is only about one hundredth of that taken by the conventional version, and this is obviously beneficial in a battery powered piece of equipment such as this one. The average current consumption of the unit is actually less than 1mA., giving an extremely long battery life.

The CMOS version of the 555 operates in the same basic manner as the ordinary version, with timing capacitor C2 first charging up to ½ V+ by way of the timing resistors - R1 - R2 - R3. The device is then triggered into the discharge mode, resulting in C2 being discharged through R4 to a potential of ½ V+ whereupon the circuit reverts to its original state with C2 charging up once again. Continuous oscillation thus results. The frequency of operation is adjusted to 1 Hz by adjusting R1, and in practice this is adjusted by trial and error to obtain (say) 60 flashes in a one minute period. Longer calibration periods can be used if better accuracy is required.

The output of IC1 assumes the high state while C2 is charging, and the low state while it is discharging. As C2 charges via R1, R2 and R3, but only discharges through R4, the discharge time is therefore much shorter than the charge time. By connecting LED indicator D1 and its current limiting resistor R4 between the output of the IC1 and the positive supply the required brief flashes are thus obtained.
Our Stereo Image Coordinator made use of a useful device. The 1537A offers some very impressive specs. Keith Brindley explains.

There is always a great deal of excitement generated in electronics on the arrival or introduction of a new circuit, concept or chip, particularly if the system is potentially a field leader. The 1537A chip is just that! The specifications which the device can offer in situ are well above those of any similar preceding systems. Table 1 gives a listing of specifications, which can be obtained in the correct applications.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>DC-200kHz</td>
</tr>
<tr>
<td>T.H.D., 20Hz-20kHz</td>
<td>0.004%</td>
</tr>
<tr>
<td>I.M.D. (SMPTE TEST)</td>
<td>0.03%</td>
</tr>
<tr>
<td>Noise</td>
<td>-90dBv, ± 1dB (worst case, unity gain)</td>
</tr>
<tr>
<td>Overshoot and Ringing</td>
<td>None</td>
</tr>
<tr>
<td>Slew Rate</td>
<td>&gt;10V/µsec, symmetrical &amp; constant</td>
</tr>
<tr>
<td>Input Impedance</td>
<td>20KΩ</td>
</tr>
<tr>
<td>Maximum Input Level</td>
<td>+20dBv</td>
</tr>
<tr>
<td>Gain</td>
<td>0dB (Unity)</td>
</tr>
<tr>
<td>Maximum Attenuation</td>
<td>&gt;94dB</td>
</tr>
<tr>
<td>Control Voltage</td>
<td>0 to +10V</td>
</tr>
<tr>
<td>DC shift vs. Attenuation</td>
<td>&lt;5mV</td>
</tr>
<tr>
<td>Power Requirements</td>
<td>Regulated ± 15V at +25, -33mA</td>
</tr>
</tbody>
</table>

Table 1. The maximum possible specifications available from a 1537A system.

With harmonic distortion of 0.004% and a signal/noise ratio of over 90 dB the system is of course well suited to studio applications, although use in this environment is by no means its only area of involvement. The IC itself seems at first glance, somewhat highly priced at around $22, but nevertheless, it requires few extra components to produce a VCA system of the superb quality (suggested in the specifications of Table 1) and overall represents good value for money to the amateur and professional engineer alike.

Amplifier Or Attenuator

The term VCA is normally used as an abbreviation of the phrase Voltage Controlled Amplifier, but in its simpler modes the 1537A is, strictly speaking, a voltage controlled attenuator i.e. with a maximum gain of unity. The inventors do, however, stress that connection of the 1537A into the feedback loop of an amplifier (such as an op amp) produces a voltage controlled amplifier. The applications section of this article show how this can be achieved.

The operation of the 1537A VCA depends upon the gain control function of a differential pair of transistors as in Fig. 1. The transistors in Fig. 1 are connected at thei. emitters. The current through R3 (I1) is, therefore, approximately equal to the sum of their two collector currents Ic1 and Ic2 through R1 and R2 respectively. The relative bias voltage, Vb, between the two bases determines the relative collector currents. If we now apply an input signal current to the joined emitters we obtain output signal currents through R1 and R2, the sizes of which are determined by the bias voltages. In other words, by altering this bias voltage we alter the size of the output signals.

Figure 2 shows a simplified internal circuit of the 1537A chip giving pin numbers and external load and emitter resistors necessary for operation. There are two basic gain control circuits within the chip, similar to that in Fig. 1 (built around Q1, 2 and Q5, 6) except for three main differences:
- the diode connection of the transistor pair not used for signal output i.e Q1 and Q6, which reduces the distortion due to transistor gain differences.
- the addition of buffers around Q4 and Q8 to reduce loading of the output collectors of the gain transistors, in turn allowing idealised characteristics over the full gain range.
- the use of transistors Q3 and Q7 as voltage to current converters enabling the input to be applied as a voltage rather than as a current.
There is, however, a much more subtle difference, on top of this and that is the use of large geometry transistors. The effect of larger geometry transistors can improve second order intermodulation by as much as ten times for a tenfold increase in transistor size. Noise can also be reduced by about 10 dB for a similar increase in geometry.

This leads us now to the simplest mode of operation of the 1537A using each gain control circuit individually, although the control voltage affects the gain of each circuit simultaneously (Fig. 3).

The ratio of $R_9$ and $R_{10}$ is calculated to allow a control voltage range of 10 volts (i.e., 0 to minus 10 V), altering the gain of the system from 0 dB to about —90 dB. The input impedance of the circuit to applied signal is low and ideally buffers should be placed before this circuit. Although this circuit does not give studio quality specifications it will, however, still produce results in the “high fidelity” range, providing impedance matches are considered.

Figure 4 shows a circuit application which gives a higher impedance input. Also included is an inverting stage in the control voltage link which allows a voltage of 0 to +10 volts to be used for controlling attenuation.

Although any operational amplifier could be used for ICs 1, 2 and 3 in the previous circuit, it should be fairly apparent that the noise, distortion and bandwidth specs of the circuit are limited to those of the op amps used.

Either of the two circuits of Figs. 1 and 2 can be adopted as the voltage controlled gain heart of a stereo system. Their outputs are about 10 dB down on the inputs so necessary amplification should be given before or after the attenuator.

**Coming Up To Scratch**

Now, three more developments to the circuitry can be undertaken to improve the specifications to those of Table 1. Figure 5 shows the circuit of the ideal system capable of these high specs.

