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FEBRUARY 1979

2nd Anniversary Issue

Semiconductor Industry: Future of Components

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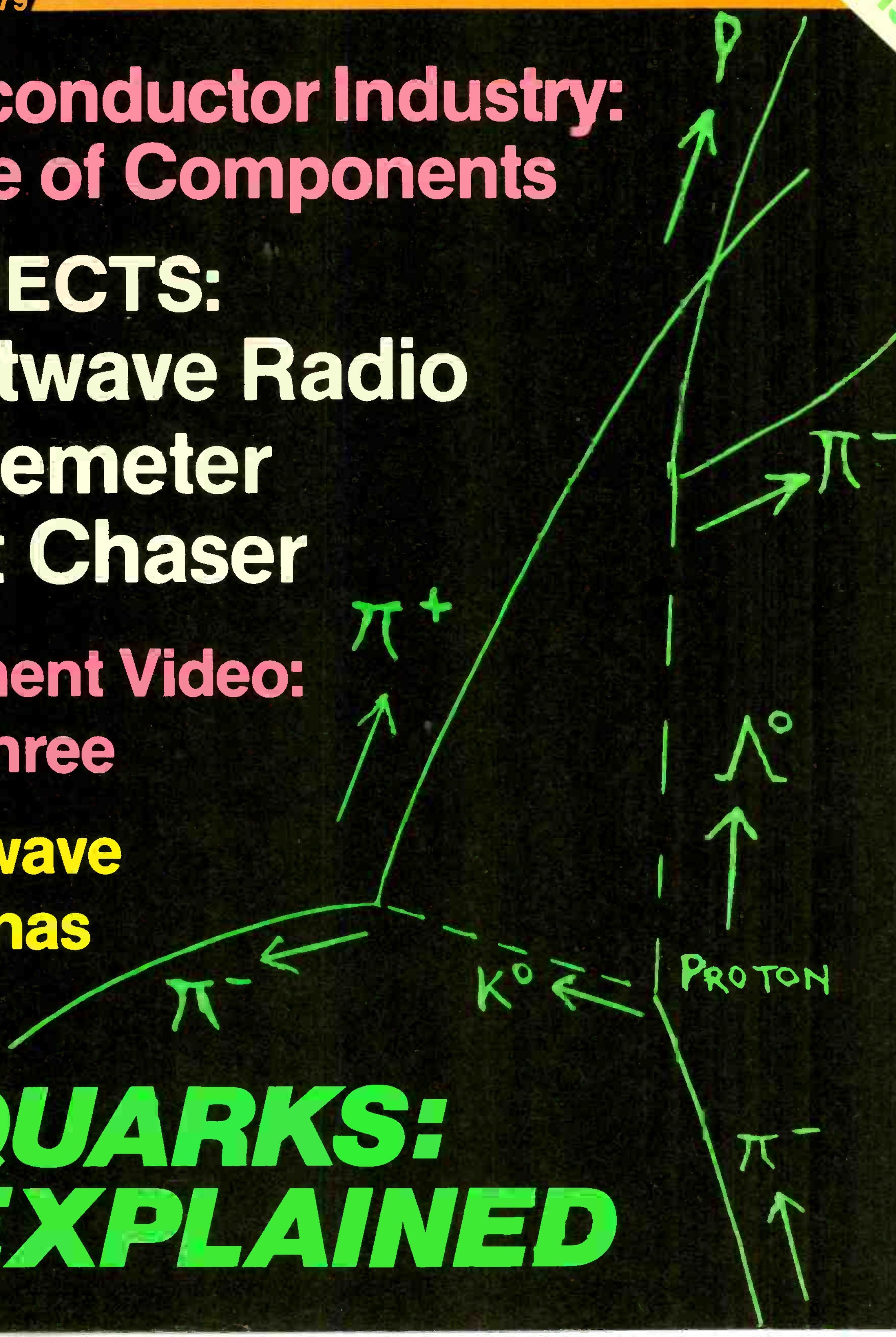
Shortwave Radio
Phasemeter
Light Chaser

Basement Video: Part Three

Shortwave Antennas



QUARKS: EXPLAINED

Vol. 3. No. 2.
FEBRUARY 1979

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PROJECTS

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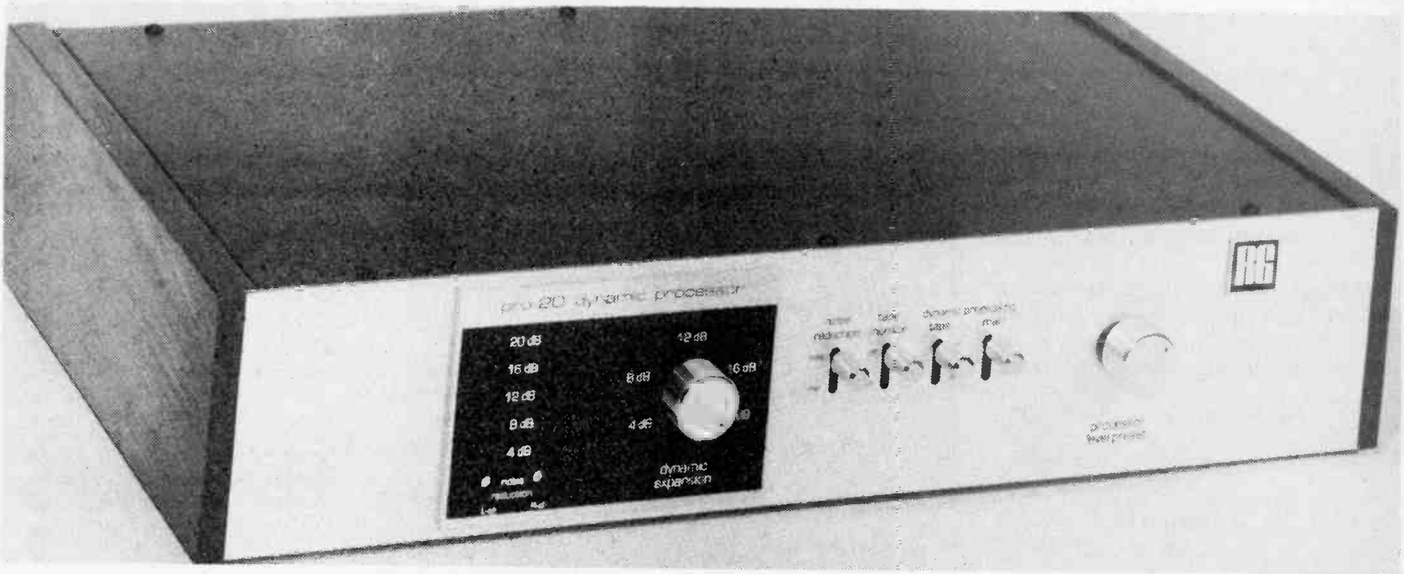
INFO & MISCELLANEOUS

NEWS DIGEST



Dynamic Processors

RG Dynamics has introduced a new series of Dynamic Processors. The features of the Pro-20 include: variable expansion from 4dB to 20dB with adjustable noise reduction (for use with records, tapes and FM); IM distortion less than 0.05%; independent left and right channel processing; and a patented design to eliminate pumping and breathing effects. The Pro-20 has complete tape facilities which include dynamic processing for both recording and playback using any tape recorder, plus monitoring from 3 head machines. Available in three packages: 19" black rack model (Pro-20B), with a silver panel and walnut end blocks (Pro-20W), or with a black panel and walnut end blocks (Pro-20BW). RG Dynamic Processors are distributed in Canada by TC Electronics (Canada) Limited, 2142 Trans Canada, Dorval, Quebec H9P 2N4.

GRS Notice

Notice No DGTR-016-78 from the DOC is reproduced below:

One result of the various General Radio Service (GRS) symposia, held throughout Canada over the past twelve to eighteen months, was the identification of a consensus among GRS users that Channel 9 (27.065 MHz) ought to be used for emergency communications only. In response to this, it has been decided to recommend to the Minister of Communications that subsection 72(2) of the General Radio Regulations, Part 11, be amended accordingly.

This change would necessitate that another channel be specified as a calling channel. Consequently, it is hereby proposed to designate Channel 11 (27.085 MHz) for calling only.

Comments are solicited on the need for or the desirability of designating 11 as the new calling channel. Responses to this notice should be addressed to the Director, Operations Branch, Department of Communications, 300 Slater Street, Ottawa, Ontario K1A 0C8 and must be postmarked not later than 30 days from the publication date.

Comments received in response to this Notice will be made available for public inspection, unless confidentiality is specifically requested, at the Department of Communications Library, 300 Slater Street, Ottawa, Ontario, and at Regional Offices of the Department of Vancouver, Winnipeg, Toronto, Montreal and Moncton. Those wishing to respond to such comments may do so in writing within a further 30-day period.

Dated at Ottawa, this 8th day of November, 1978.

W.W. Scott, Director, Regulation Development Branch, Telecommunication Regulatory Service.

HP Logic Instrument Guide

Finding the right combination of HP logic test equipment for design, production and service is easy with this new 18 page, four-color booklet, 'Choose HP When You Depend on Logic'. It explains where logic-test equipment (including logic probes, logic analyzers, logic stimulus, and automatic board and IC testers) is used in laboratory, production, and service environments. It includes selection charts which are separated into Design, Production, and Service areas so that the user can quickly choose the best instrument for his application.

In addition, the brochure includes a brief description of each instrument's major capabilities with its application. The publication (#5952-2097) is available at no charge by writing to Inquiries Manager, Hewlett-Packard (Cda) Ltd, 6877 Goreway Drive, Mississauga, Ontario L4V 1M8.

Call For IEEE Papers

You are invited to submit a paper for presentation at the 1979 International Electrical, Electronics Conference and Exposition, Exhibition Place, Toronto, Canada, October 2, 3 and 4.

This is the largest and most comprehensive conference and exposition presented by IEEE in Canada. It attracts technical experts from Canada, and around the world.

In 1979 there will be both technology-oriented and discipline-oriented sessions. Engineering applications for the 1980s will be stressed. The following topics are of particular interest.

Computer technology — hardware, software, microcomputers, peripherals.
Electronic Technology — devices, design, packaging, quality control.
Power Technology — machines, apparatus, components.
Communication Systems — satellite, vehicular, TV, data.
Power Systems — control, transmission, generation.
Industrial Systems — automation, testing, pollution, safety.
Biomedical Engineering — prosthetics, human spare parts, signal processing, data bases.
Consumer Products — microcomputer based appliances, personal computing, audio visual systems.
Energy Systems — solar systems,

alternate energy systems, heat pumps.

Original papers suitable for a 20 minute presentation at the Conference are solicited. In addition to presentation, all accepted papers will be published in the Conference Digest which has world-wide circulation and is placed in all major technical libraries.

To submit a paper, send three copies of a one page abstract to the Conference office. This abstract will be used to judge the acceptability of the paper. Be sure that the abstract page clearly gives the title of the paper and the author(s) name, address, company affiliation and telephone number. The abstract is due on or before March 1st, 1979.

Warren D. Little, Chariman, Technical Program Committee, 1450 Don Mills Road, Don Mills, Ontario M3B 2X7 Telex-06-966612 Telephone (416) 445-6641.

B&K '79 Catalogue

B&K's new BK-9 pocket-size catalogue describes their full line. New product listings include a portable 15MHz oscilloscope, new function generators, a capacitance meter and a 15MHz digital probe.

Full specs on almost fifty instruments (plus accessories) are given in the handy reference booklet. To obtain catalogue BK-9 contact the Marketing Services Dept of Atlas Electronics Limited, 50 Wingold Ave, Toronto, M6B 1P7. (416) 781-6174.

Radio College Now 50

The Radio College of Canada recently celebrated its 50th anniversary in new premises. The college is Canada's oldest electronics school.

With Grade 12 or equivalent a student can graduate from RCC in one year as a certified engineering technician. An extra six-month course will yield the higher certified engineering technologist diploma.

RCC students qualify for both the federal Canada Student Loan Plan and the Ontario Student Award Program. In addition RCC also has a student housing service near the new College St. campus in the heart of Toronto's student area.

The college has spent over $400,000 on the new facilities to help keep RCC standards high.

The new campus means that 350 students, up from the 300 in past years, can be enrolled at one time.

Tuition is $3,395 for the 12-month course, and additional $1,700 for the advance diploma which takes an extra six months.

SMPTE Award Sony

The US-based Society of Motion Picture and Television Engineers gave the David Sarnoff Award for 1978 to a Japanese scientist for his work in the development of lightweight, portable, but broadcast-quality, videotape equipment known as ENG (Electronic News Gathering).

Mr. Morizono, the winner of the award, is now general manager of Sony's Video Products Division. One notably successful project in which he played a major role resulted in the development of helical-scan videotape recorders.

Mr. Morizono has also been deeply involved in another development in broadcast video. This is the C-format VTR which has achieved broadcast-standard rating by SMPTE. The C-format recorder uses one-inch tape, half the size of the tape running through all older broadcast-standard VTR machines.

(Note: David Sarnoff was a morse operator who handled distress calls from the Titanic. He later pioneered the broadcasting industry.)

Portable Colour Monitor

Sony of Canada, Ltd has introduced the PVM-8000 Colour Video Monitor, specially-designed for ENG or EFP applications. This 8 inch, battery-operated, portable features a Trinitron picture tube and a glare-free screen. A battery-pack and protective sunshield/carrying case are optional, a battery charger is built-in.

Dictionnaire Anglais-Francais D'Electronique

This 13x21 cm paperback lists environ 14000 termes anglais in 240 pages for a prix of $16. Not all the terms are explained, but many have five or more lines of description. Available from Editions Du Lanaudiere, CP 275, Joliette, Quebec, J6E 3Z6.

Charles Tandy Dies

Charles Tandy, Chairman and President of the parent company of Radio Shack, died last November aged 60. From nine stores in 1963 the Radio Shack chain has grown to more than 6500 stores today. The new Chairman and President is Phil R North.

1 GHz Attenuators

Motorola has introduced three new series of RF modules that provide attentuator, resistor and termination functions at frequencies up to 1 GHz. All three module series are designed for RF operation with input power capability up to 50 watts.

Features of the three RF series include laser-trimmed nichrome resistor elements, thin-film construction for high stability, and beryllium oxide (Be0) substrate (an electrical isolator with high thermal conductivity) and a copper heatsink.

Prices are US $12.00 in 100-up quantities. More details from distributors.

Jerome & Francis

John Joyce, formerly with Allan Crawford Associates Ltd in Ottawa, Halifax and Vancouver, has formed Jerome and Francis Co Ltd to market and service oceanographic, industrial and electronic instrumentation.

The company's address is: P.O. Box 86549, North Vancouver, British Columbia, V7L 4L1. Telephone (604) 986-5013, Telex 04-507672.

The Electronic Industrial Division line includes: Angela Electronics Co., Bird-X Inc., California Instruments, J.J. Lloyd Instruments, Levell Electronics, Livermore Data Systems, Minco Products Inc., Ocean Applied Research, Pat's Soft-Ware, R.B. Annis Company, Scramblers, White's Electronics, and Zorelco.

The Environmental/Oceanographic Division line includes: Alden Electronics & Impulse Recording Equipment Co. Inc., Applied Microsystems, Bennett Pollution Controls, Digicourse Inc., Klein Associates Inc., Montedoro-Whitney Corporation, N.B.A. Controls, and Orion Electronics.

Single-Gun Colour TV

Two of the usual three guns and the shadowmask have been eliminated in a new colour TV tube developed by Matsushita. The clever system which prevents brightness information for one colour from modulating the beam as it scans the phosphors of another colour is based on the feedback action of UV-emitting control stripes. Using one beam allows a deflection angle of 70 degrees (rather than 50) and with the 5in (diagonal) tube now developed the power consumption is only 7W, rather than 12W.

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*Canadian price. Includes two PB12 probes. Duty and federal sales tax included. FOB shipping point. Provincial taxes extra where applicable. Subject to change without notice.

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Here's an all new scope at a new low price. The model OS255 is the first in a new family of Gould/Advance scopes incorporating more features per dollar than previous scopes.

With the 15 MHz, dual trace model OS255 you get two PB12 probes at no extra cost, sum and difference capability, channel 2 inversion, and improved trigger features. Plus the OS255 is packaged in a new tubular housing configuration designed for rugged field use and ease of servicing.

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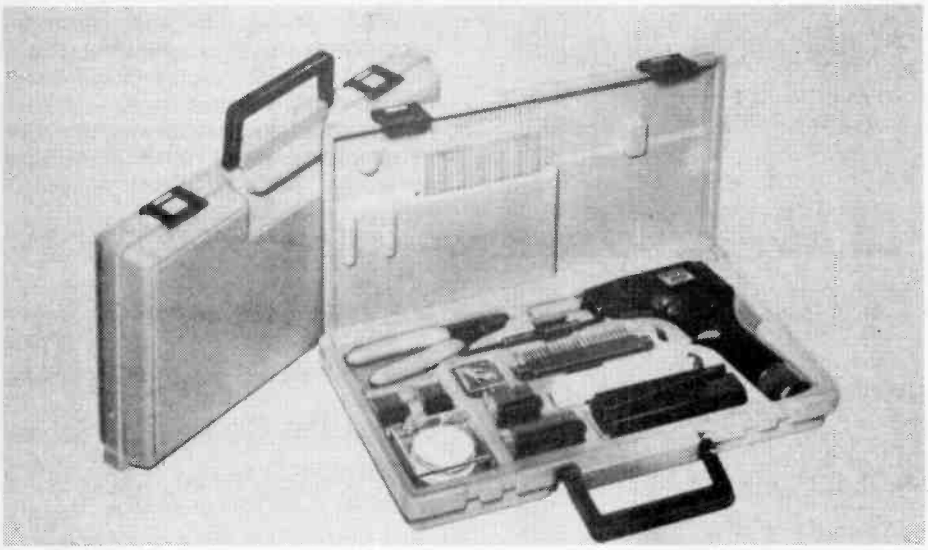


Wire Wrap Kit

Model WK-5 is a new wire wrapping kit that contains a range of tools and parts for prototype and hobby applications, packaged in a plastic carrying case.

The kit includes a BW-630 battery operated wire wrapping tool complete with bit and sleeve; model WSU-30, a hand wire-wrapping/unwrapping/stripping tool; a universal PC board; and edge connector with wire-wrapping terminals; a set of PC card guides and brackets; a mini-shear with safety clip; industrial quality 14, 16, 24, and 40 pin DIP inserter; and assortment of wire-wrapping terminals; a DIP inserter; a DIP extractor and a unique 3-colour wire dispenser with 50 feet each of red, white and blue Kynar insulated, silver plated, solid, AWG 30 copper wire.

For further information contact Len Finkler Limited, 25 Toro Road, Downsview, Ontario, M3J 2A6.

Heat Saving

Anvil Energy Systems of Agincourt, Ontario, send you a message telling how they can help save fuel costs. Three methods are suggested:

Ceiling Fans. Heated air rises from the floor to the ceiling and becomes stratified. Ceiling fans recirculate large volumes of hot air back down to the floor cutting fuel consumption and eliminating cold spots.

Automatic Temperature Scheduler. The practice of turning down the thermostat during non-productive hours can reduce fuel consumption in any heating system. An automatic system can be programmed to set back on week nights, all day Saturday and/or Sunday and can have a "Skip-A-Day" feature.

Energy Time Optimiser. This device automatically responds to outdoor temperature changes, wind velocity and building heat loss characteristics through a "7 Day" night setback system.

Crawford Represents F.W. Bell

Allan Crawford Associates Ltd has been appointed as the exclusive Canadian representative for F.W. Bell Inc of Columbus, Ohio.

F.W. Bell equipment is in use throughout the world to monitor electrical parameters in the manufacture of products as diverse as motors, transformers, razor blades, hi-fi speakers, and even tires. The equipment is used to monitor the transmission of electrical power, and to help control metal processing, chlorine production, and similar industrial processes.

The basis for most F.W. Bell products is the Hall generator, a semiconductor device which, when placed in a magnetic field, produces a voltage signal proportional to the strength of the magnetic field. It is the only device capable of use with both DC and AC fields. Bell is the world's largest manufacturer of gaussmeters and a major supplier of power system transducers.

Organic Thin Films

The electronics labs of France's atomic energy agency have developed organic thin films with potential manufacturing applications including capacitors, photo-resists, and a hygrometer. The big advantage of organic over metal films is better stability in thin layers. Among the substances used are some based on stearic acid or the behenate radical.

New Heath Cat

Just before this issue went to press we received a new catalogue from Heathkit, which included the new products for Christmas giftgiving 1978.

Starting (as usual) at the back, there is an Aircraft Navigation Computer (handheld) for $249.95 (all prices here are for kits). Next new item is part of Heath's Continuing Education Series: now expanded into automobile electrics. Two packages, Electrical Principles and The Starting System, for $49.95 each. Two more packages and an optional exam kit will be available soon.

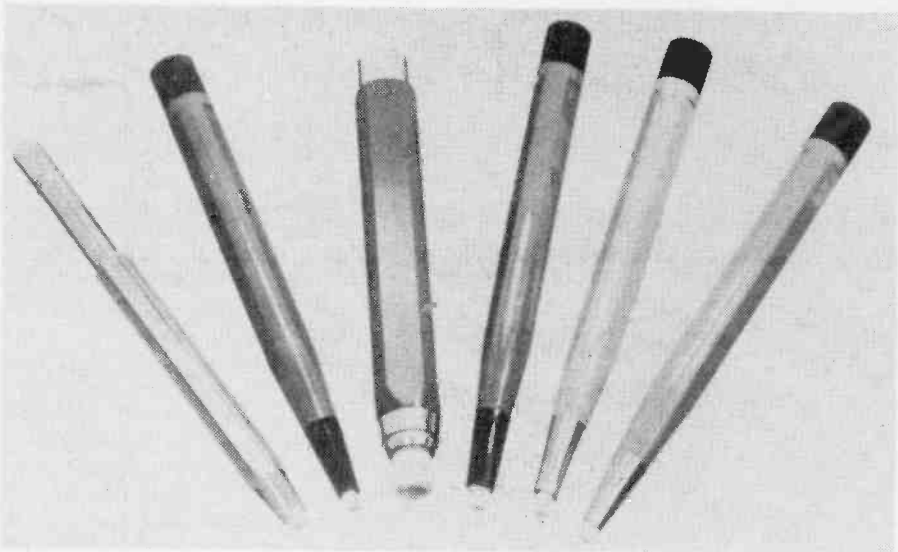
For the ham there a couple of linears — 1kW for $699.95, 2kW for $949.95. For $319.95 there is a hand-held 2m transceiver (8ch/1W) with battery charger. Optional extras include touch-tone encoder and holster.

The WH14 is the new line printer for $1499.95 (assembled). The H11A is Heath's version of LSI-11/2, PDP11 performance in a smaller size configuration. The 16-bit microcomputer costs $1895. After some new auto accessories we come to a new 5MHz dual-trace scope for $399.95. For $59.95 you can build a logic probe, or for 199.95 build an FM deviation meter. It is not marked as new, but Heath have an interesting model train controller for $119.95.

The audiophile might like to build a pair of linear phase 3-way speakers, just $999.95. More exciting is the new 1600 series of hifi equipment. This series fits any standard EIA rack (or you can choose cabinets/sidepanels if you like) and the set-up shown in the catalogue looks very classy. So far there's just one amp and an output level indicator available, prices $499.95 (2x125W) and $279.95.

Plessey Deal Nashau

Plessey Canada are now authorized dealers for disk packs, disc cartridges, diskettes, magnetic tape from Nashua. In Toronto call Dan Dragone, 661-3711. In Montreal call Jack Pizante 739-5678. In Edmonton call Ernie Webb 484-4471.



Erasing And Burnishing Brushes

Lenline offers a new line of erasing and burnishing brushes in propelling pencil, sliding pencil and regular brush types. These are fibre glass erasers and brushes, designed for a variety of industrial applications. They are adjustable for reaching corners, crevices and other tricky places.

For further information contact Len Finkler Limited, 25 Toro Road, Downsview, Ontario, M2J 2A6.

Component Technology & Standardization

A new data source is now available to engineers and scientists. The Component Technology and Standardization Manual consists of three volumes of over 1600 pages is designed to bring you information on: Cost factors, Screening techniques, Conversion factors, Environmental considerations, Construction details, Selection criteria, Operating characteristics, Circuit application, Derating criteria, and Failure rates & mechanisms. A brochure is available explaining more on how your $350 payment (& optional $95 a year updating) will save you money. Write Pat Nellis, General Electric Comapny, 120 Erie Blvd., Schenectady, New York 12305 USA or phone (518)385-2128.

Will The Aircraft Of Tomorrow Burn Coal?

With present uncertainties about oil reserves (which won't last forever, no matter how you look at them), many engineers are seriously looking at coal again for fuel. However, the technologies evisaged for harnessing this resource are mostly very different from those employed hitherto, and the mobile coal burning engine (that's locomotive) of the future will be a highly exotic species of machine compared to its predecessors. Even so, the idea of using coal to power passenger carrying aircraft probably seems far-fetched to most of our readers. How would such an aircraft possibly get off the ground? The answer, of course, is that the aircraft would not itself carry any fuel, and the equipment to extract energy from that fuel would also be located on the ground. All that is necessary is to convey the energy from the ground to the aircraft. And how would that be done? You've probably guessed it, of course — microwaves!

This idea is not as speculative as it sounds. Two and a half years ago, in fact, Raytheon engineers lifted a microwave powered helicopter off the ground, and further experiments are planned. Admittedly, powering 707 sized aircraft by microwave is still far in the future, but studies have been undertaken which indicate that it would be feasible. It has even been projected that fuel costs in such an application would be about $1.60 per mile. Such a system would require setting up flight paths with microwave transmitter stations spaced 6 miles apart, so it would take very large expenditure on installations to implement it. However, there is one application where we might see microwaves supplying power to airborne craft relatively soon, and that is 'High Altitude Powered Platforms' (HAPPs). These platforms could be used both as observation stations, monitoring events such as forest fires, and communications relay stations (which could conceivably make cable TV obsolete). About 100 of them could cover the entire North American continent.

J. C.

microfile

Canadian Computer Show

Unfortunately I didn't make it to the computer show in Toronto last November. Fortunately Mark did manage to get down there and came back with some interesting stuff. Briefly, these are the things he brought back leaflets on—

A company called Home Education System (of 250 Consumers Road, Suite 300, Willowdale, Ont, M2J 4V6) will give you a terminal, with modem, and four hours of computer time, all for $39.90 per month. The catch: only that you have to pay extra if you use the system outside the regular hours — 7:30 pm to 1:0 am weekdays, 8:00 am to 1:00 am Saturdays.

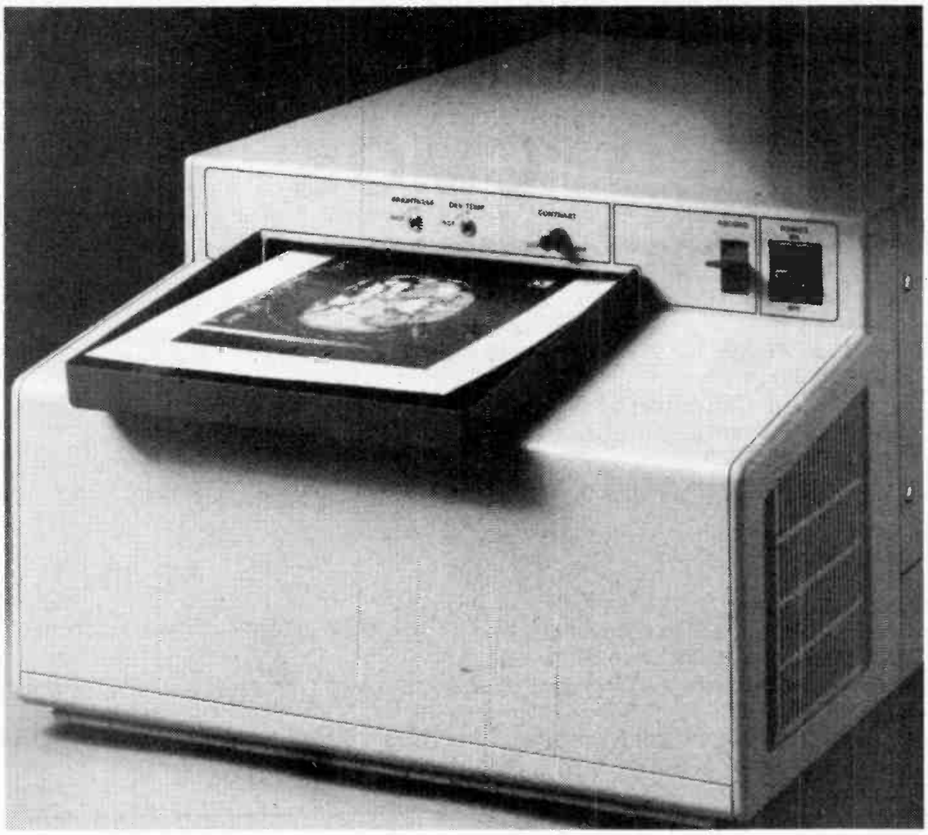
Unified Technologies Inc, Unit 8, 50 Galaxy Boulevard, Rexdale, Ont, make the 4880 desktop computer which uses the Z80 processor and 48K of RAM. An 8080 controls the video display and disk drives. The dual diskette drives, CRT, keyboard, and electronics fit into a very neat little package only about twice the size of an office typewriter. IEEE-488 bus, RS232C, and 'Centronics-compatible' parallel printer ports are provided. Standard software includes the disc operating system, FORTRAN, text editor, 8080 assembler, dynamic debugger, and peripheral interchange. Optional software is extensive.

Internet Limited, PO Box 363, Carleton Place, Ont, K7C 3P5, represent SCI Systems of Huntsville Alabama. We received sheets describing two of their printers, the 2132 matrix printer, and the 1110 rotary printer.

SCP Inc of 209 Middlesex Turnpike, Burlington, MA, 01803, USA, supplied information on their MAP-300 which enables your minicomputer to process video in real-time.

Another company in the digital video field was Norpak. We have product briefs on these — Video Image Digitiser, Visual Data Processor, Micro Video Processor, and a Raster Graphic Processor. Also from Norpak is a terminal for the Videotex service that the government has announced recently. At ETI we are unsure of the specific form Videotex will take. We know of the teletext and viewdata systems available to readers of our UK edition, which use broadcast data transmitted in the vertical blanking interval of the TV signal (used by the BBC for their Ceefax and the IBA for Oracle) or use the telephone line for two-way communication between a home terminal-cum-TV and a central computer storing information supplied by numerous services (used for the GPO's Prestel service). A third possibility for Canada is to use existing cablevision networks. The Norpak Videotex terminal is equipped to handle any of these three possible media.

(Note: we will update you on Videotex when we learn more.)



Procom II computer

A new version of the Computer Products Procom II microcomputer, available in Canada exclusively from Allan Crawford Associates, is programmed and debugged entirely in high-level language and provides space for up to eight RTP analog and digital I/O cards in a self-contained, ready-to-run package.

The system's software allows on-line generation and checkout of real-time application programs in Procom Basic. After debugging, the program and system software are transferred from a separate programming system (the Composer) to Procom II for permanent storage in PROM. Numerous combinations of memory with up to 32K bytes of program PROM and data storage RAM are available in Procom II.

The basic Procom II chassis comes complete with analog and digital power supplies, CPU card, self-test logic and a dedicated RTP I/O Port Card with paddleboard connector. The user may also select from six optional circuit cards, including; one or two PROM cards of 8K or 16K bytes; one or two RAM cards or 4K, 8K, 12K, or 16K bytes; one or two dual RS-232-C full duplex serial communication cards; and one or two additional RTP I/O Port Cards. As system requirements grow, RTP I/O can be easily expanded through the use of up to eight standard RTP I/O measurement and control subsystem chassis, each containing as many as 256 I/O points.

Challenger III Software

Ohio Scientific has introduced a new software package to make their Challenger III computers compatible with the three common computer languages: Microsoft Extended-Disk BASIC, 1968 ANSI-standard FORTRAN, and 1974 ANSI-standard COBOL. The new software, designated as OS-CP/M, is a complete 48K RAM implementation of Digital Research's popular CP/M operating system. Ohio Scientific's CP/M utilizes the Z-80 microprocessor, one of the three featured in every Challenger III Series computer system (the other two are the 6502A and 6800).

OS-CP/M consists of a CP/M Text Editor, 8080 Assembler, and Dynamic Debugger, as well as a Microsoft 8080 Macro Assembler, Extended-Disk BASIC, FORTRAN and COBOL. Documentation includes reprinted, and annotated, CP/M and Microsoft manuals plus Ohio Scientific's introduction and overview. The software package also includes three 8-inch floppy diskettes. One diskette is for FORTRAN and BASIC, one for COBOL, and one duplicator. The suggested retail price for OS-CP/M is US $600.

For further information write: Ohio Scientific, Inc, 1333 S Chillicothe Road, Aurora, Ohio, 44202, USA. Phone 216/562-3101.

Video Printer

The new Tektronix 4634 Image Forming Module produces 6 x 8 inch grey-scale prints from video sources.

The recorder can be used with systems for diagnostic ultrasound, computerized tomography, nuclear imaging, and other radiological systems that use raster scan video output.

Available to Original Equipment Manufacturers system designers only, the 4634 is priced at approximately $7,630, duty free. Quantity discounts are available.

The 4634 uses dry silver paper and a fibre-optic CRT.

A built-in interlace circuit can be activated when recording from a non-interlaced source.

For further information, please contact the Marketing Communications Department, Tektronix Canada Limited, P.O. Box 6500, Barrie, Ontario. L4M 4V3.

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Calculator Users Handbook $2.90

The Electronic Calculator Users Handbook by M. H. Babani presents formulae, conversion factors, etc, to aid users of electronic calculators. Using the book you can calculate trigonometric (and hyperbolic) functions, logs and square roots using only a single four-function machine.

Transistor Equivalents & Substitutes

The Second Book of Transistor Equivalents & Substitutes lists over two hundred pages of transistors and their equivalents from Britain, USA, Holland, Japan, Germany, Czechoslovakia and Poland. Bernard Babani compiled this book to update the information in his first book of Transistors Equivalents and Substitutes published in 1971. The book is a valuable guide to many recent transistors.

$3.25

Please add 25c per book for postage and packing. Send your order with a Cheque or Money Order, Mastercharge/Chargex number (include also date of expiry and signature) to ETI Books, Unit 6, 25 Overlea, Blvd., Toronto, Ontario, M4H 1B1.

Audio Today

Developments in audio reviewed by Wally Parsons

IN THE NEVER-ENDING search for ever increasing sonic realism all kinds of distortions have been tackled: frequency distortion, bandwidth distortion, harmonic, IM, transient distortions and what might be called sub-divisions, all have been reduced to remarkably low levels, and yet realism still remains an elusive goal seldom achieved even as an illusion, and probably never achieved in fact.

DYNAMIC RANGE

Human hearing, assuming good health of the hearing mechanism, can cover an intensity range of as much as 120 dB. Since each 10 dB represents a power range of 10 to 1, that's a power range of 10^{12}, or 1000000000000 to 1. That represents as wide a range as the rustle of a single leaf and the sound of an earthquake near its epicentre, a cat purring across the room and a jet engine a few yards away, the sound of blood coursing through one's own body and — well, you get the idea. It's a pretty tremendous range.

Music generally covers a range of about 80 dB which is still a pretty large power range. In addition, much of the dynamic excitement of music results from the presence of brief peaks of 10 to 20 dB above average level, which may also accompany dynamic peaks of 10 dB or more over the long range average. For example, an orchestral cr escendo might end in a fortissimo tutti (very loud, full orchestra) considerably louder than most passages just before and after the fortissimo. In addition, the transient peaks of the instruments themselves (e.g. cymbal crash, instrumental attack, etc.,) may be well above the average level of even the crescendo itself. To generate the excitement of the original, and, therefore, the feeling of realism, requires that the reproducing system be capable of reproducing this level at the listening position. As we saw in previous discussions towards the end of last year, this level is achieveable with modern equipment. It's not always easy, or inexpensive, but it can be done. So, cost considerable aside, why is the experience of it more the exception than the rule?

NOTHING IS EVER SIMPLE

As often happens, when we solve one set for problems we reveal another set hitherto unknown, or sometimes merely underestimated. This is the result of Law of the Cussedness of Inanimate Objects at work. Simply put, this law states: Mother Nature is a Bitch! In all my years of research on the subject, I have yet to unearth any evidence to suggest that noise serves any useful purpose in nature. Quite frankly, I suspect that it was created by some malevolent entity for the sole purpose of making life difficult for those of us engaged in communications. However, it is one of the realities of life with which we must live, and, if possible, get around.

How does noise affect dynamic range? Let us assume we wish to reproduce only music as produced by conventional instruments. This means we wish to reproduce a sound level as low as 80 dB below the loudest level. Figure 1 shows noise distribution in a flat response audio channel, along with programme level, assuming constant frequency distribution, at some arbitrary level. Also shown is a more likely frequency distribution of frequencies in the programme component. Noise level rises with frequency. Obviously, if programme level is constant with frequency, the ratio between the two decreases as frequency rises. Moreover, if programme level actually drops with frequency, as is usually the case, the ratio between the two will decrease at an accelerated rate. When wide band noise is present, it tends to mask other sounds, reducing their apparent level. The precise degree of masking depends on several factors, the most important being the shape of the wave-form, with sharp spikey wave-forms being less subject to this effect than other types. However, one phenomenon which has been observed is that high frequency noise when present at a level above audibility will often be interpreted as high frequency components of the programme. The net effect is that a noisy channel may sometimes appear to have more high frequency components than a quiet one. Actually, it does, but the components are noise components which the ear has mistakenly attributed to the programme component. Hence, the programme bandwidth, and, by inference, the channel appears to have **extended** high frequency response. Phonograph records which have their high frequencies wiped out by excessive playing may then appear to be in perfect condition unless compared with fresh copies. In wiping out the highs, surface noise has been inserted in their place. While this may seem rather convenient, a quick comparison will show that noise is no substitute for the highs originally recorded.

NOISE SOURCES

Every material which exhibits resistance generates noise, except at absolute zero. This noise is the result of molecular motion, which is absent at absolute zero. Therefore, noise is generated in any circuit by every resistance: pick-up coil resistance, transistor internal resistance, leakage resistance in capacitors, and resistors themselves. In addition, noise is generated whenever a current passes through a resistance, and since the generated noise is a function of the *instantaneous* current noise varies throughout the wave-form, producing *modulation* noise.

Every stage in an amplification system amplifies not only the signal, but the noise generated in its input, plus the noise generated in previous stages and passed along with it's signal.