Firstly, actively linearised voltage to current sources (op amp 3 and 4 in Fig 5) improve distortion figures when using a wide range of input signal voltages.

Secondly, paralleling of the two individual gain control circuits (i.e., the same input signal is fed to both devices at their inputs and mixed at their outputs) gives a 3 dB improvement in S/N ratio.

Finally, a technique is utilised which is complementary to the previous development of parallel devices, whereby the same input is applied to both gain control devices but 180 degrees out of phase. The two outputs are combined in a differential amplifier to give a single ended output. The differential amp is formed around op amp 6. This technique has the effect of reducing DC shift caused by bias and control voltages and with careful adjustment of RV1, the minimal DC shift now left at the output can be reduced even further.
Fig. 4. A higher input impedance stereo VCA with positive going control voltage.

further to near (if not actually) zero. The prototype circuit shown, upon testing, actually gave no DC shift at all (or at least none measurable on our test equipment).

The complete circuit can be used as an exceptionally high quality VCA whose signal input can be anything from a few millivolts through to about 20 volts pk to pk without distortion. The lack of DC blocking capacitors at the input and output means that the system can be used to control a DC voltage applied to the input. AC signals up to well over 200 kHz are easily catered for, due to the system's wide bandwidth.

The overlay in figure 6 shows the component layout on printed circuit board of the circuit. As far as we know this article is the first of its kind to present a circuit in a form where "experimenters" can benefit easily and directly from the written text while simultaneously using the device in a tried and tested form.

Construction

If the circuit board layout is followed then there should be no problems. IC holders are advisable though by no means necessary. RV1 should be a good quality type (cermet), to assist in setting up the output offset shift to zero, cheaper quality presets can sometimes be tricky to adjust in low voltage DC applications of this nature. Op amps 1 to 4 in the circuit are combined in IC1 and can be of a wide range of types from a quad 741 type (3403) upwards. Obviously, if you wish to obtain the best specs the quality of the op amps are critical. LF 347 or TL 074 will give the best results.

Similarly op amps 5 and 6 are included in IC3 and LF 353 or TL 072 are of optimal quality.

Setting Up

The system should work without any adjustment for an AC signal and varying the control voltage from 0 to 10 volts should give total control over the output amplitude. Some setting up will be required if the input is to be DC, though. This is best achieved by earthing the input. Measure the output voltage using a high impedance voltmeter (it should only be the order of a few millivolts). Adjust RV1 until a complete sweep of control voltage ie from 0 to 10 volts produces only minimal change in DC output voltage. The circuit is now completely set up to accept an input signal in the frequency range DC to 200 kHz. At minimum attenuation the system operates as a unity-gain wide range, high quality buffer, with a reasonably high input impedance and low output impedance. Variation of the DC control voltage over the range 0 to 10 volts will produce over 90 dB of attenuation of the output signal.

If an overall gain is required in the circuit, resistors R18 and R20 can be changed as in Table 2.

<table>
<thead>
<tr>
<th>GAIN</th>
<th>R18 &amp; R20</th>
</tr>
</thead>
<tbody>
<tr>
<td>0dB</td>
<td>10k</td>
</tr>
<tr>
<td>6dB</td>
<td>22k</td>
</tr>
<tr>
<td>10dB</td>
<td>33k</td>
</tr>
<tr>
<td>15dB</td>
<td>56k</td>
</tr>
</tbody>
</table>

Table 2. The values of R18 and R20 to give the required overall gain in the VCA system of Fig. 5.

The control voltage range of 10 volts can be altered as required simply by changing the ratio of resistors R13 and R14 to suit.

To our knowledge, there is no officially recognised standard symbol for a VCA and rather than redraw the whole circuit of figure 5 upon every reference to the circuit we thought it better to invent a symbol for the purposes of this article. A horizontal trapezoid shape appeared to be the ideal symbol, as shown in Fig. 7. It symbolizes the system as a modular buffer amplifier, whose output (symbolized by the top line), decreases as the control voltage (the bottom line) increases. We shall use the modular symbol of a VCA whenever reference is made to the circuit of Fig. 5, although any VCA module of another design should function in the applications which we give.
Use of the 1537A system module as a DC controlled analogue gate can produce many effects. Amplitude modulation of the signal occurs and the usual associated effects are observed. For instance, in Fig. 8 we can see a simple but high quality tremelo unit. Transistors Q1 and Q2 are connected as a phase shift oscillator and buffer, with speed and depth controls whose varying DC output is connected directly to the control port of the 1537A module. The frequency range of the oscillator is approximately 2 to 5 Hz. Altering the values of all three capacitors will change the main frequency, though that stated will give the best results.

The control voltage in the last application was varied as a sine wave of course, but there is no reason why other waveforms e.g. square, could not be used for control purposes. Figure 9 shows a 555 operating in the astable mode.
Fig. 8. A simple tremolo circuit.

Fig. 9. Ring modulator.

Fig. 10. A simple system enabling the construction of a tone burst generator.

mode with a frequency range of approximately 5-50 Hz. The output signal will be modulated with the square wave and the overall product is a computerized type sound if a vocal signal is applied to the 1537A module.

This square wave control can be taken one stage further if the control voltage is the output from a monostable as in Fig. 10. A tone burst generator can be very easily constructed with this mode of operation. In a tone burst, generator, a rectangular envelope 50-500 μS long is formed around a single sine wave frequency of normally 1 kHz. Tone burst generators are useful for testing the transient response of speakers. A push to make switch is used to provide the trigger to fire the multivibrator, producing the correct length pulse which in turn is inverted to form the control voltage pulse, applied to the control port of the 1537A.

The previous applications have all used automatic waveform control of the applied signal to produce the required attenuation characteristics, but this is not a necessary trait. The control voltage can be simply tapped off a variable resistor having the maximum control voltage range (ie 10 volts) across it. In this way, altering the position of the wiper alters the attenuation of the applied signal. The pot acts quite simply as a volume or level control. Ordinary non-DC volume controls can suffer from pick-up problems because the signal itself is being rotated through the pot. As only DC is applied to the pot in this application no pick-up can occur and the control can be remotely mounted from the module with no screened cable being necessary. Figure 11 shows such a volume control.

This remote control facility can be utilised in an audio mixer which includes remote faders for each channel. Figure 12 shows the general idea of such a circuit. An op amp is used as a summing amplifier into which the output of each channel’s VCA is fed and mixed. The mix is relative to the control voltage applied from the remote faders to each VCA. The circuit allows for up to N inputs, where N to practical limits will probably be a maximum of about 12, but with careful layout techniques, there is no reason why this cannot be increased further.

Figure 13, shows an interesting outline to enable digital control of the VCA, say from a computer link. In order that the computer can operate in real-time, ie control of the VCA is not just its only job, it is necessary for the interface to provide a latch for the digital word. The output of this latch is changed to a linear DC voltage by the D/A (digital to analogue) convertor whose output is taken to the control port of the VCA.

The digital latch, once set by a strobe pulse, provides the facility that after the volume required has been found, the computer is free to perform other tasks. When the volume is to be altered, the latch is reset to the new digital input.

The last six applications of the 1537A VCA system have simply shown methods of providing a control voltage (automatically, manually or digitally) to control the module in its function as an analogue gate. The following section begins with the assumption that the control voltage is already present, perhaps by one of the previous methods.
Applications
Consequently the next few circuits show the system in a much more versatile role — not just as an analogue gate, but one in where the system itself becomes part of a larger system. Figures 14 and 15 give details of circuit in which the 1537A module is used in the feedback loop of conventional operational amplifiers to allow voltage controlled amplifiers to be constructed. The resistance values used give gains of approximately 1 to 100 over the VCA control voltage range and an inverting VCAmp and a non-inverting VCAmp can be easily built as shown.

Fig. 12. High quality, remote fader controlled mixer.

Fig. 13. Main components of a digitally controlled attenuator.

Fig. 14. A non-inverting controlled attenuator.

The Aphex 1537A is available only from Octopus Audio, Suite 315, 69 Sherbourne St, Toronto, Ontario M5A 3X7. Cost is $22.00 each postpaid (Ontario residents add 7% P.S.T.).

Note the Motorola MC1537 and its second source variants will not work. The Motorola device is a dual 709 op amp.

BUYLINES
A voltage controlled resistor is shown in the application of figure 16. The apparent resistance, $R_1$, is given approximately by the formula

$$R_1 = \frac{1}{1 - A}$$

where $A$ is the gain of the VCA module (remembering that it has a maximum gain of unity). The value of $R_1$ shown gives an apparent voltage controlled resistance of 7 k to 100 k over the ten volt control voltage range.

The effect of a VCR (voltage controlled resistor) is used in the final two applications as the control element in filter circuits. Figure 17 shows a simple voltage controlled high pass filter. The component values shown filter out all frequencies below the variable limit of 1-2 kHz. Adjustment of the control voltage alters the lower cutoff point.

Figure 18 consists of the circuit of a voltage controlled band reject or notch filter whose depth of notch is adjusted by the control voltage. The component values shown set the frequency at about 300 Hz and depth of notch is variable from 0 dB to about $-15$ dB.

Conclusions

The applications given in this article show the 1537A chip to be a very versatile device. It is remarkably easy to work with, a fact which is borne out by the quality (in technical terms) of the circuitry in the breadboarded fashion of our experimental design work, let alone in the modular fashion allowed by the use of our PCB layout.
That's what I get for buying military surplus equipment – I was about to take off the back to get a look at the circuit, so it committed suicide by cyanide pill.

The instructions said it didn't matter what kind of core you use to wind the coil.

Sure it's capable of plotting! In fact, the minute I plugged it in, it began figuring out how to get you fired and take over your job.

Looks like I got the symbols for 'mega' and 'Micro' mixed up again on my last mail order.

My company has come out with a new device to find out how well your product stands up to vibration. You strap the product to a fat guy with this belt, and then use the projector to show him old Abbott and Costello movies.

I became so absorbed with the flashing LED's and digital displays on the computerized safety devices in my new car, that I drove into a tree.
IN EFFORTS to improve speaker systems a great deal of energy devoted to increasing driver efficiency. Described herein is a speaker design (patent applied for) that promises reduced size and increases efficiency at least ten fold. But before talking about the solution, let’s first consider the problem. This is that at low frequencies the travel required of the diaphragm has to be much further than at higher frequencies. This can easily be seen when looking at a gramophone record groove, where the bass frequency dominates the groove spacing, and can easily be recognized. Now a cone in free air, when driven with a bass note, would automatically take up the distance required. When the speaker is mounted in a sealed enclosure however, the air behind the cone gets compressed every time the cone moves inwards.

Efficiently Up!
The enclosed air resists that movement and tries to return the cone to centre. Reducing the size of the box has the same effect as changing a gas engine into a very high compression diesel, i.e. a much bigger starter motor is now required to turn the engine over. Similarly, with the speaker, we need 12 dB more power per octave from the amplifier, — not for playing louder, but only for compressing and rarefying the enclosed air, and heating it up.

Obviously it is a great waste of good amplifier sound to use it for just that. By raising the acoustical efficiency of the speaker, it is possible to manage with normal amplifier power used with conventional bass speakers, and still reduce the size of the box. However, the difference of 12 dB/oct is still there, and I can produce all the enclosed air, however,
the same bass level could be produced with 3W!

For every position of the cone there is a corresponding compression or rarefaction of the enclosed air, which acts as a restoring or excess centering force. The force needed to overcome this is the same for every cycle, and is therefore predictable. It can therefore be overcome by a force acting in the opposite direction, and by so balancing it cancels.

Thus, all that is necessary is to add two more coils, i.e. one to each end of the voice coil, and connect these two 'balancing coils' to a DC supply. When the cone now is moved off-centre by the voice coil, the balancing coil at one end moves closer towards and into the magnetic flux gap, which then produces a force pulling it further, and assisting the voice coil to overcome the excess centering force of the enclosed air. Naturally the balancing coils have to be wound with suitable shape, and the DC supply has to be adjusted so that the force produced is just enough to overcome the resistance of the enclosed air to the movement of the cone. If too much DC is applied, then the cone would tend to be unstable and possibly move on its own, and with not enough DC we would be back to square one, and most of the work would have to be done by the voice coil, i.e. the amplifier, and bass would be lost unless especially boosted.

By adjustment of the DC supply therefore, the balancing forces can be adjusted to compensate for just the right proportion of work to be done, and thereby relieve the amplifier of this pump load represented by the enclosed air. Furthermore, by the simple expedient of limiting the length of the balancing coils, their effectiveness is limited to normal excursions of the cone, thereby preventing excessive swing.