Consider a recording made even with only one microphone in a mono transmission. Noise is generated internally in the microphone, the cables connecting it to the console, each stage in the console, each control in the system, any signal processing which is used, each stage in the tape recorder, and in the tape itself. If this tape signal is transferred directly to disc, then noise is generated in each stage of the disc recording amplifier, the cutter circuit itself, and finally, any irregularities in the groove surface. By the time we get to pressing it we've added more potentialities for noise. Imagine this noise, then, multiplied by the number of channels in a multi-mic, multi-track, multi-channel setup, add another recording stage for a mix-down to two channels, plus another recording stage again to make a recording master tape, and it often seems a miracle that what comes out isn't all noise.

MASKING

It was noted earlier that noise masks other signals present in the channel, reducing their apparent level. If at any given instant our programme level is at 100 dB (which is very loud) and total noise is 60 dB below this, that is, at 40 dB, the noise would have little masking effect. However, if programme level were to drop by 60 dB, it would be at the same level as the noise, and most certainly would be masked by it. In fact, to be inaudible, noise has to be at least 40 dB below the signal level, unless it is actually below audibility itself. 50 dB is really a better figure, and preferably 60 dB. This means that noise *must* be below audibility, or -20 dB if the lowest level to be reproduced is 40 dB. If noise is audible at all, then the lowest level which can be reproduced is 60 dB, and with our top level at 120 dB (which is definitely not average concert hall

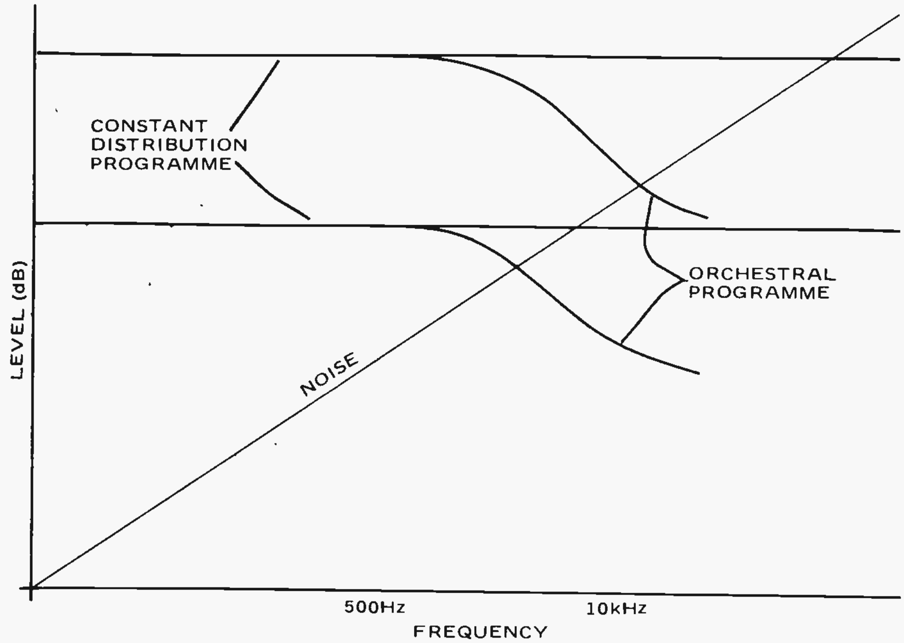


Fig. 1. The relationship between noise and various programme material.

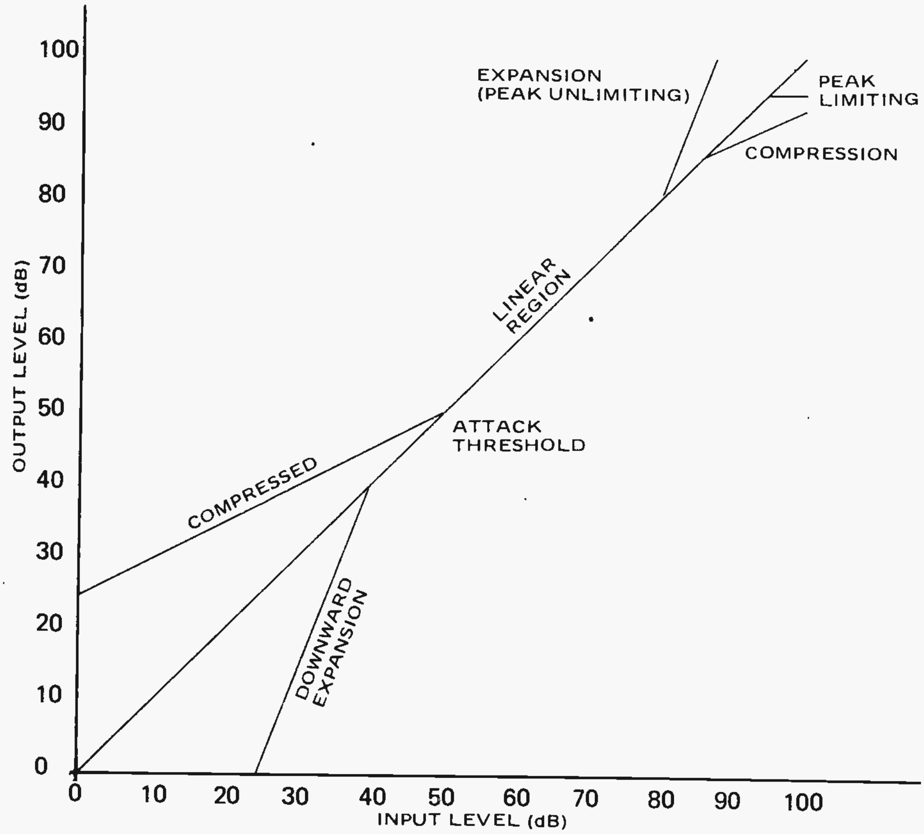


Fig. 2. Examples of commonly used signal processing techniques.

level) our dynamic range is only 60 dB. Thus, it seems not at all remarkable to learn that modern recordings and broadcasts are generally limited to a dynamic range of only 40 dB.

The implications for the music lover are considerable. If playback levels are set high enough to allow all but instantaneous peaks to reproduce at live levels, then quiet portions will be drowned in noise. If levels are brought down so that noise drops below audibility, then the peaks aren't loud enough. To get around this recordings are generally made in such a manner as to increase the level of quiet portions above the noise level of subsequent stage and also peaks are knocked down to allow high recording levels without overload, or overcutting of grooves. The result is that all but the highest peaks can be reproduced at live levels without excessive noise in quiet passages. However, this also means that quite passages are reproduced at unnaturally high levels. So we turn the level down to something more natural, but then lose the peaks.

WHAT TO DO?

In a linear amplifier, an increase in input of, say, 10 dB will result in an increase in output of 10 dB. It does not have to be this way. It is quite possible to design an amplifier such that a 10 dB increase in input results in an increase of only 5 dB in output. Or 1 dB. Or 15 dB. Or more. Or less. It is also possible to arrange for the amplifier to be dynamically linear over some specified range, and to "compress" or "expand" levels above or below some desired value. Fig. 2 shows such a relationship.

Question: how do you know how much expansion to apply on playback? How do you know what thresholds to use? Answer: you don't. This is where a good ear and lots of luck come in. The recording engineer selected his parameters on the basis of considerations which you and I cannot possibly know, and may even have used manually compression, that is, manually changed the level during a particular passage. As a result, any attempt at restoring dynamic range with an expander will, no doubt, result in more satisfactory reproduction most of the time, but there will still be anomalies. And it's extremely rare that the dynamic range will be perfectly realistic.

Suppose, in addition, the engineer used different compression characteristics in each channel of a multi-channel tape then mixed them down to two channels. Even if no further modification occurred, how does your playback expander manage to operate independently on the signal from several channels *after* they've been combined. It can only sense the total level in the one channel presented to it.

Anybody for mind reading?

Audio Today Letters

If you want to express your views or report on news write to Audio Today, ETI Magazine, Unit Six, 25 Overlea Blvd, Toronto, Ont. M4H 1B1.

SPEAKER QUERIES

I'm a recent reader of ETI and greatly enjoy your Audio Today column. I was intrigued by your explanation of various frequency bands and the vital importance of balance among them. How rarely we hear it. I fear my ears want to hear every minute detail, except the price. That's why I'm writing you The speaker system you describe in your July column is similar to one I'm planning to build. Essentially what I hope to achieve is a poorman's Dahlquist DQ-10. The drivers I'm considering are: Philips AD 12100; AD5060/W: AD0211SQ: AD1600T. Therefore, I would like to know as many details as possible.

1. What do you use for diaphram doping? What is the process involved?
2. What is the marvellous bit of surgery that removes the dip and peak in the response of the 0211SQ. I heartily agree with you that what happens outside a driver's passband must be thoughtfully considered. Which leads to the next question...
3. I have assumed that your system now uses a 6 dB/octave slope on all drivers. Is this attention enough for these drivers (In August "Audio" Mr. Thiele believes that with a 1st order network four octaves of response outside the passband is necessary, and then the problem of the physical geometry between drivers.) I would appreciate receiving the technical details of your crossover network and the methods you use in designing/tuning a multi-band system. The Dahlquist uses a very elaborate network (perhaps a damped 3rd order? And it certainly seems to work.

As far as the bass section goes, I'm still not sure of design. In my brief experience in constructing and using transmission lines, I've found them a mixed blessing. Very smooth response, low Q, but unfortunately very large and inefficient. I feel for a given volume a reflex system gives either higher efficiency or lower cutoff, however the Q can be unbearably high. There's always a sealed box, but...

I would enjoy hearing your thoughts on this bassic problem (ouch).

There are a myriad nagging questions I'd like to ask, however, to many definitive answers would take the "art" out of the science, and I'm sure you like feedback from your column, but probably aren't so fond of operating a free engineering service. So in that light (sound?) I'm very grateful for your time and knowledge.

P.S. I've been dangerously tempted to build ETI's octave analyser (489) but is octave band analysis enough? A lot can happen in between. Also, is there an electronics supply company that sells the 489 as a complete kit? (Out here on the fringes finding suitable electronics components is somewhat like trying to name more than five "State of the Art Canadian Audio manufacturers. It's not easy).

J. G. Westbank B.C.

First, to deal with your question re: the analyzer. The number of bands required is dependent on your needs. One could quite concievably require a third octave analyzer. 489 is particularly appropriate for general work, especially where portability is required as in commercial applications. For lab work more bands would be desireable. You'll notice, by the way, that the filters are similar to the circuits used in the graphic equalizer. (Oct/77) You can use the same techniques for making half-octave or third-octave analysers.

As for a kit, you think you've got troubles? As you may know by now, I also write a technical column for Audio Market News, which goes to the retail trade. The editor was interested in the analyzer but hadn't the time to build it. I offered, and even quoted a price. Then discovered I'd have to make my own boards. I hate making circuit boards. Come on, all you eager entrepreneurs out there. ETI's project "games" are fun, and so are basic things like amplifiers. But projects like this are where it's really at. Wanna package a project? Just contact ETI at the address or phone number on the mast-head and get in on the action.

Now, about the speaker.

1. The doping material is basically an elasto-polymer based on butyl, and it's called polyisobutylene. The idea was one I picked up many years ago from the late Gilbert Briggs, and used it to seal the cloth suspension I had installed on a speaker. A little goes a long way, and about 12 years ago I was able to pick up a free sample from the manufacturer. I would probably be violating a confidence if I revealed the manufacturer's name, because of that free sample business; otherwise it is only available in 100 pound drums. However, a little phoning around to chemical manufacturers might get you a supply. Talk to an engineering sales rep, not an order desk.

2. The surgery you know by now. As I said earlier, I don't want to publish it here for fear that someone unskilled will destroy an expensive speaker but a personal letter will get the reply.

3. I have no quarrel with Mr. Thiele. You will note, however that we are in agreement in contending that the first-order response is the only one in which an ideal total response is achieveable. Agreed, the pass-band and skirt response problems are formidable. My present version uses a different lower-midrange driver with higher compliance and lower resonance, with extended high-end response; the use of fluid damping on the Philips upper-midrange dome and the Peerless tweeter seems to have solved the problem associated with high drive power below the cross-over point, and I'm still experimenting with geometry.

The Dahlquist is a beautiful speaker, but I suspect that much of its effortless quality and accurate imaging is due to the use of open baffling on the smaller drivers, and the cross-over was designed to make best use of the characteristics of the specific drivers.

As for transmission line efficiency, using the drivers you contemplate, the bass unit will show an efficiency only a little lower than the other units, about 6 dB. This is easily controlled with an L-pad, and is certainly better than having it the other way around. I don't agree that the "Q" of a bass reflex has to be excessively high. This is the result of improper design, and particularly a misguided attempt to use Thiele alignments without understanding them. There seems to be a mistaken belief around that Dr. Thiele's tables magically produce better speakers. Nonsense. They provide a rational means of predicting the performance for specific sets of design parameters, no more, and no less. "Two plus two equals five" is the wrong answer whether you get it by counting on your fingers or improperly enter it on a computer.

Anyway, I'm working on the idea of a series dealing with speaker design. Comments in advance are welcome.

And many thanks for acknowledging the difference between a letter column and an engineering service. But don't let that stop anyone from writing and asking advice. And it's quite permissible for readers to answer other readers' question, or argue with them, or whatever.

Audio Today Products

Audio developments reviewed by ETI's Contributing Audio Editor Wally Parsons

PHILIPS SPEAKER KITS

The pre-Christmas doldrums have arrived at the time of this writing, which means not much of anything new. However, speaker-building makes a nice little project on cold winter nights, and Philips has obliged with a booklet (11" x 16" — this is a booklet?) with plans for four different speaker systems designed for use with their own drivers. At seventy-five cents it's good value, and I'll bet you could get it free from anybody from whom you buy the drivers. (Dealers note: this is called "merchandising", or "spending a buck to make a buck") Models range from a small 2-way model with a 4" Woofer and dome tweeter to a four-way model with 12" woofer. The last one also includes cross-over values.

As it happens, I know the drivers used and feel safe in predicting that performance should be comparable to Philips' DK series of kits and many of their ready-built models. I'm not entirely in agreement with Philips cross-over design philosophy, but their networks do seem to work well with their own drivers. What the world needs now is a line of inductors of suitable standard values for cross-over use, both air and iron core, which would eliminate a lot of complex design work, and tedious hand winding. This is the only component part I know cannot be purchased off-the-shelf and I know it discourages many hobbyists from tackling speaker projects as ambitious as their amplifiers. How about it, Philips? Or maybe Hammond, Leigh Engineering, or anyone else who currently make transformers. The line forms on the right and I'll talk to anyone who phones, writes, or shows up.

One cautionary note: unless you know what you are doing, and I do mean *know* don't play mix-and-match games with the drivers and cross-overs specified in these plans. They have obviously been designed to go together and substitution is a very dicey matter.

Have fun. Philips Electronics Ltd., 601 Milner Ave., Scarborough, Ontario. M1B 1M8.

ALLISON:FOUR

Speaking of speakers, the Allison: Four is now available. A unique device, it was developed by Roy Allison, formerly of AR and is one of a series of speakers designed to work specifically with room boundary effects. It is a *true* bookshelf speaker, which means that it must be used on a bookshelf. The distributor has lots of good literature on the entire Allison line.
The Pringle Group, A. Allen Pringle Ltd., 30 Scarsdale Rd., Don Mills, Ont. M3B 2R7, or phone (416) 449-5640.

Next month in ETI ......

APL: WHY IS IT?

A Programming Language, for computers of course. But it's also for humans, and we think you'll want to use it.

TEMP. CONTROL

Home environment control is one field where you can put your experimental electronics tendencies into action. Here are the basic principles you need.

Quarks

Truth is Stranger than Beauty — or was that Up is more Charming than Sideways? A guide to the strange world of Atomic Physics by Robin Moorshead.

IT WAS THE GREEK PHILOSOPHERS who coined the term 'atom' as the basic indestructable building brick of all matter. They even realized that matter and energy were closely related when they said all matter was made of the elements fire, water, earth and air. However it was 2000 years before man really began to investigate the subject scientifically.

Modern science began with the parallel developments of physics and chemistry in the seventeenth and eighteenth century. These scientists discovered the true nature of chemical reaction which led to the idea that all matter consisted of a limited number of elements, which they believed were made of indestructable atoms. They thought that all that was necessary was to find out how many elements there were and that part of science was complete. At the same time Newton formulated the "universal law of gravitation" which was the first "force field" to be understood.

By the end of the nineteenth century the picture had become more complex. With the discovery of more elements it was found that they could be laid out in patterns and groups, a fact which strongly suggested that they had internal structure.

When the electron was discovered this single picture of the atom was finally shattered. But a new simple picture was developed consisting of electrons floating in positive charge clouds like currants in a bun. The physicists had added a second force field, the electromagnetic, to the list which helped them to explain the relationships between the positive and negative charges in the atom.

FORCES AND AGENTS

The discovery of radioactivity gave the physicists a new technique. As the unstable nuclei exploded the high velocity debris could be used to shatter other atoms. This soon led to the discovery of the proton, the neutron and two new forces.

There had to be an incredibly powerful force binding the protons together in the nucleus since the electromagnetic force should blow the tightly packed positive charges apart instantly. Secondly it was discovered that the neutron itself was radioactive, it would only live for about 11 minutes outside the nucleus. This suggested that there was another rather weak force which held together the parts of a neutron. They were named the strong nuclear and weak nuclear forces respectively. The disintegration of the neutron caused tremendous problems, since they calculated that apparently energy was lost when the event happened. The only way to explain this without abandoning the law of conservation of energy was to propose a fourth particle the neutrino. This would carry away the missing energy. So when the neutron disintegrated this happened:

neutron → proton + electron + neutrino

It was over twenty years before the neutrino was finally discovered.

The nineteenth century concept of a force field had by now given way to the idea that a force was transmitted by an "agent". So when two particles interacted they did so by exchanging the agent of the force. The agent of gravity was called the graviton (which has not yet definitely been detected). The agent of the electromagnetic force was the photon (which is easily detected). This meant that the strong nuclear force needed an agent which was called the 'mesotron'. But there was an important difference between the latter and the first two, since the gravitational and electromagnetic forces act over infinite distance, but the strong nuclear force acts over only 10^{-13}cm. The agents of infinite forces have no mass, but the mesotron had considerable mass. A new particle was discovered with the right mass but it didn't behave as predicted, a problem not solved until after World War II.

PARTICLES AND LAWS

Also at this time a particle called a 'positron' was discovered, it was opposite in every respect to the electron, in fact antimatter. Furthermore when it collided with an electron they annihillated one another producing a very energetic photon. This was confirmation of Einstein's equation $E=mc^2$ which mathematically relates matter and energy.

So to sum up the situation before World War II we have:

known particles:
- Electron
- Proton
- Neutron
- Mesotron (with some "wrong" qualities)
- Photon

Suggested:
- Neutrino
- Graviton

Forces:
- Gravitation
- Electromagnetic
- Weak nuclear
- Strong nuclear

Combined with this they had established several laws which governed particles' behaviour when they collided:

(a) Mass-energy is conserved ie: If two particles collide and create two new particles their combined masses may be greater or less than before but this is compensated for by them having more or less kinetic energy.

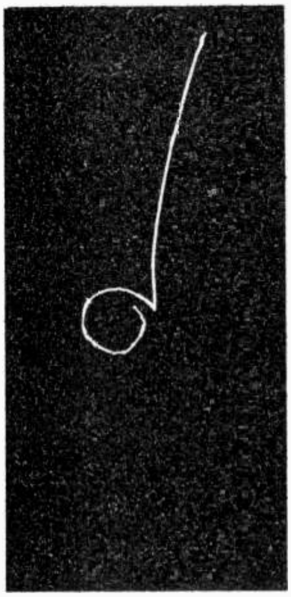
(a) Electric charge is conserved, ie: an electron cannot collide with a neutron and produce a positive particle, it must produce a negative one (and any number of neutral ones).

(3) Most of these particles spin, which again cannot be lost when they collide — like electric charge it must reappear in the new particles.

(4) At the time they believed also that any particle created through the strong nuclear force must disintegrate by it (likewise the weak nuclear). This was later found to be wrong.

The situation was quite satisfactory at the time, with a manageable number of particles and laws which governed all they had observed. But this simple picture was not to last long. Betwen the wars techniques had been developed to accelerate particles to immense velocity, so that they no longer needed to rely on radioactive disintegrations but could produce large numbers of very energetic missiles at will. Also they could see there events happening in "cloud chambers" where the particles would leave vapour trails exactly as high flying aircraft do.

It was with these techniques that the conundrum of the misbehaving mesotron was solved soon after World War II. In fact the mesotron they sought was found and it behaved exactly as expected, but it rapidly decayed yielding the particle they found before the war. So it had to be named and became the μ meson (the first discovered) and the π meson (the new particle). These are now known as muons and pions.



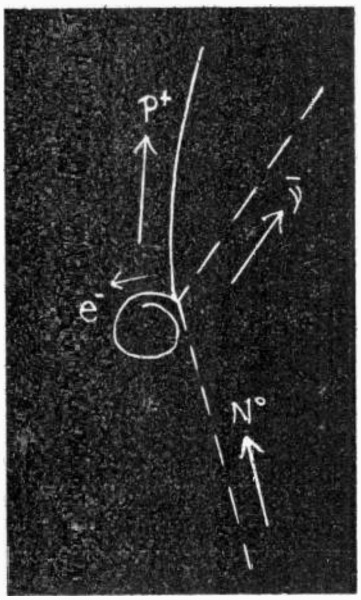


Fig 1 (top left) is what the disintegrations of a neutron would look like, meaningless at first but very meaningful on interpretation. The neutron enters from the bottom leaving no trail as it is ncharged, when it disintegrates it yields a light negatively charged electron which has a curved track due to an applied magnetic field, the proton curves in the opposite direction being positively charged but much less than the electron since it has 2 000 times the mass of the electron. So in fact to the physicist it becomes Fig 2 (top sight). The hatched lines represent uncharged particles which do not leave trails.

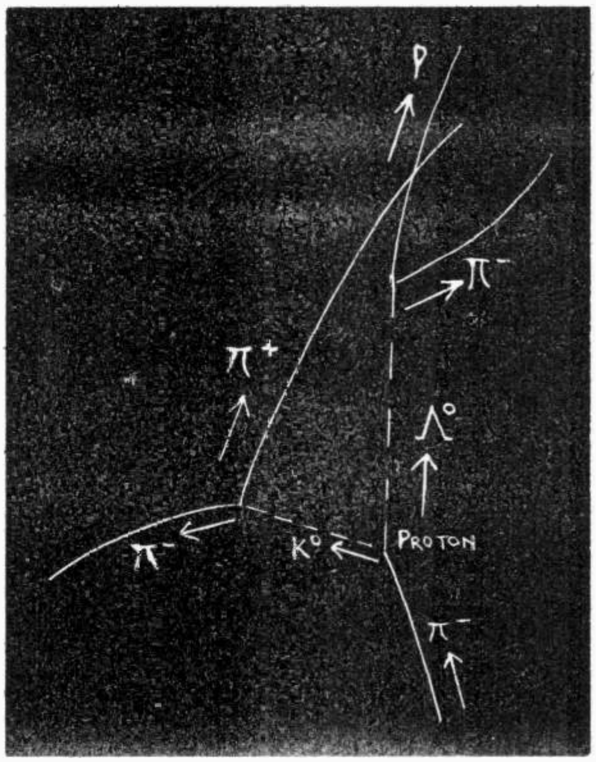
Fig 3. (below) shows the formation of a kaon and lamda hyperon from a pion striking a proton.

STRANGELY STRANGE

Now the trouble really started, most peculiar disintegrations were observed producing new particles which had no place in the scheme of things, and worse than that they broke the law that said if they were created by a strong interaction they must decay by it. They were created strongly and decayed weakly. Another feature of their creation was always being produced in pairs. An example of such a happening is shown in Fig 3, here a pion strikes a proton producing two new particles, a 'kaon' and a 'lamda hyperon', these then subsequently disintegrate to yield various known particles. This strange behaviour could be explained by analogy to the law of conservation of electric charge . If matter possessed a new quality like charge which had to be conserved when such a particle was produced so an opposite must also be produced. This quality was termed 'strangeness'. The kaon has a strangeness of +1 and the lambda hyperon that of —1, the net result being zero change in total strangeness. Strangeness is now more commonly known as 'Hypercharge'.

The difficulties did not stop there, particles popped up all over the place and everything was in disarray, clearly it was necessary to classify the particles as the elements had been just 100 years ago.

The hadrons ("hard ones") are so named because they respond to the strong nuclear force. They themselves are divided into two subgroups on the basis of the way they spin, into baryons and mesons. Another ▶



difference is that mesons can be created in any number during a reaction, but the number of baryons is constant like total strangeness, ie if a baryon is created so must an antibaryon, and only a baryon can annihilate an antibaryon. The leptons are the 'small charge', little particles only involved in weak interactions. The photon is in a class of its own at present but would be with the graviton if it was discovered.

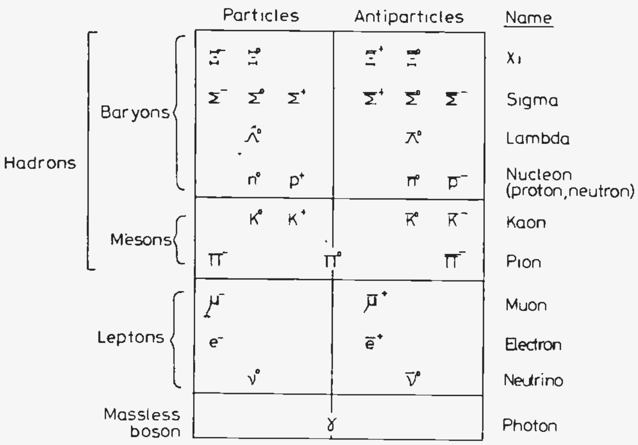


Fig. 4. Classification of particles.

As more and more particles appeared (over 100) they were all classified, and subgroups began to appear within the larger groups. The parallell to the classification of the elements 100 years ago is quite remarkable. Of course this immediately once again suggests internal structure.

UP, DOWN AND SIDEWAYS

In 1963 two independent workers came up with a system which would explain all the hadrons in terms of just three particles, the up, down and sideways (or strange) quarks, and their antiparticles. The leptons did not lend themselves to this explanation and are still regarded as truly elementary.

The baryons are said to be composed of three quarks and two mesons, one quark and one antiquark. (No satisfactory explanation of why there are no groups of one four, five or six quarks has yet been offered). The properties of the quarks are such that their sum would be that of the particle they make up.

		SPIN	ELECTRIC CHARGE	BARYON NO	STRANGENESS
QUARKS	U (UP)	$1/2$	$+2/3$	$1/3$	0
	D (DOWN)	$1/2$	$-1/3$	$1/3$	0
	S (STRANGE)	$1/2$	$-1/3$	$1/3$	-1

		SPIN	ELECTRIC CHARGE	BARYON NO	STRANGENESS
ANTI-QUARKS	$\bar{U}$ (ANTI-UP)	$1/2$	$-2/3$	$-1/3$	0
	$\bar{D}$ (ANTI-DOWN)	$1/2$	$+1/3$	$-1/3$	0
	$\bar{S}$ (ANTI-STRANGE)	$1/2$	$+1/3$	$-1/3$	+1

Fig. 5

A proton for example consists of one down (d) and two up (u) quarks. So if the properties of the three quarks are summed up we have;

	U	U	D	OBSERVED QUALITIES OF PROTON
SPIN	$1/2$	$1/2$	$1/2$	$= 1\frac{1}{2}$ (FRACTIONAL)
CHARGE	$+2/3$	$+2/3$	$-1/3$	$= +1$
BARYON NO.	$+1/3$	$+1/3$	$+1/3$	$= +1$
STRANGENESS	0	0	0	= 0

Fig. 6

The important feature of spin is whether it is fractional or integral, the spin of the baryons is always fractional and that of the mesons integral.

An example of a meson could be the positive pion ($\pi+$) which consists of one quark and one antiquark, the up (u) and the antidown ($\bar{d}$):

	u	$\bar{d}$	OBSERVED QUALITIES OF PION
SPIN	$1/2$	$1/2$	= 1 (INTEGRAL)
ELECTRIC CHARGE	$+2/3$	$+2/3$	= +1
BARYON NO.	$+1/3$	$-1/3$	= 0
STRANGENESS	0	0	= 0

Fig. 7

The real justification for the quark theory can be seen by examining one of the "subgroups" found in the baryons. If one compares strangeness, electric charge and number of types per grouping ("istopic spin") we get a group thus:

STRANGENESS	NUMBER OF TYPES
3?	1?
2	2
1	3
0	4

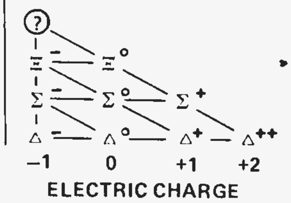


Fig. 8

This suggests another particle which would sit at the apex of the triangle. It would be a baryon, it would have no partners, and it would have three doses of strangeness. In fact it would be a baryon with three strange quarks (S,S,S). And sure enough it was found soor afterwards and is known as the omega minus (Ω—).

So once again the world was simple consisting of the following:

QUARKS	LEPTONS
UP	ELECTRON
DOWN	MUON
STRANGE	NEUTRINO (ELECTRON TYPE)*
	NEUTRINO (MUON TYPE)

*** It was realized in 1962 that there were two types of neutrino, one associated with the electron and one with the muon.**

Fig. 9

CHARMING COLOURS

So all particles with mass could be explained by these seven particles (and of course their antiparticles). But it was thought a pity that there was not a fourth quark, so there would be four quarks and four leptons. This was more than just the appeal of four to four symmetry, the leptons were 'paired' into electron plus its neutrino and muon plus its neutrino, so why not the same for quarks. The up and down quarks seemed 'paired' so why not a partner for the strange quark?

However as we progress into the late 1960's despite the fantastic accelerators and other resources, the quarks themselves remained undetected. Some evidence emerged that hadrons behave as a 'bag of bits', but proved impossible to split the bag open. At the same time the fourth quark ceased to be hoped for just in terms of symmetry. It was now an essential member of the group of eight, and if it were not found the whole system was in danger of collapse. The reasons for this are very complex, they relate back to an hypothesis put forward as far back as the 1930's. This was that the weak nuclear force was the electromagnetic force 'in disguise'. This would require a new quality like strangeness to exist. Since it was the 'charm' that would ward off the collapse of the quark theory it became known as the charmed quark. It was eventually found in 1976.

Since it is obvious some immense force must bind the quarks together in hadrons, physicists were naturally interested in this. This became known as the 'colour force'. The agents of transmission of this force are called 'Gluons'. The reason it is called the colour force is that physicists have always found it offensive to have two or more identical particles confined together. So it was suggested the quarks assumed colour. (The colour is just a label, there is no implication that they are actually coloured). In the $\Omega-$ for example which has three identical quarks, one is red, one green and one blue, with no net colour since they equal white. The mesons are also 'colourless' since they consist of a quark and an antiquark, and antiquarks have the complimentary colours (cyan, magenta and yellow). So they would always consist of a coloured quark with its complimentary coloured antiquark, again a net colour of white. But pause a moment, we now have four quarks in three colours (and the same number of antiquarks). Life is not as simple as it was in 1964.

NOW YOU SEE IT?

As far as the isolation of individual quarks is concerned there are two schools, one who believes they have done it. The other which believes it is impossible.

Those who believe they have done it claim to have done so by suspending minute balls of niobium metal in an oscillating magnetic field. By this technique they can measure the electric charge on the ball to an accuracy of 1% of that of one electron! So the fractional charge of ⅓ or ⅔ of one electron charge associated with individual quarks should be very apparent, being 33 times greater than the error. This they claim to have done.

There are at least three suggested explanations as to why quarks cannot be isolated. One for example suggests the quarks can be thought of as being on the ends of a piece of string. As energy is fed into the system the string stretches, absorbing energy. So when it breaks it absorbs energy to create a new pair of quarks, so they are never seen in isolation. It is obvious that the validity of the quark theory lies in the isolation of an actual quark, or in a watertight explanation of why they cannot be separated.

However the story does not stop here. In late 1977 it was reported from the U.S. that two new quarks appear to be necessary to explain a newly found particle the 'upsilon'. These are named the 'top' and 'bottom' quarks which will have the qualities of 'truth' and 'beauty' (like strangeness and charm). Presumably if we wish to retain the symmetry between leptons and quarks we will expect the appearance of two new leptons!

BUT ON THE OTHER HAND

The fact that the search for the 'fundamental particle' seems to go through layer after layer of structure has caused considerable disquiet amongst scientists and philosophers. The Chinese view matters such as this in a rather different way to the West and call such particles 'stratons', implying they are just another layer. Also it has been observed that our approach to the subject may be doomed to failure, since it is in many senses based on the false premises of the original Greek philosophers. Currently there is much discussion about the concept that there is no one way of looking at a subject such as this, nor may there ever be. It may well be that we will always have to use one explanation when we explain one aspect, and another explanation when we wish to explain another. This has been the case for the electron since the 1920's since it is a particle with known mass, but also behaves like a wave. For some purposes it is talked of as a particle and for others as a wave.

The Eastern philosophy that all things are in harmony with one another has not gone unnoticed by the philosophers and scientists, and there have been interesting developments in this field, with respect to forces. Newton unified terrestrial and celestial gravitation, Maxwell unified electricity and magnetism, Einstein at the time of his death was trying to unify these two together. Since then the weak nuclear force and the electromagnetic have been unified, and finally early in 1978 total unification has been proposed with the one force 'supergravity'. Perhaps somebody will come along and unify all matter!

Jobs for Students?

We got some, but most students are going to be looking for themselves.

ONE DAY Steve and the boys were sitting around in ETI's offices, wondering what we could do to help out Canada's electronics industry, when suddenly someone mentioned something about summer jobs for students. Wouldn't it be a good idea if we encouraged electronics companies to announce summer positions in ETI, and for students to be able to look in ETI for these annoncements?

BENEFITS

We feel that there are many benefits for companies hiring students. They are enthusiastic, versatile, and derive enjoyment from whatever challenges might be encountered. They help make up for vacationing full-time employees. They enable the company to explore short-term projects without having to transfer staff, or worry about staff after the project is over. In addition, many companies depend upon employing students in the summer to evaluate and train them as future full time employees.

Electronics Today is an ideal place to announce such positions, as it is in effect already prescreening applicants, narrowing down the field to those enthusiasts who enjoy reading about, and being involved in electronics.

THE PLAN

Thus it was that we hatched the plan, and commenced a program to encourage this activity. We announced it in the magazine in November, and mailed further announcements to 300 electronics companies across the country, from a list provided by the Ministry of Industry Trade and Commerce.

Hardly were we prepared for the "flood" of replies we received . . . all six of them, representing about 30 positions. They do look very tantalizing however, it's just a little disappointing that many more were not forthcoming.

Reasons for lack of response range from our deadline (mid-December) being too early, positions filled by former summer employees, relatives, friends etc. on a non-official basis, and even some companies waiting to hear what the government plans are this year for aiding summer employment.

Details of the announcements we received are to be found below, in addition we have some comments which we hope will help students hunting for jobs on their own. We hope to be involved with summer jobs in some way next year, perhaps with a new plan. Suggestions are welcome of course.

JOB HUNTING: YOUR SKILLS

It's best to start job hunting on a positive note. Make a list of what skills, experience and interests you have, in detail. Even if you think initially that you already know what your skills are, this exercise is useful, since it can inspire you to think of some places to look for jobs, and in addition, having this list freshly in mind enables you to comfortably drop bits of your experience into conversations with potential employers.

As an example, if you are looking for a job in electronics, you may have all or some of the following talents:

Electronics Development: May include soldering, breadboarding (with a CSC testboard for example), Vero or Vector board prototyping, wirewrapping, printed circuit board design, layout, artwork, and pcb manufacture, drafting a circuit diagram from rough notes, familiarity with local electrical code, CSA regulations or whatever.

Mechanical Skills: Basic metalwork, cabinet beautifying (making a prototype look professional), designing a pcb to fit in a box or vice-versa.

Troubleshooting/Servicing: Knowing how common circuits work, being able to understand circuit operation from a diagram, knowing how to use a meter and scope.

Selling: Being fluent in electronics, and able to explain to the potential user why he needs the product and how to use it.

Enthusiasm and Learning Ability: It is very important that your potential employer is convinced you are willing to work hard, and quickly learn those parts of his operation with which you are not familiar. It would even be useful to read up on things you may not have tried, such as making pcbs for example.

Having accounted for your useful qualities (and our list is by no means complete) this may indicate specific jobs for which you would be best suited.

BEGIN THE SEARCH

Might as well get started on the easy part first. Look for companies advertising positions. Go to university and college employment centres (don't be afraid to go to an establishment in

"No, I've never actually handled a $60 million missile contract — but there's a first time for everyone isn't there!"

which you are not enrolled, after all, how is your future employer to know that's not where you are?), look in the newspapers, visit the local Manpower centre. This may turn up some leads to follow up, but don't stop there!

SEARCH: PHASE TWO

There are alot of companies who would probably hire a person, if the right individual was to happen along. But they are unwilling to advertise, since the person they want is kind of special, and they don't want just anyone who responds to an ad. Therefore, you must do them a service and find them. After all, one of the special qualities they would look for is somebody with the self motivation to do just that!

The first thing to do is to develop a list of companies in whom you are interested. Ask your friends and relatives. Contact students in their last year at a college or university electronics course (they won't be needing their summer jobs back). Look in the Yellow Pages under Electrical and Electronic and Radio, TV (service or station), Engineering, Sound, Audio, etc. Write down everything which catches your fancy. You might also try a local government office for a directory of industrial companies in the area.

It is useful to note here that company size is quite an important factor in deciding your approach. The point is that your ideal approach is to impress the person who can hire you as directly as possible. You are most likely to be able to impress a technical person rather than a "personnel" person. The smaller the company (whether it's the village service shop, or a small electrical consultant firm), the more likely the technical chief has some, or all the hiring responsibility. Hence smaller companies can be a better bet if you are approaching them. In addition, large companies tend to have more sons and daughters, neices, nephews etc., and summer employment can have a bad name because of the embarrassing situations where a student is working for an employee of his father. The moral is: don't hold out too much hope of getting a job with a big company, unless you are replying to an advertised position.

Suppose you're still stuck. How to track down those elusive small electronics companies. What do they all have in common? They all need to buy parts, and use printed circuit boards, so phone or write component outlets and pcb manufacturers and ask them. Even the local Radio Shack is used by many a small business to quickly pick up the odd parts. The angle you might take is: "I'm compiling a list of companies which I can contact regarding a summer job for myself. The kind of company I'm interested in would perhaps be developing and producing electronic equipment, so I felt that you might know of a few since they would be using your parts/pcbs/whatever." You may end up working for them! But if you don't, you should get some useful leads, especially since people in the business often know when a company is looking for someone.

Keep orderly notes as you go, telling who said what about whom, and get names and positions, so that when you contact their lead you can say "so and so recommended I speak to you".