Brake to Stop

Practically every modern car has servo-assisted brakes, and this is taken for granted. I therefore see no reason why not to apply the same sort of solution to bass speaker work load. There is no difficulty in supplying DC, which, for car speakers, can be taken from the car battery without trouble, and from rectified lines for home equipment. The alternative the conventional approach of the big box, with walls that are difficult to prevent from vibrating and thereby colouring the sound, and paying for the woodwork and room space required. But in the mobile field, there really is no choice.

Fig 4. A much simplified and improved version with utilising virtually a standard loudspeaker chassis, but where the coil is much much longer and carries both DC and AF signals.

In Summary

A transducer with electro-magnetically extended bass response, with a vibratory diaphragm, incorporating adjustable means to oppose the centering force exerted upon the said diaphragm by the enclosed air of the transducer's sealed enclosure, said means comprising a magnet assembly defining a gap across which a magnetic flux extends to form a magnetic field, two coils secured to said diaphragm and movable axially in said gap, said coils' operative length limited to the designed travel distance of said diaphragm, and a DC supply for said coils, adjustable for balancing the air stiffness of differently sized enclosures, and lowering of 'main system resonance' to that exhibited by conventional, normally much larger enclosures.

Howzat?

It's a custom IC. If you look close enough, you can see the tiny little chrome exhaust pipes.
Having expounded upon the subject of gates, Ian Sinclair now strings them together.

GATES are designed to give a signal out for a definite combination of signals in. Railway signalling, for example, has for years depended on mechanical gating systems, so that signals cannot be set to accept a train until the points have been correctly set. Electronic gates are smaller and faster to operate, so that we can make gating actions which are much more complicated, all from the set of gates we know, the AND, OR, NAND, NOR and NOT.

Just for starters, look at the set of gates in Fig. 1. This shows four inputs, all to NAND gates, with the outputs of the NAND gates feeding into a NOR gate. What is the truth table for this lot? A drop of Boolean Algebra can solve this fairly quickly, but it’s the hard slog for us. Four inputs means sixteen possible combinations ($2^4$) of inputs, all different, so we start by writing them all down. It’s easier if we’re fairly methodical about it, so we write columns for the numbers in order, and in the column write the binary numbers in sequence up to 1111. A quick count should now show that we have 16 lines of figures, and provided that we have kept to the binary sequence, we should then have every possible combination of ones and zeros. Now draw two more columns for the outputs of the NAND gates, and label them (X and Y) and one final column for the output Q of the NOR gate. The table is now ready to complete, the worst part is over.

Starting with the NAND gate whose output is X, ignore inputs C and D and concentrate on inputs A and B. X will be at zero only when A= 1 and B= 1. For all other inputs, X= 1, so that we can complete the X column fairly quickly. Now ignore A and B and fill in the columns for C and D, with their output, Y. Once again, because the gate is a NAND type, Y is zero only when C and D are both 1; all other values of Y are 1, and can be marked in.

Now for the last column. The action of the NOR gate is that the output is low if either input is high, and will be 1 only when both inputs are low. There’s only one line in which X=Y=0, and that’s the last line. For this logic circuit, then Q= 1 for A = B = C = D = 1, so that the circuit is a 4-input AND gate. Simple, really!

The point of all this is that with the basic gates we can make a circuit with any sort of truth table we want, so that the output will be 1 for whatever set of inputs we like to specify.

De-Luxe, Piping Hot Logic
Suppose, for example, we have a central heating system that is controlled by logic gates. The system has a boiler
which can be switched on by a relay which clicks over when the gate that operates it goes to logic 1. The hot water from the boiler will heat the radiators only when it is pumped through the pipes, and the pump is switched by another relay similarly arranged so that it can be operated by the output of a logic gate. How about inputs? Well, we could imagine that this is a de-luxe system and that we have detectors for outside air temperature, inside air temperature in all rooms, water temperature, and also, of course, a time switch. What sort of system could we design?

To start with, the time switch could operate a bistable that switched AND gates. That way we could have the heating pump operated by one set of gates during the day and another set during the night — a bit of an improvement on the usual single thermostat. Then we could make good use of the temperature detectors in the rooms — we could, for example arrange the gating so that we had a 1 output if two out of three selected rooms were at a lower temperature than the set amount. The truth table for such a 2 out of 3 arrangement is shown in Fig. 3. The gate arrangement shown alongside should produce this truth table — check it out for yourself.

Of course we could arrange that the rooms we chose for the night temperature measurements were not the same rooms as we used for the daytime measurement, and we would also want to ensure that the water was not pumped around when the air temperature inside was high enough. Another thermostat senses the temperature of the water in the hot-water cylinder, and the boiler fires if the pump is working OR if the cylinder temperature is low. Complicated? Not really, and to do the same actions by any other methods would be a nightmare — which is why so many houses waste heat needlessly.

Practice Makes Perfect
Logic circuits can be built with separate transistors (these are called discrete circuits) but it's much simpler to make use of the ready-made ICs which are cheap and easily obtainable. The best types for experimental work are the ones referred to as TTL (Transistor-Transistor Logic). A typical circuit for a TTL gate (it's a 2-input NAND gate) is shown in Fig. 4. The gate consists of four transistors, a diode, and four resistors, and four gates like this can be packed onto one tiny silicon chip with plenty of room left. The IC coded SN7400N contains just this package of four NAND gates.

The action is something like this. The transistor Q1 at the input is made with two separate emitters, taken to different connections, A and B. We can make more emitters, so a seven-input is obtainable. The base of Q1 is connected to the supply voltage through R1, so that if either emitter of Q1 is grounded, the transistor can conduct between collector and emitter. The collector, though, is connected directly to the base of Q2, so that when A or B is ground and Q1 conducts, this has the effect of connecting the base of Q2 to earth, switching Q2 off. O.K., so far? If A or B is low, Q2 is off; if both A and B are high, Q2 is switched on.

When Q2 is off, its collector voltage is high, so that Q3 is switched on. The emitter voltage of Q2 is low, so that Q3 is off. The output is high, connected to +5 V through Q3. When Q2 is on, its collector voltage is low and its emitter voltage is high, so that Q3 is off and Q4 is on. Perhaps you'd like to make up a truth table for each part of the circuit just to convince yourself.

Fig. 4 A TTL NAND-gate circuit.