ARMED WITH LIST . . .

When you've got your list started, it's time to start contacting companies on it. If you are organised early, you can approach this as an enjoyable way to get to know the local electronics industry. In other words, how about using the following angle: "I'm interested in working in electronics, and I'd appreciate the opportunity to come and see what your company does." You might also say something about a summer job, but try not to get a "no" on the phone, if possible. If you ask "does your company hire students in the summer?" then you are likely to get a "no". What you really want to do is have the employer get to know how good you are, then ask "will you hire me?". Asking to see his company flatters him, and allows you both to get to know each other on relaxed terms, so that when making the decision as to whether to hire you, he feels he knows you already and is thus making a safe bet.

Even if a particular visit does not turn up a job, it educates you as to what goes on and gives you some intelligent experienced conversation topics for your next visit.

Naturally, when going on one of these visits be prepared with some basic information about yourself to leave behind if the opportunity arises. This is discussed under "RESUME".

If you have less free time, (but remember, you'll have lots of free time if you don't get that job!) then a mail "campaign" is in order, but it's up to you what material you send to represent you in each case. You should phone the company first and get a person's name and position to send your letter to. Ask the secretary or switchboard person for the name of the head of the technical or production department (or whatever is appropriate).

THE RESUME

It has been said that when applying for a job, your resume is the most important item. Perhaps more correctly it should be said that it contains information that must not be omitted, but it won't necessarily get you the job.

The employer needs to know certain basic information about you, name, address, phone number and SIN being examples. The format of a "standard" resume is most applicable to a person who has been working for a while, whose previous work experience and schooling are conveniently summarized into paragraphs, and which directly support their suitability for the position. However, as a student, it is probably your personal activities which most directly contribute to your applicable experience, and these are not quite so amenable to this format. In fact, by the time you're down to the bottom of the first page of "serious" background you're probably describing where you went to kindergarten.

By all means use a resume to fill in the basic info about yourself, work experience, clubs you belong to, and

Well finally, before you go, do you mind if we ask you one or two questions, Mr. Er – ?!!"

relevant special courses. Where you are in the education system can be helpful as it gives the employer an idea of how much you'll be costing. (Ever notice how much more enticing an advertisement is with prices on it?) Some students prefer not to point out their actual ages, feeling that their ability far exceeds that which might be expected.

Your resume need not be too formal (there are many books on how to do it "properly"), especially if the person you are addressing it to appears to be technical rather than "personnel". After all, while reading it he may be deciding whether or not he wants you sitting across the desk from him all summer!

STAND OUT

The main thing you must do is stand out, whether in person, or as represented by the material you send. This means do *anything* to get your submission noticed, whether hilariously funny, or very dramatic. Anything to keep your name out of the filing cabinet or garbage can, but just short of getting you commited to the lunatic asylum.

AN EXAMPLE

Imagine this: you discover there's a small company in town who produce custom control circuits. They've got maybe a couple of engineers, and a few people (perhaps local house-wives part-time) assembling circuits for them . In this sort of operation, typically the people "at the top" also have to do some relatively mundane (for them) tasks, such as the engineer doing his own pcb design, or final drawings. In the summer the load can get heavier with vacations, and existing staff trying to fill in. You can help relieve this problem, and help raise productivity by taking over some of the "lower level" design tasks, or higher level production work (testing, troubleshooting). It doesn't take all that much to raise the productivity enough to pay for yourself.

You don't know anybody who works there at all, and you've got no easy "in" to get yourself talking to the person who can hire you. So . . . you build a small project with LED readout, which when switched on flashes your name and "HIRE ME". You send it along with some details about yourself, and how you can help.

Now, when the boss opens your package, and looks at the contents, he's got something the whole office is sure to see and a demonstration of your abilities. How could he pass up the opportunity to hire such a star? Little companies are built on extraordinary individuals, who are willing to get done what needs doing

This is of course an extreme example and few people are going to go to such great lengths (and expense) unless they are pretty sure it will get results. BUT, the principle is: GET NOTICED. Around the magazine, one staff member mocked up an article about himself in the magazine's own style when applying to a job ad in the magazine. Another person feels that under the right circumstances his ideal job application would include a cartoon strip showing his previous experience, and what he could do for the company who hires him. (He frequently cuts out cartoons from the paper and fills in new captions.)

GET GOING

That's about it, the rest is up to you. So good luck, stop reading, put this magazine down right NOW and get going!

JOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOBSJOB

THE ADGA GROUP, 116 ALBERT STREET SUITE 400, OTTAWA, ONTARIO, K1P 5G3.
Contact Mr D J. Wells by letter or phone, with resume.
Engineering Consulting firm primarily involved in electronics.
Student requirements: 2 Electronic Engineers to field test HF communication equipment. ALSO 5 Electronic Technologists for digital design and maintenance, field installations of VHF and microwave equipment.

THE CLASSIC ORGAN CO. LTD , 300 DON PARK RD., UNIT 12, MARKHAM ONT. L3R 1C3.
Contact Henry Wemekamp, President by letter, include resume, hobby experience and area of interest.
Manufacturer of custom electronic organs and hybrid pipe-electronic organs for church and home use; also time multiplexed switching systems and mpu controlled capture combination actions for pipe organs.
Student requirements: 2-3 for pcb assembly general wiring, chassis work etc. Must have adequate knowledge of electronic circuits and components to be able to work from schematics. Must have good soldering skills. ALSO 1 (possible) to write software and modify machine language programs on 1802 COSMAC cpu; for control systems and digitally controlled synthesizer. Experience with ELF or equiv. necessary.

COM DEV LTD, 582 ORLY AVENUE, DORVAL QUEBEC H9P 1E9.
Contact K Flood by letter.
Company designs and manufactures microwave components and subsystems for satellite and terrestrial communications.
Student requirements: 1 Scientific computer programming, 1 Assembly and test of sateilite components.

C-TECH LTD., 1150 MONTREAL ROAD, CORNWALL ONTARIO K6H 5S2
Contact: W Hamilton or L M Johnson by letter including resume.
Company involved in sonar including low frequency electronics, electromechanics and underwater electro-acoustics.
Student requirements: 1 or 2 2nd or 3rd year E.E students to work as lab assistants, build and test circuits as an aid to design engineer. Similar previous experience would be desireable, persons who like to work with hands and hardware would be most suitable.

MACDONALD, DETTWILER & ASSOCIATES LTD., 10280 SHELLBRIDGE WAY, RICHMOND, B C. V6X 2Z9.
Contact: Wendy Seath by letter, enclose resume, stating salary expectations and availability date.
Vancouver based designer and manufacturer of innovative digital systems for receiving and processing data from remote sensing and meteorological satellites and aviation information flight operation systems.
Student Requirements: 2 Software, 1 Hardware. Knowledge required: Student in science electrical engineering or computer science. Finished at least 2 years (software) or 3 years (hardware). Good marks. Some experience in assembly language, or FORTRAN programming or practical experience in digital electronics. Position description: To assist engineers and project teams developing hardware and software systems for a variety of aerospace applications.

MILLER COMMUNICATIONS SYSTEMS LTD., P O BOX 13220, KANATA, ONT, K2K 1X4
Contact Mr A H Jarvis by letter.
Fully Canadian owned company in the high technology field covering spectrum monitoring computer control receivers; communications electronics and customized electronic systems.
Student requirements: 3rd and 4th year students in the above company fields and areas of associated software and microprocessor application.

MITEL CORPORATION OTTAWA (KANATA) ONTARIO P O. BOX 13089
Contact Mr. J G Stanton Personnel Manager by letter with resume.
Electronics firm designs and manufactures electronic equipment for telephone companies, a high technology industry.
Student Requirements: 5 Engineering students (Electronics majors) ALSO 5 Electronic Technicians/Technologists. No previous work experience necessary. Work will include assembly and testing of product. General engineering support work with opportunities to work on more advanced work.

CANADIAN ARMED FORCES

The Forces have two major sections, the "Regular" Forces, and the "Militia", both of which may be of interest to students. Enlisting with the Regular Forces allows you to go to university (for example) now, paid for by the Forces, in exchange for your services during summers, and for a number of years after graduation. Occupations would involve the recruit's skills.

The Militia is a more "part-time" oriented organisation. With the Militia one can obtain a summer job, and to ensure future summer employment the recruit may be involved with his or her unit on a part-time basis during the school year. Courses that may be taken may involve the person's interests, such as Radio Operator for example.

Employment with the military tends to involve more commitment than an ordinary job, such as going away on courses or exercises, but it's likely to be exciting if taken with the appropriate attitude.

For more detailed information, contact your local recruitment office. If the number's not in the phone book under "Governments-Canada-National Defence", call the long distance information number for the nearest big city, who will give you a toll-free number for recruitment.

JOBS WITH GOVERNMENT BODIES

Contact with a few government agencies indicates that summer positions with the government are filled quite well without extra announcements thankyou. It doesn't appear likely that one could get a government job that had not been advertised, so keep your eyes tuned at the employment centres. Applications tend to be the "fill in the form and wait" type. Since there are many more applications than positions, be early, and do what you can to stand out.

Op Amps: Part 1

Open up any data sheet on a particular op-amp and you will be confronted with a many as forty different electrical parameters and performance graphs which should reveal all that you need to know about the device. Most of these parameters will be qualified by the conditions under which they were measured and the test arrangements used to make the measurements. This apparent 'overkill' of data is likely to be very confusing to the newcomer, however it need not be so. Tim Orr explains.

LET'S DISCUSS SOME basic principles. An op-amp (or operational amplifier) is just a high gain amplifier, you stick a voltage into it and a much larger voltage comes out of it. Op-amps have two inputs, inverting and non-inverting, which are denoted by — and + respectively. The op-amp amplifies the difference in the voltages applied to these two inputs, the output going positive if the + input is positive with respect to the — input, and vice versa, however, virtually useless, because the voltage gain is uncontrollably large and the distortion high. The way in which both of these parameters are controlled is by the use of negative feedback. An op-amp with negative feedback is shown in Fig. 1. It employs two resistors to set the closed loop voltage gain, and as long as this is small compared to the open loop gain, it will be determined by the resistor ratio RF/RI. The open loop gain, the voltage gain when RF is removed, is typically of the order of 100 000. This massive gain is clearly much too large to be used without feedback. Closed loop voltage gains of 100 are about as much as it is practical to use.

BIASED EXAMPLE

The arrangement in Fig. 1 is known as a 'virtual ground' amplifier. The non-inverting input is connected to ground and the inverting input is maintained by the feedback applied via RF at a voltage which is virtually ground potential.

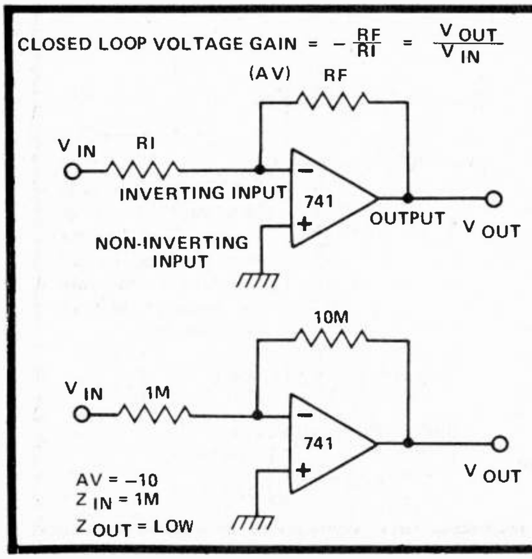
The input impedence of the amplifier in Fig. 1 is simply RI. The output impedence is a little more complicated, it is approximately

$$\frac{\text{output impedence of the op amp} \times \text{closed loop.gain}}{\text{Open loop gain}}$$

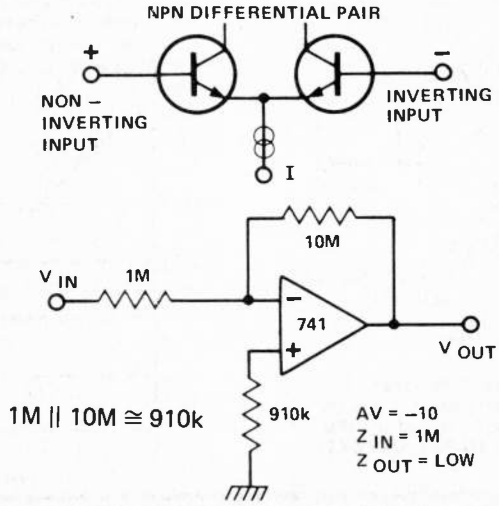
Suppose we want an amplifier with a gain of 10, and an input impedance of 1M. This means that RI is 1M. Therefore RF must be 10M (see Fig. 2). With a 1 V sinewave as the input signal we get a 10 V sinewave as the output. However, when the input signal is held at 0 V (ground potential), the output voltage is not 0 V, it is positive! This is an error voltage, which may be undesirable. The cause of the problem is the 'INPUT BIAS CURRENT' of the op-amp. The input of many op-amps looks like the circuit shown in Fig. 3 If these transistors are to operate correctly they need a standing emitter current which implies that they need an input base current. It is this base current which is the op-amp's 'INPUT BIAS CURRENT.' For a 741 this current can be as large as .05 uA. In the arrangement of Fig. 2 this current can only come through RF, which means that the output voltage could be as large as 0.5 uA X 10M, which is +5 V! One way to remedy this error is to use a circuit shown in Fig. 4 A resistor has been inserted between the non-inverting input and ground. This resistor has the value of RF in parallel with RI. It allows both the inputs to sink slightly and thus maintain the voltage balance at the inputs. The output voltage is then nearly 0V. However, the two input transistors may not be that well matched, so the input bias currents may be different into each input. This is known as the 'INPUT OFFSET CURRENT' and its effect can be nulled by making the 910 k resistor in Fig. 4 a variable resistor. If the bias currents (for a 741 say) were zero, then the output voltage would still not be 0 V.

GET SET, THEY'RE OFF

The output voltage could range between ± 60 mV. This is due to the 'INPUT OFFSET VOLTAGE' which for a 741 can be as much as ± 6 mV, which is then multiplied by



Figs. 1 and 2 (far left) show (upper) the basic inverting op-amp stage. Gain is given by the ratio of resistors RF/RI, input impedance is simply RI while the output impedance is more complicated (see text). Fig. 2 (lower) shows a stage with a gain of 10 and an input impedance of 1M.



Figs. 3 and 4 (left) show (upper) a typical op-amp input stage. This is a differential amplifier made up of a pair of NPN transistors driven by a constant current source. Fig. 4 (lower left) shows a 910k resistor in the + input of the op-amp. This reduces the effects of the INPUT OFFSET CURRENT.

the closed loop voltage gain of the stage (in this case 10) giving us ±60 mV. This can be compensated by using the circuit shown in Fig. 5. Terminals 1 and 5 on a 741 can be used to compensate for the input offset voltage. The input offset voltage is the V_{be} imbalance between the two input transistors.

Now that we know how to eliminate the spurious DC offsets, we can try designing some dynamic circuits and find out why they don't work as expected! For example, try putting a 1 V sinewave at 200 kHz into a circuit of Fig. 5. What you would expect is a 10 V, 200 kHz sinwave at the output — but you don't get one. What appears is a rather bent 200 kHz triangle waveform. This is because the 'slew rate' of the op-amp has been exceeded. The slew rate is the speed at which the output voltage can move, and for a 741 is typically 0.5 V/μsec when it crosses zero, so the op amp faced with this demand just gives up and SLEW limits, drawing out straight lines as it does so.

LISTEN TO THE BAND(WIDTH)

Another problem is 'BANDWIDTH'. A 741 has a GAIN BANDWIDTH product of approximately 1 MHz. This means that the product of the voltage gain times the operating frequency cannot exceed 1 MHz.

For example, if you want the amplifier to have a gain of 100, then the maximum frequency at which this gain can be obtained is 10 kHz. Fig. 6 illustrates this phenomenon. Curve A is the open loop response, note that the voltage gain is 1 at 1 MHz, hence the gain bandwidth product of 1 MHz. The slope of the curve is —20 dB/decade, which is caused by a single 30p capacitor inside the IC. Now, if the resistor ratio is set to give a voltage gain of 100, then the op-amp gives a frequency response shown by curve C, which is flat up until 10 kHz. A gain off 10 rolls off at 100 kHz (D) and a gain of 1 000 rolls off at 1 kHz (B). Thus it is very easy to see just what the closed loop frequency response will be. However, don't forget the slew rate problem. You may be able to construct an amplifier with a voltage gain of 10, which works up to 100 kHz, but the output voltage will be limited to less than 3 V pp! Another problem is distortion in the op-amp. Negative feedback is used to iron out any distortion generated by the op-amp, but negative feedback relies on there being some spare voltage gain available. For instance, say the op-amp generates 10% distortion and there is a surplus voltage gain of 1 000,

$$\text{i.e. } \left(\frac{\text{open loop gain}}{\text{closed loop gain}}\right),$$

then the distortion will be reduced to approximately,

$$\frac{\text{open loop distortion}}{\text{surplus voltage gain}} = \frac{10\%}{1\ 000} = 0.01\%$$

So, negative feedback is used to eliminate distortion products. However, if there is no surplus voltage gain, as in the case of a 741 amplifier working at 10 kHz, with a closed loop gain of 100, then the distortion will rise dramatically at this point.

CURRENT THINKING

Most op-amps have a voltage output, although some have a current output. If you short-circuit a voltage output them large currents could flow and thermal destruction might follow. To overcome this problem, most op-amps have a current limited output so that they can suffer an indefinite short to ground. A 741 is limited to about 25 mA. Another current of note is the supply 'BIAS CURRENT. This is the current consumed when the op amp is not driving any load. For a 741 this current is typically 2mA, which makes it rather unsuitable for small battery applications.

There are some op-amps which can be programmed by inserting a current into them so that their supply current can be controlled. This means that they can consume only micropower when in their 'standby' mode, and they can by quickly turned on to perform a particular task.

VOLTAGES DIFFERENTLY

In the few examples shown so far, the op-amp has been used to amplify voltages which have been generated with respect to ground. However, sometimes, it is required to measure the difference between two voltages. In this case you would use a 'Differential' amplifier, Fig. 7. By using two matched pairs of resistors, the formula for the voltage gain is made very simple. It is thus possible to superimpose a 1V sine wave on both the inputs, and yet have the output of the amplifier ignore this common mode signal and only amplify any differential signals. The amount by which the common mode signal is rejected is called the CMRR (the Common Mode Rejection Ratio) and is typically 90 dB for a 741. Thus a common mode 1 V signal would be reduced to 33 uV.

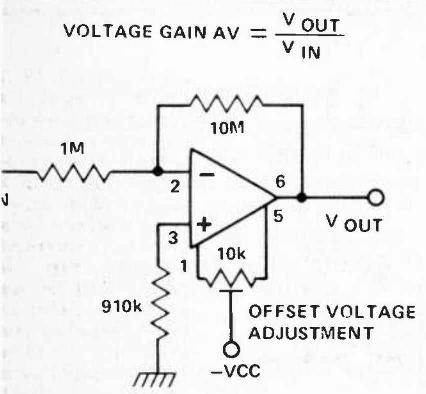
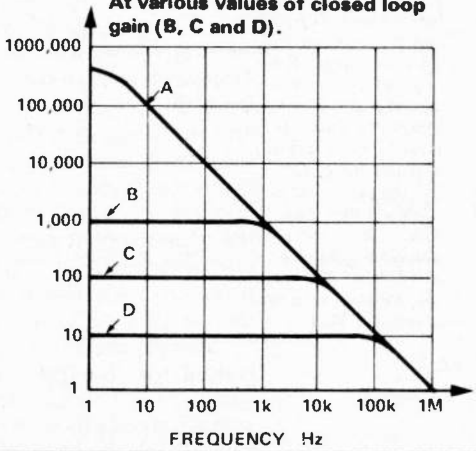


Fig. 5. A variable resistor connected between pins 1 and 5 of a 741 can be used to reduce the effects of the INPUT OFFSET VOLTAGE.

Fig. 6. Graph of open loop response of a 741 (A) together with curves indicating response At various values of closed loop gain (B, C and D).



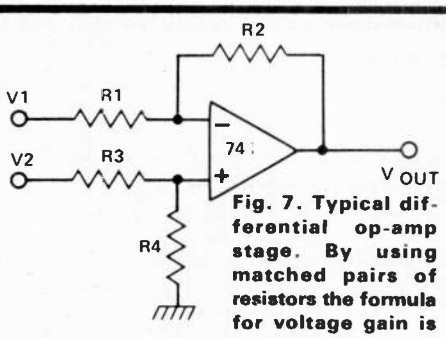


Fig. 7. Typical differential op-amp stage. By using matched pairs of resistors the formula for voltage gain is made simple.

$$V_{OUT} = \left[\left(\frac{R1 + R2}{R3 + R4}\right)\frac{R4}{R1}V2\right] - \frac{R2}{R1}V1$$

BUT IF WE MAKE R1 = R3
AND R2 = R4

$$\text{THEN } V_{OUT} = \frac{R2}{R1}(V2 - V1)$$

Another rejection parameter to be noted is the supply voltage rejection ratio. For a 741 the typical rejection is 90 dB, that is, if the power supply changes by 1 V the change in voltage at the op-amp output will be 33 uV.

When designing with op-amps it is very important to know what voltage range the inputs will work over, and the maximum voltage excursion you can expect at the output. For instance, the 741 can operate with its inputs a few volts from either power supply rail, and its inputs can withstand a differential voltage of 30 V (with a power supply of 36 V).

This is not true of all op-amps, some have a very limited differential input voltage range, for instance the CA3080 will zener when this voltage exceeds 5 V and the amplifier performance will then be drastically changed.

The output excursion of the op-amp is also important. The 741 can only typically swing within about 2 V of either supply rail, whereas the CMOS op-amp can swing to within 10mV of either rail so long as the load into which it is driving is a very high impedance.

NON-INVERTING AMPLIFIER:

An op-amp is used to provide voltage gain, but in this case the output is in phase with the input. The minimum voltage is unity and occurs when RB is an open circuit. The op-amp has maximum bandwidth at unity gain, and any increase in the gain will cause a reciprocal decrease in bandwidth.

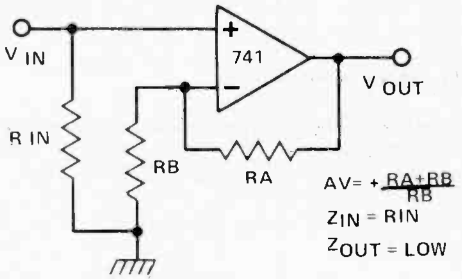


Fig. 8. Non-inverting amplifier.

HIGH SLEW RATE AMPLIFIER:

The slew rate of the op-amp has been increased by increasing the overall current generating capability, by the addition of a pair of transistors. These transistors increase the output voltage range by allowing the voltage to swing to within OV5 of either supply rails. The output of the op-amp hardly moves at all. Without an input signal, the output voltage is 0 V and the op-amp drains approximately 2 mA from the supply rails.

This current passes through the 180R resistors and sets up a voltage which is not quite sufficient to turn on either transistor. When a positive voltage is applied to the input, the op-amp tries to swing negative but it has a 47R (R4) resistor connected from its output to ground.

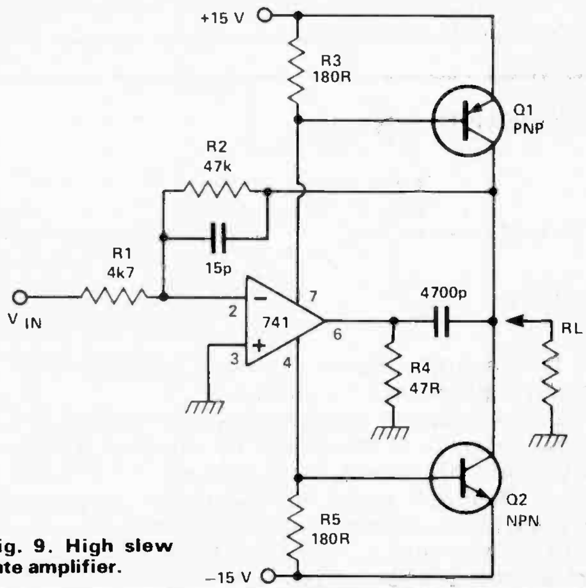


Fig. 9. High slew rate amplifier.

SIMPLE INTEGRATOR:

An op-amp and a capacitor can be used to implement, to a high degree of accuracy, the mathematical process of integration. In this case, current is summed over a period of time and the resultant voltage generated is the integral of that current as a function of time. This means that if a constant voltage is inputted to the circuit, a ramp with a constant slope is generated at the output. When the input is positive, the output of the op-amp ramps negative.

In doing so it pulls the inverting terminal negative so as to maintain a 'virtual earth' condition. In fact the input current (Vin/R1) is being equalled by the current flowing through the capacitor, thus equilibrium is maintained. The equation governing the behaviour of a capacitor is C × dV/dt = i, where dV/dt is the rate of change of voltage across the capacitor.

Therefore $\frac{dV}{dt} = \frac{i}{C}$ Thus $\frac{dV}{dt} = \frac{Vin}{R1C}$

So, when a square wave is applied to the circuit in Fig. 10, triangle waveforms are generated. R2 was added to provide DC stability. Its inclusion does slightly corrupt the mathematical processes, but not enormously. A good point about this integrator design is that it has a very low output impedance. You can put a load on the output and the op-amp will still generate the same waveform — that's what is so nice about negative feedback.

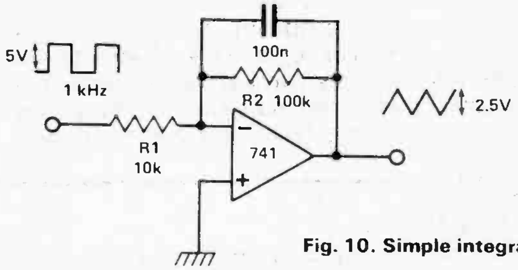


Fig. 10. Simple integrator.

Thus, as it tries to swing negative, it draws lots of current from the negative rail. This current flows through R5, and in doing so turns on Q2. This transistor then pulls R2 down and thus provides negative feedback. The same sequence of events occurs when the input is negative except that R3 and Q1 are then involved. Thus the high current capabilities of descrete transistors are combined with a high voltage gain of an op-amp to produce a moderately powerful amplifier. The voltage gain is set by R2/R1.

Transistors Q1 and Q2 introduce a phase shift, which may give rise to a high frequency instability and oscillation. This can be cured by some frequency compensation applied to the amplifier or by increasing the overall voltage gain.

NO NOISE IS GOOD NOISE

The last op-amp characteristic to be discussed is 'Noise'. The noise figures given in the specifications are very confusing. This is due to the fact that noise is specified in so many different ways that it is often difficult to compare devices. One may be specified in terms of Equivalent Input Noise and another device in terms of nV/(√Hz)(nano volts per root Hertz)! As a generalisation it is true to say that most op-amps are relatively noisy. Some op-amps are labelled low noise, and these are quieter than the average op-amp but more noisy than a well designed descrete component amplifier. For audio work you can use ordinary op-amps for processing high level signals (100 mV to 3 V), but for amplifying low level signals (1 mV to 100 mV) you would be advised to use a low noise device. The larger the voltage gain you obtain from an op-amp stage, the worse will be the noise, therefore keep the closed loop gain to a bare minimum.

That is the end of the theory, now for some practical examples of op-amps in use.

SIMPLE DIFFERENTIATOR:

Mathematically, differentiation is the reverse process to integration. Thus, in the differentiator circuit the C and the R are reversed with respect to the integrator circuit.

The input waveform is a triangle with a constant rise and fall slope. This constant slope, when presented to a capacitor will generate a constant current. When the slope direction reverses, then so will the current flow. This current when supplied via R2 will result in a square wave output.

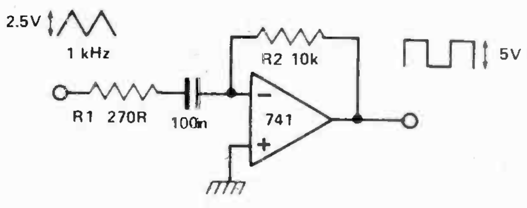


Fig. 11. Simple differentiator.

12 V REGULATED POWER SUPPLY:

The large open loop voltage gain of an op-amp is very useful in providing a regulated low output impedance power supply. A 5.1V voltage reference is generated by a zener diode ZD1 (this voltage reference could be made more stable by running it at constant current). A PNP transistor is used as a series regulator. However, this transistor inverts the signal from the op-amp output, and so, in order to get negative feedback, the feedback is taken to the non-inverting input! The operations is as follows. The inverting input is held at 5.1V. If the 'PSU OUTPUT' tries to fall, the voltage at the non-inverting input falls. Therefore the op-amp's output will also fall, thus turning on the PNP transistor which then pulls up the 'PSU OUTPUT.' Thus the output voltage is stabilised. Also, the output impedance is very low, due to this negative feedback. The output impedance at high frequencies (where the op-amp gain is low) is further reduced by the 100n capacitor. To squeeze the last drop of voltage out of the system, before a collapsing unregulated supply rail causes the regulated supply to drop out, a 5.1V zener diode (ZD2) has been included. This allows the op-amp output to work at about 7 volts below the unregulated supply rail. Thus, a regulated output is maintained until the PNP transistor saturates. This means that the unregulated rail can fall to within about 200 mV of the regulated rail!

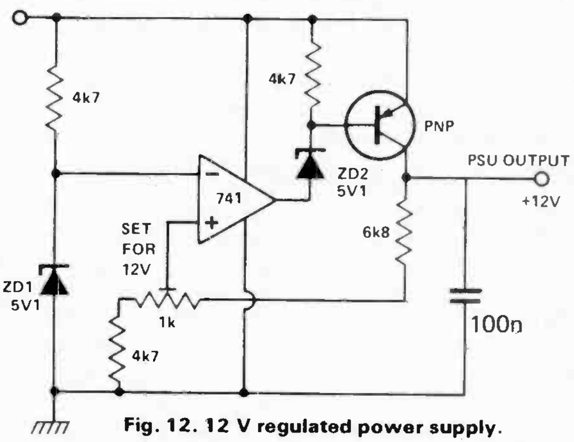
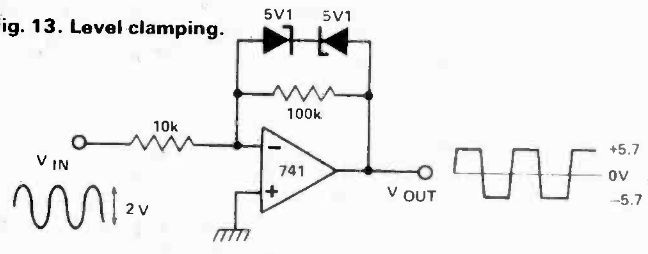


Fig. 12. 12 V regulated power supply.

LEVEL CLAMPING:

It is sometimes required to limit the excursion of the output voltage of a linear amplifier. This can be achieved by using non-linear feedback, in this case with zener diodes. Once the voltage at the op-amp's output exceeds the zener breakdown voltage plus a forward diode drop (0.7V) from the forward biased Zener), the effective impedence of the feedback becomes very low. Thus the voltage gain, above this zener voltage, also becomes very low. The output voltage appears to be clamped at a fixed potential. By changing the zener value, this potential can be varied at will. Also, by making the two zeners have different values, correspondingly different negative and positive levels can be obtained. This circuit is, however, far from ideal. The zener diodes don't have very sharp 'Knees' in their transfer characteristics and the clamping can sometimes be very sloppy, particularly when low voltage zeners are used. Also, the zener diodes tend to have a large amount of charge storage, which impairs the high frequency performance.

Fig. 13. Level clamping.



Sometimes, however, sloppy clamping is considered useful. For instance, if the zeners are replaced by two ordinary diodes in parallel and pointing in different directions. Then any signal applied to the input will receive some non-linear distortion. This distortion is rich in odd harmonics, and is the basis of many FUZZ box designs for musical effects units.

VOLTAGE TO CURRENT CONVERTER

The virtual earth of an op-amp and the current source characteristic of a transistor can be combined to produce a precision linear voltage to current converter. Consider the 'SOURCE' circuit. A positive voltage is applied and the op-amp adjusts itself so that a 'virtual earth' condition is maintained. This means that a current i flows through the input resistor R, where i = Vin/R. Now this current has got to go somewhere, and so it flows through the PNP transistor and comes out of the collector and into its load. Thus, the input voltage generates a current which is linearly proportional to it. There are, however, three sources of error that will affect this linearity. First the input offset voltage of the op-amp may become significant at low levels of Vin. Second, the input bias current may well rob a lot of the current when Vin is low. Third, the base current of the transistor must be subtracted from the final output current. Note that the current gain of the transistor will change with collector current variations, and so the base current loss is not a fixed percentage. However, a precise voltage to current converter can be made using an op-amp with a FET input so that the bias current is low. Also, an input balance can be used to zero out the input offset voltage, and if a FET is used to replace the bipolar transistor, then the base current problem can be removed.

The 'SINK' circuit merely swaps the transistor for an NPN type. Note that the input voltage now must be negative.

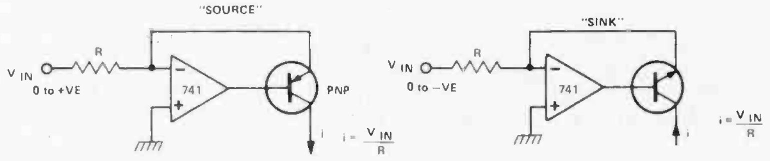


Fig. 14. Precision linear voltage to current converters.

SCHMITT TRIGGER

When DC positive feedback is applied around an op-amp, its output will come to rest in one of two states, that is in its most positive or most negative position. This type of circuit is known as a Schmitt Trigger and it is said to exhibit the property of hysteresis. Consider the circuit shown in Figure 15. Let us assume that RB is 2k and RA is 1k and the output voltage is +10V. Therefore the voltage at the non-inverting terminal is +3V3. When the input voltage becomes more positive than +3V3, the output of the op-amp will start to swing negative and in doing so will increase the voltage difference between the inputs. This will in turn make the output swing even more negative. Thus the process becomes regenerative, the output finally 'snapping' into its negative state (−10V say). The only thing that will now change the op-amp's output is if the inverting input goes more negative than the non-inverting input. When this occurs it will revert back to its original state. The two input voltages at which these transitions happen are known as the upper and lower hysteresis levels. The graph in Fig 15 shows the circuit's transfer function. Figure 16 is another Schmitt trigger circuit, but the mode of operation is inverted.

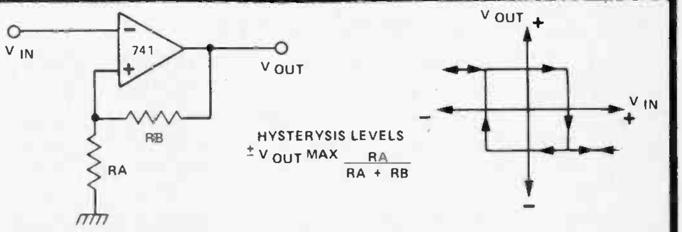


Fig. 15. Schmitt trigger configuration.

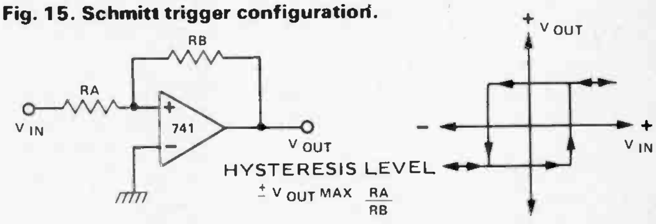


Fig. 16. Schmitt trigger with mode of operation inverted with respect to that shown in Fig. 15.

TRIANGLE SQUARE OSCILLATOR

A Schmitt trigger and an integrator can be used to construct a very reliable oscillator which generates triangle and square wave forms. The operation of the circuit is very simple and always self starting. The Schmitt trigger is formed from IC1, the integrator from IC2. Suppose the output of the Schmitt is positive. This will cause the integrator to generate a negative going ramp. This ramp is then fed back to the input of the Schmitt. When the lower hysteresis level has been reached the output of the Schmitt snaps into its negative state, current is taken out of the integrator which then generates a positive going ramp. The integrator's output ramps up and down between the upper and lower hysteresis levels. The speed at which the integrator moves is determined by the magnitude of the voltage applied to it. In this circuit, the magnitude of the voltage and hence the oscillation frequency, are controlled by a potentiometer, giving a 100 to 1 control range. This circuit is the basis of most function generators. By bending the triangle it is possible to synthesize an approximation to a sinewave. With a bit more electronics it is also possible to make the oscillator voltage controlled.

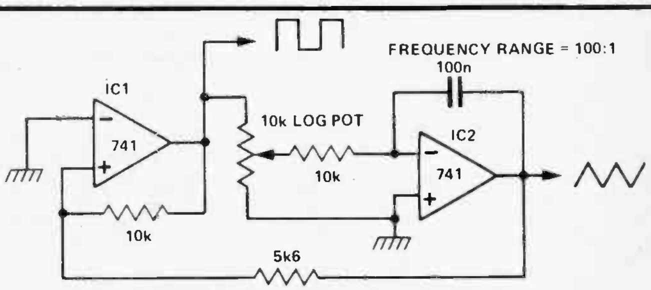


Fig. 17. A Schmitt trigger and integrator combined to produce a triangle and square wave generator.

This series will continue in future issues with many more op-amp circuit configurations including envelope shapers, sample and hold circuits, and some oscillators.

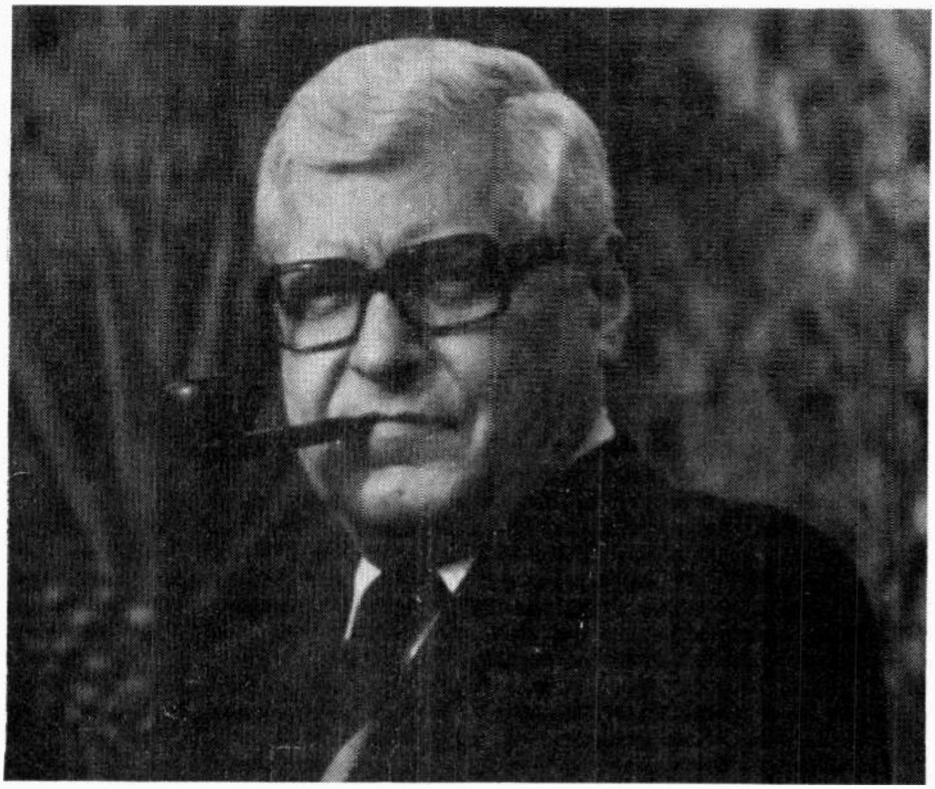
Bits, Bytes and Pieces

John R. Welty, Vice-President and General Manager of Motorola's Semiconductor Group is optimistic about the future of electronics components, all of them.