Now this type of circuit may look rather odd compared to most of the transistor circuits you've built or seen, but there are good reasons. One is that these circuits are easy to make in IC form, another is that they switch over very quickly — on an average it takes one of these gates only 13 ns to switch over — that's just the time it takes a beam of light to travel the length of a fairly large room. It's these types of fast-switching circuits that are used in most computers at the moment, although pocket calculators and micro-computers use a different (MOS) type of circuit which is not so fast-switching.

The Riot Act
The way these circuits are designed, though, means that we have to use them correctly, so here are the rules.

**Rule 1.** The supply voltage has to be 5 V. You can get away with 4.5 V, but you can't get away with 6 V. The supply should preferably be a stabilised 5 V power supply. Reason? The inputs are always to the emitters of transistors with the bases connected to supply voltage. If you use a 6 V supply, far too much base current will pass when an emitter grounded. Remember that the base current is limited only by R1 in Fig. 4.

**Rule 2.** Inputs of gates have to be supplied either from the outputs of other gates or from some switching arrangement that will connect them either to earth through a large value resistor (anything over 1k), then it behaves just as if it had been left unconnected or connected to +5 V. The reason is that the input circuit is like that of an emitter follower output, and the emitter tries to follow the base. Inputs from switches, relay contacts, or transistor collectors are useable.

**Rule 3.** The output of a gate will switch anything from 5 to 10 inputs of other gates. This is called the fan-out of the gate, so that the gate with a fan-out of 10 will drive ten more gate inputs. If you want to use the output of a gate, to drive a relay, a power transistor should be used so that the power transistor operates the relay, and the gate operates the transistor. The reason this time is that the tiny transistors inside the IC cannot be expected to handle a large amount of power.

For Beginners
At this stage of the game it would be good to get some actual hands on experience. There are many excellent books and circuit articles on the topic. Three Babani books: No 224, 50 CMOS IC Projects; BP78, Practical Computer Experiments; and BP84, Digital IC Projects. These are available from ETI. Two excellent references are Don Lancaster's TTL and CMOS Cookbooks, published by Sams books and available from many retailers (but not ETI).
The TTL circuits which are so useful for learning about digital logic are not ideal for all applications. For one thing, they need a well-stabilised 5 V supply, and 5 V is an awkward figure for the experimenter who has to rely on batteries. Another snag is that TTL circuits take quite a lot of current. The big plus factor for the TTL circuits from our point of view is that they are easy to handle, readily available, and not easily damaged.

Logical FET-Tish

There’s another family of logic ICs, though, called variously CMOS, Cos-Mos, MaCMoS, and so on. Unlike TTL circuits which use ordinary (bipolar) transistors in integrated form, CMOS ICs use MOSFETS (Metal-Oxide-Silicon FETs) in integrated form. These FET circuits can be used to make up the usual range of gates and bistables that we expect to use, and in addition a few circuits (such as transmission gates) that are not possible with TTL circuits.

What makes these CMOS circuits attractive, though, is that they can be operated on voltages ranging from about 4 V up to 12 V, so that the popular 9 V battery can be used as a power supply for most CMOS circuits. In addition, the use of FETs means that the input resistances are very high, and CMOS circuits can be operated with very low currents. A CMOS output can drive a large number of inputs, because practically no current is needed. This also is a bonus point for battery operation, because it means that CMOS circuits take very little battery current and batteries have a long life unless the circuit includes components (like LED displays) which have a greater appetite for current. Incidentally, the name CMOS comes from Complementary MOS, because the FETs that are used are of two types, P-channel and N-channel, corresponding to PNP and NPN bipolar transistors respectively.

With so much going for them, why don’t we use CMOS for all our digital work? Well, we do use them a lot, and you’ll see them used in ETI projects, they’re also used in all pocket calculators and in digital watches, but they are not the ideal type of ICs for learning about digital circuits. The reason is the very high input resistance. As we mentioned earlier, any electronic component which has a high input resistance is easily damaged by the electrostatic voltages which exist on your hands, on insulating materials, and on any isolated prices of metal — any metal that is not connected to earth by a resistance of less than a few meghoms. The result is that if we pick up a CMOS IC and touch the pins — it might die. No the best introduction to digital logic circuits, is it?

We get around the problem in two ways. One is that the circuits have built-in diodes which help to short-circuit excessive voltages. The other is the fact that damage can occur only when one lead is at a very different voltage from another. Now when the IC is connected into its circuit, all of the pins will be connected through resistors either to ground or to supply voltage, and the voltage between two pins can’t be more than the battery voltage, which is safe enough. Our main problem, then, is just to get the darn thing into circuit in one piece. CMOS ICs come packed with their pins embedded in plastic foam. It’s not any old foam, but a conducting material that makes sure that all the pins are shorted together, keeping them all at the same voltage. Keep the ICs in this and they’re safe, come sparks or lightning.

Do Not Touch!

Now for the awkward bit — how do we put them into the circuit. Well, we build all the rest of the circuit first, checking to make sure that each pin of the IC will be connected to a part of the circuit which has components connected, or is grounded. The CMOS IC goes in last, and there two ways of dealing with this. One way is to solder IC holders into the circuit instead of soldering in the ICs directly. We then hold the ICs by the ends of the case, fingers away from the pins, whip off the plastic foam, and plug in the ICs, making sure that we’ve got them the right way round. Unless we are particularly unlucky we should be able to do this without touching any of the pins. The other method is direct soldering. The negative in the board is connected to ground through a flexible wire fitted with alligator clips. The ICs are fitted, one at a time into their places, and the pins are soldered in one at a time using a grounded soldering iron. The ground pin of the IC is soldered in first, then the + supply pin, then all the others. This is no more trouble once you have had a bit of experience, but the less experienced constructor is advised to use holders at first — apart from anything else, it’s a darn sight easier to remove ICs.

Glow-Worm’s Benefit

One little item we haven’t touched on yet, how do we know when a gate or bistable output is high? Voltmeters being the price they are, we need some sort of display. For transistor circuits, as good a method as any is a 6 V 60 mA cycle dynamo rear light bulb. If we use 6 V supplies for our transistor circuits, then a 6 V bulb in series with a transistor collector will indicate when the collector voltage is low (bulb on), Fig. 5a. The trouble with this is that 60 mA is rather a lot of current to have to pass just to indicate whether a transistor is on or off, and it’s certainly too much to load onto our TTL ICs.