EVER SINCE THE DEVELOPMENT of the integrated circuit back in the mid-1950s, a recurrent theme in our industry related to the impending demise of the discrete semiconductor business. The press, some of our friends in the financial community, and many other observers of the semi-conductor scene, have often tended to downplay the importance of discrete components in the future of the industry. The usual scenario drawn by these observers called for the discrete industry curve to generally flatten during the 1970s— continue on a descent throughout the 1980s — and almost fall completely off the industry charts by the 1990s.

The primary reason for this somewhat gloomy outlook, of course, was the phenomenally rapid growth of the IC technology, in which a steadily growing number of discretes were and are, being integrated into the silicon chip and losing their identity as discrete components. As you know, the integrated circuit technology advanced, in a relatively short period of time, from devices containing 10 or 15 transistors to the current situation in which they contain thirty or forty *thousand* transistors in the same sized silicon chip. And, there certainly isn't any doubt that the number will escalate to the hundreds of thousands by the early 1980s, and to perhaps a million per chip by 1985 or so.

The advent of the microprocessor, and the rosy future that all of us in the industry are predicting for it, has no doubt tended to compound the "image" problem that exists within the discrete component industry.



CHANGING SOCIETY

The microprocessor has been the most publicized product ever developed by the semiconductor industry, and perhaps rightly so. I honestly believe that the micro-processr will eventually be recorded in history as one of the most important, if not THE most important, industrial development of the twentieth century.

The amount of change, and the speed of change, that the micro-processor will bring to the worldwide social, political and industrial institutions during the next decade will stagger event the most fertile of imaginations. The number of new or improved electronic products for the home, the automobile, the factory, the office, the school, the government and the military organizations not only in the U.S., but around the world, will number in the thousands. And that will only be the beginning, we will barely have scratched the surface of what can be accomplished through the microcomputing technology.

The rapidly growing volumes of microprocessors being used are, to a large degree, responsible for our pred ıctions that the U.S. semiconductor industry will double its present size in the next four or five years. Another reason, less dramatic perhaps that the growth in microprocessors, is the quiet but significant revolution that the MPU technology is creating within the discrete component industry.

It is estimated that more than 50 per cent of the microprocessors being produced today are for new product applications which previously were not feasible for either technical or financial reasons. While these new microprocessors are having somewhat of a negative impact on conventional standard logic integrated circuit families, their impact on discrete components is definitely positive. Microprocessors cannot function by themselves. Depending on the application, a number of different types of discretes are required for rectification, for voltage regulation, for power handling and for carrying out the actions determined and ordered by the microprocessor.

WHAT OF DISCRETES?

Before I get more deeply involved in the subject of MPU— related discrete components, I would first like to spend a few minutes on the industry's outlook for the discrete component business in general.

In the fall of 1978 , in my capacity as chairman of the Semiconductor Industry Association, I had the opportunity to unveil our industry outlook at the association's annual forecast meeting in Palo Alto.

I'd like to share with you the data we presented regarding our concensus view of the next three years for the discrete component business.

(Figure 1) This chart depicts the worldwide sales of discrete components by U.S.-based semiconductor manufacturers between 1977 and 1981. No foreign manufacturers are included, and the data is presented in both current dollars and annual growth percentages.

Several points are worthy of note. First of all, we believe that industry sales will grow to slightly more than 1.5 billion dollars this year, up nearly twelve per cent from the 1977 level, which was essentially flat with the previous year.

By 1981, the industry sales are expected to climb to approximately 1.75 billion dollars, an increase of nearly a quarter of a billion dollars. During the four-year period—from 1978 through 1981 — we expect compound growth rate for discrete components of about six per cent.

The change in product mix is a little less obvious. Small signal transistors, for example, was the largest selling product line last year; the second largest seller this year, and by 1981 we find it relegated to third place—and almost a fourth place—position. This is, of course, due to the fact that small signal transistors are most vulnerable to integration.

In all other major discrete product lines we anticipate varying levels of growth. If you compare the actual 1977 sales with the anticipated 1981 sales, you can see that we anticipate modest growth for diodes, and rather dramatic growth for power transistors, rectifiers, thyristors and optoelectronics. It is precisely these four product lines whose growth will be affected, in a very positive sense, by the emerging microprocessor technology.

In next year's forecast, when we add a 1982 column, and the following year, when we add the 1983 forecast, I think the comparisons will be even far more startling than they are right now, because the 1981 forecast reflects just the onset of high-volume microprocessor applications.

Current Dollars in Millions	1977	1978	1979	1980	1981
Diodes	167	178	169	174	176
Small Signal Transistors	318	317	304	302	300
Power Transistors	313	347	359	375	407
Rectifiers	226	271	271	289	309
Thryristors	146	158	159	173	189
Optoelectronics	155	209	228	260	285
All Other Discretes	68	78	77	82	87
Total Worldwide	1394	1558	1567	1655	1753
Annual Growth in Percent	**1977**	**1978**	**1979**	**1980**	**1981**
Diodes	0	6.6	-5.0	2.9	1.1
Small Signal Transistors	1.9	0	-4.1	0	0
Power Transistors	1.3	10.8	3.5	4.5	8.5
Rectifiers	1.3	19.9	0	6.6	6.9
Thyristors	22.7	8.2	0.6	8.8	9.2
Optoelectronics	-21.7	34.8	9.1	14.0	9.6
All Other Discretes	-5.6	14.7	-1.3	6.5	6.1
Total Worldwide	0.5	11.8	0.6	5.6	5.9

Fig. 1. Discrete forecast by major product category. (U.S. based manufacturers, per SIA)

GROWTH

Figure 2 shows the growth we anticipate for all MPU—related discrete products. As in the charts that will follow, this is a relative growth chart, with 1978 unit sales being equal to one.

It's easy to see that we anticipate the most MPU—related growth being enjoyed by rectifiers and power transistors. Both of these product lines begin to take off from their already high level during 1979, and by 1981 their sales will be about three and one half times their current level. Zener diodes and small signal transistors will be nearly three times their present level, while optoelectronics and thyristors will increase just slightly. This graph has even more impact if you'll recall that Fig. 1 indicated that power transistors became the largest selling discrete line this year and rectifiers are in the number three positions. The growth of these two product lines alone for MPU—related applications will account for a large percentage of the total discrete industry growth between this year and 1983.

In the next two figures, I have segregated this same data into

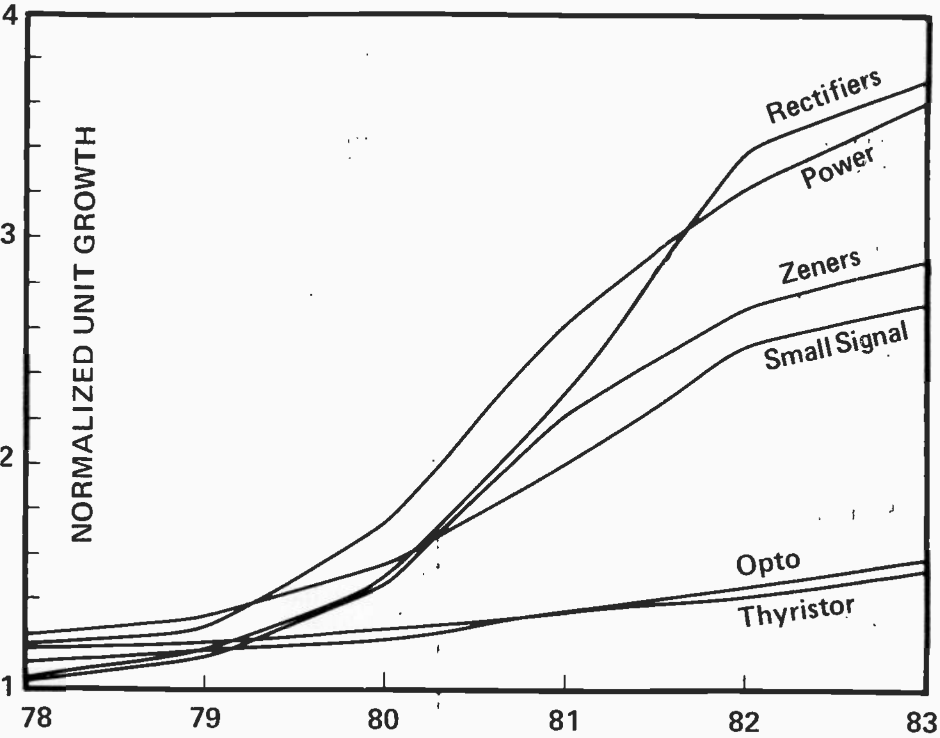


Fig. 2. 1978 - 83 growth trends, total MPU-related discretes.

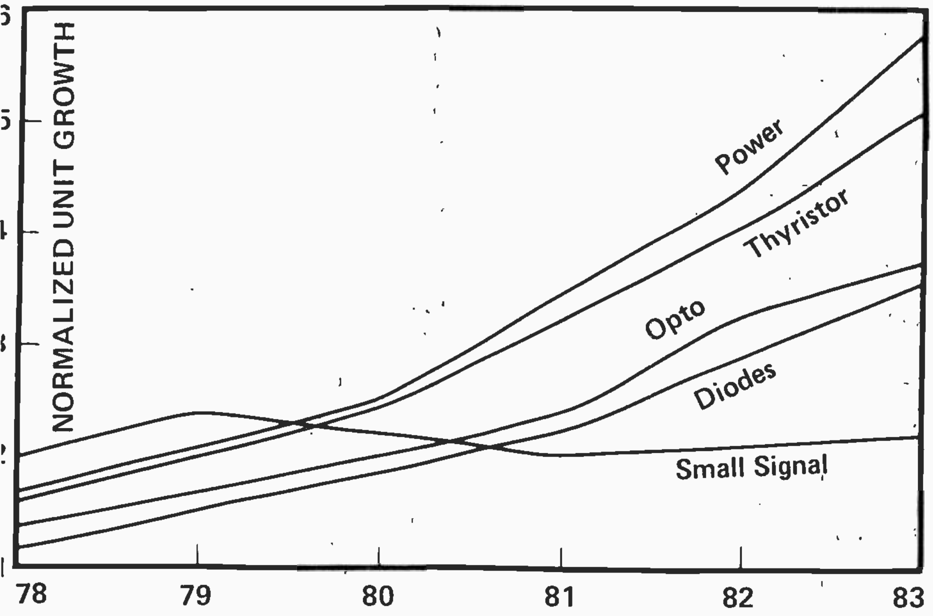


Fig. 3. 1978 - 83 growth trends, non-automotive MPU-related discretes.

automotive and non-automotive microprocessor-related applications. I did this to dispell any notion that the anticipated MPU—related discrete growth is entirely due to the widely-publicized, high-volume automotive applications that loom on our horizon. Automotive applications will certainly be the major cause of the discrete growth, but non-automotive MPU applications will also be very respectable.

NON—AUTOMOTIVE

Figure 3 shows how the data looks without the automotive applications. Power transistors and thyristors are the leaders in this case, more than doubling their current MPU—related applications. Optoelectronics and diodes, starting from a lower base, will triple their present usage in MPU applications, while small signal transistors will remain relatively flat.

The markets most impacted by these new MPU and discrete combinations are the computer, industrial and consumer sectors, in reverse order of their importance.

COMPUTERS

While the computer applications will be large and varied, they will be less spectacular than either the industrial or consumer applications. The main product areas in which discrete usage will increase because of MPU applications are rigid discs, electrostatic printers, line printers, matrix printers, floppy-disc systems and both CRT monitor and keyboard terminal systems. A wide variety of discretes will be used to drive hammers in MPU-controlled printers, to position heads in MPU-controlled disc memory systems, and in the horizontal and vertical circuits for CRT monitors, as well as in the power supplies of most computer products.

INDUSTRIAL

In the industrial market, the volume and variety of discrete MPU-related applications will be greater than they are in the computer market. The most obvious usage will be in automated process control and production equipment. Everything from making steel to McDonald hamburgers will be improved, in terms of speed and precision, by the microprocessor technology. Again, a variety of discretes will be required to handle the power and carry out the orders of the MPU. While it's impossible to peg a precise discrete usage number for these applications, they will certainly be used by the tens of millions each year.

There are several other industrial applications I would like to mention briefly, because they are interesting and possess the potential for extremely high discrete component usage.

The first is in the area of large displays, such as the animated sign boards that are beginning to appear in our major sport stadiums. The display technology is quickly evolving, and I think we will see a proliferation of this type of equipment over the next few years, not only for sporting events, but in promotional and advertising signs of every size and description. The potential for discretes here is very large. Some of the current sports displays, for example, already contain as many as 60,000 thyristors or power transistors alone. In addition, a great number of discretes are already being used in the associated power supply systems. Again, this is a market that will probably require millions of discrete devices each year.

Another important industrial market that is on the verge of explosion is the entire field of energy management. Because of the nationwide concern for energy conservation, various states are beginning to legislate "time of day" or "demand" measurements of energy usage to allow for higher charges during peak load periods. As this legislative movement gains momentum, we will see the emergence of many different types of energy management systems. One of the first to appear will be a new generation of electric meters that will employ the MPU technology as well as a number of discrete components. Other energy management systems will soon follow, and they will all use discretes as well as microprocessors. The potential for thyristors alone in this newly emerging market over the next five years should be well in excess of 15 million units.

Traffic control is another newly emerging market for discretes, again because of the application of microprocessors in traffic signals. In the past, conventional logic such as HTL or CMOS have been used in such signals, but the number of MPU-controlled signals is growing rapidly. This, in turn, will greatly increase the usage of opto-couplers and thyristors in such applications.

Another very important area, in which a dramatic shift in the technological make-up of the industry will result in significant growth potential for discretes is in telecommunications. The present shift from electromechanical to digital switching is the result of the tremendous cost effectiveness of MPU's and the associated, dedicated LSI devices. This development is again increasing the demand for discrete components, particularly power transistors and bridge rectifiers. The accumulated potential for these discretes in switching alone should be greater than 15 million dollars during the next five-year period.

Discrete usage in telecommunications will also be enhanced as the new fiber optic transmission techniques become refined and applied. The potential for emitters and detectors in this area alone is in the neighborhood of another 15 million dollars over the next five years.

While the computer and industrial applications are diverse and growing, some of the most exciting potential lies in the consumer segment of the discrete market.

CONSUMERS—WATCH OUT!

The home appliance market is a good example. Microprocessors will be used in huge and steadily growing numbers in washers and dryers, refrigerators, dish washers and microwave ovens. An even greater number of discretes will be required. The MPU-controlled electronic system will replace the mechanical clocks and cams in order to provide more effective control and flexibility to the user. In most of these major appliances, four to eight thyristors will be required. In addition, opto-couplers will be required to isolate the electronics from the rest of the appliance in order to reduce the potential of electrical shock and provide the high levels of product safety being required by present government legislation.

The security systems market is another new and rapidly emerging business that holds great potential for additional discrete usage. A popular political slogan of the past was "A chicken in every pot." The slogan of the future appears to be "A security system in every home." This market is on the verge of tremendous growth, and I suspect that at some point in the future every new home will come equipped with a sophisticated security system. While these systems will be MPU-controlled, a great number of discrete will be required to actuate the alarms and indicators.

There are a number of other emerging consumer markets that bode well for increased discrete component usage. MPU-controlled video games . . . electronic TV tuning . . . and home environmental control systems . . . to name just a few. All of these new, MPU-generated product developments will require discrete components each year.

Now let's turn our attention to the automotive applications for MPU-related discretes.

AUTOMOTIVE USES

Figure 4 shows the relative growth trends for the major discrete product lines in automotive applications. While optoelectronics will grow slightly, major growth will be recorded by the four others: rectifiers, power transistors, zener diodes and small signal transistors.

While the initial application of microprocessors to automobiles has created a great deal of excitement in the marketplace, there is a great deal yet to come.

In their current application, which extends through the next two or three model years, MPU's are being used primarily in ignition control systems. After collecting data on such things as

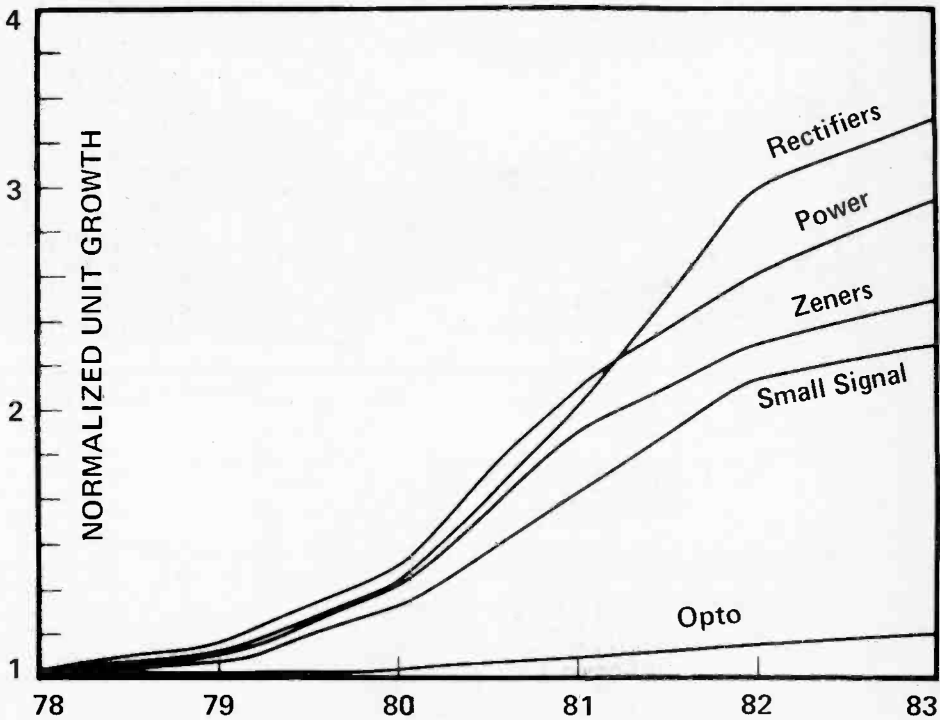


Fig. 4. 1978 - 83 growth trends, automotive MPU-related discretes.

speed, temperature, humidity and altitude, the microprocessor automatically adjusts the carburation, spark and timing. In effect, it tunes the car while it is being driven. This application is the auto industry's first step in meeting the government-mandated challenges to reduce emissions, improve safety and increase fuel efficiency.

The engine control systems of the future will add a pre-ignition system to the vehicle, primarily for the purpose of knock detection. Also, such things as oxygen sensors will be added to the exhaust system to monitor the efficiency of the combustion. This information will then be fed back through a microprocessor which would further adjust the carburation, if required.

Another future MPU application in autos is in the area of load management, or more simply put, transmission control. Transmissions of the future will not include definite gears such as first, second, or third. Instead, they will have an MPU-controlled servo-mechanism that will automatically adjust itself according to the load the vehicle is being required to carry. As a result, the proper gear ratios will always be chosen to maintain optimum torque efficiency and maximum engine efficiency.

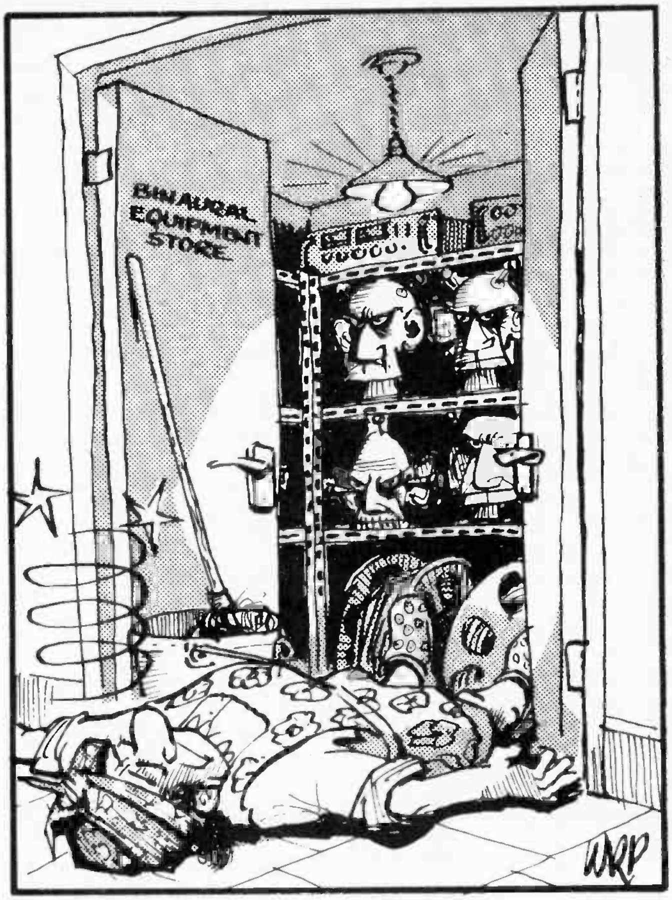
Another interesting application which is down the road a bit will be in leveling systems. Federal regulations are already requiring that all bumpers be at a certain distance from the ground in order to minimize the damage from impact. To accomplish this, bumpers either have to be very wide to take into account bumper height changes brought about by acceleration and deceleration, or systems need to be developed to keep bumper height constant at all times. Such systems are already under development, using Hall effect sensors to detect uneven loading or leveling situations. The detected data is then coupled back to a microprocessor, which, in turn, drives an actuator which self-corrects or compensates for the uneven loading. In all cases, the actuators would be driven by discrete devices, most likely power transistors or thyristors.

There are also a number of other new automotive applications for discretes that are indirectly related to the MPU applications. The emergence of the one-wire electrical system utilizing fiber optics seems to be a distinct possibility. This, in turn, would create brand new markets for such things as opto-couplers and other discretes. New types of digital dashboard displays will also provide new liquid crystal applications sometime in the future.

These are just a few examples, but I think they illustrate the reason for our confidence for the steadily increasing penetration of discretes in the automotive market. This year, total discrete sales for automotive applications amounts to about $3.80 per car. By 1982 or 1983, that amount will grow to about $11.50 per car. The difference—about $8—will be almost entirely created by the variety of new, MPU-related applications. In addition, nearly $6 of that $8 growth will be in engine control systems.

WHO SAYS DISCRETES DEAD?

Perhaps these reliable workhorses of the industry have less glamour, and receive less publicity, than some of our more exotic LSI developments, but they provide an extremely critical link between the feasibility of exotic integrated circuits and their actual implementation. Discretes are alive and well and growing, and such will be the case for many years to come.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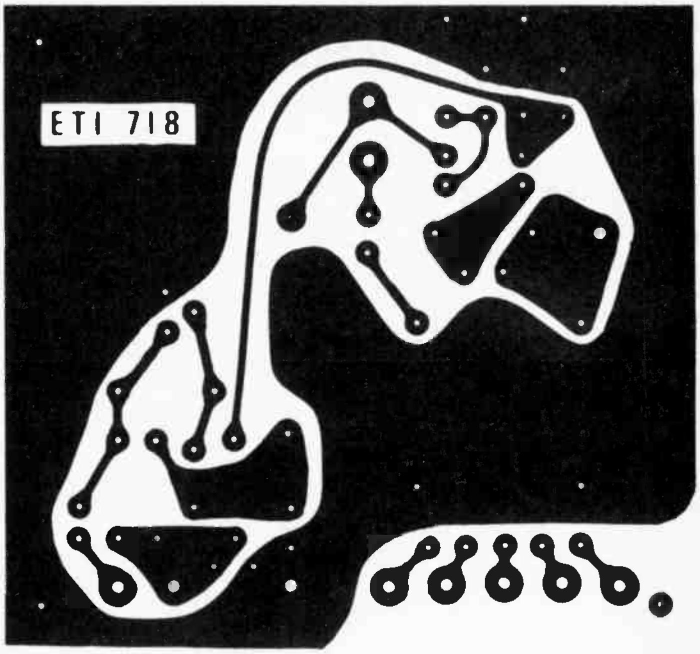
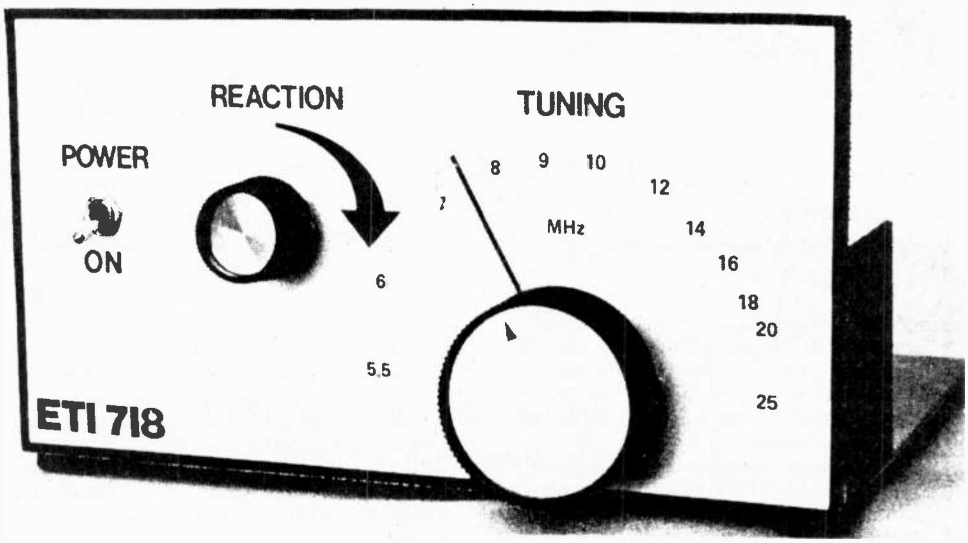

ETI 718

Shortwave Receiver

Maybe you can't afford a super-radio like some of those offered commercially, but we've got the answer. . .

APART FROM THE very early sets, which were based upon coherers and other devices you never hear of today, the first radios were very straightforward designs totally unlike today's sophisticated superhets. The early Tuned Radio Frequency (TRF) sets were simply a tuning circuit with some gain and a detector circuit, but later designs used positive feedback, in the form of reaction, to increase the performance. It is still possible to get a lot of fun from sets of this type.

By using modern solid state components a very simple reaction set can be built which offers surprisingly good performance at low cost. The Field Effect Transistor has almost identical performance to the earlier valve and is the basis of this design.



The circuit of fig. 1 uses an MPF 131 dual gate MOSFET as a regenerative detector, followed by a MPS6515 audio amplifier stage which is capable of driving a crystal ear piece, high impedance head phones, or being fed to the input of an amplifier. The frequency coverage is approximately 5.5 to 25 MHz, or 54 to 12 meters.

This coverage includes many interesting features such as the international broadcast bands at 49, 31, 25, 19, 16, and 13 metres, as well as amateur bands at 40, 20, and 15 metres.

OPERATION

Satisfactory operation depends on the proper use of regeneration, which unless operated correctly will result in poor performance and interference to neighbouring sets.

Initially, set C1 about half closed and increase the regeneration until a point can be found where signals are heard when tuning. Increasing the regeneration will increase the volume, until a point is reached where a whistle is heard when tuning across a station. The most sensitive point is where this whistle just fails to arise.

Regeneration has to be adjusted in conjunction with the tuning, because the setting of RV1 will change as the set is tuned across the band. The tapping position of the coil also influences regeneration, and may have to be lowered to obtain correct operation on some frequencies. The tapping point found to give the best results will also depend on the length of antenna used. As a starting point, try the middle tap and then move the tapping point up or down the coil to give the strongest signals, while still able to achieve regeneration.

Reception of CW signals is possible by using the regeneration control so the set is just oscillating, while the tuning gang is set so that a beat note is heard. This can also be done for SSB signals but the tuning will be very critical.

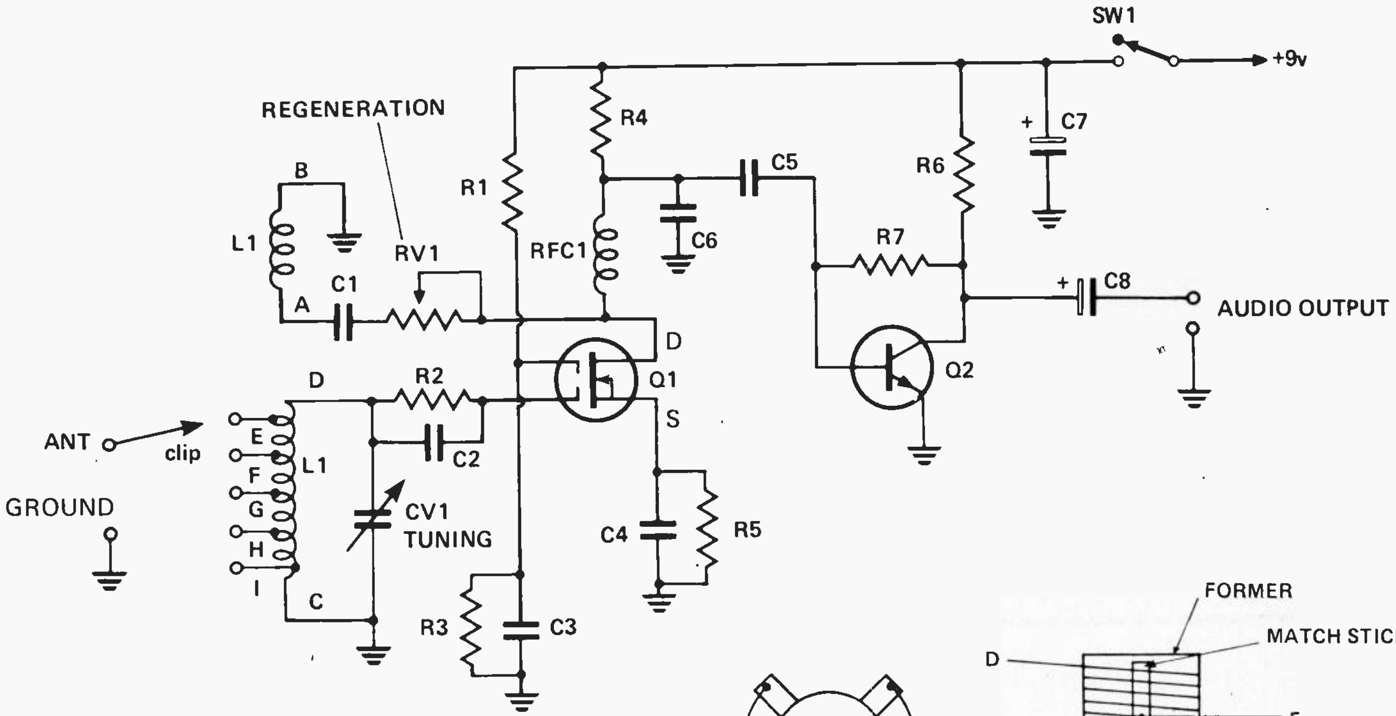
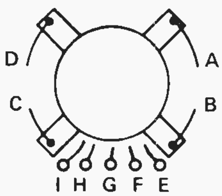
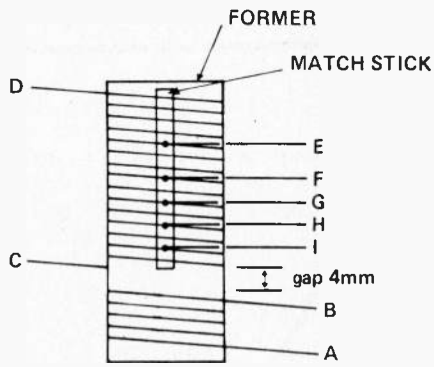


Fig. 1. Circuit diagram of the receiver.



L1
TOP VIEW



L1

HOW IT WORKS

Signals from the antenna are coupled into the tuned circuit (L1, CV1) via the clip lead and the coil taps. The tapping point is varied to give the best match from the antenna to the circuit, yielding the best performance.

The tuned circuit acts as a filter, only letting the desired frequency through to the FET (Q1), since the tuned circuit resonates at a frequency set by the position of the variable capacitor, (CV1). As the value of the capacitor is varied, so the resonant frequency of the tuned circuit, and the frequency of reception, is varied.

The radio frequency signal at the desired frequency is then fed to the FET (Q1), where it is amplified and appears at the drain. Because the radio frequency choke (RFC1) presents a high impedance (or near open circuit) to radio frequencies the signal passes through C1 and RV1 to the regeneration coil wound on L1. Some of this signal, the amount determined by the setting of RV1, is coupled back to the tuned circuit.

For regeneration to occur, the signal fed back to the input must be the same polarity or 'phase' as the incoming signal. A phase reversal occurs in the FET, so a second phase reversal is necessary. This is achieved by connecting the feedback to the reaction coil upside down (i.e. to the bottom of the winding, and the ground to the top). In this condition of positive feedback the circuit can be made to oscillate.

The feedback signal now passes through the tuned circuit again to the FET, although this time it is 'detected' before it is amplified once more. Detection recovers the audio information from the signal before audio amplification. The radio frequency choke looks like a short circuit to the low frequency audio signal which passes through it. It cannot however pass through resistor R4, but is coupled to the audio amplifier (Q2) via C5, where it is amplified before being fed to the output. Any unwanted RF signal which happens to get through the RF choke is shorted to ground by a small value capacitor (C6).

Maximum circuit gain, and therefore maximum audio output, occurs when the regeneration control is advanced so that the circuit is just not oscillating. This point also yields the best 'selectivity', or the ability to distinguish between close stations.

Table 1 – Coil Winding Details

The coil form used was a cylinder of 12mm (about ½") diameter, about 30mm high, hollow inside (air cored). If a suitable one cannot be purchased, it can be made by soaking paper in epoxy mixture, then rolling it up the right diameter. About 3 thicknesses of paper would be strong enough. The correct shape can be held with the fingers (it should be about circular), but use "5 minute" epoxy so you don't have to stand there all night.

Reaction coil: 4 turns of 24 AWG enamelled wire, closewound at the base of the former in a clockwise direction.

Tuning coil: 15 turns of 24 AWG enamelled wire, closewound, starting 4 mm above the top of the reaction winding in a clockwise direction. Taps at 2,4,6,8 and 11 turns from the bottom of the winding. Turns which are tapped are raised over a matchstick.

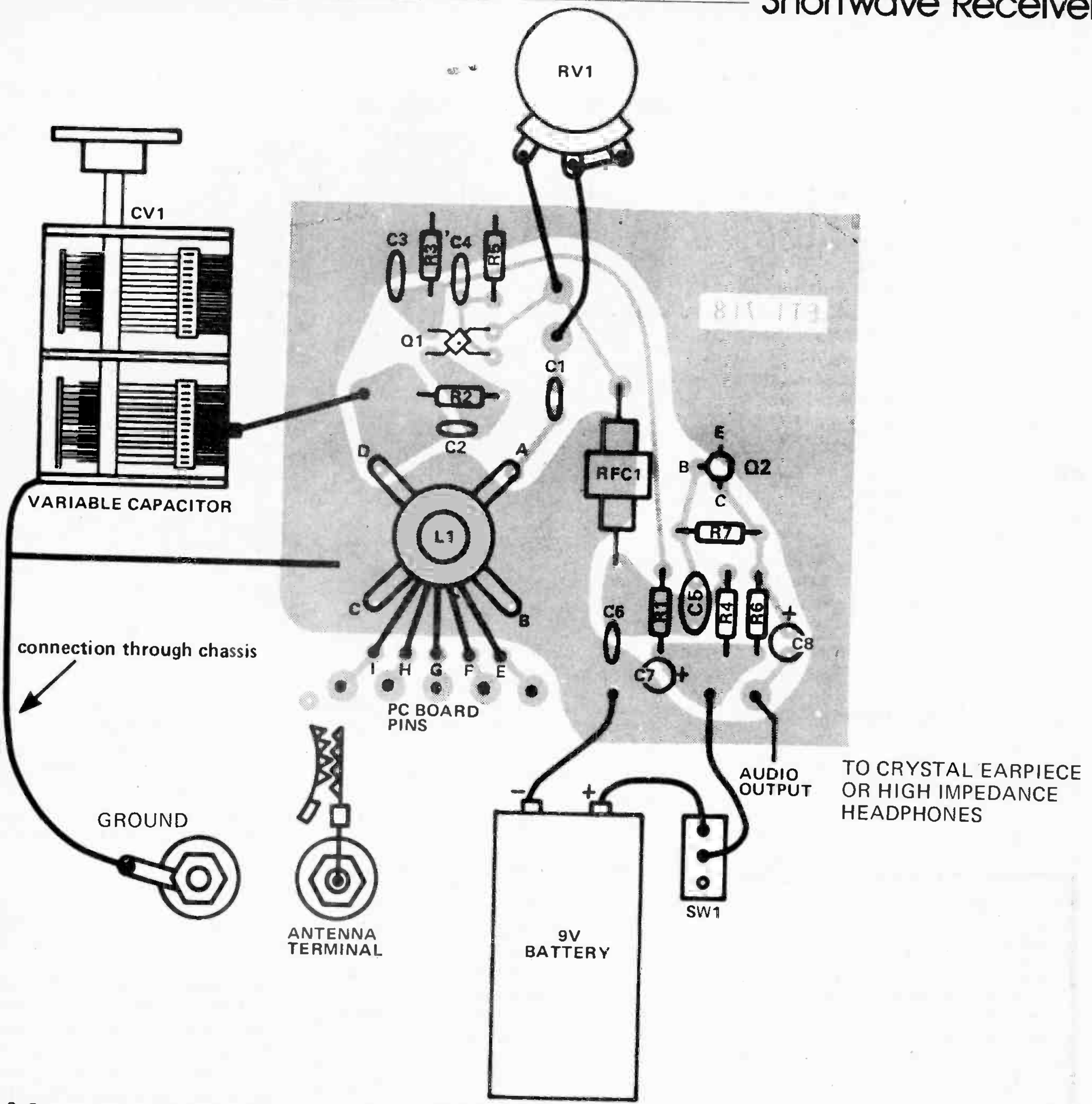


Fig. 2. Component overlay, as seen from the component side of the board. Note carefully the connections to the coil.

PARTS LIST

RESISTORS all ¼W, 5%
- R1 . . . . 4k7
- R2 . . . . 1M2
- R3 . . . . 10k
- R4 . . . . 2k2
- R5 . . . . 1k
- R6 . . . . 10k
- R7 . . . . 4M7

POTENTIOMETER
- RV1 . . . . 2k lin pot

PC Board for this project is available from Spectrum Electronics. See their ad in this issue for address.

CAPACITORS
- C1. . . . . 10n ceramic
- C2. . . . . 270p ceramic
- C3,4 . . . . 100n ceramic
- C5. . . . . 100n greencap
- C6. . . . . 1n ceramic or greencap
- C7. . . . . 10μ tantalum 16VW
- C8. . . . . 4μ7electro 16VW

VARIABLE CAPACITOR
- CV1. . . . . 415p tuningcapacitor or similar (see text)

SEMICONDUTORS
- Q1 . . . . MPF131 dual gate MOSFET
- Q2 . . . . MPS6515 or similar

MISCELLANEOUS
- pc board . . . . . . ETI 718
- pc board pins
- coil former. . . . . 12 x 30 mm air cored
- RFC1. . . . . 2.5 mH RF choke
- box to suit . . . . . (see text)
- SPST on/off switch
- planetary drive, 5 to 1 reduction
- length of 24 AWG enamelled wire
- 9 V battery and battery clip
- knobs, rubber feet, crystal earpiece or high impedance headphones, headphone socket

CONSTRUCTION

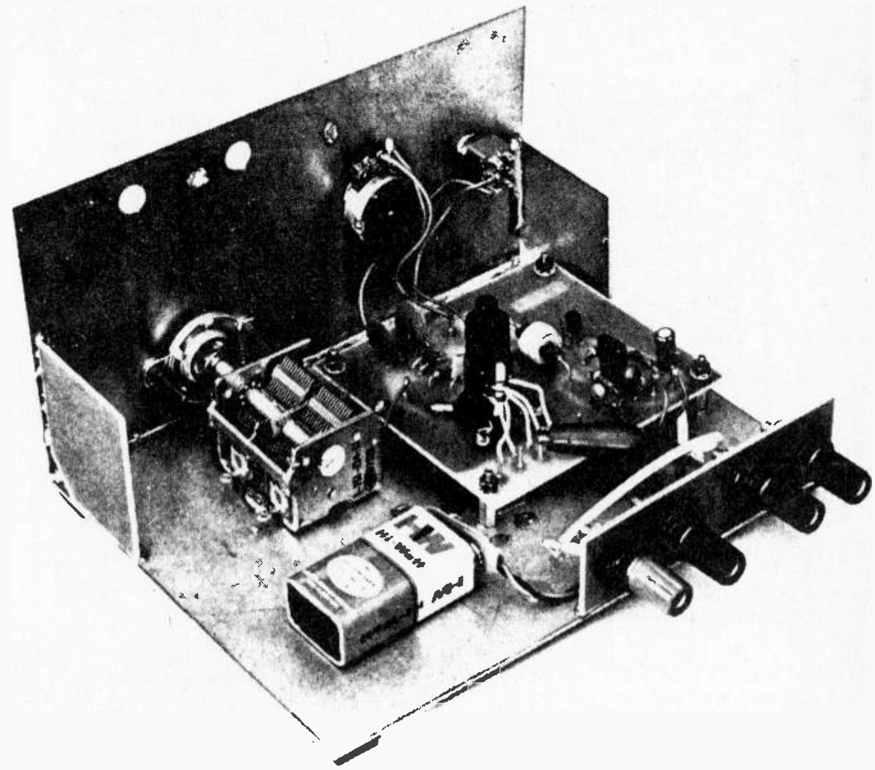
All the components except the tuning capacitor are mounted on a printed circuit board, (see fig. 2). Other types of construction such as vero board can be used but may not offer the same repeatability of results. The coil (L1) is wound separately as in Table 1 and later mounted on the PC board. If the type of former in the parts list is used, the solder lugs on the former will line up with holes in the PC board and the former can then be held down onto the board by its connections. Short lengths of wire are used between the coil taps and the PC board. Printed circuit pins are then soldered into the tapping points and the tap changed by means of the alligator clip from the antenna terminal.

In our receiver we used one section of a second hand dual gang tuning capacitor. Most gangs from an old radio will do as long as only one section is used, the lowest freqency of operation depending on the value of capacitance.

140 mm deep, and is constructed entirely from single sided PC board (copper side inward). This method is both cheap and easy, the front panel being soldered onto the base plate. ' Squares of PC board are soldered into the ends for rigidity of the front panel.

A planetery drive mechanism is used with the tuning capacitor and is attached to the front panel with two nuts and bolts. A plastic cursor can be cut from a sheet of thin plexiglas and attached to the outside of the drive mechanism with epoxy to provide a dial pointer.

The regeneration potentiometer and the ON/OFF switch are also mounted on the front panel, with the antenna,ground and output connections mounted on a small piece of PC board at the rear. All wiring should be kept as short as possible, especially to the regeneration control and the tuning capacitor.



Rear view of the completed unit. We used one section of a dual gang tuning capacitor. The terminals from left to right are: Antenna, ground, and the two output connections.

ANTENNA AND GROUND

Although some signals can be heard with a small indoor antenna, an outdoor antenna is much better. The antenna should be as long and as high as practicable, running perhaps from the house to a tall tree or other building. Figure 3 shows a typical antenna installation which will give good results. The lead in from the antenna should be kept as short as possible, so a good position for the set would be close to a window.

A ground is not essential but is generally worthwhile, since it can help to avoid the effects of hand capacity by grounding the metal chassis. The set can be earthed to a water pipe or run to a metal spike driven into the ground.

PERFORMANCE

The number of short wave signals that can be heard depends upon the time of day, early morning, late afternoon and night being the best. After a few periods of listening at various times you will know what to expect. Using an indoor antenna we were able to receive strong signals throughout the day and the number of stations heard rapidly increased towards dark.

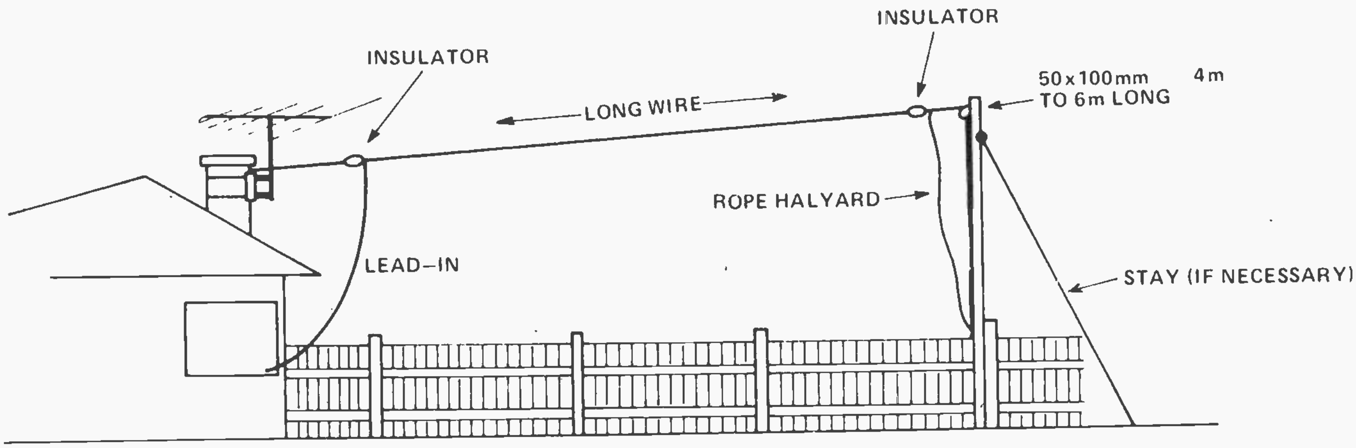
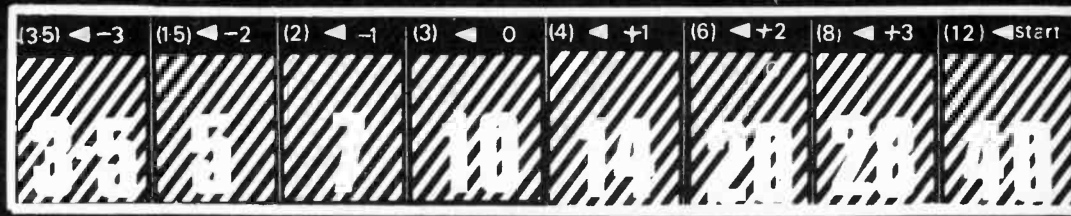
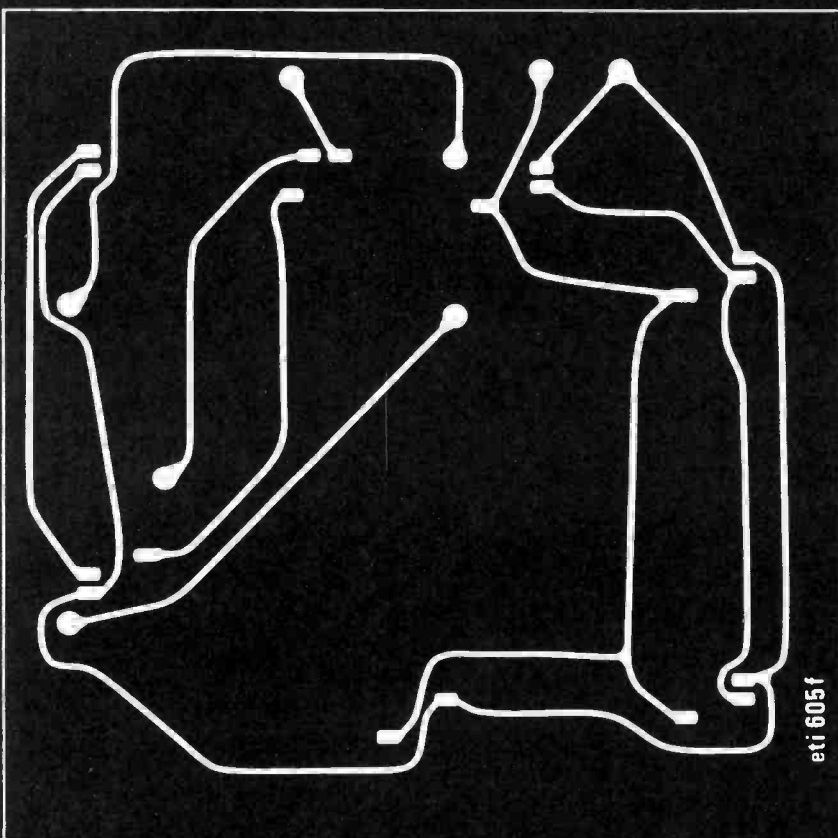
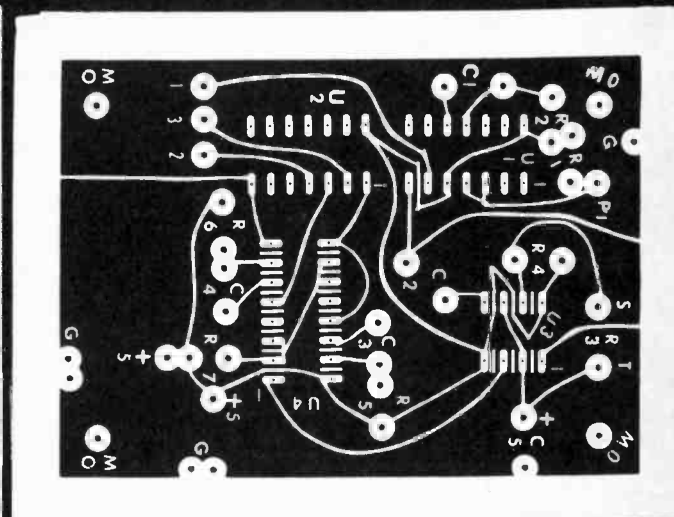


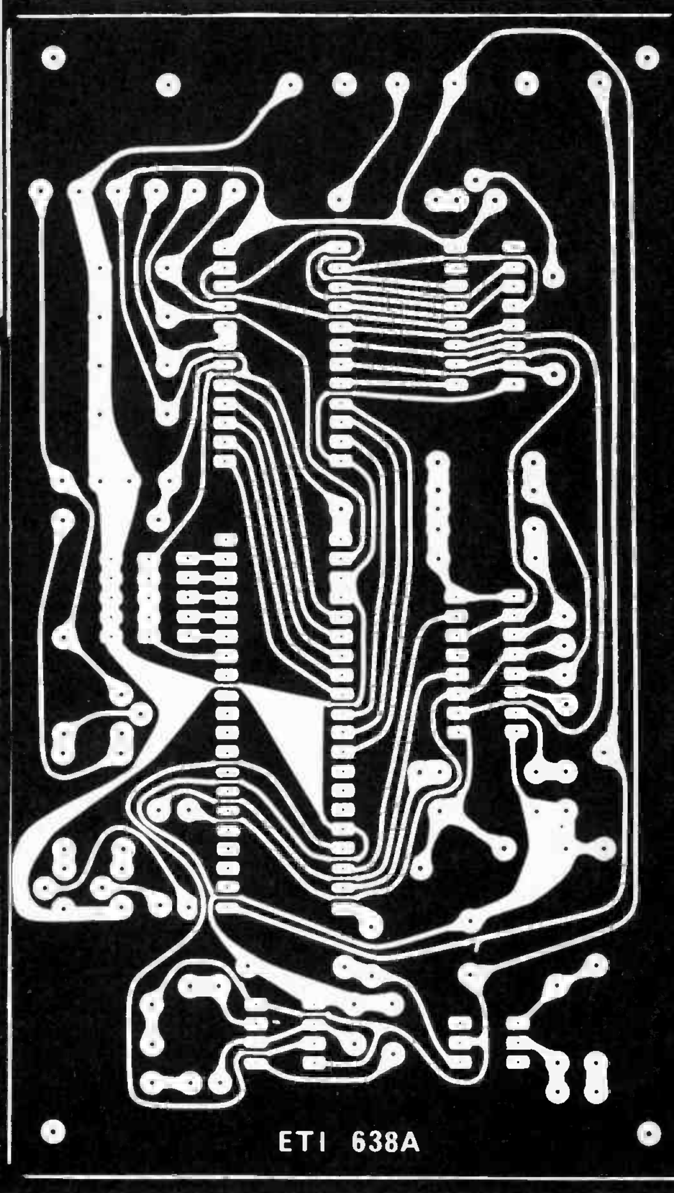
Fig. 3. A typical Long Wire antenna. The Lead–in should be as short as possible

ETI PCB



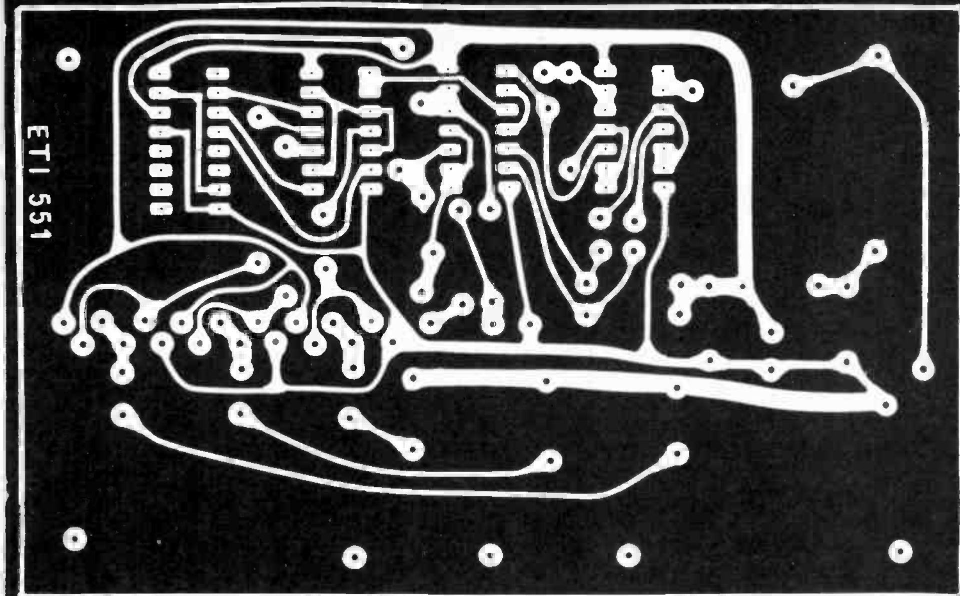


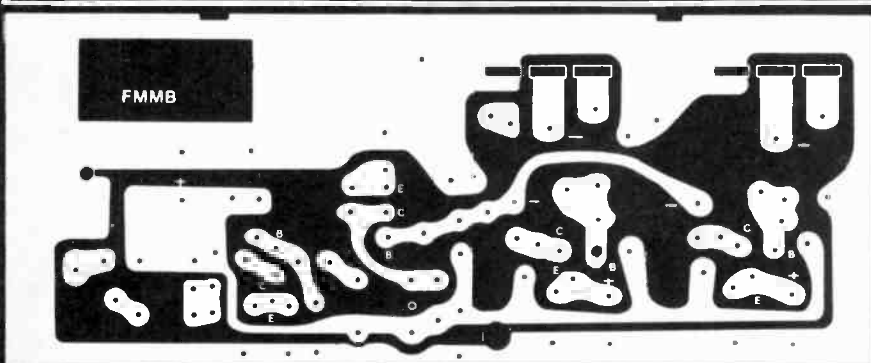


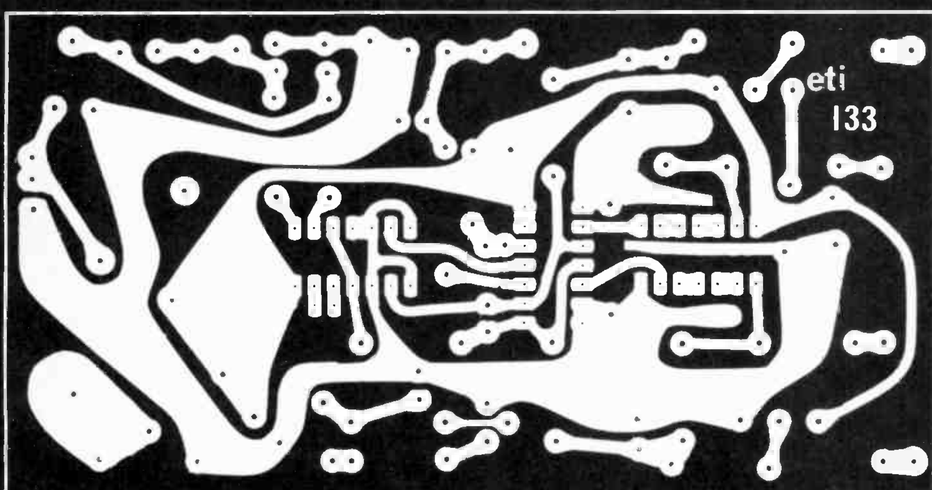


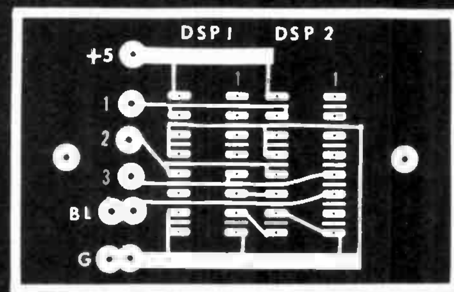
Negatives

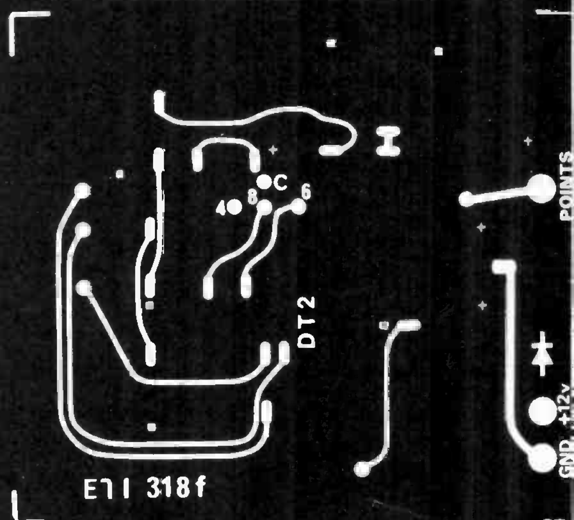
HERE ARE the negatives for December, January and February issues. Unfortunately we have been unable to fit in all the pcbs, so we have left out the very simplest ones. These negatives can be used with presensitised boards (eg. Injectorall). The typical exposure time under a number 2 photoflood bulb with reflector we expect to be about 20 minutes. Use test strip to make test exposures to find out optimum exposure for your setup. Full details were given in January 1978 issue.

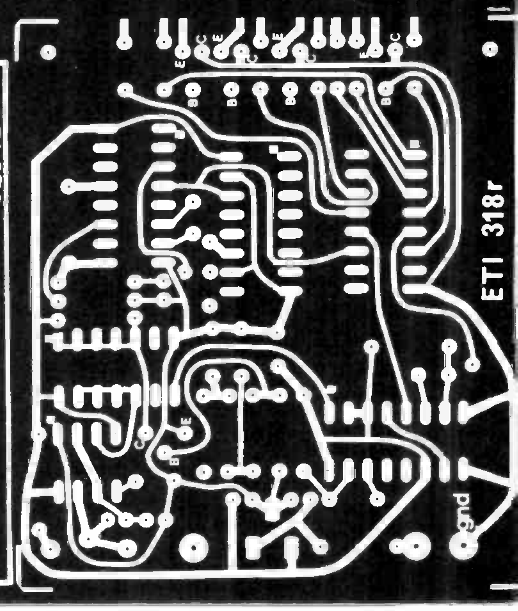


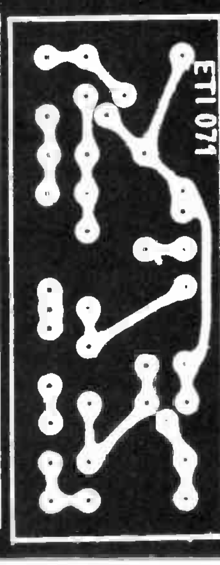












Phasemeter

This instrument measures phase angles of voltage, current or power from sub-audio frequencies to 100 kHz or beyond. Readout may be either digital or analogue. By Dr. P. C.Bury

THE POWER being dissipated in an ac circuit is one of the more difficult quantities to measure with normal laboratory equipment — unless the circuit is purely resistive. This is because the power dissipated is given by the expression $P = IV \cos\phi$ where I is current, V is voltage and ϕ is the phase angle between them. Theta (ϕ) varies from 90^o for an ideal inductance, through 0^o for a resistance, to -90^o for a capacitance. Since $\cos \pm 90 = 0$, both inductance and capacitance dissipate no power at all. They store it during one half-cycle and release it to the source again during the following half-cycle.

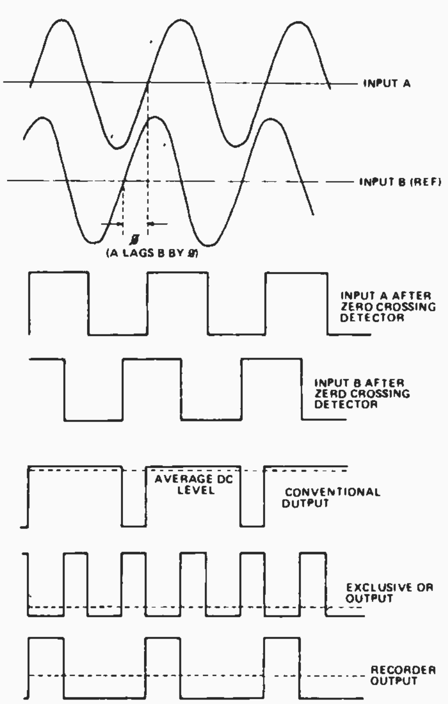


Fig.1. Comparison of the conventional 'flip-flop' method and the exclusive-OR method used in this project.

Therefore, in order to measure power, one either needs a wattmeter — an expensive instrument if any great accuracy is desired — or a knowledge of ϕ, the phase angle. While ϕ can be estimated from a dual trace oscilloscope, this article describes a simple and accurate way of measuring it directly. In addition to power measurements, measurement of the phase difference between two voltages is useful when working on filters, feedback loops and phase-shifting networks: it can be used to measure the Q of an inductor, and hence check for shorted turns, or the loss factor in a capacitor. A further application of growing importance in the audio field is the phase of the sound from individual drive units in a loudspeaker enclosure, or members of an array of loudspeakers.

The phase relationship between two voltages is conventionally measured by detecting when each crosses zero voltage (see Fig. 1) in one direction, and arranging for one voltage to turn a flipflop ON and the other to turn it OFF. The percentage of time that the flipflop is on, and hence the average value of the flipflop output, is proportional to the phase difference between the two voltages. This method has three inherent disadvantages —

(i) Voltages with little or no phase difference can give readings of 0^o and 360^o, or a reading which varies randomly between these limits.

(ii) Any noise on either signal can cause false triggering and jittery readings.

(iii) Any harmonic distortion can produce a shift in the zero crossing point and hence an error of initially 0.6 degrees per 1% of distortion.

The method used in the circuit described here is to form the exclusive-OR of the square waves produced by zero crossing detectors from the two voltages.

For those who have not encountered the exclusive-OR (XOR) function before, this is a logic function (in the same way that AND and OR are logic functions) that gives an output (logic 1) if its two inputs are different, but not if they are the same. Thus two square waves which are in phase will produce no output: two which are exactly out of phase will produce a maximum continuous output; and intermediate phases will produce an output proportional to the phase difference (see Fig. 1). This system has the advantage of being almost immune from noise problems since no triggering or latching circuits are involved.

Because the circuit response is symmetrical about 0^o and 180^o, there are no output discontinuities or ambiguities of reading. However an additional flip-flop is required to sense which voltage is ahead of the other and indicate it. The circuit is implemented with CMOS gates which have the advantage of being able to be used in either linear or digital mode.

CONSTRUCTION

We assume that only the more experienced constructor will build a somewhat specialised instrument of this type, and that they will be capable of assembling, handling the CMOS, with due care, boxing it without step by step instructions. The pc board can be copied from the diagram (Fig. 3),

The layout of the components is shown in Fig. 4.

Some care is needed to keep the input leads as short as possible as the gain of

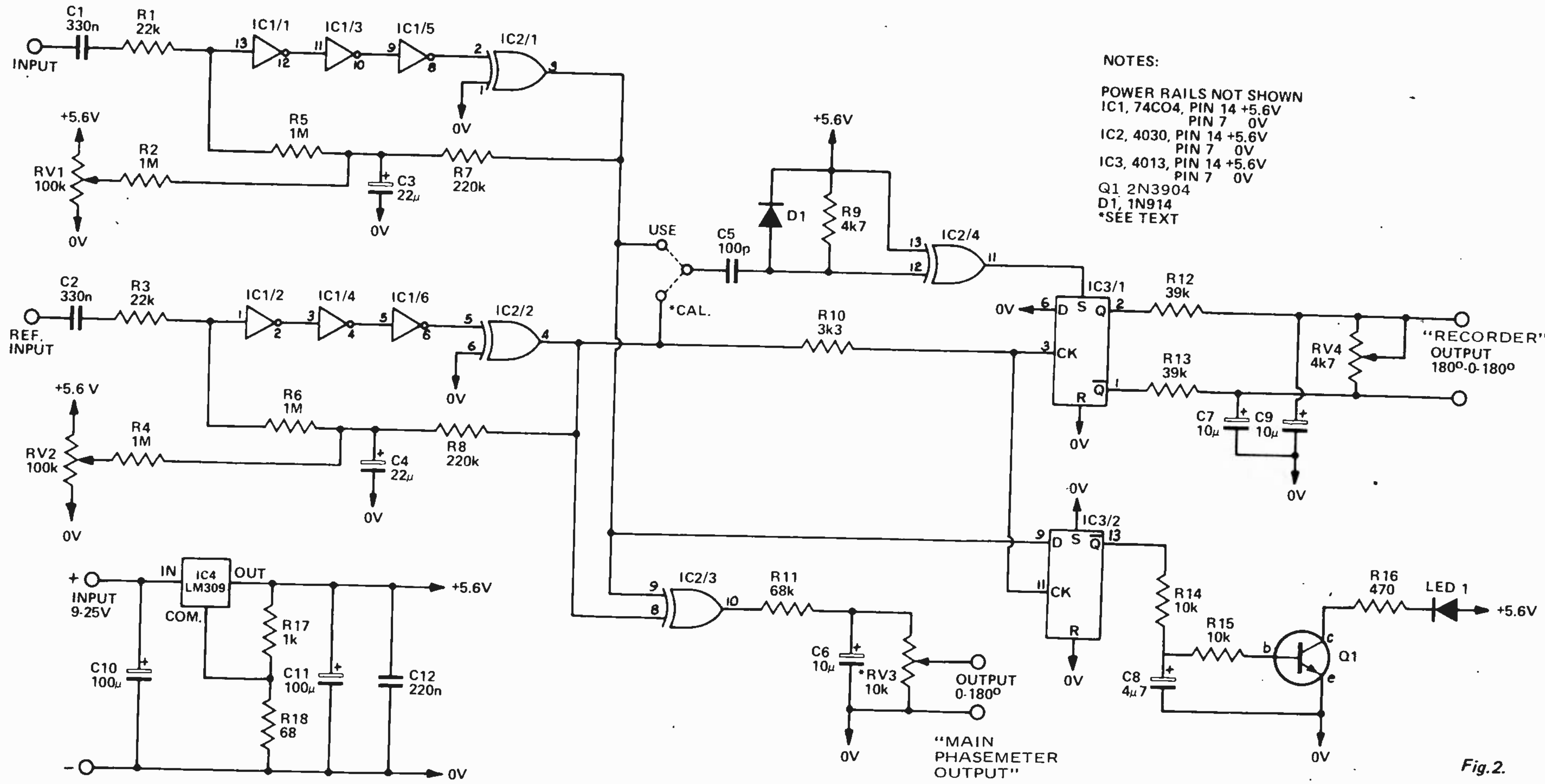


Fig.2.

HOW IT WORKS

The two inputs are first squared. For example the reference input is amplified by gates IC1/2, IC1/4 and IC1/6 (see Fig. 2) and then applied to IC2/2, one of the spare EX.OR gates whose other input is grounded. This conveniently behaves as a Schmitt trigger type of bistable circuit. The average of the output of this gate is formed by R8 and C4, and this is inserted via R6 as the dc level at gate IC1/2.

This produces two important consequences. Firstly it forces the output of IC2/2 to a symmetrical 180°on/180°off condition which is maintained stably by almost complete dc feedback. And secondstance it may be set to 180 mV for a 180° phase difference and read on a digital multimeter. Alternatively up to 50 μA can be drawn to give a reading on any suitable meter or multimeter. The use of an external meter is of course a much more economical proposition.

In order to detect which of the inputs is leading the other, the two voltages from the squaring circuits are also fed to the D type flip-flop IC3/2. One voltage is used for the clock input and the other as a data input. This type of flip-flop is really a data latch, and whatever bit is present at the D input at the moment when the clock voltage changes from low to high is held would leave one flip-flop unused. In fact it turns out that there are two functions that these gates can usefully perform. First, for setting up the input squaring circuits: if the flip-flop is slaved to the squaring circuit, the exact 180° condition can be set when the complementary outputs Q and Q have equal average values. Secondly these gates can be arranged to turn the flip-flop on and off to give a conventional phase meter circuit output. While this does not give as accurate a reading, it does give one which is of opposite polarity for leading and lagging voltages and which can therefore be recorded graphically and unambiguously on an instrument such as a chart recorder. This is therefore desflip-flop is slaved to the reference input as it is set when IC2/2 goes low and reset when IC2/2 goes high, and this enables the 180° duty cycle to be set (see below). When C5 is connected to IC2/1 (the USE position) the flip-flop will have equal outputs at Q and $\overline{Q}$ if the two inputs are exactly in phase. It produces a positive value of Q relative to $\overline{Q}$ when the input leads the reference voltage and a negative value when it lags, the average voltage between them being proportional to the phase difference. R12, R13, C7, C9 and RV4 are used to filter this output and set it to some convenient value.

Of the other components, R10 is used to delay the voltage to the clock inputs ly, because we now have a true squaring circuit rather than a zero-crossing detector, all errors due to even-order harmonic distortion are cancelled. R4 and RV2 are used to adjust for input offset and set the exact 180° condition.

IC gates IC1/1, IC1/3, IC1/5 and IC2/1 process the signal from the other channel in an identical manner, and the two squared outputs are fed to gate IC2/3 which is the gate that forms the EX.OR of them. Its output is filtered by R11 and C6 and a voltage proportional to the phase difference of the inputs may be taken from across C6. RV3 is used to set this to a convenient value – for instance until the next clock pulse. Thus if the D input stays low until after the clock input goes high, the output Q will always remain low showing that the D input lags the clock input. The complementary output Q will be high and this is used to turn on the transistor and LED indicating this lag condition. Since any noise arriving at the clock input can cause spurious resetting of the flip-flop, it is preferable to use a clean voltage to drive it. This is why this channel has been designated the reference. Noise on the other channel is almost completely ignored.

These then are the basic EX.OR functional parts of the phasemeter, and this ignated the recorder output.

In operation one input of the EX.OR gate IC2/4 is connected through C5 to the output of one of the squaring circuits. Its other input is tied to the positive rail so that it functions as an inverter with respect to the other input With C5 connected to the output of IC2/2 (the CAL position), when IC3/2 goes negative C5 and R9 differentiate this, and IC2/4 gives a short (½ μsec) positive spike, which is used to set IC3/1. Since the data input of this flip-flop is always low, the clock pulse will always reset it again. Thus the slightly to compensate for the set-up time at the data inputs, and the LM309 regulator and associated components holds the supply voltage constant at just under 6 volts. This is important as the full-scale readings from the outputs is proportional to the supply voltage. The circuit can be run from a 9 V battery and draws about 20 mA with the LED off and 40 mA with it on. Alternatively any power supply that produces between 9 and 30 volts may be used, but it should be a floating supply to simplify the measurement of the phases of currents, and R16 and the voltage rating of C10 should be increased if more than 15 volts are used.

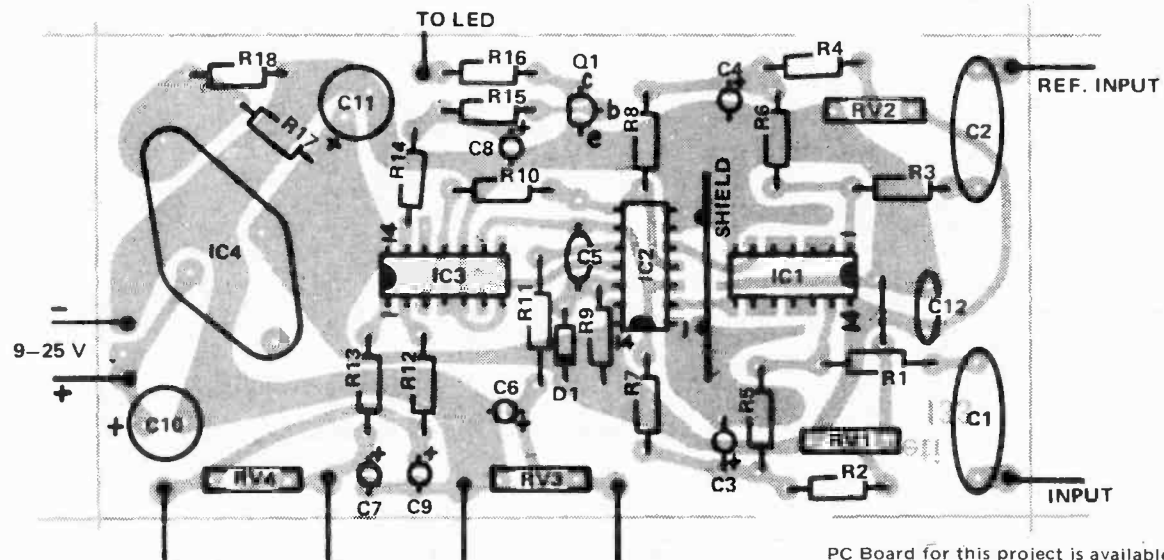


Fig.4.

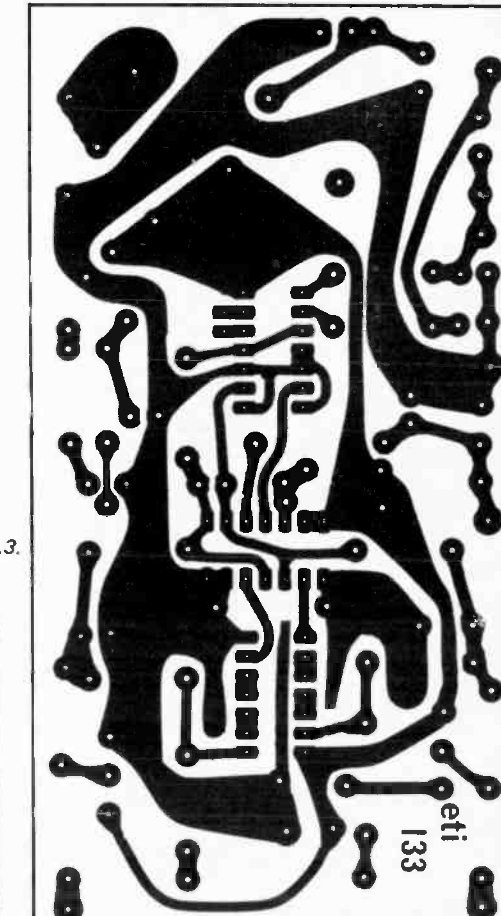


Fig.3.

PC Board for this project is available from Spectrum Electronics. See their ad in this issue for address.