Fig. 5 Displaying a binary digit. (a) transistor-and-lamp, (b) LED symbol, (c) LED typical characteristics. This LED has a forward voltage drop of 2.1 V at 12 mA. Note the low peak reverse voltage of only 3 V. LEDs must always be protected from reverse voltage.

Books are a great way to go further in digital electronic. Here are a few...
For most display purposes, then, we make use of LEDs. The name is short for Light-Emitting Diode, and that's just what they are - diodes that emit light when current passes through them. These aren't silicon or germanium diodes, but they are P-N junctions made using compound materials such as Gallium Arsenide or Indium Phosphide. It just happens that crystals of these materials are transparent, so that any light generated happens to be visible to the eye.

![LED diagram](image)

**Fig. 6** The seven-segment display.

Until Death Us Do Part

electron and a hole find each other and live happily ever after. In normal diodes or transistors we try to avoid recombination like the plague, because it removes electrons and holes from circulation. When recombination takes place, energy is released, the same amount of energy as was needed to separate the electron from the hole in the first place. As it happens, the amount of energy that is released is just the right amount to create a light ray; the colour of the light depends on the amount of energy.

LEDs behave otherwise like any other semiconductor diodes, but they need a higher voltage between anode and cathode to conduct, about 2 V for some types. The symbol is shown in Fig. 5,6 along with typical data.

The LED principle is also used in making seven-segment displays (Fig. 6) which, as the name suggests, have seven bar-shaped strips of LED. These can be used to display all the numbers 0 to 9, and also a few letters, and are used to show the outputs of bistable counters. Wait, though, bistables count in scale of two, and these displays are decimal - something wrong here? There would be, but as it happens there's an IC which acts as a binary to seven-segment converter - put in a binary number and out come the voltages which light up the correct strips of the display to show the decimal number. The truth table, shown in Fig. 7, looks a bit fearsome, but it's all done with the usual set of NAND'NOR and NOT gates.

Right now, another type of display is becoming available, though still a bit pricey. This is the LCD display. LCD means Liquid Crystal Display, and the liquid crystals are curious substances (related to amino-

![LCD example](image)

A seven segment incandescent display. Seven segment displays come in all types, fluorescent, LED, LCD, plasma as well as incandescent.

![Truth table](image)

**Fig. 7** Binary-to-seven segment decoder truth table. The number 1 under a segment letter (a to g) indicates that segment is lit. Note that a four-input binary number can have values up to 15 (1111) but only a count of 9 is displayed by this decoder. Hexadecimal decoders display letters to indicate the numbers 10, 11, 12, 13, 14 and 15.

acids, if chemistry grabs you) which can be turned from opaque to transparent by applying a small electric field. These displays can be made into the seven-segment pattern, and have the great advantage that they need very little current. Unfortunately, they need a high-frequency AC supply, and the life is limited because the liquid crystal material is broken down by sunlight. Watch displays have a ultra-violet filter to extend the life of the liquid crystals, but two to five years is reckoned a good life time.

ETI – JUNE 1981
IF YOU INDULGE in the practice of reading product reviews, you'll have noticed that, in reviewing loudspeakers, frequency response is reported for the on-axis condition as well as for specified degrees off-axis, usually 30° and 60°. Alternatively, the on-axis response may be reported, along with a polar response showing directivity at different, arbitrarily selected frequencies.

Generally speaking, most manufacturers appear to aim for a wide polar response at all frequencies. Indeed, reviewers will usually draw attention to this characteristic, in such a way as to imply that wide polar response, or dispersion, is a virtue in a particular speaker, or that lack of same is a fault.

One gets the impression, then, that wide dispersion, uniform with frequency, is a Good Thing, and there are those who would go so far as to suggest that it is the most important single characteristic, assuming that other characteristics such as frequency response, distortion, etc., are "reasonable", whatever that means.

It is also common practice to place a pair of loudspeakers flat against an end or side wall of a room, sometimes angled inwards a little, by an amount which is calculated using a technique called "by guess and by golly", to the accompaniment of much crossing of the fingers. A variation of this arrangement brings the speakers forward and away from all walls, the results judged by ear, and rationalized by reference to "boundary reflections" and similar esoteric terms said to enhance the imaging process.

Not long ago I had occasion, in a dealer's showroom, to audition a pair of speakers, highly regarded in avant garde circles, whose manufacturer recommends that they be placed flat against the wall. The salesman pulled them out from the wall, about a third of the room's length, because there was no other way of using them.

So much for optimum placement.

A Toronto dealer asks, disdainfully, in a television commercial: "Are you a robot? A robot selects audio components by a computer readout. A human being uses his ears". We are shown what purports to be his showroom with customers apparently selecting speakers by ear. Too bad they can't have a computer readout instead; with the random array of speaker placements they haven't a prayer of making a valid judgement by ear alone.

Obfuscation!

Evidently, stereophonic reproduction is not very well understood by many people in the business. Those of you who visited this corner last month will recall that sound localization is accomplished by a complex process of interaural level and time differences, either together, or with one or the other predominant, depending on frequency. Thus, binaural mechanisms are used to localize single sound sources, although several individual sources may be perceived simultaneously.

In reproducing stereo information, we do not attempt to recreate each individual sound source. Instead, we create the illusion of each sound source by presenting to the ears two sonic signals in such a way as to reach the listeners' ears with the same relationship which a real individual source would present to each ear.

Thus, a front and centre source would arrive at each ear with the same intensity and at the same time. So, we must arrange for each channel to deliver a signal to the ears with the same relationship, thus fooling the listener into hearing a sound from front and centre.

If a signal is supposed to appear somewhere to the right of centre, then a signal from the right channel must be louder and/or arrive slightly sooner than the otherwise identical signal from the left channel. This is reasonably easy to accomplish if the listener is equidistant from each speaker.

But what if he isn't?

Optimum Listening Field

Much is said about the sound field produced by musical instruments and loudspeakers. But what of the listening field? Obviously, it's quite possible to arrange for a single listener to be placed equidistant between two speakers, but since two people cannot occupy the same space at the same time, except perhaps at the Outer Limits of the Twilight Zone, it becomes quite difficult for several persons to share the same listening experience with equal satisfaction.
Fig. 1 shows the effect on a centre image of listener position. It's quite apparent that the only listeners who could perceive correct localization would be those along the line $C_0-0_0$, and the further from $C_0$ the listener is the narrower the total image width. As the listener moves to either side the speaker on that side becomes more prominent and the far one's output becomes inaudible except for signals radiated only from that speaker. The net result is an image in which only left and right can be localized, and the centre sounds shift to the nearest speaker. This is particularly true for middle and high frequencies, but even bass suffers from this effect due to phase differences.