PARTS LIST

RESISTORS all ½W 5% unless stated otherwise

R1	22 k
R2	1 M
R3	22 k
R4-R6	1 M
R7,8	220 k
R9	4k7
R10	3k3
R11	68 k
R12,13	39 k
R14,15	10 k
R16	470
R17	1 k
R18	68

POTENTIOMETERS

RV1,2	100 k Trim
RV3	10 k "
RV4	4k7 "

CAPACITORS

C1,2	330 n polyester
C3,4	22 μ 16 V electro
C5	100 μ ceramic
C6,7	10 μ 16 V electro
C8	4μ7 16 V
C9	10 μ 16 V
C10,11	100 μ 25 V
C12	220 n polyester

SEMICONDUCTORS

IC1	74C04 (CMOS)
IC2	4030 "
IC3	4013 "
IC4	LM309k
Q1	2N3904
D1	1N914
LED	

MISCELLANEOUS

PCB ETI 133

Case to suit

Terminals and sockets to suit

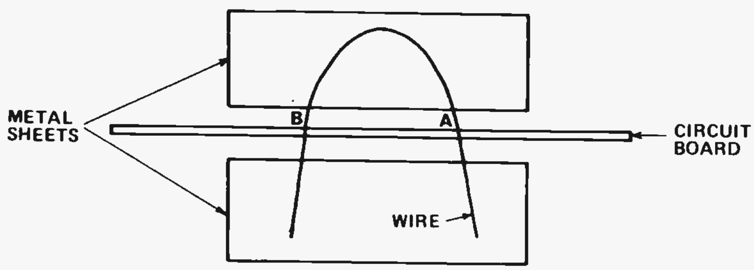


Fig. 5. Details of the shield between IC1 and IC2.

the input stage is extremely high and oscillation can occur if they become coupled to the later stages. To help isolation, small metal sheets, about ¾" x 1½" should be soldered above and below the board between IC1 and IC2. These can conveniently be attached to the link between points A and B in the circuit as shown in Fig. 5. For the same reason, the CAL and USE points should not be taken to a panel-mounted switch but the connection changed on the board itself. We have used two molex pins at these points, marked X in Fig. 4, which work quite satisfactorily.

When the board is assembled, it can be mounted behind the front panel, supported directly by stout wires to the two inputs and the recorder output. Connect a power supply and check that the voltage across C11 is six volts or just under. Calibration and testing are simplified if the leads of C11 and the positive lead of C3 and C4 are left long enough to be able to clip a lead thereon.

CALIBRATION

To calibrate the instrument, first connect capacitor C5 to the CAL position, the meter to be used to the recorder output and a signal of about 100 mV at about 1 kHz to the reference input. Adjust RV1 to give a null reading on the meter. Disconnect C5, leaving the end free, and adjust RV4 to give a convenient reading on the meter to correspond to 180° (eg 180 mV or 45 μA). If this is hard to set exactly, connect a fixed resistance in parallel with RV4 to give better control for any individual meter.

Next connect jumper leads from the positive sides of C3 and C4 to either side of C7 (i.e. one to V+, the other to V−, it doesn't matter which), connect the meter to the main output and adjust RV3 to give a 180° reading (with parallel resistance if needed as in the previous paragraph). Finally, remove the two jumper leads and connect one between the two inputs, connect C5 to the USE position and adjust RV2 slowly and carefully until the LED is just on the point of turning on and off. The meter should now be reading less than half a degree: if not, repeat the calibration procedure.

As a check of proper operation, you should now be able to vary the communal input from millivolts to volts and from sub-audio to over 100 kHz without the phase difference showing more than about one degree. Another excellent test is to connect different signal generators of different frequencies to the two inputs. The output should read exactly 90°, as the signals will be in phase exactly as often as they are out of phase. Our prototype failed this test, reading 92°, and it was only after considerable trouble that we traced this to non-linearity in our trusted (and expensive) multimeter. We guess the moral is to use a digital meter if accuracy is really important. Note that the recorder output is undefined under these conditions.

The high-frequency accuracy is limited by the rise and fall times of the CMOS outputs, by any mismatch in R1 and R3 and their stray capacitances, and by propagation delay differences between the two input and squaring circuits. These, on the two units tested, have been about 50 nsec. This would be equivalent to 1° phase error for every 25 kHz of signal frequency. Thus the meter is usable, but certainly not accurate, up to about one megahertz.

Input protection is provided by resistors R1 and R3 and the internal diodes in the 74C04. We have tested this system to inputs of 80 Vrms before any degradation of the gates occurred, but a value of say 25 Vrms (70 V p/p) should be regarded as a fairly safe working maximum. If IC1 is mounted in a socket, it can be simply changed if accidently overloaded. Under no circumstances can 120 V be applied directly to the inputs!

When using the instrument for measuring phase in AC line circuits, common sense precautions should be observed to ensure no damage occurs to the instrument or the operator! First use a neon test prod to identify the hot lead: secondly always switch off the power when connecting or making any alterations to the circuit under test: thirdly make sure that the resistor R makes reliable contact and cannot accidentally become disconnected, otherwise the reference input can get the full line voltage through the load. Finally use a voltage divider or an oscilloscope X10 probe to reduce the voltage to a safe level.

The circuit shown in Fig. 6 can be set up on an insulating board with a socket for the load to be plugged into. Resistor R is chosen to give a voltage of 1 volt or less when the load current flows through it and must be rated to dissipate a few watts if large currents are to be handled. A value of 0.22 Ω, 5 W is suitable for most situations. And remember that, when set up like this, the instrument reads the phase of the voltage relative to the current.

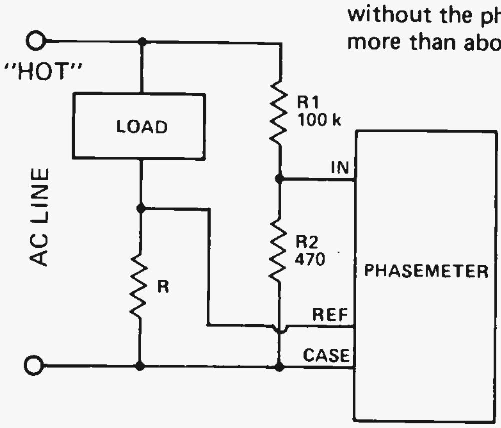


Fig.6. How to use the meter to show the relative phase of mains voltage to mains current.

Light Chaser

Low cost, simple design handles up to 1000 W per channel and can be expanded if required.

A LIGHT CHASER is a mechanical, or in this case, electronic, gadget which controls three or more sets of lights arranged in a chain. These are flashed on, one at a time in sequence, to create an illusion of movement. Such devices can be seen at fairgrounds, on advertising signs and in shop windows. Here is a design that is simple and cheap to build, and suitable for any of these applications.

DESIGN FEATURES

We have seen many designs for light chasers ranging from three relays switched sequentially by a motor and cam follower contacts to elaborate phase control circuits. We chose to steer for a happy medium retaining features like easily adjustable rate and zero crossing switching but still being simple and cheap to build.

To reduce cost, we decided against using an isolation transformer. Because of this, the *entire* circuit is at line voltage and should therefore be treated with due respect. By using a series capacitor which costs about $1.50, we save a power transformer ($4.50) and three pulse transformers (about $2.00 each), resulting in a $9 – $10 saving.

The unit can be expanded beyond three channels if desired by moving the reset line of IC4 (pin 15) from the fourth output to the (n+1)th, where n is the desired number of channels. The sequence in which the pins on IC4 go high is 3,2,4,7,10,1,5,6,9 and 11. Therefore for a 6 channel unit pin 5 will be connected to pin 15. The output stage consisting of the NAND gate, transistors, capacitor and triac will of course have to be duplicated for each additional channel.

The unit as described is suitable for about 500W per channel but if additional heatsinks are used this could be raised to the 15 A limit of the triacs or, if different triacs are used (e.g. Teccor Q2025C) even higher currents can be handled.

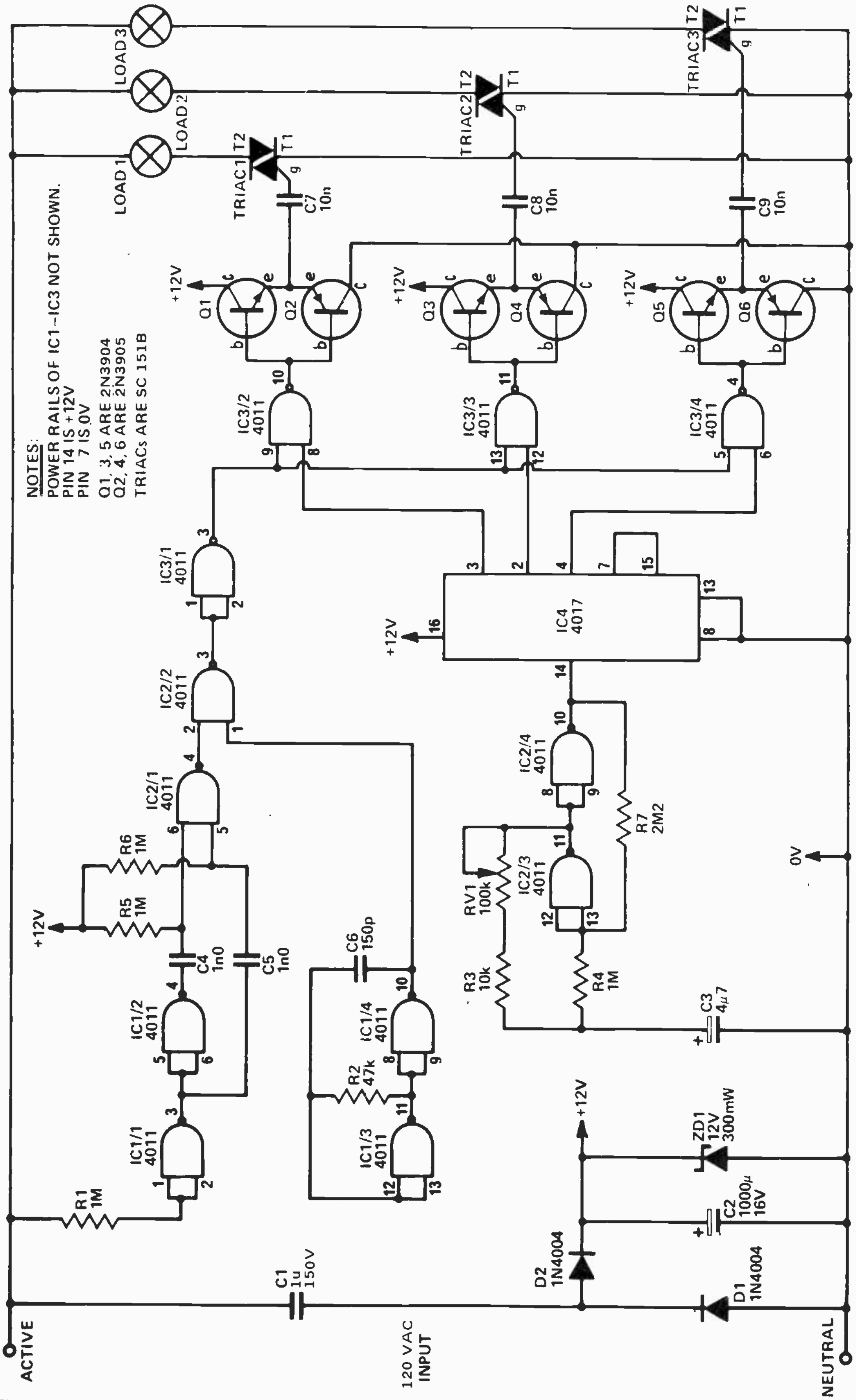


Fig. 1. The circuit diagram of the complete chaser.

HOW IT WORKS

A light chaser consists of three or more ac switches which are turned on, one at a time, in sequence. To make this explanation simpler, we have separated the circuit into several sections.

Power Supply
The 120 VAC is reduced to the 12 VDC required to operate the control circuitry by the use of a series capacitor C1, the diodes D1 and D2, the smoothing capacitor C2, and is then regulated by zener diode ZD1.

Synchronization Generator
The input to IC1/1 is connected to the 120 VAC supply via the 1 M resistor R1. The value of this resistor, combined with the effects of the protection diodes inside the IC, prevent damage to the IC. The output of this device is a 60Hz square wave which is synchronized with the line. IC1/2 is used to invert this square wave and then the RC networks R5/C4 and R6/C5 are used to generate negative pulses on the two inputs of IC2/1 on each zero crossing of the 60Hz signal – i.e. 120 pulses per second. The width of these pulses is about 0.6 ms.

High Frequency Oscillator
This is formed by IC1/3 and IC1/4, and runs at about 80 kHz. Its output is gated with the synchronizing pulses by IC2/2; this results in 600 μs long bursts of 80 kHz at the start of each half cycle.

Low Frequency Oscillator
This is formed by IC2/3 and IC2/4 and its frequency is variable by RV1 from 1 Hz to 10 Hz. We have used this form of oscillator in preference to that used for the high frequency oscillator to prevent reverse biasing the tantalum capacitor.

Counter
This is IC4 which is normally a divide-by-ten counter with ten decoded outputs which go high in sequence. By connecting the fourth output back to the reset, a divide-by-three is formed. This IC is clocked by the low frequency oscillator.

Driver & Output Stages
There are three identical output stages consisting of a two input NAND gate, a two transistor buffer, a series capacitor and a triac. The function of the gate is to direct the high frequency tone bursts onto the appropriate triac gate. The counter IC4 selects the required gate.

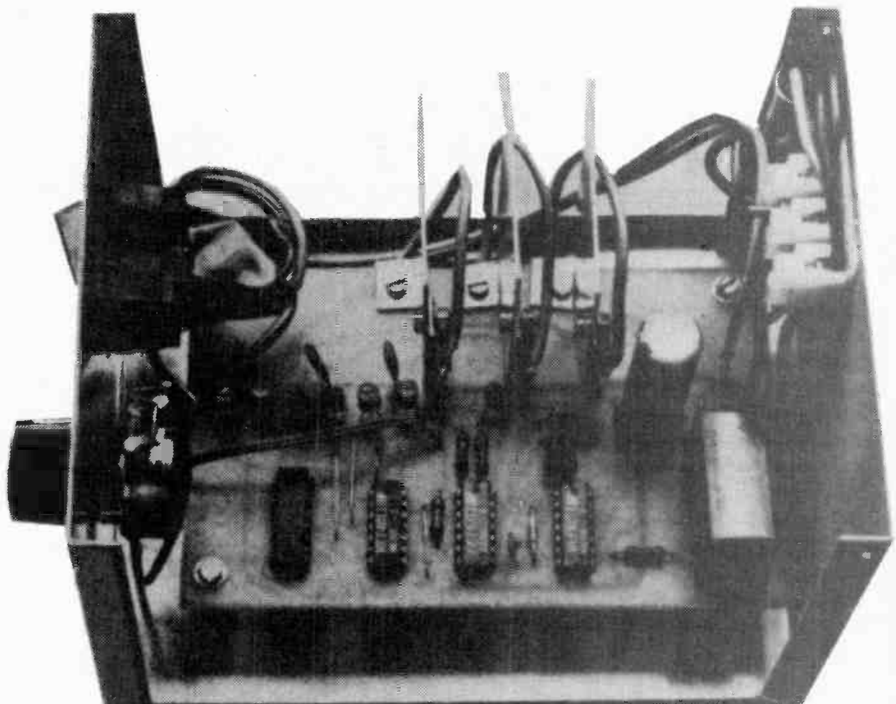
General
The use of a short tone burst at the start of each half cycle is intended to minimise RFI as the triac can only switch on at this point. This does, however, limit its use to incandescent loads. For use on fluorescent loads C4 and C5 can be increased to 10 n.

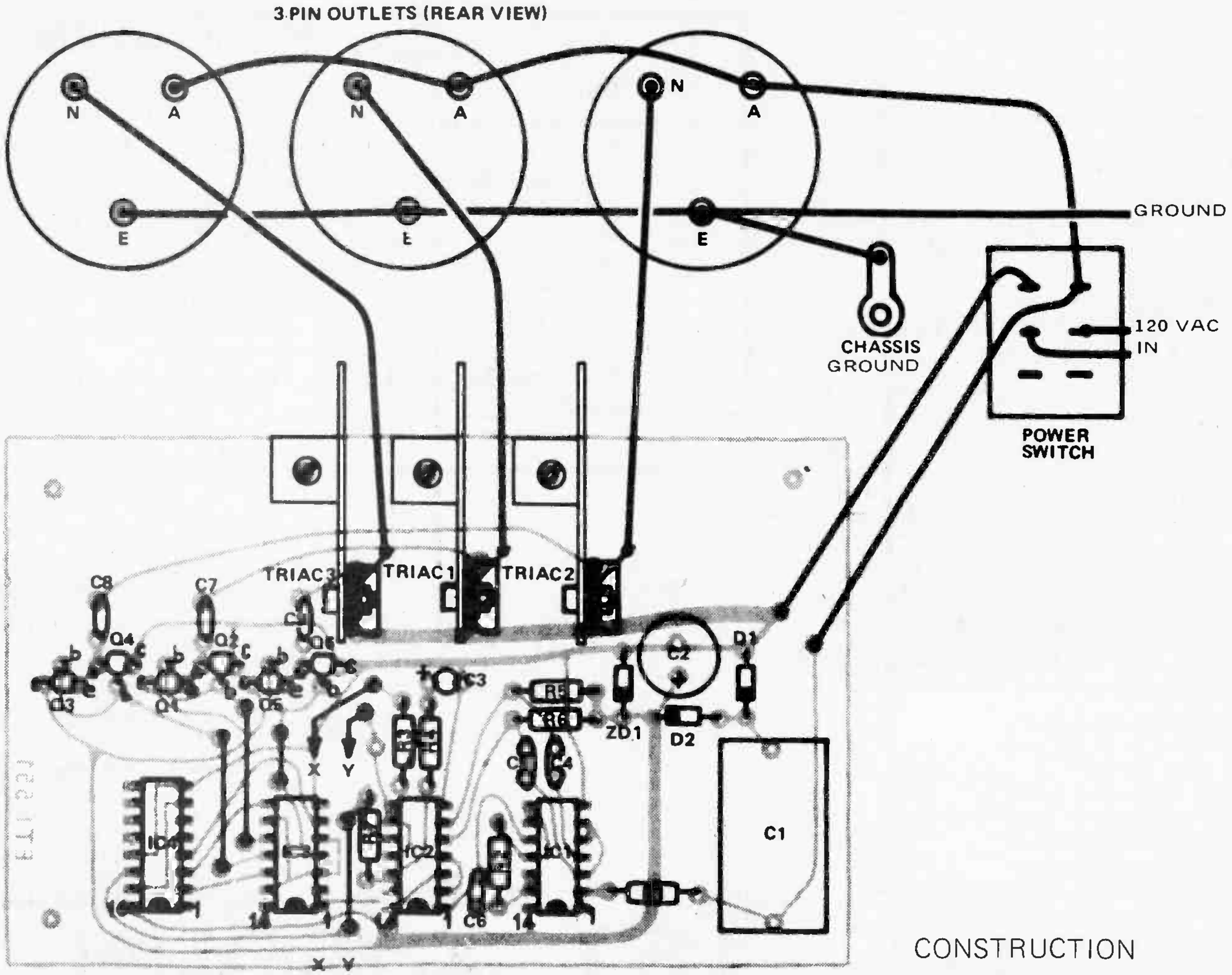
The fact that we have not used an isolation transformer reduces the cost, but it does mean that the complete circuit must be considered live! We did not use fuses in the prototype, but they can be used if required in the input leads. Ensure that the fuses used will protect the triac.

WARNING

The circuit described here does not use an isolation transformer and therefore all sections of the circuit must be considered dangerous.

If the unit does not work when switched on, disconnect the AC line and then, using a separate DC power supply, apply 10 V across C2. Now add a 60Hz AC signal of 12 – 32 V onto the normal AC input. In this way the control circuitry can be safely checked up to the triacs.





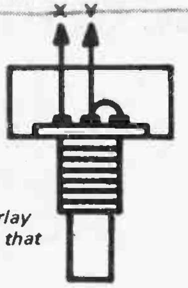


Fig. 2. The component overlay and wiring diagram. Ensure that the chassis is well earthed.

PARTS LIST

RESISTORS all ½W 5% unless stated otherwise
- R1 . . . . . 1M
- R2 . . . . . 47k
- R3 . . . . . 10k
- R4–R6. . . 1M
- R7 . . . . . 2M2

POTENTIOMETER
- RV1 . . . . 100k lin (trim or rotary)

CAPACITORS
- C1. . . . . . 1u 150 VAC
- C2. . . . . . 1000μ 16V electro
- C3. . . . . . 4μ7 25V tantalum
- C4, 5 . . . . 1n0 polyester
- C6. . . . . . 150p ceramic
- C7–C9 . . . 10n polyester

SEMICONDUCTORS
- IC1–IC3 . . 4011 (CMOS)
- IC4 . . . . . 4017 (CMOS)
- Q1, 3, 5 . . 2N3904
- Q2, 4, 6 . . 2N3905
- D1, 2. . . . 1N4004
- ZD1. . . . . 12V, 300mW
- TRIAC 1–3 SC151B

MISCELLANEOUS
- PC board ETI 551
- Metal box to suit
- Three 3 pin power outlets
- Power switch

PC Board for this project is available from Spectrum Electronics. See their ad in this issue for address.

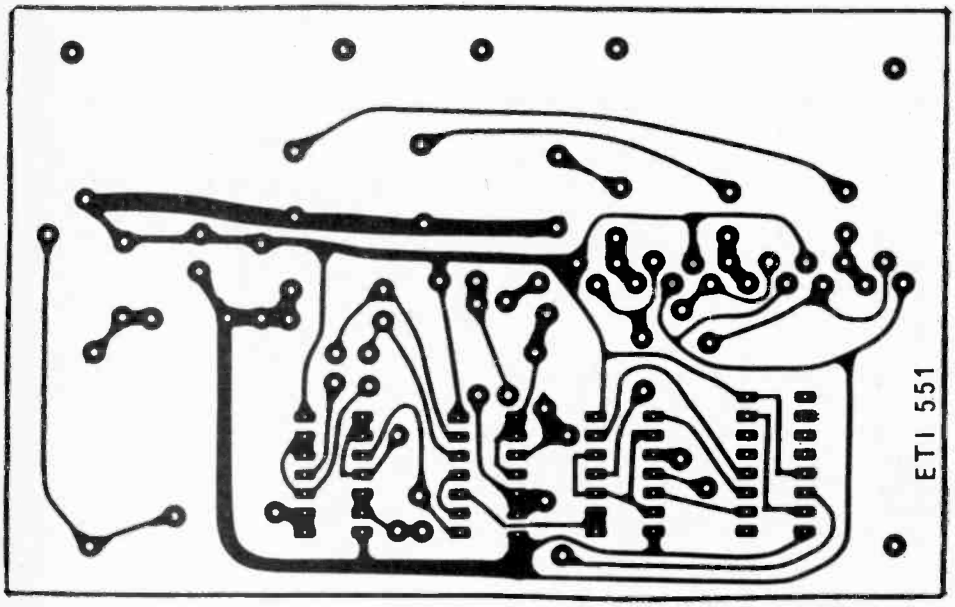
CONSTRUCTION

The pc board should be assembled with the aid of the overlay in fig. 2. Ensure that the diodes, capacitors and transistors are oriented correctly.

The CMOS ICs should be inserted last ensuring that the pins are not handled more than necessary and that pins 7 and 14 (the power supply rails) are soldered first.

The heatsinks and the triacs used depends on the intended load. We used about 2500 square mm of aluminum on each triac, and found this to be satisfactory for about 500W per channel. The tabs of the triacs are live and separate heatsinks, insulated from ground, should be used or the triacs should be insulated from the heatsink.

We mounted our prototype into a simple folded aluminium box, with an external rate potentiometer and three 3-pin sockets. If an external potentiometer is not required a trim potentiometer can be mounted on the board. To adjust this potentiometer an insulated trimming tool must be used. The unit can be wired according to fig. 2 taking care with insulation as many points are at 120V.


ETI 551


HICKOK
LX 303

ICM 7208 Counter

CMOS chip makes counting and display very easy.

Description

The ICM 7208 is a fully integrated seven decade counter-decoder-driver and is manufactured using the Intersil low voltage metal gate C-MOS process. As such it has applications as either a unit, frequency or period counter. For unit counter applications the only additional components are a 7 digit common cathode display, 3 resistors and a capacitor to generate the miltiplex frequency reference, and the control switches.

Specifically the ICM 7208 provides the following on chip functions: a 7 decade counter, multiplexer, 7 segment decoder, digit & segment drivers, plus additional logic for display blanking reset, input inhibit, and display on/off.

The ICM 7208 is intended to operate over a supply voltage of 2 to 6 volts as a medium speed counter or over a more restricted voltage range for high frequency applications.

As frequency counter it is recommended that the ICM 7208 be used in conjunction with the ICM 7207 Oscillator Controller which provides a stable HF oscillator, and output signal gating.

Features:

- Useful for:
  - a. Unit counter
  - b. Frequency counter
  - c. Period counter
- Low operating power dissipation 10mW
- Low quiescent power dissipation 5mW
- Counts and displays 7 decades
- Wide operating supply voltage range
  $2V \leq |V_{DD} - V_{SS}| \leq 6V$
- Drives directly 7 decade multiplexed common cathode LED display
- Internal store capability
- Internal inhibit to counter input
- Test speedup point
- All terminals protected against static discharge

Counter Input Definition

The internal counters of the ICM 7208 index on the negative edge of the input signal at terminal #12.

Format Of Signal

The noise immunity of the Signal Input Terminal is approximately 1/3 the supply voltage. Consequently, the input signal should be at least 50% of the supply in peak to peak amplitude and preferably equal to the supply. **NOTE: The amplitude of the input signal should not exceed the supply; otherwise, damage may be done to the circuit.**

The optimum input signal is a 50% duty cycle square wave equal in amplitude to the supply. However, as long as the rate of change of voltage is not less than approximately $10^{-4} V/\mu sec$ at 50% of the power supply voltage, the input waveshape can be sinusoidal, triangular, etc.

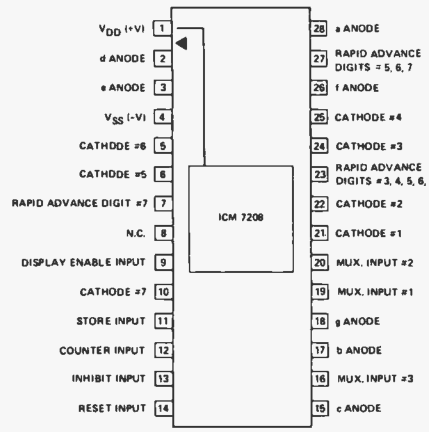


Fig. 1. Pinout.

Fig. 2. Absolute maximum ratings.

Power Dissipation (Note 1)	1 watt
Supply voltage $\|V_{DD} - V_{SS}\|$ (Note 2)	6 V
Output digit drive current (Note 3)	150 mA
Output segment drive current	30 mA
Input voltage range (any input terminal)	Not to exceed the supply voltage
Operating temperature range	-20°C to +70°C
Storage temperature range	-55°C to +125°C

*Absolute maximum rating define parameter limits that if exceeded may permanently damage the device.

Fig. 3. Typical operating characteristics.

($V_{DD} - V_{SS} = 5V$, $T_A = 25°C$, TEST CIRCUIT, display off, unless otherwise specified)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Quiescent Curent	I_{DD1}	All controls plus terminal 20 connected to V_{DD}. No multiplex oscillator		30	100	μA
Quiescent Current	I_{DD2}	All control inputs plus terminal 20 connected to V_{DD} except store which is connected to V_{SS}.		70	150	μA
Operating Supply Current	I_{DDS}	All inputs connected to V_{DD}, RC multiplexer osc operating $f_{in} < 25KHz$		210	500	μA
Operating Supply Current		$f_{in} = 2MHz$			700	μA
Supply Voltage Range	V_{DD}	f_{in} 2MHz	3.5		5.5	V
Digit Driver On Resistance	R_D			4	12	ohm
Digit Driver Leakage Current	I_D				500	μA
Segment Driver On Resistance	R_S			40		ohm
Segment Driver Leakage Current	I_S				500	μA
Pullup Resistance of Reset or Store Inputs	Rp		100	400		Kohms
Counter Input Resistance	R_{IN}	Terminal 12 either at V_{DD} or V_{SS} potentials			100	Kohms
Counter Input Hysteresis Voltage	V_{HIN}			25	50	mV

NOTE 1 This value of power dissipation refers to that of the package and will not be obtained under normal operating conditions.

NOTE 2 The supply voltage must be applied before or at the same time as any input voltage. This poses no problems with a single power supply system. If a multiple power supply system is used, it is mandatory that the supply for the ICM 7208 is not switched on after the other supplies otherwise the device may be permanently damaged.

NOTE 3 The output digit drive current must be limited to 150 mA or less under steady state conditions. (Short term transients up to 250 mA will not damage the device.) Therefore, depending upon the LED display and the supply voltage to be used it may be necessary to include additional segment series resistors to limit the digit currents.

Testing Procedures

The ICM 7208 is provided with three input terminals: 7,23,27 which may be used to accelerate testing. The least two significant decade counters may be tested by applying an input to the 'COUNTER INPUT' terminal 12. 'TEST POINT' terminal 23 provides an input which by-passes the 2 least significant decade counter. Similarly terminals 7 and 27 permit rapid counter advancing at two points further along the string of decade counters.

Display Considerations

Any common cathode multiplexable LED display may be used. However, if the peak digit currents exceeds 150 mA for any prolonged time, it is recommended that resistors be included in series with the segment outputs (terminals 2, 3, 15, 17, 18, 26, 28) to limit current to 150 mA.

The ICM 7208 is specified with 500 μA of possible digit leakage current. With certain new LED displays that are extremely efficient at low currents, it may be necessary to include resistors between the cathode outputs and the positive supply V_{DD} to bleed off this leakage current.

Display Multiplex Rate

The multiplex frequency reference is divided by eight to generate an 8 bit sequencer. Thus the display multiplex rate is one eighth of the multiplex frequency reference.

The ICM 7208 has approximately 0.5 μs overlap between output drive signals. Therefore, if the multiplex rate is very fast, digit ghosting will occur. The ghosting determines the upper limit for the multiplex frequency reference. At very low multiplex rates flicker becomes visible.

It is recommended that the display miltiplex rate be within the range of 50 Hz to 200 Hz which corresponds to 400 Hz to 1600 Hz for the reference frequency.

Control Input Definitions

INPUT	TMNL	VLTG	FUNCTION
1. Display	9	V_{DD}	Display on
		V_{SS}	Display off
2. Store	11	V_{DD}	Counter Inform. Stored
		V_{SS}	Counter Inform. Transferring
3. Inhibit	13	V_{DD}	Input to Counter Blocked
		V_{SS}	Normal Opertn.
4. Reset	14	V_{DD}	Normal Opertn.
		V_{SS}	Counters Reset

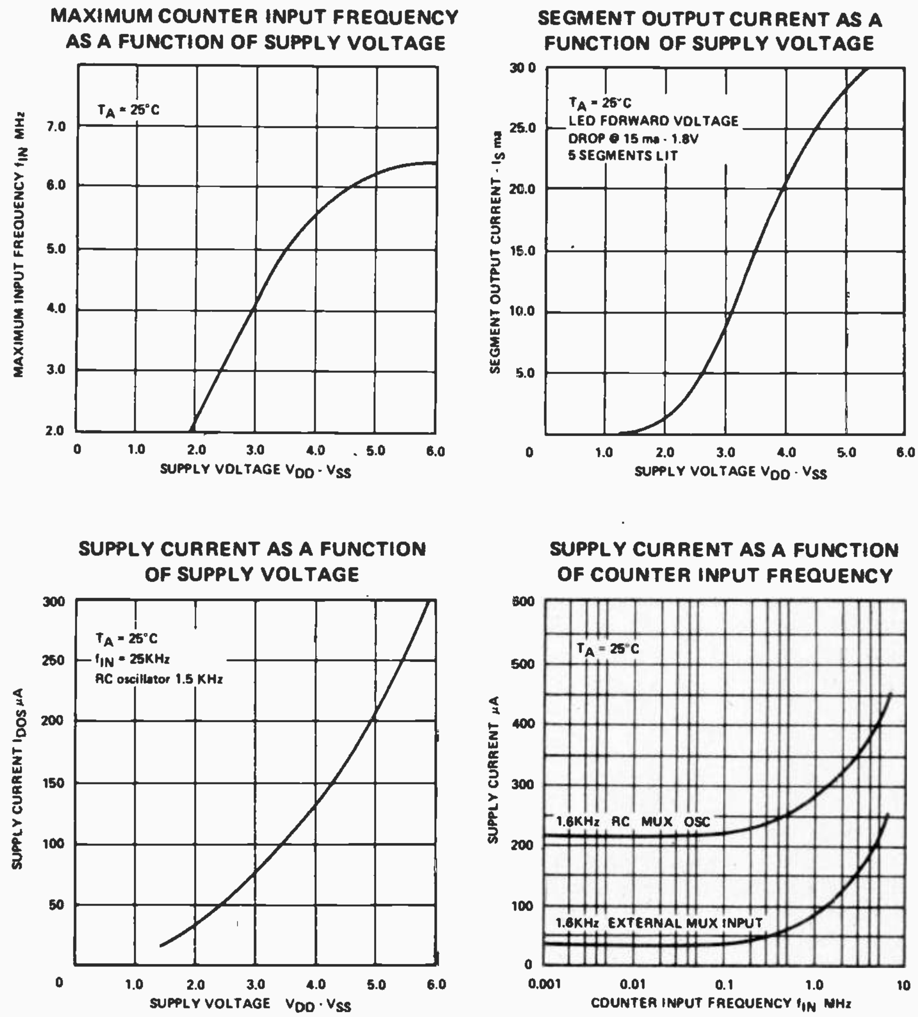


Fig. 4. Typical performance charactieristics

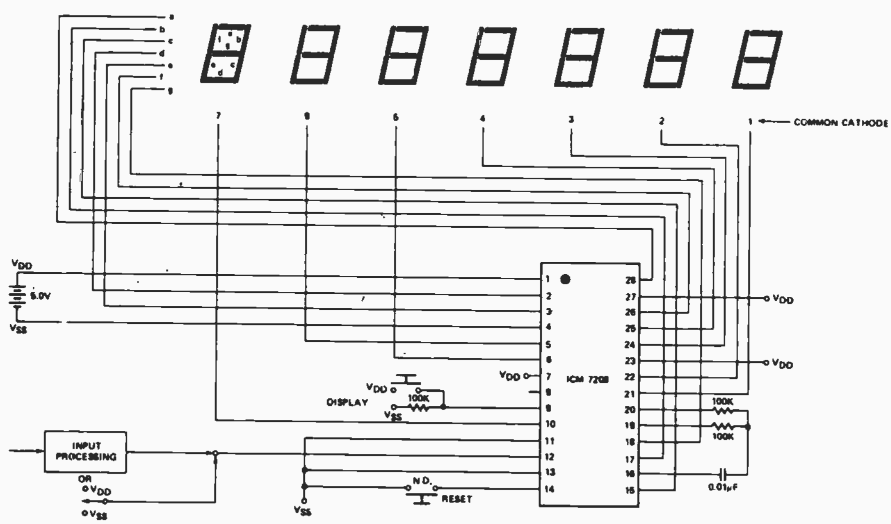


Fig. 5. Unit counter schematic.

Resurrecting Your Video Machine

In Part Three of Getting Into Video, Steve Rimmer discusses what you need to know to get your machine rolling.

The first thing to do is to plug in the VTR and check out what happens and what declines to happen. You might get a picture first thing, but what is more often the case is that, family and friends gathered expectantly, you stab the "Start" button and nothing moves. At this point, apologize to the spectators and remove the cover plates.

The inability of the wheels to turn in VTRs is very often due to the affinity of the chemical sometimes used to clean the heads for synthetic rubber of the sort used to make drive belts. It tends to eat them. If everything seems to be bent on remaining motionless, locate the motors that are intended to dispel this condition. You will very possibly find them whirling happily away, their drive pulleys oozing with a black, tarry goo that was once the belts. Some meticulous cleaning with a rag soaked in paint thinner should remedy this situation.

If the motors don't turn, make sure that there is power being applied to them, that their starting capacitors, if they have them, are good, and so forth. These motors are usually well de-rated and rarely burn out.

The mechanical aspects of VTRs are usually the most troublesome to deal with and once you have cleared up any problems with the meter you will probably find that the electronics are functioning without any further attention.

On the other hand . . . if you still are unable to get the set working with everything revolving as it should, with the tape threaded correctly (and turned the right side round, some video tape is recorded on the shiny side), and everything else set up as it should be, it is not particularly advisable to plunge right into the maze of resistors and capacitors that make up the VTR's circuitry without a service manual. There are a number of things that go on in a video recorder that even a seasoned electronics experimenter will find a bit peculiar. Service manuals for these machines vary in availability and, should you elect to buy one from the manufacturer of the machine, you may find them to be very expensive. In the end, though, they are worth whatever they cost, for having one will very likely mean the difference between success and failure.

If you did not get a manual from the previous owner of the machine and cannot or do not wish to buy one, there are a few places from which you might be able to borrow one long enough to photocopy it. The first is the manufacturer, himself; depending upon the individual you deal with, you might be able to get the book out on loan (usually unofficially), sometimes with a deposit left behind to assure its return. Shops which service your particular machine may permit you the same arrangement. If you have access to the TV department of a school, university or industrial concern you might be able to get the book from them for a few hours.

In some cases you may be permitted access to the manual, but will not be allowed to remove it from the premises. In this case you will either have to locate an unguarded copy machine or read the pertinent passages off into a tape recorder. This last technique poses a few problem when it comes to schematics and diagrams: you might have to get a bit James Bondish here and use a camera.

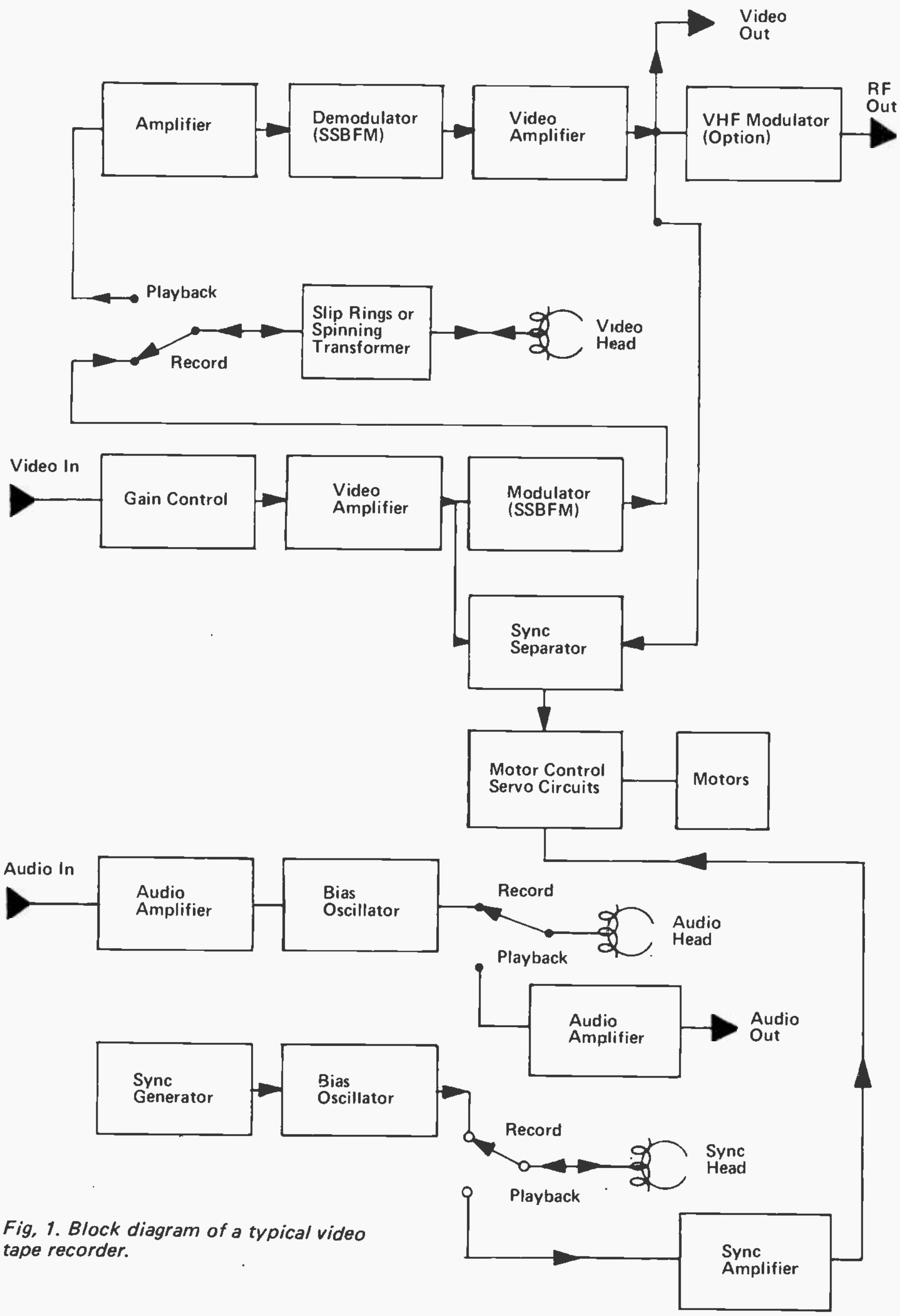
If you cannot find a book for a machine with your exact model number, try for one with a number that is fairly close. Usually engineers who design next year's machine simply upgrade this year's, so the design of an Ampex 4900, for instance, is sufficiently close to that of a 5000 to use the latter's literature in servicing the former.

Note that the model numbers, especially in machines intended for the North American market, are usually four digits and change in increments of one hundred.

If you are unable to locate a manual and are left with no alternative but to try it alone, work from the block diagram in Figure 1. The following descriptions of its functions may enlighten.

HOW IT WORKS

The video signal is brought into the VTR, usually by way of a UHF or BNC type connector so labelled on the rear apron of the machine. It may, instead, be labelled "Camera", indicating that



Fig, 1. Block diagram of a typical video tape recorder.

the machine was to be used with a television camera. This, however, does not mean that the video cannot come from another source. In some cases, such as the Philips 3400 series machines video is also brought in via a modulated i.f. signal from a television receiver and demodulated inside the VTR. Sound is also derived.

Once the video is inside the set it usually encounters a gain control of some kind, either a straightforward pot or tube or transistor with variable bias. In some cases the gain control may be augmented or replaced by an AVC system of some sort. There will usually be a meter or an eye tube to indicate when the gain control has been properly adjusted and a recording level of 100%, or 0 dB, has been reached.

Once the video has passed through a few stages of straight amplification, it encounters a rather unique sort of modulator. Usually resembling an astable multivibrator, the modulator generates a carrier of several megahertz which is frequency modulated by the video. The modulated carrier then travels to the tape head via slip rings, or a transformer arrangement in whcih the secondary is mounted on the revolving disc which holds the video head.

At the same time as the video is being modulated onto the carrier, it is also fed to a servo circuit where its sync is extracted and used to control the speeds of the video head and their capstan motors.

Upon playback, the signal from the video head is received by a demodulator which converts it back into straight video information. It is usually then amplified and sent to the servo system, as was the video in the recording situation, and, as well, is made accessable via a UHF connector on the rear apron of the machine. It may also be sent on to a modulator, which places it on an RF carrier in the VHF televison broadcast band for display on an ordinary TV set.

Above and below the wide path of video tracks on the tape are two narrow audio tracks, one of which carries the sound and the other, which holds sync information. They are both dealt with in the same fashion as in a standard audio tape recorder.

CARE AND FEEDING

Just as with an audio tape recorder, most VTRs will require an external source of signal and a medium upon which to display these signals on playback, usually referred to as a "monitor". The easiest way to provide both of these requirements is to adapt a standard home type television set.

Before we get into the surgery required to adapt a TV set for VTR use, a word on TV sets in generalis probably in order. First of all, whatever television set you do wind up using in conjunction with your recorder will probably require a bit of modification, so it is better not to use the set you and your family usually watch (just in case something goes wrong). Secondly, for those aspects of the modification which actually require changes in the TV set's circuitry, it is better to use a black and white set, as opposed to a color TV, as the former can usually tolerate a lot more fooling around with its workings without rolling over and playing dead. Lastly, it is very important that the chassis of your monitor set is not connected to one side of the line if you are planning to make any direct connections to it. Most television sets use a power transformer to supply the various voltages required by the circuitry of the set. With this arrangement, neither side of the power line is electrically connected to the chassis ground and, as a result, there is no way that the plug can be put in the wall so as to cause the chassis to be "hot". There are a few sets, however, which, because of the reduced cost of omitting the power transformer, use what is called an AC/DC power supply in which one side of the line cord is attached directly to the chassis. Depending upon which way the plug is put in the wall the chassis may wind up connected to the hot or the ground side of the power line. Consequently, if another device is connected to the chassis all of its grounded metalwork may be connected to the hot side of the line, as may be any human being who happens to come in contact with it. Furthermore, if one of the external devices connected to the hot chasis has a three wire ground, the chassis may find itself connected to ground and the hot side of the line at the same time, a condition which may result in an explosion, a fire, or the vaporization of part or all of the wiring associated with the equipment in question. Therefore, when selecting a TV to be used as a monitor, make sure that the set has a transformer power supply and that the chassis is completely isolated from the line.

There are only two circumstances in which an AC/DC set can be used in safety. It is perfectly permissable to attach a 300 ohm balanced antenna line to the antenna input of one, thus VTRs with their video signals fed through a VHF modulator can feed an AC/DC set in this manner without any hazard. It is also acceptable to connect a VTR using an inductive pickup off the television's last i.f. tube in which the VTR contains the necessary demodulator as a part of its internal circuitry again, without any danger. Note, however, that few VTRs are so equipped, and no other type of pick off can be effected on a non-isolated chassis without the possibility of encountering the results just mentioned.

MATING WITH YOUR TV SET

Now, returning to the problem at hand, the first thing that will be required is a way of tapping a video signal from the television set's circuitry. This is not as easy as it sounds, however. The ideal video signal for use with a VTR will be positive going (that is, with sync on the bottom), have an amplitude of about one volt and work into an impedance of seventy five ohms unbalanced. In most cases, this condition does not normally exist in an unmodified television set. It may be necessary, therefore, to operate.

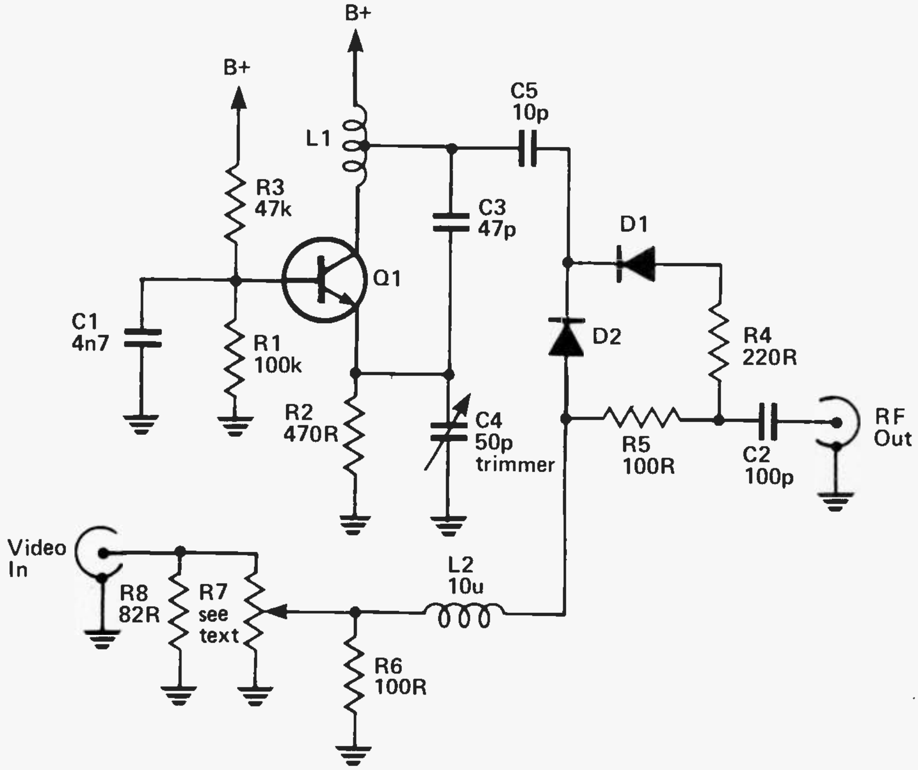


Fig.2. This is the circuit of a very simple video modulator. It can be built with flea clips on a perf board (the capacity between tracks on a pc board may present problems unless it is carefully laid out). Construction is not critical provided leads are kept short and direct. It should be housed in a metal container fitted with the appropriate video in and RF out connectors (259's type 59's or BNC will do fine). B+ can be a 9V battery.

L1 — 8 turns of No 18 or 22 hookup wire (solid) air wound around a pencil, tapped two turns from the top.
C4 — Any small trimmer capacitor in the 50 to 75p range.
D1, D2 — Small signal high frequency diodes (eg 1N60) Computer switching diodes will work but may distort the grey scale.)
R7 — Any 10 turn pc trimmer. Pots in the range of 1k to 20k have been tried and worked successfully.
Q1 — Any VHF small signal NPN transistor The 2N2222 works well.
L2 — Any RF choke on hand.

Before you begin cutting you should obtain a schematic for your set. It will save you a lot of time and might keep you from ultimately turning your TV into a medium sized pile of spare parts. With a bit of luck, the schematic will show you some wave forms at various points on the chassis and you will, therefore, be able to locate a video signal of the proper polarity. The best bet for finding one is usually on the plate of the video amplifier tube. Some sets will have two stages of amplification in this circuit, two tubes, in which case a suitable signal might be available on either the plate of one tube or the cathode of the other. Either the waveforms on your diagram or a scope, if you have one, will provide you with some more specific locations.

At this point, you have several choices. If you intend to get your signal off a cathode, it will probably be necessary to replace the cathode resistor with a seventy five ohm unit, removing any bypass capacitors in the meantime, and pick the signal off via a .1 uF, 600 volt capacitor. If you choose to take it off the plate, probably a more easily accessable source, you will need to attenuate it considerably, not only to avoid damaging your VTR (there will be about a hundred volts of signal here), but also to keep from loading the circuit. You will have to calculate the necessary resistance needed to drop the plate signal down to one volt across seventy five ohms. Here, too, you will have to install a .1 uF, 600 volt coupling capacitor in order to avoid upsetting the DC levels of the circuit. In either case, you can bring the video out through a UHF connector on the rear apron of the set (the traditional way).

A third alternative is to construct an external amplifier, two tubes or transistors, or a suitable IC, to match the signal at some point in the set to the input of your VTR. In the long run, this may wind up being the best solution, as it would facilitate the use of several sets, if desired, without major surgery required on any of them. The amp would have to have a high impedance input shunted by a low capacitance, a seventy five ohm output, fairly low noise and a bandwidth in the range of four or five MHz. It would probably take the configuration of a common cathode, or common emitter stage followed by a cathode or emitter follower working into a seventy five ohm load.

You will probably also wish to derive sound from the receiver, which can usually be tapped off with a .1 uF (or larger) 600 volt capacitor connected to the top lug of the volume control, and taken out through a monaural phone jack. This method is preferable to obtaining sound through a headphone jack, should your set have one, as the B plus voltage for the output tube, which supplies the audio to the headphone jack, is usually less well filtered than that of the pre-amp tubes and sound from this source usually contains more hum. Furthermore, the frequency response will be limited by the output transformer, which is usually not of a very high quality and the distortion will be increased by the output stage, which is usually class A.

Getting the video produced by the VTR on playback back into the set for display is a much easier proposition than getting it out in the first place was. Most VTRs have internal VHF modulators which will plunk your picture down somewhere in the low end of the standard TV braodcast band. Thus, the output of the modulator is simply connected to the set's antenna input with some twinlead, or with coax and a matching balun, in the case of those VTRs which have seventy five ohms outputs from their modulators, and its signal is tuned in to the channel of your choice. Usually this is adjustable over the range of channels two to five via an externally accessable slug.

If you are blessed with a set which does not incorporate a modulator into its workings, as do some models designed principally for studio use, it should not be much of a problem to add one externally. There are several on the market, both in factory wired versions and in kit form, most of which are not too expensive. The little "video cubes" used with TV games should also work. You might also try the circuit given in Figure 2, which is the same type of arrangement used on many VTRs.

If you do not elect to use a modulator, you can feed your straight video signal directly into your TV via (yes, once again) a UHF connector and a .1 uF, 600 volt capacitor. It will probably have to be attenuated somewhat, but it can go right onto the grid of the video amplifier. IF you have a two stage video amp, select whichever grid yields a positive picture and proper sync.

If you do decide to use this direct method, you will probably also have to install a switch to select between the signal produced by the video detector of your set and the one coming out of your VTR.

With a video tape recorder and this combination tuner and monitor made from a TV, you are now ready to start "playing around" with television.

Next month in ETI . . . .

SPACE SHUTTLE

Held over for next month. What's inside the Rockwell flying space craft.

PROJECTS

Tape - Slide Synchroniser
Synthesiser Sequencer
Electronic Dice

Service News

More and more, sophisticated test equipment is needed to keep the technician competitive.

A "HANDS-ON" SERVICE seminar, jointly sponsored by Radio Trade Supply, B.&K. and M.T.T.S.A. was held at the Airport Holiday Inn, Toronto, on November 29th, 1978. An extremely comprehensive display of the very fine B.&K. test equipment was available for comment and examination. The guest speaker was Mr. Norman Furness, Engineering Assistance Manager of Atlas Electronics Ltd. The equipment on display included the Model 1474 30 MHz Dual Trace Triggered Scope; the Model 2800 Portable DMM; the Model 3020 Sweep/Function Generator; the Model 415 Sweep/Marker Generator; and the Model 2040 40-channel PLL CB Signal Generator.

EQUIPMENT NOW NEEDED

Mr. Furness opened his remarks by pointing out that equipment that a relatively short time ago was purely industrial in nature is now becoming an absolute necessity if the practising domestic electronics technician is to function efficiently in today's field. He pointed out that the microprocessor first used in the NASA space programmes is now in common use in calculators, micro-wave ovens, electronic games, and many other very familiar pieces of equipment that the domestic electronics technician must be prepared to service. The field is expanding continuously. He went on to say that B.&K. have long recognized that the service industry as a whole, not just TV, would need more highly sophisticated equipment, and they have stayed well abreast of these requirements.

A major part of Mr. Furness' address was devoted to the advantages of the digital and the disadvantages of the analog meter. He stressed the fact that the analog meter was subject to numerous inaccuracies, for example parallax and interpolation. Mr. Furness said "With the digital meter there is no reading error. It tells you what it is looking at; not what you are looking at, but what *it* is looking at."

Another very strong point in favour of the digital meter, as demonstrated by Mr. Furness, is the fact that the decimal point is placed for you, and the ability to read positive or negative is entirely automatic. You do not have to reverse connections.

IF ONLY?

The audience was then treated to a very informative demonstration of IF alignment using the 415 Sweep/ Marker Generator. Mr. Furness pointed out that there is money to be made in IF alignment, and in fact he mentioned a man who does nothing else and is able to make an extremely good living. He seemed to be of the opinion that many technicians are somewhat reluctant to embark upon an IF alignment, but after the demonstration I am sure many of those present would view this job with considerably less trepidation.

Mr. Furness also discussed briefly the use of the 3020 Sweep Function Generator, its many and varied applications; the obvious advantages of the Dual Trace 30 MHz Scope, explaining its applications, particularly in the stereo audio field.

A very special vote of thanks is certainly due to Mr. Norman Furness and Atlas Electronics Ltd. for devoting their time and very considerable skills to those technicians who had the good sense to attend a very informative seminar.

ATTENDANCE

A week or so after the meeting I spoke to Mr. Graham Hartlen of Atlas Electronics Ltd., and after a very friendly discussion of things in general he expressed some surprise at the very meagre turn-out. He told me they had been led to believe a turn-out of approximately 100 technicians was expected, and needless to say they were somewhat disappointed. However he did state that those attending seemed to be knowledgeable and enthusiastic.

On completion of the technical part of the evening the MTTSA took over, and after the usual business, minutes, treasurer's report, etc., a proposal was made to change the name of the Association to "The Ontario Television Electronics Association (Metropolitan Toronto Chapter)". This was passed unanimously and after a few general annoucements the meeting was adjourned.

COMMENTS

I have to agree without reservation to the remarks made to me by Mr. Frank White, Jr. (Radio Trade Supply) and Mr. Graham Hartlen, that in view of the vast amount of work put forth by the sponsors, the turn-out was incomprehensible. In a city the size of Toronto, and I cannot begin to estimate the number of practising electronics technicians here, to have approximately 50 technnicians turn out on a fine evening must make the organizers wonder whether they are wasting their time. At this meeting there was no attempt to sell these products. It was purely educational in format, and even non-members of the Association were most welcome and of course were at liberty to leave before the Association business was conducted. Mr. White was of the opinion that the problem was publicity, and maybe the Association should consider some other form of publicity, as from my own research many interested technicians would have attended had they known in time. As I have offered before, providing I am given at least 2 months' notice, more if possible, I will gladly print times, places, etc. of any future seminars.

All the best.

Richard Cartwright.

QRM QRM

LATE NEWS ! ! ! ! Just as this page was heading to the printers, Bill phoned us to say that he had word that for some reason he had passed the exam. This makes VE3APZ one of the first hams to hold the new Digital privileges. Congratulations to B.J., and to any others who made it too ! ! !

This month Bill Johnson is depressed because he thinks he failed his first sitting of the Amateur Digital exam.

'Well, at least my amateur radio operators certificate allows me to experiment with digital signalling and packet radio - as long as I don't want to use pulse.'

'Pulse modulation would probably upset my neighbor's TV anyway.'

'Who cares about pulse - there are better ways to communicate .'

This is a random sampling of some of the more printable comments heard in the corridors of 55 St Clair Avenue East in Toronto on Wednesday, November 15, 1978 as twelve amateurs from the Toronto area failed the first sitting of the new Amateur Digital operator's certificate exam. Doctor John DeMercado had shown his hand and the much-awaited questions that form the gateway to pulse modulation techniques for the amateur were revealed to an unsuspecting amateur public. (No official results have been published at time of writing — the above failure rate reflects the opinions of those who wrote it')

The sweat started flowing with the first question. It was entirely based on a formula that nobody interviewed could even remember seeing in any of the more than twenty volumes of reference works recommended by Dr. J. for study. I skipped that question (worth 20%). The next three questions could have been answered by anybody who holds a current amateur radio operator's certificate and has read, and thoroughly understands my previous dissertations in the Bits, Bytes and Bauds series (ETI Canada Sept 77 to Mar 78) on digital techniques. The last question was straight out of grade thirteen math and my failure to remember the formulae involved mostly my fault, although it was helped by my understanding that that level of math could not possibly be required of the average amateur.

The disclosure of the actual contents of the examination was forbidden in a strongly-worded paragraph in the instructions which underlined Dr. J.'s avowed intent to put a stop to the practice of some clubs whereby they 'programmed' their code and theory students for a predetermined subject matter which was known from previous exams to be in the pool of questions recirculated by regional offices. The new exams, both digital and the regular amateur and advanced, will be set every quarter by the Ottawa office and sent to the exam room in sealed envelopes addressed to the individual candidate.

I suppose I really failed the exam because of my experience with computers. I only made a cursory look over the study material, recognised principles that I knew well from past experience, and, taking into account what I knew of the level required for amateur exams in the past, didn't go into any great depth in my studies. The others who failed felt the same as I.

So, beware, and take heed. If you are planning to take the next digital exam — remember it's a lot tougher than you might think (unless Dr. J. was just seeing how smart we really are for an easier exam in January.)

One of the problems of studying for this exam is the lack of a single reference volume. Candidates for the amateur and advanced amateur exams have two excellent books by Morton Biback and Glen Emo, called the 'Ham Handbook for Beginners' and the 'Ham Handbook for the Advanced'. As mentioned before, several articles have appeared in ETI in recent months that appeared at the time (correctly as it turned out) in our crystal ball to be of value to those studying for the digital. We are going to continue to lead the way with up-to-date technical information for the amateur, and are presently preparing a series of articles aimed at those who need a one-stop-shopping source of information to use as study material for the exam. Hopefully, we can start this series later this year, allowing time for Dr. J. to decide on what level of technical expertise the DOC should reasonably expect from candidates for the digital exam.

I know that people out there read this column, because some of my closer friends have told me that they like reading my ramblings-on. The editor, however, is getting a little doubtful that there are really radio amateurs out there who read QRM, because he hasn't received much mail about it yet. So please write down your questions and caustic comments, keeping the unprintable words out if you can, and send them to:

QRM Letters,
Electronics Today International
Unit Six
25 Overlea Boulevard
Toronto, Ontario
M4H 1B1

and I'll do my damndest to answer them and print the more interesting ones. We will even accept letters from CBers who want to be hams. If I don't get any response, the editor has threatened to cut me down to half a page, and I'll have to write in Morse code in the margins to communicate with you.

73 till next month,
Bill

More Shortwave Antennas

John Garner discusses what to connect to the antenna terminals.

FIRST SOME NEWS about the ANARC convention this year, and then on with our look at shortwave antennas, started last month.

This year's convention of the Association of North American Radio Clubs (ANARC) will be held in Minneapolis, Minnesota on the weekend of June 22, 23, and 24. The 1979 Convention Committee is under the leadership of Kim Andrew Elliott, Chairman with assistance from Tom Gavaras and Greg Ravenhorst. All SWLs and DXers are cordially invited to attend this all-wave convention. It is not necessary to belong to a club to attend. Plan now on going to Minneapolis in June. You will be glad you did. See you there!

DIPOLE ANTENNAS: THE HALF-WAVE DIPOLE

This is a directional antenna with best reception being obtained when the antenna is broadside to the incoming signal. The length of the antenna, as the name implies, is one half of the wavelength of the frequency for which it is to be used. It is a center-fed tuned antenna intended for best results over a small band of frequencies. The total length of this antenna is divided in the center by an insulator, thus giving two "poles", each a quarter wave length long. The lead-in for this antenna should have an impedance of 75 ohms and may be either co-axial or twin lead type. If co-ax is used for the lead-in then the center conductor should be connected to one half of the antenna at the center insulator and the outer shield should be connected to the other half of the antenna at the insulator. If twin lead is used then the conductors should be connected one to each side of the antenna at the center insulator. The lead-in should drop freely from the antenna for as great a distance as possible before any bends are made. After this any necessary bends should be as gradual as possible. Since the half-wave dipole is cut for a specific frequency band, it will be necessary to erect a dipole for each band you wish to use. Figure 1 shows a typical half-wave dipole and the Table 1 shows the overall length of the half-wave dipole for use on the various bands.

Table 1. Antenna length for various bands.

Band	Length of Antenna
13m	21 ft
16m	26 ft
19m	31 ft
25m	41 ft
31m	51 ft
41m	68 ft
49m	81 ft
59m	94 ft

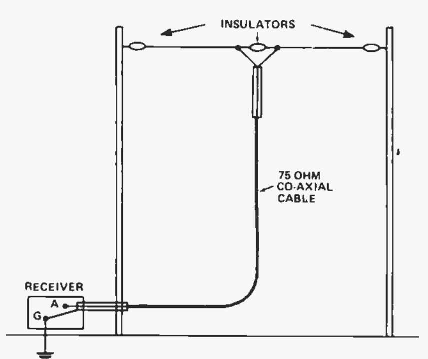


Fig. 1. Half-wave dipole.

THE FOLDED DIPOLE:

Like the dipole this antenna is also directional and best reception is obtained with the antenna broadside to the incoming signal. The total length of the antenna is one whole wavelength but since the two ends are folded into the center this antenna only occupies one half of a wave length of space. The lead-in is connected at the center to the two ends as shown in Figure 2. The lead-in should have an impedance of 300 ohms for this type of antenna. TV twin lead is a good lead-in. In fact the entire antenna may be made from TV twin lead. A length of twin lead equal to one half wave length is used for the antenna. The two wires at each end are soldered together and the twin lead is cut on one side only at the center. The lead-in should be allowed to drop freely for as great a distance as possible before making any bends in it. The folded length "L" is the same as for the half-wave dipole although the actual antenna length is twice this. Since this antenna is also efficient only over the narrow band of frequencies for which it is cut, it will be necessary to erect a series of them to cover all the frequency bands required. It would in this case be found convenient to install a multiswitch to provide ease of antenna selection.

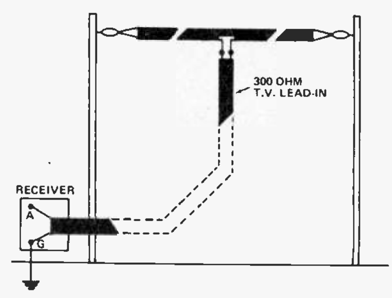


Fig. 2. Folded dipole.

THE TRIPLE DIPOLE:

The triple dipole is a directional broadband type of antenna with its best reception being obtained when it is broadside to the incoming signal. It can be used from 5 to 30 MHz. As its name implies the triple dipole is made up of three dipoles, each cut to a different length and interconnected with the others to give the antenna its broadband characteristic. The longest of the three dipoles is used to support the other two as shown in Figure 3. A suitable lead-in for this type of antenna would be 75 ohm co-axial cable. As with the other dipoles, the lead-in should be allowed to fall away freely from the antenna for as great a distance as possible before making any bends. Then all bends should be gradual. The length of the longest dipole is 50 feet on each side of the center insulator. The second is made up of two 35 foot lengths of wire. One end of each of these is connected to the center insulator and the other ends are connected to the supports. The shortest dipole is made up of two 12 foot wires connected in the same way. The angle or distance between the dipoles is not at all critical and will not have any great affect on the reception qualities of this antenna.

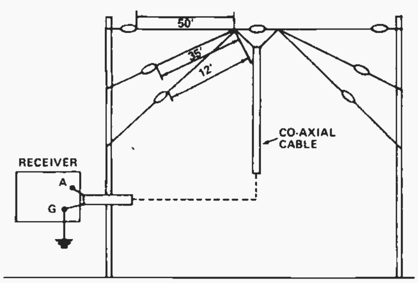


Fig. 3. Triple dipole.

THE VERTICAL DIPOLE:

The vertical dipole is an omni-directional type of antenna and will have its greatest efficiency when cut to a specific length corresponding to a given frequency band. The dimensions for this antenna are the same as for the horizontal half-wave dipole. However since it is erected vertically it takes on the omni-directional characteristics. Figure 4 shows a typical installation for this type of antenna. A length of 75 ohm co-axial cable makes a suitable lead-in for this antenna. Those listeners wishing to obtain reception over a number of frequency bands, should build a vertical dipole for each of the bands they require. This series of vertical dipoles can then be supported from a common support and each of the lead-ins brought into the receiver. Again a multi-switch can be used, which will provide a method for the easy selection of the required antenna. It should be remembered that the lead-in will have to be taken away from the antenna at right angles for as great a distance as possible. In this case it will mean therefore that special supports will have to be used. Like other types of vertical antennas, the vertical dipole is more responsive to man-made and atmospheric noise than horizontal types of antennas.

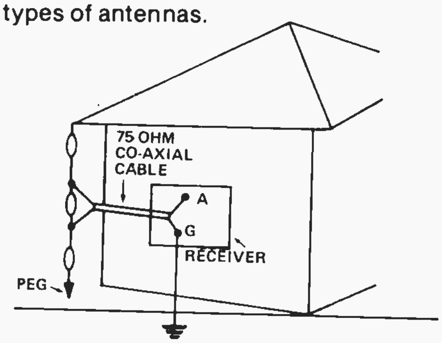


Fig. 4. Vertical dipole.

OTHER TYPES OF ANTENNAS

There are many other types of antennas but these that I have mentioned this month and last month are the most common and easiest to install. I would suggest that you experiment with several types and see which suits you best. Of course apartment dwellers have a problem usually since most landlords won't allow outside antennas. The "slinky dipole" antenna might be a good answer. It is made like the Slinky spring toys and can be extended across a room. I haven't tried it out yet but expect to some day.

MAILBAG

Remember if you have any questions about shortwave or any comments or suggestions about this column please drop me a line. Write to — Shortwave World, P.O. Box 142, Thunder Bay, Ontario, P7C 4V5.

EQUIPMENT REVIEW

PANASONIC RF8000

"A portable radio that costs the earth — But it gives you the world"

The range and performance of the RF-8000 make it one of the most versatile portable radios in the world. Each component and circuit has been thoughtfully designed to give the best reception possible in every conceivable condition. The technical engineering quality is of the highest, and in fact many of the high grade components are the same as those used in professional communications and even space research equipment. From the sensitivity and selectivity specific-ations alone — the keys to radio performance — it can be judged that the RF-8000 is one of the finest shortwave radios available anywhere at any price.

The very wide frequency range of 150 kHz to 230 MHz covers every reception mode: AM, FM, SSB, and CW. The 24 bands include 12 shortwave bands, 2 marine bands (MB), longwave and medium wave and 8 VHF bands. These are used not only by FM broadcasting stations, but also by information and communication stations such as police, fire and emergency services, aircraft control, and amateur radio enthusiasts.

INSIDE THE RF8000

It would be difficult to improve on the performance of the RF-8000 without turning it into a completely professional unit, Ultra-high SW selectivity and sensitivity figures, for example, are obtained through the use of a crystal-controlled double superheterodyne system, tuned RF stages and a 6-stage IF circuit, ladder type ceramic filters, and antenna matching circuitry. A double superheterodyne system with crystal local oscillation is also used for narrow-band VHF reception. Again, VHF selectivity and sensitivity are enhanced by an RF circuit with a 4-gang variable condenser, and balanced dipole antenna. In all, the IF stage uses 27 transistors. Selection of bands is fully automatic, using a pushbutton system. The two dials are rotated by two DC motors (one for the clutch and one for the selection) driving a digital-controlled turret-type selector using a memory circuit. The turret turning system has gold-plated direct contacts which minimize loss and help to keep reception completely stable. By using linear frequency variable capacitors the SW tuning scale is a linear type for easier read-out. The 4-stage AF circuit has 6 transistors, including FET. And to keep the power supply completely stable, there are five separate regulating circuits using Zener diodes. Other refinements which separate the RF-8000 from ordinary radios include a BFO circuit for detecting SSB and CW carrierless signal a manual gain control for SSB and CW, a manual dial calibrator to assist in precise tuning, and a switch to narrow the bandwidth for improved reception under difficult conditions. There is also a graduated squelch control to cut FM interstation noise, and an automatic noise limiter circuit. External antennas of various impedances can be connected at the back.

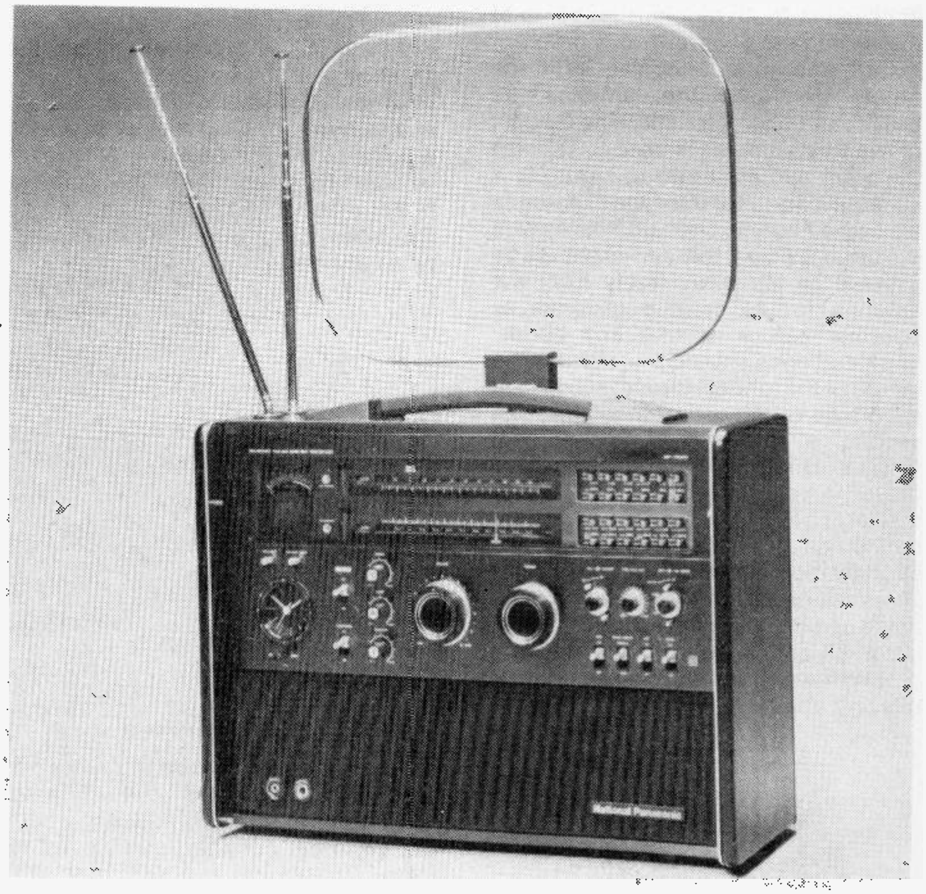
There are individual bass and treble controls and a loudness circuit for boosting low frequencies when the volume is low, to provide a richer sound. With terminals for auxiliary input, record out, and external speaker, the range of the AF section is very wide. There are protective resistors connected in series in both headphone and earphone terminals which prevent possible damage to the amplifier when equipment of a lower impedance is connected.

Built into the receiver is an accurate "tuning fork" clock. One 'D' size battery is used for the clock. Power for the receiver is 120 volt, 60 Hertz AC or 12 volt source such as a car or boat battery; or 8 "D" size batteries.

Dimensions of the RF-8000 are 512 mm wide, 361 mm high, 213 mm deep (20-3/16" x 14-¼ x8-3/8"). The receiver weighs 21.9 kilograms (48 lb. 5 oz.) with batteries installed.

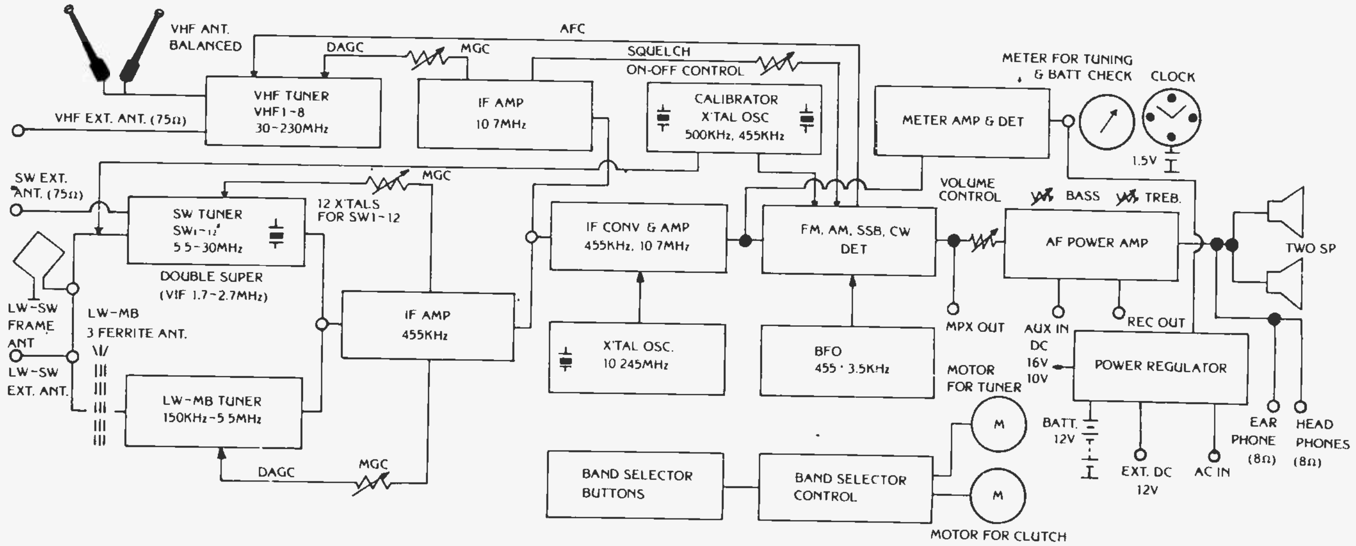
The Canadian list price for this fine receiver is $4,200.00. It would sure make a nice Valentine gift for your sweetheart. If the price of the RF-8000 is out of your reach then consider one of Panasonic's Command series of receivers which were described in last month's Shortwave World.

Next month I will have some information on Sony receivers. Until then 73 and good listening.

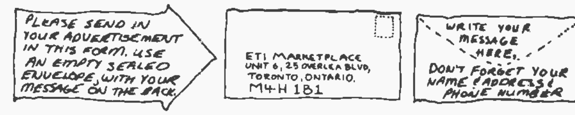


Panasonic RF-8000 Shortwave Receiver.

Block diagram of RF-8000.



MARKET PLACE



HELP! I WOULD APPRECIATE HEARING FROM ANYONE ON A SOURCE FOR HEAT SINK, MOUNTING PLATE & ANGLE (AS A SEPARATE UNIT) FOR THE E.T.I. 50D50 AMP. Wm. MARKIN, BOX 153, ERRINGTON, B.C., V0R 1V0

FOR SALE: KIM—1 MICRO COMPUTER MODULE. COMMERCIAL REGULATED 5 & 12V DC POWER SUPPLY. KIM USERS MANUAL, PROGRAMMING MANUAL AND HARDWARE MANUAL. $300.00., JOHN M. CLARKE, P.O. BOX 92 CRESTON, SOUTH NEWFOUNDLAND A0E 1K0 (709) 279-1157

MUST SELL: 12—DIGIT BIG DISPLAY CALCULATOR MINT CONDITION, SUITABLE FOR OFFICE/HOME USE. WAS $300 ASKING $50. MR LIN, 742—E61st AVE, VANCOUVER, B.C. V5X 2C2.