A Different Angle
The solution to this problem lies in angling the speakers inward toward the listening area. This is fairly common knowledge, but usually the methods used are cut and try, and often unsatisfactory. As it turns out, this is due to the fact that for this to work the speakers must have the correct dispersion patterns at all frequencies.

As it happens, James M. Kates, formerly of Acoustic Research, has an excellent paper in the November 1980 issue of the Journal of the Audio Engineering Society, available at most major public libraries, dealing with the subject of optimum dispersion patterns for use with a variety of listening geometries. One of the more interesting aspects of this work lies in the need for a radiation pattern at low frequencies which is narrower than at high frequencies, with the provision that the front of the lobe should not begin to fall off as rapidly. Moreover, the greater the angle between listener and speakers, the narrower the beamwidths must be (Fig. 3-6).

These requirements are completely at odds with conventional practice.

Indeed, it can be quite difficult to achieve a narrow beam at low frequencies with single drivers.

But, to return to the subject of placement and orientation, it's apparent that, for a central listener, arrival times and intensity are equal for identical signals whether the listener is on axis or off, and the actual radiation pattern is immaterial. Only frequency balance is affected.

Suppose a listener is located at the extreme right along line $D_2$ of Fig. 2. Suppose further that the left channel speaker is arranged so that the listener is on axis, and the right channel speaker is oriented to the same angle $a$. If the right channel speaker's response off axis is down by a sufficient amount, the on-axis signal from the left speaker will appear to be equal, thus preserving the central localization. As the listener moves closer to the central position he will move off axis from the left speaker, and closer to on-axis for the right speaker.

If the patterns are symmetrical, and the shapes appropriate, the image will remain stable.

If a room is arranged in such a way that the maximum listening distance involves listeners at the rear wall, and their maximum off-centre position is extreme left or right, it follows that the speakers should be oriented to the appropriate opposite corners of the room, and for maximum separation should be placed in room corners.

I am aware that corner placement presents advantages and disadvantages, and that such a placement is not always the best one from the standpoint of speaker/room interaction, but the angular relationships still hold.

It will be noted that for short distances $Y$ relative to $D_3$ in Fig 2, the level differences between speakers will greater and the angle $a$ smaller, than for longer distances. This accounts for the differences in required beam widths for different optimum angles. A short distance $Y$ requires a narrow beam precisely because we need to bring down the level of the near speaker by a greater amount than for a long distance $Y$, where the differences are less.

The Shape of Things
It should be apparent, too, that for any listening distance other than the one for which the speakers and their orientation have been optimized, the satisfactory listening field width $2D_2$ is bounded by the axis of the speakers. This is seen when you consider a listener moving from the extreme right hand position along the axis of the left channel speaker. As he moves closer to front and centre, he moves to a more nearly equidistant location between speakers. At the same time he moves closer to the on-axis position of the right channel speaker, thus preserving localization, assuming of course that the combination of listening angle and recording characteristic is such that the sound field does not break up into separate left and right sources.

Thus, the most satisfactory listening positions are found within a triangle bounded by the speaker axis and $2D_2$.

The same listener moving towards the rear and centre positions will be moving off axis for the left speaker and nearer to on-axis for the right speaker but will never quite arrive at an on-axis location. Rear listening areas are therefore less well defined, but even so the shift in balance will be such that localization will remain substantially unaltered if the rear boundaries parallel the opposite front boundaries.
I am presently building a “Noise Reduction System” and “Dynamic Range Expander” using the Signetics NE570 Compander IC.

The design that I am using is a Signetics design, similar to the ETI design, except that the internal 741 Op Amp is bypassed by an external high performance Op Amp, to improve performance.

I would like to use an 18 dB/Octave hp/lp filter with these circuits, enabling me to tailor the control capacitors of the compander IC's for optimum control for each band. The output of each circuit will then be added in an Op Amp Mixer to restore full compressed/expanded bandwidth.

My question is, What will be the effect, due to compression and expansion at the crossover point.

R.K. Calgary

The way I read this letter, you plan on a complementary system, with bass and treble processed separately and independently. This is the same basic approach used in the Dolby “A” system (with more channels), and DBX using a Model 2BX Compander.

Since the slope of the filters is not infinite, signal components at or near the crossover will modulate both channels to some extent. At the crossover point this will not matter but at frequencies slightly to either side there will be some effect.

I would suggest using an adjustable crossover. Start at 1 kHz and experiment upwards. The idea is to select a point at which normal frequency distribution results in minimum energy. Thus, you would not select either 500 Hz or 5 kHz.

I’d like to know how it works out.

All the drawings are from the Journal of the Audio Engineering Society, Volume 28, No. 11, November 1980.
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Chucking Small Bits
Theo Boon
A major problem in drilling printed circuit boards is finding some method of holding 3/64" and 1/32" twist drills in a standard 3/8" drill chuck. The author (being a machinist) found that roll pins serve as excellent sleeves (check the yellow pages under Machine Shop Supplies).

Incinerated ICs – Stopped!
B. D. Dever
Now here's a good idea if your soldering iron is a bit too hot for soldering delicate components to a printed circuit board – why not use a standard light dimmer between the iron and the wall socket?

Electronic Switch
S. Yacu
This circuit provides remote switching of up to eight loads, and uses only two switches for selection. One switch is used to select the load to be controlled, the second controls whether the load is energised or not. If the state of one of the loads needs to be changed, SW1 is depressed until the number of the load appears on the 7-segment display. The decimal point then indicates whether or not the load is energised. To change the state of the load, SW2 is depressed (pressing SW2 again will change the load's state again).

The circuit is based on a 7442,1 of 8 multiplexer and a 7490 binary counter. When SW1 is closed, the Schmitt trigger IC1 will oscillate and clock the 4-bit counter. This drives the 7-segment decoder and the 1 of 8 multiplexer. The outputs from the multiplexer are inverted and fed to the J-K flip-flops. When SW2 is pressed and released, a pulse will occur at the collector of Q10. The pulse will clock the selected flip-flop and activate or deactivate the relevant relay driver transistor (Q1-8).
Wide Range Voltage Controlled Oscillator

Any section of IC1 can be used but all unused inputs must be grounded — otherwise the CMOS will pick up line hum and operate in its linear region, overheating as a result.