FOR SALE: 300 CPS DIABLO DAISYWHEEL PRINTER PARALLELL PORT, TTL COMPATIBLE, SERVICE MANUAL INCL. $600.00. (NEW $2000)! ALSO — MOTOROLA ySOKIT MICROCOMPUTER — INCLUDES STEP-BY-STEP TRAINING COURSE. GREAT FOR BEGINNERS! $150.00. M ROBINSON, 14 MARKET ST., GEORGETOWN, ONTARIO, L7G 3B7.

WANT TO BUY: SUPER SELECT-A-TENNA FOR AM RADIO STEVE BYRNS, 92 PENHALE ST., THETFORD-MINES, QUEBEC G6G 3J8

WANTED: SCHEMATIC OR SERVICE MANUAL FOR FRIDEN MODEL 132 ELECTRONIC CALCULATOR. PETER HEEMBROCK, P.O. BOX 646, BASSANO, ALBERTA T0J 0B0. (403) 472-3512 (8 AM—5PM WEEKDAYS ONLY).

HARK! POOR BUT NOBLE CAMPUS RADIO STATION SEEKS GOOD OLD SHORT WAVE RECEIVER, HALLICRAFTERS SX-28A OR SIMILAR. EXTREMELY REASONABLE. STEVE. CKRY, 258A VANIER COLLEGE, 4700 KEELE STREET DOWNSVIEW, ONTARIO, M3J 1P3 (416) 667-3919.

FOR SALE: KIM—1 MICROCOMPUTER, S—100 INTERFACE, "SOLID STATE MUSIC" VIDEO INTERFACE, WAMECO 8K BARE BOARD. ROB STEVENS, 23 BERWICK HILL N.W., CALGARY ALBERTA. (403) 275-1580.

WANTED: HP-67 (OWNERS MANUAL ONLY). WILL PAY $10.00 FOR A USED ONE. F. CHAN, 942 BROADVIEW DR., N. VANCOUVER, B.C. V7H 2G1

CONTENTS

CONTENTS

CONTENTS

PART I UNDERSTANDING AUDIO ICs

PART II PREAMPLIFIERS, MIXERS AND TONE CONTROL

PART III POWER AMPLIFIERS AND SUPPLIES

PART IV HYBRID CIRCUITS

Shortwave/ Transistor/ Audio IC

Above are the contents pages for these three pocket-sized books. The books were published in England by Babani Press & Bernards (Publishers) Ltd., and we now have stocks in Toronto for ETI's readers. Titles, authors and Canadian prices are as follows: Please add 25c for postage and packing.

'Shortwave Circuits & Gear For Experimenters & Radio Hams' by B.B. Babani, $2.60.
'28 Tested Transistor Projects' by R. Torrens, $2.85.
'Handbook of IC Audio Preamplifier & Power Amplifier Construction' by F. G. Rayer, $2.85.

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Binary To Decimal (And Back)

16 bit versions for the Commodore PR100 and the Texas Instruments TI 57
By Roy G Cooper.

THE DEMONSTRATION PROGRAM in Commodore's PR 100 handbook is a decimal to binary routine that uses a very elegant method for determining the highest binary digit present in a decimal number. Unfortunately this method is very difficult to use in a program for more than eight binary digits. So much for elegance!

Both conversion programs listed here use a pedestrian approach that checks for the presence of all sixteen digits possible within the capacity of the program. If you must feed in say a decimal 5, the calculation will take almost the same time (about 20 seconds for the TI 57 and twice that for the PR 100) as if you had entered 65535.

Both decimal to binary versions are self-contained, have built-in loaders, and need no memory manipulation between between runs. The binary to decimal programs are a tighter fit, and some concessions had to made. Both calculators must have their working memories cleared between runs, and the PR 100 must be loaded externally. The TI 57 routine is self-loading but a step was lacking for the final halt. In consequence the answer is flashed as an error.

If you dislike flashing answers more than you dislike loading memory you can always remove the loader and add a halt. Actually, since the programs were worked out for the PR 100 as being the most limited in programming ability, and translated fairly directly for the TI 57, it shouldn't be too difficult to trim a little fat here and there and accomodate both.

As a result of leading zero suppression it may be necessary to fill in missing zeroes in the least significant register.

Adapting these routines to other calculators of equal or greater capacity should be relatively simple. Just in case someone reading this has glossed over warnings in this particular handbook (as I did), I feel compelled, as a humanitarian, to add a few words that could save an enormous amount of time and frustration.

The algorithms used for more complex functions in calculators often produce small errors. This is particularly true for powers of small numbers. In normal mathematics these errors are insignificant and can be ignored; in these programs they can't, A one in the Zth. place where you can't see it in the display will still be unacceptable as zero and can foul up a conditional transfer. More than one early version of these programs came to grief for this reason. Where decimal ones and zeroes masquerade as a binary number, as they do here, a negative error where seven nines might appear instead of the expected one and seven zeroes, is equally disastrous.

Try out each power that you intend to use. If the display is correct, key in minus, the same number, and equals. Crank up the maximum number of decimal places and any positive error is revealed. Errors on the minus side will, of course, be apparent in the original display.

The sneaky ones are easily dealt with. Use of the INTEGER key will eliminate them entirely.

Where negative errors exist some other method must be used. Quite a few step-consuming alternatives are apparent in these programs.

If, after conversion, you have program steps to spare, you might like to add a high-limit screen between a and b in the decimal to binary program. This is easily implemented without the normal conditions with:- $2y^x16$ (or its equivalent), minus, RCL, (decimal memory), equals log. The program halts with an error sign if the capacity is exceeded. Without this screen an erroneous answer is produced.

SOFTSPOT is ETI's programmable calculator software department. We know there are many of you who have gone to a lot of effort to write routines for your machines — how about sharing the fun. Send us a copy of your pet program, preferably with flow chart. To make things interesting we will restrict our choices to only those programs making use of loops or conditionals.

All programs we publish will be paid for.

Mail to: ETI Softspot
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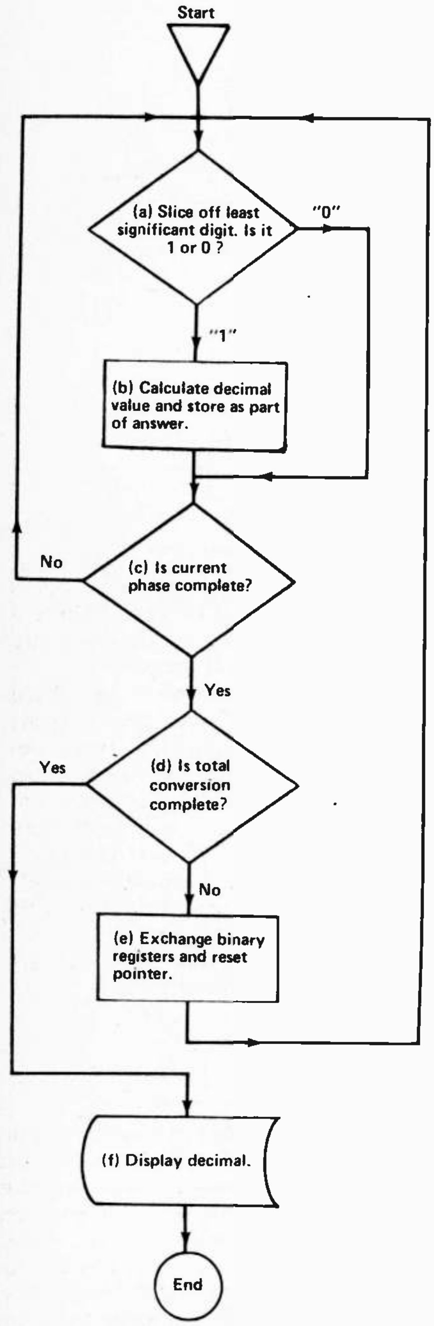
Don't forget to mention what kind of calculator you use — and we'd also be interested to know where you bought it.

BINARY TO DECIMAL FLOW CHART



BINARY TO DECIMAL: PR 100

STEP	CODE	KEY
00	81	1
	91	0
	21	F
	75	÷(M)
	81	1
	52	MR
	81	1
	21	F
	51	FRAC
	85	—
10	92	.
	81	1
	95	=
	94	+/—
	15	SKIP
	14	GOTO
	83	3
	82	2
	82	2
	34	y^x
20	52	MR
	83	3
	95	=
	21	F
	84	+(M)
	72	5
	52	MR
	81	1
	21	F
	52	INT
30	51	M
	81	1
	81	1
	21	F
	84	+(M)
	83	3
	21	F
	84	+(M)
	71	4
	61	7
40	85	—
	52	MR
	71	4
	95	=
	15	SKIP
	14	GOTO
	91	0
	91	0
	52	MR
	83	3
50	85	—
	81	1
	72	5
	95	=
	15	SKIP
	14	GOTO
	73	6
	62	8
	52	MR
	82	2
60	51	M
	81	1
	25	C
	51	M
	71	4
	14	GOTO
	91	0
	91	0
	52	MR
	72	5
70	13	R/S

M REGISTERS
1 Binary Number
2 " " "
3 Binary Power
4 Transfer Pointer
5 Decimal Number

EXECUTION
1 Clear all
2 Place decimal (F, FP, 0)
3 Mode Sw to Load.
4 Key in program.
5 Mode Sw to Run
6 Clear M3, 4, 5 (not req'd for first run).
7 Key in 8 most significant digits. M2
8 Key in 8 least significant digits. M1.
9 Clear, GOTO 00, R/S
For subsequent conversions proceed from 6 above.

BINARY TO DECIMAL: TI 57

Step	Key Code		Key Stroke
00	32	2	STO 2
	81		R/S
	32	1	STO 1
	01		1
	32	3	STO 3
	85	0	2nd Lbl 0
	01		1
	00		0
	-39	1	2nd INV PROD 1
	33	1	RCL 1
10	-49		2nd INV INT
	65		—
	83		.
	01		1
	85		=
	-75		2nd INV x ≥ t
	51	1	GTO 1
	33	3	RCL 3
	34	5	SUM 5
	33	1	RCL 1
20	49		2nd INT
	32	1	STO 1
	86	1	2nd Lbl 1
	02		2
	39	3	2nd PROD 3
	01		1
	34	4	SUM 4
	07		7
	65		—
	33	4	RCL 4
30	85		=
	76		2nd x ≥ t
	51	0	GTO 0
	33	3	RCL 3
	65		—
	03		3
	02		2
	07		7
	06		6
	08		8

40	85		=
	76		2nd x ≥ t
	51	2	GTO 2
	33	2	RCL 2
	32	1	STO 1
	15		CLR
	32	4	STO 4
	51	0	GTO 0
	86	2	2nd Lbl 2
49	33	2	RCL 5

M REGISTERS
1 Binary Number
2 " " "
3 Binary Power
4 Transfer Pointer
5 Decimal Number
7 Zero reference for conditional transfers.

EXECUTION
1 Clear all.
2 Place decimal (2nd FIX 0)
3 LRN, Key in program, LRN RST
4 Key in 8 most sig. digits.
5 Key in 8 least sig. digits.
Note: For subsequent runs CLR, RST, STO 4, STO 5. Then continue from Step 4 above.

DECIMAL TO BINARY: PR100

STEP	CODE	KEY
00	51	M
	81	1
	81	1
	72	5
	51	M
	71	4
	61	7
	51	M
	72	5
	25	C
10	21	F
	55	x↔M
	82	2
	51	M
	83	3
	82	2
	34	y^x
	52	MR
	71	4
	85	–
20	21	F
	52	INT
	52	MR
	81	1
	55	x↔y
	95	=
	15	SKIP
	14	GOTO
	72	5
	62	8
30	81	1
	21	F
	85	–(M)
	71	4
	21	F
	85	–(M)
	72	5
	52	MR
	72	5
	15	SKIP
40	14	GOTO
	81	1
	72	5
	52	MR
	71	4
	85	–
	81	1
	95	=
	15	SKIP
	14	GOTO
50	91	0
	73	6
	52	MR
	83	3
	13	R/S
	52	MR
	82	2
	13	R/S
	51	M
	81	1
60	52	MR
	72	5
	21	F
	33	10^x
	21	F
	84	+(M)
	82	2
	14	GOTO
	83	3
	91	0

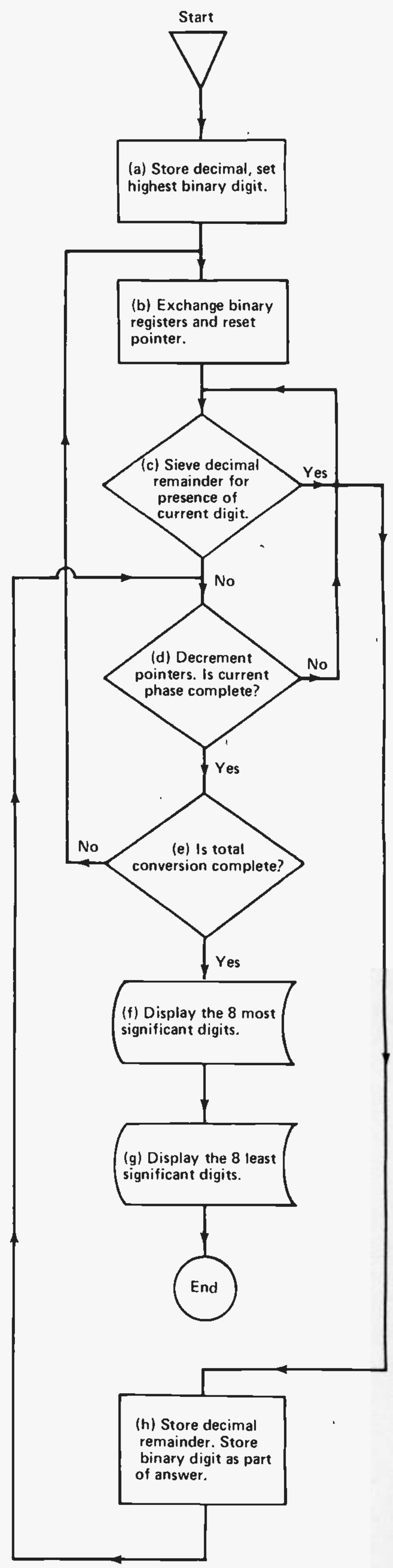
M REGISTERS
1 Decimal Number
2 Binary Number
3 " " "
4 Binary Power
5 Transfer Pointer

EXECUTION
1-5 As for Binary to Decimal
6 Key in Decimal Number (65535 max)
7 GOTO 00, R/S.
Note: All memory clearing and entry is contained in the program. For subsequent conversions proceed from Step 6 above.

DECIMAL TO BINARY: TI 57

Step	Key Code		Key Stroke
00	32	1	STO 1
	03		3
	02		2
	07		7

DECIMAL TO BINARY FLOW CHART



06		6
08		8
32	4	STO 4
86	0	2nd Lbl 0
07		7
32	5	STO 5
15		CLR
38	2	2nd EXC 2
32	3	STO 3
86	1	2nd Lbl 1
33	1	RCL 1
65		—
33	4	RCL 4
85		=
76		2nd x ⩾ t
51	3	GTO 3
86	2	2nd Lbl 2
01		1
-34	5	INV SUM 5
02		2
-39	4	2nd INV PROD 4
33	5	RCL 5
76		2nd x ⩾ t
51	1	GTO 1
33	4	RCL 4
65		—
01		1
85		=
76		2nd x ⩾ t
51	0	GTO 0
33	3	RCL 3
81		R/S
33	2	RCL 2
81		R/S
86	3	2nd Lbl 3
32	1	STO 1
01		1
00		0
35		y^x
33	5	RCL 5
85		=
34	2	SUM 2
51	2	GTO 2

M REGISTERS
1 Decimal Number
2 Binary Number
3 " " "
4 Decimal Equivalent of binary digit
5 Transfer Pointer
7 Zero reference for conditional transfers.

EXECUTION
1-3 As for Binary to Decimal.
4 Key in Decimal number (65535 max) R/S.

Note: For subsequent runs, RST, CLR, then continue from Step 4 above.

Tech Tips

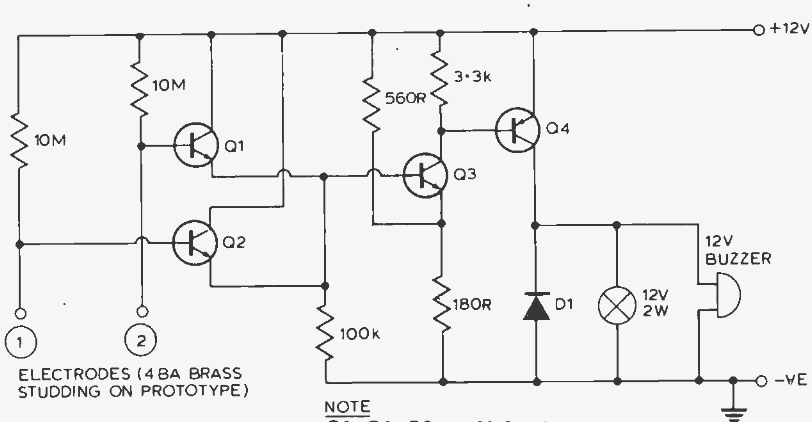
Tech Tips is an ideas forum and is not aimed at the beginner. ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible, and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI Tech Tips, Unit 6, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1

Brake Fluid Indicator

D. Shorthouse

This circuit indicates by means of a warning light and a buzzer when the fluid in the tank of a braking system is getting low.

Normally both electrodes are immersed in the brake fluid, and the bases of Q1 and Q2 are at ground potential (the fluid makes a connection between the electrodes and the brake cylinder which is connected to the car chassis). If the fluid level should fall, and either of the electrodes becomes dry, Q1 or Q2 will turn on which will turn on Q3 and Q4 and the alarm energised.

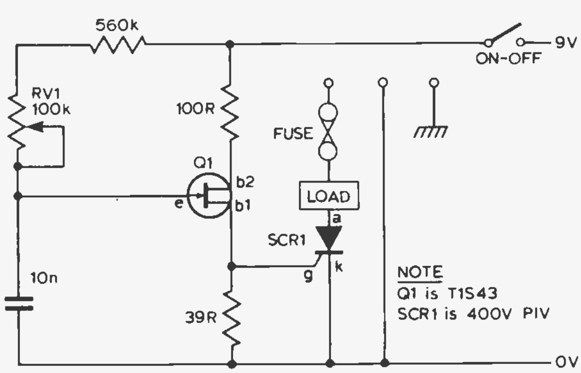


NOTE
Q1, Q2, Q3 are 2N3904
Q4 is TIP32A
D1 is 1N4001

Lighting Effects

D. Stewart

This circuit can be used to produce some interesting lighting effects. A unijunction relaxation oscillator is used to trigger the thyristor. The frequency of the oscillator is controlled by RV1. The load (a light bulb) will not be triggered at the same frequency as the unijunction oscillator, and some interesting effects can result. Care should be taken with this circuit as it is not isolated from the AC line.



NOTE
Q1 is T1S43
SCR1 is 400V PIV

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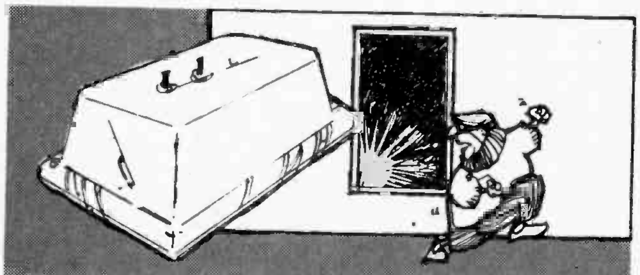

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Switches light off (e.g. garage light) after time predetermined by choice of capacitor (½ min. to ¼ hour). Comes with circuit board, 2 switches, SCR, transistor, 5 resistors...and easy-to-follow plans.

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NO YES!

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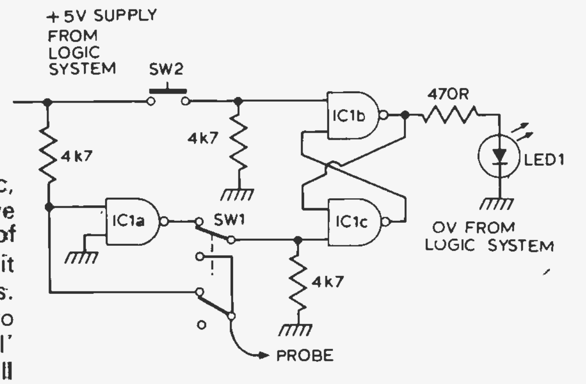
Tech Tips

Logic Noise Detector

G. Robinson

Ever since the advent of binary logic, spurious noise spikes and pulses have been the curse of the designers of even elementary systems. This circuit will help detect 'noisy' logic levels. With SW1 in position I, any logic zero spikes occuring on a steady logic 'I' will set the R-S latch and the LED will be illuminated. With SW1 in position 2, an extra inverter is brought in, and the circuit will be triggered by any logic 'I' spikes.



NOTE
SW1 is 2 POLE CHANGEOVER
SW2 is PUSH BUTTON
IC1 is 7402
LED1 is TIL209

Test Unit for Sequential Logic

D. Rayner

Any one testing a sequential logic circuit requires input pulses free of contact bounce. This unit does this, providing two switched, jitter-free outputs and a 'slow' variable speed clock. The complements of these signals are also provided.

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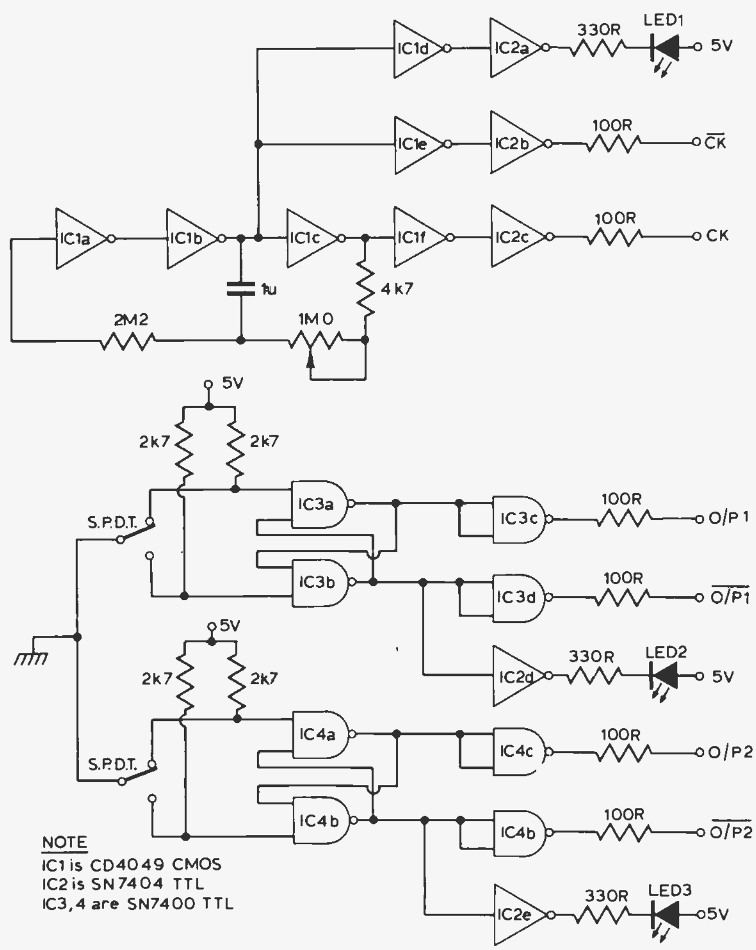

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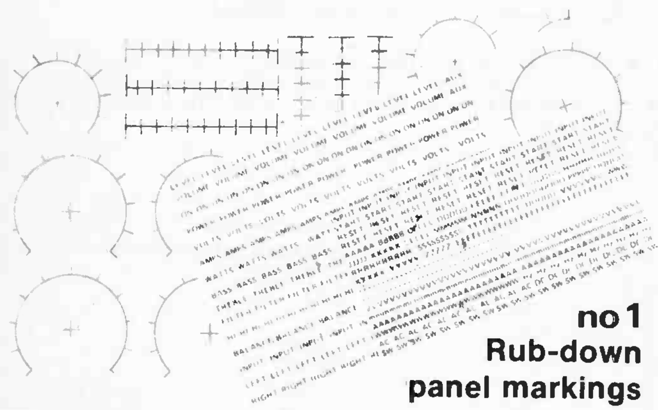

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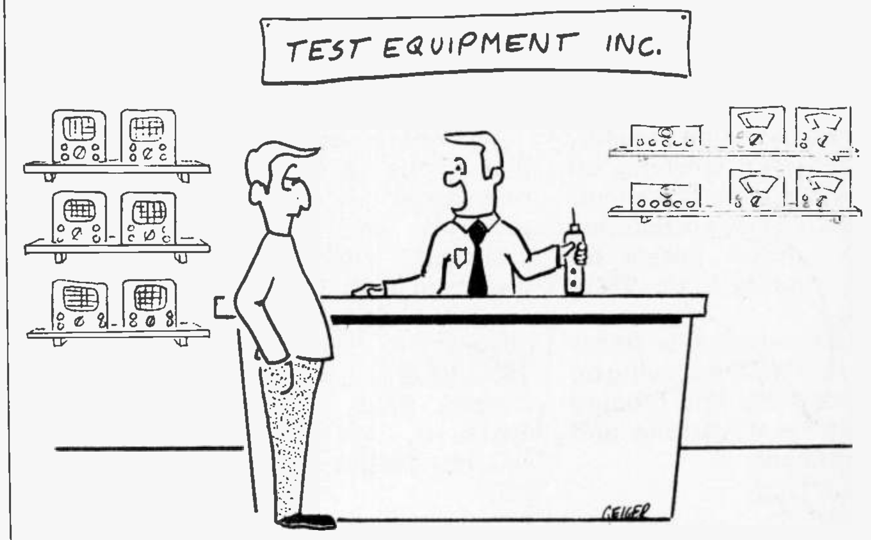

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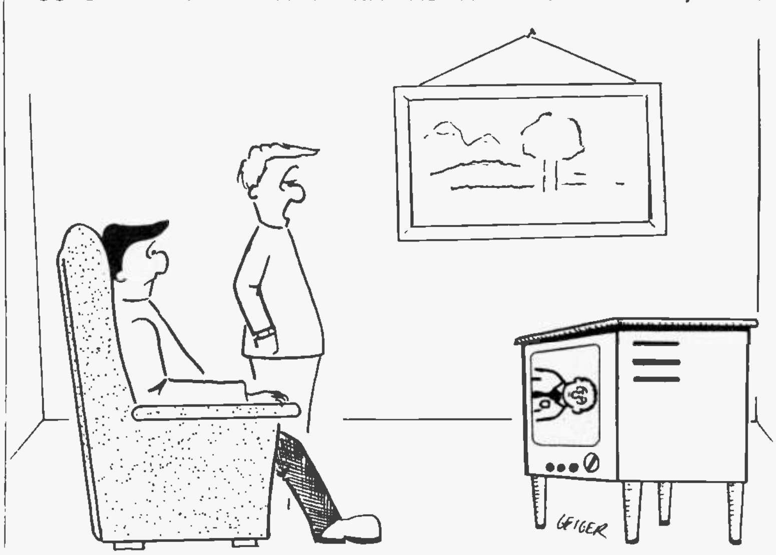

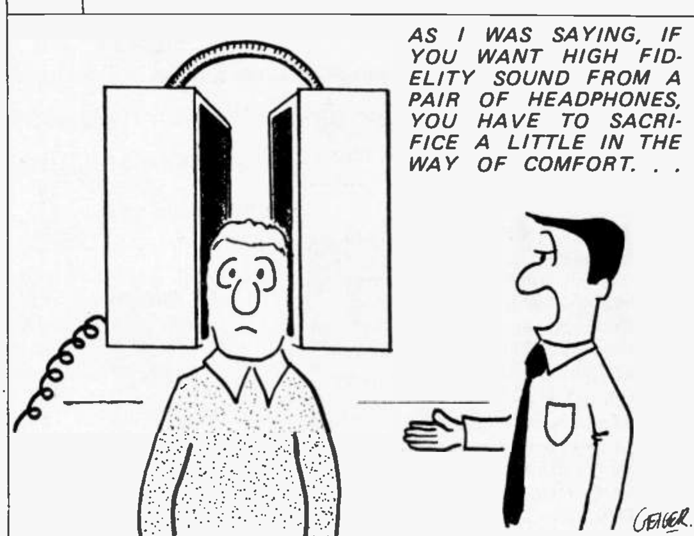

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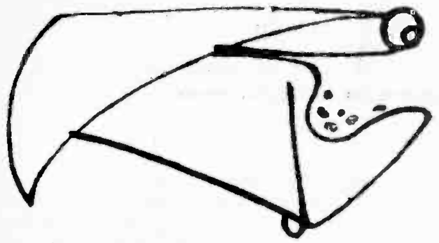

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ETI Project File

Updates, news, information, ETI gives you project support

PARTS PARTS PARTS

We are continually beseiged with letters from readers asking where they can get parts in their area. Since we can't take a country-wide tour to check where all the elctronics parts-places are, how about sending us a note on any stores you have found useful, what they are good for (if you own the place you can contribute too!) and so on. At some time in the future we would like to help out the "lost" readers by publishing a rundown of where to get what.

PROJECT FILE is our department dealing with information regarding ETI Projects. Each month we will publish the Project Chart, any Project Notes which arise, general Project Constructor's Information, and some Reader's Letters and Questions relating to projects.

PROJECT NOTES

Since this magazine is largely put together by humans, the occasional error manages to slip by us into print. In addition variations in component characteristics and availability occur, and many readers write to us about their experiences in building our projects. This gives us information which could be helpful to other readers. Such information will be published in Project File under Project Notes. (Prior to May 78 it was to be found at the end of News Digest.)

Should you find that there are notes you wish to read for which you do not have the issue, you may obtain them in one of two ways. You can buy the back issue from us (refer to Project Chart for date of issue and see also Reader Service Information on ordering). Alternatively you may obtain a photocopy of the note free of charge, so long as your request includes a self addressed stamped envelope for us to mail it back to you. Requests without SASE will not be answered.

PROJECT CONSTRUCTOR'S INFORMATION

Useful information on the terminology and notation will be published each month in Project File.

ETI Project Chart

ISSUE DATE	ARTICLE
Feb 78	Tachomonitor
Apr 78	Neg.
Feb 78	LCD Panel Meter
Apr 78	Note: C
Apr 78	Neg.
Feb 78	CB Power Supply
Apr 78	Neg.
May 78	Note: N
Feb 78	Freezer Alarm
Apr 78	Neg.
Mar 78	Hammer Throw
June 78	Neg.
Feb 79	Note:C,D
Mar 78	True RMS Meter
Apr 78	Neg.
Jan 79	Note:N
Feb 79	Note:N
Mar 78	Home Burglar Alarm
Apr 78	Computer PSU & Neg.
Apr 78	Audio Delay Line & Neg.
Apr 78	Gas Alarm & Neg.
May 78	White Line Follower
June 78	Neg.
May 78	Acoustic Feedback Eliminator
June 78	Neg.
May 78	Add-on FM Tuner
June 78	Neg.
June 78	Audio Analyser
June 78	Ultrasonic Switch & Neg.
June 78	Phone Bell Extender & Neg.
July 78	Proximity Switch
Aug 78	Neg.
July 78	Real Time Analyser MK II (LED)
Aug 78	Neg.
July 78	Acc. Beat Metronome.
Aug 78	Neg.
July 78	Race Track
Aug 78	Neg.

ISSUE DATE	ARTICLE
Aug 78	Sound Meter & Neg.
Dec 78	Note: N
Aug 78	Porch Light & Neg.
Aug 78	IB Metal Locater & Neg.
Aug 78	Two Chip Siren & Neg.
Sept 78	Audio Oscillator
Nov 78	Neg.
Sept 78	Shutter Timer
Nov 78	Neg.
Sept 78	Rain Alarm
Oct 78	CCD Phaser
Nov 78	Neg.
Oct 78	UFO Detector
Nov 78	Neg.
Oct 78	Strobe Idea
Nov 78	Cap Meter &Neg.
Nov 78	Stars & Dots
Nov 78	CMOS Preamp & Neg.
Dec 78	Digital Anemometer
Feb 79	Neg
Dec 78	Tape Noise Elim
Feb 79	Neg
Dec 78	EPROM Programmer
Feb 79	Neg
Jan 79	Log Exp Convert.
Feb 79	Neg
Jan 79	Digital Tach.
Feb 79	Neg
Jan 79	FM Transmitter
Feb 79	Neg
Feb 79	Phasemeter & Neg
Feb 79	SW Radio
Feb 79	Light Chaser & Neg

Canadian Projects Book

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Ceramic Cartridge Preamp	Double Dice
Mixer & PSU	Reaction Tester
VU Meter Circuit	Sound-Light Flash
Headphone Amp	Burglar Alarm
50W-100W Amp	Injector-Tracer
Note: N Apr. 78	Digital Voltmeter

Key to Project Notes

C:- PCB or component layout
D:- Circuit diagram
N:- Parts Numbers, Specs
Neg:- Negative of PCB pattern printed
O:- Other
S:- Parts Supply
T:- Text
U:- Update, Improvement, Mods
***:- Notes for this project of complicated nature, write for details (enclose S.A.S.E., see text)

PROJECT CHART

This chart is an index to all information available relating to each project we have published in the preceding year. It guides you to where you will find the article itself, and keeps you informed on any notes that come up on a particular project you are interested in. It also gives you an idea of the importance of the notes, in case you do not have the issue refered to on hand.

Every few months we print a pull out section in the magazine which may be used as a photographic negative for making printed circuit boards (as described in our January 78 issue). Each edition of this sheet contains projects from the preceding few issues. Information on where to find which negative is included in the chart.

Write to: Project File
Electronics Today International
Unit 6, 25 Overlea Blvd.,
TORONTO, Ontario
M4H 1B1

Component Notations 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 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 100n, 5600pF is 5n6. Other examples are 5.6pF = 5p6, 0.5pF = 0p5.

Resistors are treated similarly: 1.8M ohms is 1M8, 56k ohms is 56k, 4.7k ohms is 4k7, 100ohms is 100R, 5.6 ohms is 5R6.

Kits, PCBs, and Parts

We do not supply parts for our projects, these must be obtained from component suppliers. However, in order to make things easier we co-operate with various companies to enable them to promptly supply kits, printed circuit boards and unusual or hard-to-find parts. Prospective builders should consult the advertisements in ETI for suppliers for current and past projects.

Any company interested in participating in the supply of kits, pcbs or parts should write to us on their letterhead for complete information.

READER'S LETTERS AND QUESTIONS

We obviously cannot troubleshoot the individual reader's projects, by letter or in person, so if you have a query we can only answer it to the extent of clearing up ambiguities, and providing Project Notes where appropriate. If you desire a reply to your letter it must be accompanied by a self addressed stamped envelope.

True RMS Voltmeter

In the RMS Voltmeter which we published last March, there is an error in the input attenuator circuit. R4 should be 1.2k, and R5 should be 15k.

Hammerthrow

This project also appeared in March 78 (month of bad luck!) and has a couple of problems. On the circuit diagram the line connected to IC8 pin 1 should be grounded, this is correct on the pcb. On the component overlay, the leads of Q1 are incorrectly labelled. They are correct in the circuit diagram.

Reader Service Information

Editorial Queries

Written queries can only be answered when accompanied by a self-addressed, stamped enveloped, and the reply can take up to three weeks. These must relate to recent articles and not involve ETI staff in any research. Mark your letter ETI Query.

Projects, Components, Notation

For information on these subjects please see our Project File section.

Sell ETI

ETI is available for resale by component stores. We can offer a good discount and quite a big bonus, the chances are customers buying the magazine will come back to you to buy their components. Readers having trouble getting their copy of ETI could suggest to their component store manager that he should stock the magazine.

Back Issues and Photocopies

Previous issues of ETI-Canada are available direct from our office for $2.00 each. Please specify issue by the month, not by the features you require. The following back issues are still available for sale.

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June	March	
July	~~April~~	
September	May	
November	June	
	July	
	August	
	September	
	October	
	November	
	December	

We can supply photocopies of any article published in ETI-Canada, for which the charge is $1.00 per article, regardless of length. Please specify issue and article. (A special consideration applies to errata for projects, see Project File.)

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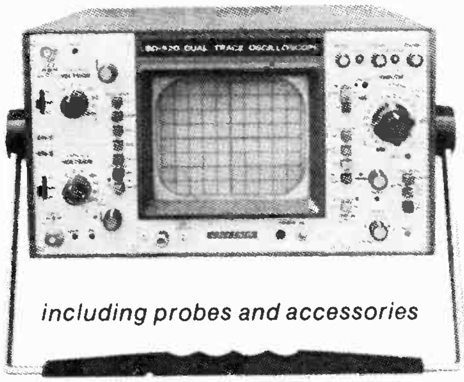

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- Portable compact type and improved facility

LBO 508 20MHz DUAL TRACE OSCILLOSCOPE

A brand new addition to a growing family of Leader oscilloscopes. This 20 MHz dual trace oscilloscope is small in size and light in weight. Front panel controls are logically grouped and located for fast and easy operation. The LBO 508 is a 20 MHz oscilloscope with a 10 mV/cm — 20 V/cm sensitivity in 11 calibrated steps. The high intensity CRT delivers excellent contrast while the regulated high voltage supply provides stable brightness.
The applications for this new outstanding oscilloscope are limitless. The LBO 508 is ideally suited for research and development, production, quality control, education and servicing.

- Compact, lightweight, horizontal package
- Add and subtract mode
- Front panel x-y one touch operation
- Automatic and T.V. sync. triggering

including probes and accessories

LBO 508

LBO 507

including probes and accessories

LBO 507 20MHz SINGLE CHANNEL OSCILLOSCOPE

Yet another brand new addition to the growing family of Leader oscilloscopes. This single channel 20MHz is small in size and light in weight. Front panel controls are logically grouped and located for fast and easy operation. The LBO 507 is a 20MHz oscilloscope with a 10 mV/cm — 20V/cm sensitivity in 11 calibrated steps. A 200mV/cm horizontal amplifier is incorporated to permit front panel x-y operation. The high intensity CRT delivers excellent contrast while the regulated high voltage supply provides stable brightness.
This general purpose oscilloscope is ideally suited for research and development, production, quality control, education and general service applications.

- Compact, lightweight, horizontal package
- DC to 20 MHz bandwidth
- Front panel x-y operation
- Automatic and T.V. sync. triggering
- Unique trigger circuit for maximum display stability

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