With the values shown, a frequency range of about 50Hz to 2kHz is obtained — just right for an audio sweep oscillator. If the mark/space ratio is unimportant, it can go down to 1Hz.

The control voltage, which ideally should be in the range 1.5V to 3.5V, is applied to the power supply connections. IC2 is used to square up and buffer the output.

Ten-minute Timer
Roger Harrison

The circuit is a hybrid Schmitt trigger, using a FET and a bipolar transistor. Initially, Q1 will be on and Q2 will be off. The output will be high (+12V). The timer is initiated by pressing S1. C1 will rapidly charge to -12V and Q1 will be cut off. Q2 will then turn on.

When S1 is released, C1 discharges through R1 until the voltage across C1 equals Vp of Q1. The circuit will now change state and Q2 will turn off rapidly, providing a suitable output step which can be used to operate a relay driver or any external circuit.

A delay of approximately 10 to 12 minutes can be obtained with the values shown if the Vp of Q1 is around 1.5 volts. Longer delays can be obtained by using a FET with a lower Vp and increasing the value of C1.

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<thead>
<tr>
<th>Y Deflection</th>
<th>X Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth DC - 10 MHz (3 dB)</td>
<td>Timebase: 0.2s - 0.2 µs/cm</td>
</tr>
<tr>
<td>Overshoot: Less than 1%</td>
<td>Triggering: 2 Hz - 30 MHz 3mV</td>
</tr>
<tr>
<td>Sensitivity: 5 mV - 2V V/cm</td>
<td>Auto + level control</td>
</tr>
<tr>
<td>Input Imp: 1 M ohm</td>
<td>Bandwidth: 2Hz - 1 MHz</td>
</tr>
</tbody>
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Component Tester: For single components and in circuit
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Circle No. 10 on Reader Service Card.
One Contact Touch Switch

G.N. Durant
The switch is operated by stray line hum, connected to the touch plate when briefly touched. The hum is coupled to the input of IC1a (used as an inverter) via R1 (a low pass filter). The output of IC1a is not sufficient to operate the final stage, so it goes through a Schmitt trigger (IC1b,c). Once the trigger output starts to change, R3 provides the trigger for a rapid change.

I2 is a seven stage ripple counter. Q1 is driven from the output of the seventh stage via R5 (current limiter resistor). C2 and R4 reset IC2 at switch-on so the outputs are all low and the switching transistor is off. When the touch-plate is touched, IC2 will receive a 60 Hz signal. At pin 3 the logic state changes every 64 pulses, switching Q1 on and off. The plate is touched until the desired state obtained and then released.

Q1 sends a pulse through to IC3, a solid state CMOS switch. This can be fed via an inverter if desired. The switch must not be used at more than its supply voltage - up to 15 V. The 'off' switch resistance is about 10^13 ohms and the 'on' resistance is about 80 ohms at 15 V VDD (at 9 V VDD it is 120 ohms).

Tech-Tips is an ideas forum and is not aimed at the beginner; we regret that we cannot answer queries on these items. We do not build up these circuits prior to publication.
ETI is happy to consider circuits or ideas submitted by readers; all items used will be paid for. Drawings should be as clear as possible and the text should be preferably typed. Anything submitted should not be subject to copy right. Items for consideration should be sent to the Editor.

ETI – JUNE 1981

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Circle No. 2 on Reader Service Card.
Magnetic Light Dimmer
T. Hopkins

A partial solution to the problem of leaving lighting on unnecessarily is to have a reset-table timer in place of a switch. However, the choice of delay is difficult, particularly when the room may be used continuously.

Ideally, it should be impossible to leave the room without turning out the light. One solution, shown in Fig. 1 is to build the circuit into a wall box and carry a small magnet on a keyring. When the magnet is placed over the reed switch, the lights are turned on and, if the circuit is mounted on a steel front panel, the magnet will stay in place for as long as is required.

The magnetic dimmer shown in Fig. 2 allows a choice of six different light levels depending on which reed switch is operated. The resistor values shown were chosen to suit the available triac. Other triacs may require changes to some of these values.

The reed switches used measured approximately 1.125" and were mounted on a piece of tinplate with epoxy resin (Fig. 3). The front was then covered with a thin layer of plastic. A magnet of ½" diameter was used to operate the dimmer.
Automatic Antenna Retract
Ian Hawke

This circuit was designed to retract automatically a motorised car antenna every time the ignition is turned off. With ignition on, relays A and B are energised (total current drain about 100 mA). When the ignition is turned off, relay A is turned off and 12V from the battery drives the antenna down and charges C1 via R3. With the values shown for C1 and R3, after about a three second delay relay C is energised and interrupts power to relay B, removing supply voltage from the circuit. This circuit suits the two-wire control motorised antennas commonly available. The values of R2 and R3 may need to be adjusted to suit different motors as the retraction time varies.

**IGNITION SWITCH**

(+12V)

**RLA1**

D1

R1 22R 1W

RLB1

**RLC1**

**RLA2**

D2

O1

BC108

R2 56R 1N

C1 570 25V

**D1,2,3**

G1

RL1,2

1N4001

2N3904

Coil resistance 250R or greater. Contacts to suit.
VLF Sine Generator
G. Loveday

Generating very low frequency sine waves (i.e. less than 0.1 Hz) presents several problems. Timing capacitors usually have to be large valve electrolytics, any amplifier used must be D.C. coupled, and the amplifier’s input impedance must be very high. One standard method is to first generate low frequency square waves, and then to shape these into an approximation of a sine wave by the use of several non linear devices, such as diodes. The circuit shown in Fig. 1 is a relatively simple approach based on the familiar Wien bridge. An n-channel FET and a pnp transistor are arranged in a DC coupled circuit and the voltage gain is determined by the negative feedback R3 and R4. The gain need only be about three, thus if the bias required by the FET is 3V the output level will be approximately half the supply voltage.

Since R1 can be a high value resistor the value of the capacitor is only 1u5 for sine wave outputs of 0.01 Hz. This capacitor is available in polycarbonate. The amplitude of the output can be adjusted by RV1 to give low harmonic distortion and to be about 10V peak to peak. As expected, with this Wien bridge circuit, frequency stability is good with changes in both supply voltage and temperature.

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